

Beyond the sum of parts:  
Shared flow, shared physiology and shared time in  
Javanese gamelan performance

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# Abstract

The experience of shared flow generally refers to the optimal balance between challenge and ability for a given task, resulting from interpersonal action in a group situation. The performance of Javanese gamelan is an ideal setting to investigate shared flow, due to its intrinsic group-based nature, allowing for shared flow and its native equivalent, *ngeli*. Previous empirical work often assesses shared aspects of flow by either subsuming individual experiences or looking solely at external measures of interaction. This thesis instead aims to capture the experience of shared flow in the context of gamelan, by investigating links between internal and external flow-related measures. Furthermore, the implications of contextual differences in gamelan performance, such as between pre-composed and improvised music, and between levels of expertise are accounted for.

Four studies were devised to empirically measure shared flow in gamelan playing. The first study implemented self-reports alongside measures of physiological responses using heart rate and skin conductance, indicative of sympathetic and parasympathetic nervous system activity. These methods were advanced in the second study by i) further accounting for the differences in interaction that might result from memorised or notated performance, and ii) incorporating additional measures of interaction by means of self-other overlap and consensus of time distortion alongside physiological synchrony. The final two related studies aimed to investigate more specifically how time distortion is associated with the experience of shared flow state by exploring qualitative and quantitative data.

Quantitative results indicate complex relationships between both physiological synchrony and shared time, and shared flow, whereby associations are influenced by performance context and musical expertise. Meanwhile, mixed methods findings suggest an optimal middle ground of conditions for “time flying” to occur in shared flow, akin to individual flow state. This thesis presents significant improvements in the conceptualisation and capturing of shared flow in the context of gamelan, with major implications for future research in assessing shared flow across multiple domains, in music and beyond.

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## Declaration

I declare that this thesis is a presentation of original work, and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as references. This thesis contains parts of the following papers of mine that are unpublished, have been published or submitted for publication pending review.

Chapter 2 contains a literature review that builds on parts of an assignment submitted in December 2019 as partial fulfilment for my Master of Arts in Music (Music Psychology pathway) at the University of York.

Study 1 (Chapter 4) is available at:

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The following conference paper presentations and talks were given during my PhD, based on the material in this thesis:

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## List of Abbreviations

|                                                    |                                                       |
|----------------------------------------------------|-------------------------------------------------------|
| AIC – Akaike information criterion                 | IOS – Inclusion of Other in the Self                  |
| ANOVA – Analysis Of Variance                       | ISC – Inter-subject correlation                       |
| ANS – Autonomic Nervous System                     | ISC-HR– Inter-subject correlation of heart rate       |
| AVE – Average Variance Extracted                   | ISC-SC– Inter-subject correlation of skin conductance |
| BIC – Bayesian information criterion               | ISXC – Inter-subject cross-correlation                |
| CFA – Confirmatory Factor Analysis                 | LRT – Likelihood ratio test                           |
| CFI – Comparative Fit Index                        | <i>M</i> – Mean                                       |
| <i>CI</i> – Confidence interval                    | MAXQDA – Max Qualitative Data Analysis software       |
| <i>df</i> – Degrees of freedom                     | <i>Mdn</i> – Median                                   |
| DFS-2 – Dispositional Flow Scale                   | MT – Musical Training                                 |
| ECG – Electrocardiogram                            | <i>N</i> – Sample                                     |
| EFA – Exploratory Factor Analysis                  | NaCl – Sodium Chloride                                |
| Est. - Estimate                                    | NCH - Dublin’s National Concert Hall Gamelan          |
| <i>F</i> – Ratio of two variances                  | <i>p</i> – probability of significance                |
| FDR – False discovery rate                         | PANAS – Positive and Negative Affective Schedule      |
| Gold-MSI – Goldsmiths Musical Sophistication Index | <i>r</i> - Correlation (Pearson’s)                    |
| GSG - Gamelan Spréacha Geala                       | <i>R</i> <sup>2</sup> - Coefficient of determination  |
| GSP – Gamelan Sekar Petak                          | RMSEA – Root mean square error of approximation       |
| GSR – Galvanic Skin Response                       | RQ – Research question                                |
| <i>H</i> – Test statistic for Kruskal-Wallis tests | SBGP – Southbank Gamelan Players                      |
| HR – Heart Rate                                    | SC – Skin conductance                                 |
| Hz – Hertz                                         |                                                       |
| IBI – Interbeat Intervals                          |                                                       |
| ICC – Intraclass correlation coefficient           |                                                       |
| IF(Q) – Interactive Flow (Questionnaire)           |                                                       |

*SD* – Standard deviation

*SE* – Standard error

SFS – Shared Flow Scale

SRMR - Standardized root mean square residual

*T* – Test statistic

TD – Time distortion

TD<sub>consensus</sub> – Consensus of time distortion

TLI – Tucker-Lewis Index

VIF – Variance inflation factor

*W* – Test statistic for Wilcoxon rank sum tests

z value – Describes the value's relationship to the mean of the group of values

$\chi^2$  – Chi Squared

$\sigma^2$  – Variance

$\tau_{00}$  – Random intercept variance



# List of Gamelan Terminology<sup>1</sup>

*Balungan* – skeletal melody of a piece, performed by melodic instruments and used as a basis for embellishment by elaborating instruments and *bonang*

*Bonang* – set of small gongs suspended on a wooden frame of boxes parallel to the floor. Typically two registers, *bonang barung* as the lower, and *bonang panerus* as the higher register. Most techniques involve interlocking across both instruments based on the *balungan* line (see *imbal* and *sekaran*)

*Cengkok* – melodic patterns played by elaborating instruments, determined in accordance with the *seleh* notes

*Colotomic* – description of structure in Indonesian music, whereby rhythm is divided across structural instruments in a cyclical manner

*Garap* – the workings out of instrumental parts, particularly elaborating instrumental parts

*Gatra* – set of four notes or rests, a unit in the larger scheme of a piece of *karatiwan*

*Gender* – elaborating instrument, with thin ribbed bars suspended over hollow cylinders. Played with two small felted mallets

*Gong* – refers to the main gong, *gong ageng*, and/or smaller *gong suwakan*. *Gongs* usually punctuate the ends of cycles.

*Gongan* can be used to refer to the section of music between *gongs*. When not italicised, gong refers to the general organological classification, not the aforementioned instruments

*Imbal* – interlocking pattern whereby pairs of two notes across two instruments come together to form a repetitive stream. Usually played by both *bonang* together with *sekaran*, but can also be played by *saron* pairs

*Irama* – refers to both tempo and density, whereby both are intertwined

*Karatiwan* – the encompassing word for gamelan music, instrumental and /or vocal, and specific to Javanese gamelan

*Kempul* – structural instruments, smaller gongs suspended from a frame, usually in front of the *gongs*

*Kenong* – structural instruments, large gongs suspended from boxes parallel to the floor, with one usually provided for each pitch. *Kengongan* can be used to denote the section of music between *kenongs*

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<sup>1</sup> Definitions largely informed by Sorrell (1990) and Pickvance (2005)

*Ketawang* – a form of a piece with 16 beats to the *gongan*

*Kethuk and kempyang* – structural instruments, small gongs suspended from boxes parallel to the floor and played with a single mallet, usually played as a pair.

*Ladrang* – a form of a gamelan piece with 32 beats to the *gongan*

*Lancaran* – a form of a piece with 16 beats to the *gong*, though structurally different from *ketawang*

*Laras* – tuning systems that a gamelan set is comprised of (see *pélog* and *sléndro*)

*Ngelik* – typically the second section of a piece, often accompanied by a vocal chorus

*Pathet* – like a mode, a pathet is a set of tonal hierarchies, whereby some notes are emphasised

*Pélog* - one of two tuning systems, heptatonic

*Ompak* – one section of a piece, usually the first in a shorter form piece or a transition in a longer piece

*Rebab* – two-stringed upright fiddle played with harmonics, function of elaborating around the melody (see *garap*)

*Saron* – melodic instrument, with thick bars and smooth surfaces. Three subtypes according to their relative registers are the *saron peking*, with the highest pitch and highest density of melodic material, *saron*

*barung*, and the *saron demung* with the lowest pitch

*Sekaran* – meaning a “flowering” cadential phrase, usually played by the pair of *bonangs*

*Seleh* – point of resolution, usually the fourth note of a *gatra*

*Sléndro* – pentatonic scale, one of two tuning systems

*Slenthem* – melodic instrument, thin bars with ribbed surface positioned using strings above hollow cylinders. The result is a resonant sound that cuts through the ensemble

*Suling* – elaborating instrument, vertically positioned bamboo flute played by blowing across the top hole

# Chapter 1. Introduction

Late afternoon in the bright Surakartanese sun, you stop for a moment to take in your surroundings under the shade of a jeruk tree. There is no hurry to arrive at your destination - time is elastic: *jam karet*. Amongst the spiced aromas of a nearby satay seller, and the clatter of tuk tuks, your attention is drawn to a continuous metallic melody, punctuated by a lofty, resonant gong. As you approach the source of these sonorities, the clarity of them intensifies. Behind the gap of a door curtain, you catch a glimpse of the instruments responsible. You notice a dozen or more players seated behind varieties of metallophones and percussion-type instruments, each contributing a unique aspect of the greater whole. At first, the drummer seems to be guiding the actions of the players, but then you realise the contrary may be true. The communication among them seems effortless. As the musical material unfolds and repeats, you are carried with it, yet remain static all the same. You have little idea how long you have been observing them, and they have little care for how long they have been playing. They are simply flowing with the music, and flowing together.

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Between the second and the third *seleh* of the fourth *kenongan*, you notice a pair of eyes in the gap of the entranceway. You become curious as to what this spectator has made of your rehearsal. As a *bonang* player, you have spent the whole time at odds with the drummers' tempo, finding humour in the speed you are ultimately delivering your *imbal-sekaran*. Not to mention the fact that the *rebab* player cued the *ngelik* perhaps after one too many *ompak* repetitions. It's all subjective, to a point. Providing you are all attuned to each other – which you know that you are. You've done this all before, so much so that whatever happens along the way, you do know what happens next. By now, it is automatic. You know that this strange voyeur at the door is in awe of that, unaware of the intra-ensemble mechanics, this unspoken connection that guides you. It is that which allows you to flow through the music, and flow together.

## 1.1 Flowing between gongs

The vignette above illustrates some of the main peculiarities of gamelan. Originating from Indonesia, it is intrinsically an ensemble-based form of music-making,

encompassing a variety of mostly percussion instruments, limited in their harmonic potential in the form of pentatonic and heptatonic tuning systems. The distinctly unfamiliar sonorities of the gamelan ensemble, particularly to Western ears, may provide a novel auditory experience to the listener by means of such resonant and metallic sounds as described above. Such novelty has notoriously fed the “exoticist” desires of composers since the romantic era (Sorrell, 2007). Yet, aside from acoustic qualities, gamelan playing yields a fresh perspective for a Western classical performer on what it means to play as part of an ensemble. Devoid of an explicit conductor, or leader akin to that of a principal violinist, gamelan requires mutual awareness and responsiveness. For players, their focus is on what their part contributes to the whole. In gaining insights into the phenomenon of group music-making more generally, a growing body of empirical research has shed light on the behaviours, interactions, and coordination strategies of ensemble musicians (Delius & Müller, 2023; Gugnowska et al., 2022; Khalil et al., 2022; Kohler et al., 2022). One mechanism which could aid collaborative musical contexts is the experience of “shared flow”, though this has seldom been explored empirically (Tay et al., 2021). For now, and more loosely, shared flow can stem from the classic definition of individual flow state, being a state of optimal experience of engagement and absorption resulting from a balance between challenge and skill for a given task (Csikszentmihalyi, 1990). What distinguishes shared flow from individual flow, however, is that it occurs as a result of interpersonal action in a group situation (Pels et al., 2018).

While there are plenty of different kinds of ensembles that could be examined in the exploration of shared flow, this thesis focuses on an ensemble type that affords greater opportunities for flow states, namely Javanese gamelan. Although there are some differences between gamelan practices specific to different regions, its conceptual basis of meaning and structure varies minimally (Loth, 2016). Therefore, this thesis will refer to gamelan music with no regional distinction, with an emphasis on Javanese gamelan due to its prominence in the existing literature, and its ties to the University of York and wider groups who participated in the empirical studies to follow.

Javanese gamelan requires that all individual instruments work harmoniously, allowing for the potential occurrences of shared flow, and the native equivalent, *ngeli*, meaning

to float together (Tan et al., 2020). Underpinning the egalitarian ethos of gamelan is the interlocking synchrony of structural instruments and repetitive cyclical patterns, whereby governance is distributed throughout the ensemble in an algorithmic sense, and individual and combined outcomes are reciprocally predicted and monitored (Matthews, 2018). As opposed to the case of a Western orchestra, where the first violin or conductor may act as lead roles, gamelan is non-hierarchical in that all instruments are of equal significance (Sorrell, 1990). It is an inherently ensemble-based set of predominantly metallophones and resonant percussion instruments struck with mallets. No conductor is present, and in their absence is a drummer guiding temporal and structural changes (Brinner, 1995).

Traditional structures involve a combination of metric layers, whereby structural and temporal changes require individuals to think beyond their individual role (Matthews, 2018), as will be discussed in more detail in the literature review. Furthermore, as a result of the manufacturing processes, gamelan instruments are tuned to one another, which in turn lends themselves well to group improvisatory settings (Loth, 2014). The possibilities for prescribed or improvised performances yield potential consequences for the social dynamics of the ensembles (Hadar & Rabinowitch, 2023), and in turn, the potential for shared flow to arise.

When traditional structures and pieces are learnt from memory, much more emphasis is put towards the group dynamic than if individuals are focused on their individual parts (Benamou, 2010). Group improvisation, on the other hand, involves a great degree of shared awareness, and self-other merging, blending perceptions of self-generated and other-generated behaviours and actions (Feng et al., 2020). It therefore lends itself more to shared flow due to the entire focus being on the shared task as a result of the social interaction. Further to this distinction is the presence of a shared goal, which is an important feature of flow. Such a goal is engrained in the performance of prescribed music, while continuously developed and negotiated through the course of an improvisation. Accordingly, it seems plausible that the resulting flow experiences occurring from each context may differ.

In addition, the level of skill or expertise is also seen to be a necessary condition for shared flow to occur. Depending on individual ability and level of group training, which

is seen to be paramount to fostering shared flow experiences (Pels et al., 2018; Salanova et al., 2014), a highly skilled gamelan group may reach shared flow in playing a traditional piece, so long as all individuals are extremely familiar with their individual parts. Meanwhile, a beginner group may find greater potential to be absorbed in an activity that does not overly challenge them. This is also supported by work from Sawyer (2015), who put forward the view that shared flow is more likely to occur when all agents are equally involved in the creative process, and consequently, “group flow” may be unachievable if players do not have comparable skills. Little work, however, has been done to compare the shared flow experiences of experts with that of beginners.

## **1.2 The current field of shared flow research**

As the above has attempted to highlight, there are numerous confounding factors in the experience and interpretation of shared flow, including the level of interaction resulting from the context, the degree to which there is a shared goal or structure, and the expertise of those involved. One key issue with shared flow research, then, is the equivocation of heterogeneous definitions and contexts. Numerous terms have been used to describe the experience of flow in collaborative contexts, while each of these contexts may suggest a differing level of interaction between members of a group. For instance, the flow that might arise amongst a workgroup, collaborating on a business pitch together (Galimberti et al., 2015; Salanova et al., 2014), is likely a wholly different experience from that of a basketball team (Sawyer, 2015) or musicians (Gloor et al., 2013).

There remains a standard practice of using self-reports to capture experiences of shared flow. Whether extending individual flow state questionnaires to that of group beliefs through the use of plural pronouns (Zumeta, Basabe, et al., 2016), or devising entirely separate individual measures (Salanova et al., 2003, 2014), these strategies are limited in their singular unit of analysis. The problem with this is twofold:

- i) flow itself is often seen as a subconscious experience and any retrospective assessment via self-report is likely to be insufficient, and
- ii) extending an individual’s perspective to that of the group is not enough to capture a potential shared flow experience.

Similarly, gamelan playing has, for the most part, been researched qualitatively or in the form of quantitative self-reports, the aims of which largely focus on well-being benefits and outcomes resulting from playing gamelan (Henley et al., 2012; Macdonald et al., 1999; Wilson et al., 2009). Seemingly missing is a focus on the behavioural and psychological processes that allow for such outcomes to arise.

What is lacking is a method to rigorously measure the experience of the group in relation to flow, as has already been explored in studies on social and musical interaction (Khalil et al., 2022; Volpe et al., 2016). Therefore, by looking beyond self-reported experiences, not only might the issue of individual units of analysis be mitigated, but also the differing degrees of interaction as a result of context and expertise can be accounted for.

### **1.3 Aims and objectives**

This thesis aims to surpass the shortfalls of self-reports by incorporating an assessment of underlying mechanisms associated with shared flow – namely those reflective of the experiences of the group - from a more external perspective. Although self-reports are used, they are taken as a starting point.

While each individual empirical study is presented alongside its own set of research questions or objectives, the overarching objectives guiding this thesis are:

- 1) To determine the most appropriate methodologies in assessing shared flow, going beyond individualistic self-reports.
- 2) To understand the implications of differing performance contexts to the experience of shared flow.
- 3) To assess the influence of expertise or musical training in how shared flow is captured.
- 4) To provide conceptual clarity to the notion of shared flow and its application towards a range of contexts.

## 1.4 Overview of thesis

This thesis involves a first introductory part, forming a review of background literature and methodological applications in the study of shared flow so far. This is followed by three empirical studies, which are then discussed and summarised.

The next chapter (2) reviews the concepts of “flow” and “shared flow”, before contextualising theories in the realm of creative arts and music. The review then turns to studies focused on gamelan playing, first summarising how the musical dynamics and interactions required of players lend themselves to shared flow, before comparing outcomes of studies situated in gamelan playing with aspects related to flow factors. Following this, chapter 3 discusses the ways in which shared flow has been studied thus far, focusing on a range of self-report measures and external measures reflecting group dynamics and interactions. By looking towards physiological measures, alternative means of further grasping intra-group mechanisms are presented.

The first empirical study in this thesis (chapter 4) explores the use of physiological measures in conjunction with self-reports, as a means to represent the degree of interaction between players. In this study, two groups – i) complete beginners, and ii) a range of advanced beginners and experts – played a traditional piece and an improvisation. Using inter-subject correlation to derive a measure of synchrony of heart rate and skin conductance between players, relationships between these measures and self-reported shared flow scales are analysed. This study addresses the following research questions:

**RQ1** Is the Shared Flow Scale in gamelan playing valid and reliable in its proposed factor structure?

**RQ2** Is there a difference in significantly correlated windows of physiological synchrony between participants when playing traditional gamelan music compared to improvising as a group, and does this differ between levels of expertise?

**RQ3** How does self-reported shared flow relate to average physiological synchrony in traditional and improvised playing?



Following this, a second potential underlying dimension of shared flow is introduced: the experience of time during performance. Chapter 5 therefore discusses the relevance of time perception to shared flow, within a performance context. Alongside this, an expansion to the theory of shared flow is introduced, and alternative scales to measure the range of flow experiences underlying it are described. Finally, an additional confound not previously accounted for in Study 1 is discussed - that of the distinction between performing from memory and performing from notation. Chapter 6 then provides a summary of the procedure and methods adopted that contributed to the following reported experiments, i.e., Study 2, Study 3.1 and Study 3.2.

Study 2 (chapter 7) furthers the initial quantitative investigation presented in Study 1 (chapter 4) by incorporating a measure of consensus of time distortion (or “shared time”) and self-reported interpersonal closeness, alongside physiological synchrony, and shared flow. This study aims to understand how shared flow can be empirically measured, using the triangulation of these measures, and ultimately determining how a combination of internal and external perspectives may best represent self-reported shared flow. As such, the following research questions are explored:

**RQ1** Is there a positive correlation between self-reported shared flow and IOS?

**RQ2** How is self-reported shared flow associated with both shared time ( $TD_{\text{consensus}}$ ) and shared physiology?

**RQ3** Can the level of joint attention and social interaction underlying shared flow resulting from condition and musical expertise be capturable via triangulation of the IOS, a measure of time consensus and measures of physiological synchrony?

The final studies go deeper into participants' experiences and understandings of shared flow, and the directionality of perceived time distortion experienced in relation to shared flow. Study 3.1 (chapter 8) details a qualitative investigation into participants' experiences of shared flow and time distortion by means of thematic analysis of semi-structured focus groups. This study primarily aims to investigate participants' awareness of the influencing factors on time and shared flow.

Subsequently, study 3.2 (chapter 9) pairs qualitative insights by means of follow-up surveys with the measures of time distortion and shared flow, to account for participants' reasoning into their experiences of time, and in turn, shared flow. The purpose of this is to assess whether subjective time distortion as a standalone measure is associated with antecedents of shared flow and shared flow factors, and the contributing factors outlined by participants in Study 3.1 Both Studies 3.1 and 3.2 are then discussed in tandem in chapter 10.

Finally, the findings across all empirical studies are contrasted and summarised in the general discussion (chapter 11). Recommendations for future work in the field of shared flow and gamelan research are made in chapter 12, before concluding in chapter 13.

## **Chapter 2. Literature Review**

The objectives of this chapter are threefold. The first is to review existing literature on the study of flow and shared flow. Beginning with the original conception of “flow”, theories of group interaction as a necessity for flow to occur later stem from this, although each is explored in heterogeneous contexts. The resulting situation is one in which a broad spectrum of labels is given to the kind of flow that may arise in collective contexts. Even within musical contexts, there are still inconsistencies in accordance with musical styles, practices, and contexts. Second, this review turns to shared flow in music performance contexts. Third, this discussion is extended towards the ways in which gamelan is a fertile environment in which flow can arise in accordance with its structure, instrumentation, and performer dynamics. As gamelan has been adopted in a variety of educational and therapeutic settings, a discussion of studies involving gamelan and their associated outcomes that may be pertinent to flow is provided.

### **2.1 Defining flow states**

#### **2.1.1 Conceptualising individual flow state**

Flow is traditionally understood as a psychological state of peak involvement, or engagement, originally coined by Csikszentmihalyi (1975) and rooted in the discipline of positive psychology (Csikszentmihalyi, 2000). Although it is a multifaceted phenomenon, for the most part, it is seen as an optimal experience resulting from the combination of the reward stemming from success and the ability one has to meet the challenge of a given task. More demanding cognitive tasks elicit higher levels of flow (Payne et al., 2012), while situations in which the task is too cognitively demanding or not demanding enough may produce anxiety or boredom respectively (Hallam, 2008). It is akin to theories of “transportation”, comprising of absorption and concentration, lending towards a loss of time-perception (Green et al., 2004). Yet, in contrast to “transportation” revolving around the passive experience of a narrative, flow state is rooted in active engagement with a task. Expanding on these principles, Csikszentmihalyi considers there to be nine aspects of flow state (Csikszentmihalyi, 1990, 2000; Nakamura & Csikszentmihalyi, 2005), rooted in what it is that makes an activity enjoyable (Csikszentmihalyi, 1997). Some are pre-conditions, or those facets

that are necessary for flow to arise, while others are components, attentional processes, or experiential characteristics of flow; these are detailed below.

### *1. An autotelic experience*

Originally part of what inspired the study of flow research in the first place (Csikszentmihalyi, 1975; Nakamura & Csikszentmihalyi, 2005), this was later considered a necessary condition for flow to occur. Autotelic activities refer to those that are intrinsically motivated, whereby the reward of the activity stems from the activity in and of itself (Csikszentmihalyi, 1990). They oppose *exotelic* activities, which encompass most mundane daily tasks and chores. Nevertheless, some activities can be both, especially where job satisfaction is concerned (Csikszentmihalyi, 1997).

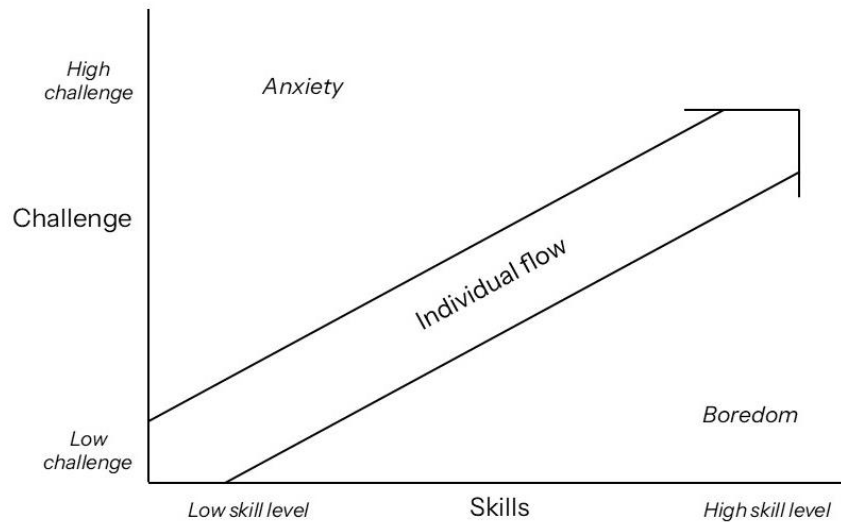
### *2. Balance between the challenges and the related individual skills for a given task*

Crucial to the idea of flow, and one of the more commonly associated dimensions (Fullagar et al., 2013; Keller et al., 2011), this dimension refers to the process in which an action at hand must stretch an individual's existing skills without over-exerting them. All the while, the challenge is perceived to be appropriate for their ability.

**Figure 1** depicts this balance graphically, with an image which frequently emerges in the study of individual flow (Canham & Wiley, 2003; Fullagar et al., 2013; Peifer et al., 2014; Tian et al., 2017).

**Figure 1.**

*Graphical Depiction of Balance Between Challenge and Skills. Adapted from Csikszentmihalyi (1975, p. 49).*



### *3. Clear goals for the task*

By having clarity of purpose and direction, attention and behaviour are structured towards the end goal, as opposed to unending action for action's sake. Such goals may also be invented during the activity, particularly in the instances of improvisation (Csikszentmihalyi, 1990), yet this requires a certain level of flexibility.

### *4. Unambiguous, ongoing feedback on the progress of task accomplishment*

This flexibility would not be possible without having continuous feedback, in which an individual can gauge how they are progressing within the activity. Not only does this overlap with goal-setting, but it also allows for maintaining the balance of challenge and skills (Nakamura & Csikszentmihalyi, 2005). By means of feedback, an individual may get a sense of whether any adjustments must be made to achieve or re-enter flow state, should the challenge become too great or too little.

### *5. Concentration on the task at hand*

The level of focus during the activity becomes such that all other thoughts of daily life dissipate. Such intense states of concentration allow for the greatest potential for success, or the opposite if concentration lies on matters of no relevance to the activity:

“If a musician thinks of his health or tax problems when playing, he is likely to hit a wrong note.” (Csikszentmihalyi, 1997, p. 112). A natural consequence of this quality of flow is that any associated anxieties are ruled out by necessity (Csikszentmihalyi, 1975).

#### *6. Merging of action and awareness*

These intense states of concentration naturally escalate towards an individual losing the sense that they are distinct from the action they are executing (Csikszentmihalyi, 1990). As opposed to the banality of everyday situations in which mind-wandering is prevalent, during flow experiences, the totality of one’s attentional resources is directed towards the task at hand. Subsequently, an individual becomes one with their actions, and their actions become one singular, flowing action (Csikszentmihalyi, 1975, 1997).

#### *7. Loss of self-consciousness*

As a result of the attentional demands flow consumes, there is little scope left for one to be burdened by usual anxieties and self-consciousness, to the point where any concern for protecting ego disappears (Csikszentmihalyi, 1997). Yet, this does not equate to being out of touch with physical reality. Rather, an individual is engulfed by such reality, through a heightened awareness of their body and their movements, instead of their self-construct and concern with the judgements of others (Csikszentmihalyi, 1975).

#### *8. Sense of control*

Through both a merging of action and awareness and loss of self-consciousness, there is no regard for failure. An individual involved in such a flow-enabling activity where they possess the necessary set of skills knows that they have the possibility, and not actuality, of control (Csikszentmihalyi, 1990). Such a distinction is made as there is always a risk of a glancing error in challenging circumstances, yet there is no attention left to be concerned about the possibility of flaws or mistakes that may occur during flow (Csikszentmihalyi, 1975, 1997).

## 9. *Transformation of time*

Typically, a flow state results in an obscured sense of time. The psychological, inner sense of time supersedes any relevance of the clock, warping to the point where hours feel like minutes or minutes feel like hours (Csikszentmihalyi, 1990). While the former is more common in periods of intense concentration and enjoyment, the latter can also be true where the briefest of technically challenging actions are experienced in slow motion by the individual performing them.

These nine dimensions of flow have permeated the discourse on the topic since their conception. Some steps have been made to further categorise them, in terms of those that precede flow and those that occur as a result of flow (Nakamura & Csikszentmihalyi, 2005). Many others have expanded on or synthesised these dimensions, and while the overall picture of Csikszentmihalyi's flow still looks more-or-less the same, a point of deficiency in the work up until this point is a lack of attention and precision on group contexts (Norsworthy et al., 2021).

### **2.1.2 Characterising shared flow states**

Thus far, flow states have primarily been studied at the individual level, focusing on them as personal experiences or characteristics. Notwithstanding, ideas of “social flow” or “shared flow” arose in some of Csikszentmihalyi's earliest work (Csikszentmihalyi, 1975). At the time of writing, “shared flow” appeared to be distinct from optimal individual experiences in group settings, while limited research had primarily focused on the latter in the context of sports and learning (Csikszentmihalyi & Csikszentmihalyi, 1988).

Csikszentmihalyi's ideas somewhat coincided with Turner's notion of “communitas” and was long preceded by Durkheim's writings of “collective effervescence” (Olaveson, 2001). “Collective effervescence” is a heightened sense of unity, achieved through the synchronisation of emotions towards a sense of group consciousness (Pizarro et al., 2022; Rimé & Páez, 2023), characterised by “intimacy, intensity, and immediacy” (Olaveson, 2001, p. 101). Turner's work on “communitas” was thought to expand on Durkheim's writings, though not explicitly, describing temporary states of unity in ritual (Rimé & Páez, 2023) which is comprised of egalitarian human bonds (Olaveson, 2001).

In contrast with the task-specific and structured nature of flow states, collective effervescence is thought to lead to long-term social bonding and collaborative continuation (Pizarro et al., 2022), while “communitas” was regarded by Turner as unstructured or rudimentarily structured (Olaveson, 2001). In this regard, ideas of shared flow states could arguably be seen as related, or as an intersection between the two, as will be seen; structured, yet largely temporary, blending unity and intensity towards a common goal.

Over the past couple of decades, differing theories, terms, and definitions of flow in group settings have often been assumed as homogeneous and equivalent (Pels et al., 2018), irrespective of heterogeneous contexts and defining features. Accordingly, the experience of flow in collaborative contexts has been referred to by various terms: “shared flow” (Nakamura & Csikszentmihalyi, 2005; Zumeta, Basabe, et al., 2016); “group flow” (Sawyer, 2015); “combined flow” (Hart & Di Blasi, 2015); “team flow” (Hout et al., 2018); “interactive flow” (Raettig & Weger, 2018); “networked flow” (Gaggioli et al., 2011; Galimberti et al., 2015); and “social flow” (Walker 2010). This thesis will largely adopt the term “shared flow” for the sake of consistency and for its conception in the original theories of Csikszentmihalyi. While terminological disparity in itself is not necessarily an issue, the problem lies in a lack of explanation as to why a particular theory is adopted while others are ignored (Pels & Kleinert, 2023).

Shared flow typically comprises the experience of a group, and of the individual as they participate in interpersonal action within an interactive context (Pels et al., 2018). It is generally accepted as an optimal experience akin to that of individual flow, whereby a group situation encompasses psychological and physical presence within the context of an interactive group task, or individual tasks in a group setting in which participants are aware of their simultaneity (Pels et al., 2018). Yet, there is divergence in agreement over whether it is a higher-order phenomenon, beyond any individual member, or whether it is experienced individually (Norsworthy et al., 2021). For some researchers, shared flow is often seen as an extension of individual flow state, where it typically arises through and contributes to synchronous or coordinated action (Gloor et al., 2013; Walker, 2021) or challenging cooperative activity (Magyaródi et al., 2022). Some authors treat it as a state of the individual that arises only because of the group context,



in a manner akin to that of emotional contagion (Hatfield et al., 1993; Salanova et al., 2014; Walker, 2010; Zumeta, Basabe, et al., 2016). Alternatively, some of the most prominent theories propose that shared flow is an emergent property of the group rather than the sum of individual parts, although a precise definition is missing (Pels & Kleinert, 2022). It is frequently understood as the experience of a flow state that emerges on a group level as a consequence of social, interactive contexts (Pels & Kleinert, 2022; Walker, 2021) and is therefore more than the combination of states of its members. Four conceptualisations of shared flow are outlined below to identify intersections and agreements between them, beginning with what is attributed to be the first and most widespread.

#### *2.1.2.1 Sawyer's theory of "group flow"*

Csikszentmihalyi's theory of individual flow state later inspired his student Sawyer's "group flow" and group creativity (Sawyer, 2003, 2006, 2007). Often accredited as the first to formulate a distinct theory surrounding flow state in group contexts, his central point rests on the notion that group flow goes beyond the sum of independent flow experiences:

There are many metaphors one can use to describe a talented group when they are "on," in interactional synchrony, performing well. One might say that they have a good chemistry, or that things are clicking or in sync ... For just about any sports team, one can speak of the group spirit, the team spirit, or the *esprit de corps* ... All of these metaphors focus on the entire group and on their performance together. Even if the individual performers are prepared and focused, a good group performance doesn't always emerge. When a group is performing at its peak, I refer to the group as being in group flow, in the same way that an individual performing at his or her peak often experiences a subjective feeling of flow. (Sawyer, 2003, p. 43)

Central to the notion of group flow, Sawyer discusses how group flow is an emergent quality of the entire group. In opposition to reductionism, the essence of "emergentism" applied to psychology details that while group processes and behaviours are comprised of individual actions, such group phenomena cannot be

broken down and studied through individuals (Sawyer, 2002). Consequently, it is theorised that group flow arises as a result of the interactional dynamics, and emerges from this; it does not depend on all members being in individual flow, and indeed, they may not be (Sawyer, 2003).

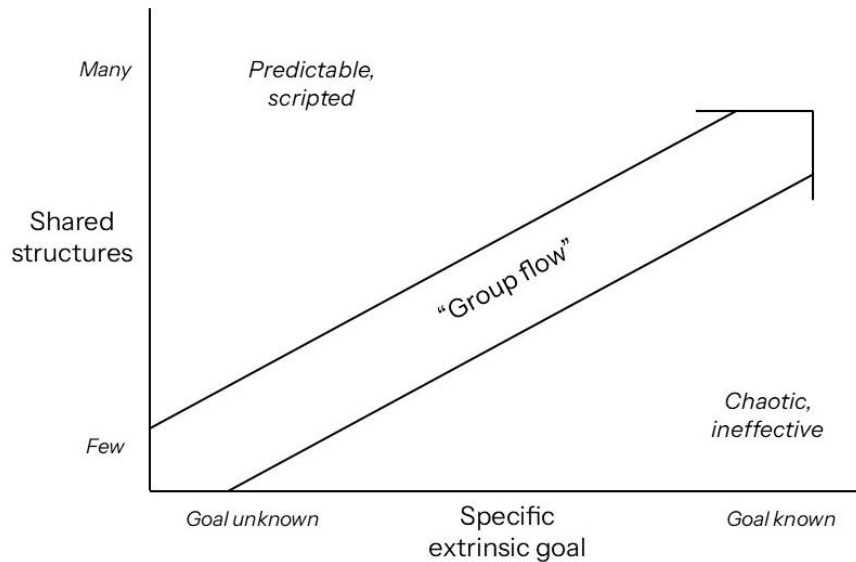
As part of this theory, he theorised ten flow-enabling conditions for “genius groups”, which he applied to contexts of jazz musicians, business teams, and sports (Sawyer, 2003, 2006, 2015). Many are comparable to that of Csikszentmihalyi’s individual flow state but with some distinct differences. Here, each condition is described while contrasting them with any applicable individual flow counterpart.

### *1) The group’s goal*

Just like in individual contexts where a clear goal is paramount for flow to arise, so too is this the case in group contexts. In many team-based sports, the clear goal of the group is in fact to score goals, and so the nature of the extrinsic goal is self-evident. In improvisatory settings, on the contrary, the group’s goal is not so specific. On a general level, a group may wish to entertain and put on a good performance, although the momentary goals are decided on as they come (Sawyer, 2003). While this is not dissimilar from Csikszentmihalyi’s views on the matter (1990), Sawyer posits that rather than flexibility being a pre-requisite for this to occur, there is a co-occurrence of both a balance of flexibility and structure and the clarity of the extrinsic goal. **Figure 2** depicts this in a similar manner to that of the classic balance of skill and challenge diagram (Csikszentmihalyi, 1975).

**Figure 2.**

*Representation of Balance Between Extrinsic Collective Goal and Pre-existing Structures in “Group Flow” (Sawyer, 2003, p.168)*



## *2) Close listening*

The term “listening” might stir up images of only those contexts that contain an audible component, ranging from workplace debates to jam sessions. Instead, it should be thought of as an openness to attend to what other group members are contributing in the moment and possessing a sensitivity in responding accordingly (Sawyer, 2006). No such counterpart seems to feature in Csikszentmihalyi’s dimensions, arguably because this condition is entirely specific to the group.

## *3) Complete concentration*

Contrary to the dimension of close listening, group flow requires similar levels of close concentration to that of individual flow. In group contexts, however, concentration is no longer just focused on the individual and the task they are faced with, but instead, it is extended towards what others are doing too. Accordingly, it may be all the more difficult to achieve complete concentration in group settings (Sawyer, 2015).

#### *4) Being in control*

Dichotomous descriptions emerge under the category of control. Sawyer asserts that in any environment the individuals of a group must have autonomy and competence, while also remaining flexible (2007). And yet, the kind of control here may not be interpreted as knowing exactly what one needs to do. Such ideas of (un)consciousness arise in group creative contexts: “Many musicians describe the experience of being surprised by what they play, or they discuss the importance of not being consciously ‘in control’” (Sawyer, 2003, p. 68). Perhaps - harking back to the related facet from that of individual flow - the control being referred to here is a control of the potential competence necessary, rather than a control of performing flawlessly.

#### *5) Blending egos*

Sawyer describes this aspect as a balance of deep listening and contributing creatively (Sawyer, 2007). It would be unproductive in group contexts for individuals to lose ego or self-consciousness altogether, as they might in individual flow experiences, as understanding the needs and desires of others ensures that ideas can be built upon one another. Examples of this are particularly prominent in group improvisatory settings, whereby theatre troupes may build upon the ideas of one another through statements of “yes, and...”, while improvised solos in jazz quartets may allude to snippets of other bandmates’ solos that were performed before (Sawyer, 2003).

#### *6) Equal participation*

An important facet of successful teamwork or group-working that allows for group flow, and might distinguish it from individual flow, is that all members have an equal part to play and possess comparable levels of competency. This is not to say all must be of exactly the same hierarchical status, as those in leadership or managerial positions may be involved provided they encourage the autonomy of the rest of the group (Sawyer, 2007).

#### *7) Familiarity*

The role of familiarity is twofold. Firstly, a group that does not have knowledge of each other’s performative contributions and peculiarities may find they do not have the

required level of trust to allow for some of the other necessitating conditions of group flow to arise (Sawyer, 2003). There should be a shared understanding through unspoken guiding principles, which allows for effective communication, blending of egos, and distribution of responsibilities. Secondly, while it has already been said that the group must be familiar with the goal, there must be enough common knowledge to be able to achieve such a goal (Sawyer, 2007). Both may of course backfire; if a group are overly familiar with one another or the task at hand and the structures guiding them, the result may be monotonous.

#### *8) Communication*

At the heart of group flow is a high degree of communicative interaction (Sawyer, 2003). In business, this can be in the form of stimulating verbal discussions and constant feedback advising of improvement, or in musical conversations there is a division of senses between what you are hearing and how you are responding (Sawyer, 2006). There is seemingly some overlap here with the condition of close listening, but beneath the surface, communication requires more active action, which is facilitated by close listening.

#### *9) Keeping it moving forward*

A team may continue to move forward, by means of constantly seeking innovation, building on what has come before (Sawyer, 2007). This is integral to the dynamism of business solutions, whereby products should constantly be improved upon to identify the next best thing. Meanwhile, it is just as relevant to any improvisatory or creative context, or that which requires any level of close listening (Sawyer, 2003).

#### *10) The potential for failure*

In short, this facet asserts that in many situations, a context that may be conducive to group flow arising usually comes with a risk of failure (Sawyer, 2007). Mistakes may arise in front of a paying audience, but it is through constant rehearsal that a group will become well acquainted with troublesome moments. The way in which Csikszentmihalyi describes the flow facet of having a “sense” of control as not *actual*

control is strongly related (1990), but just worded to the opposite effect. The potential for everything to fall apart is what brings a group so close together.

It is clear that Sawyer's theory was inspired by the of the work of Csikszentmihalyi, given the various overlapping features between flow in individual contexts, and his notion of "group flow". The most obvious of these include having a strong sense of control, a clear goal, and complete concentration. Several others, for instance, ego-blending, can simply be seen as an adaptation of the notion of ego-loss towards that of a collective context.

Nevertheless, while Sawyer's theory seems to be comprehensive in terms of sufficient and necessary conditions, it has been criticised for a lack of attention towards its more cognitive dimensions and how the emergence he described - particularly in terms of it being beyond a subsuming of individual states - comes into being (Gaggioli et al., 2011). Furthermore, much of Sawyer's basis is theoretical. Some qualitative data has lent support, yet the concept has not been investigated quantitatively, or in its entirety (Pels & Kleinert, 2022; Tay et al., 2021). Consequently, several other theories of how flow in collective contexts can be conceptualised have arisen since Sawyer's. While they may share some of the most basic assertions, they differ in other important aspects, not least in how they are labelled.

#### *2.1.2.2 Gaggioli and colleagues' theory of "networked flow"*

Gaggioli's theory of networked flow was conceived in direct response to Sawyer's "group flow" model, arguing a lack of concern over cognitive processes that facilitate many of the phenomenological perspectives Sawyer describes (Gaggioli et al., 2011). To this, ideas of "mirror" neurons were applied, and the potential co-codification of action and observation, where emphasis is placed on the psychological phenomenon of *social presence*. The authors argue that through such means, a physical co-presence is perhaps not as necessary as a social one, allowing for the potential for Networked Flow to occur in virtual realms (Gaggioli et al., 2015). Six facets constitute the Networked Flow Model (Gaggioli et al., 2011), detailed below.

### 1) *Meeting*

This facet refers to the establishment of shared intention or objection, which could be highly related to the idea of shared goals put forward by Sawyer (2007). Nonetheless, it specifies that each person possesses individual intentions before they are subsumed. In order to do so there must be an establishing of rules and an assigning of roles, before the second and third phases.

### 2) *Reducing the Distance*

Here, distances between individuals are reduced, towards that of the collective, through sharing beliefs and intentions. Starting from mutual dissatisfaction, group members move towards a point of liminality. There may be an increased perception of the common end goal, but one which is not yet directly expressed.

### 3) *Liminality-Parallel Action*

Boundaries are then established and consolidated. Group members both feel social presence and shared objectives, while also experiencing liminality in order to understand how it can be overcome. Through this, a collective intention emerges, though neither a leader has been agreed upon, nor has the goal's parameters been defined.

Within these three dimensions, which could be seen as prerequisites or antecedents for flow, social presence is paramount, allowing for the establishment of a common goal.

### 4) *Networked Flow*

A leader, or leaders, are identified and the actions of the group's members are guided by a shared "optimal" experience. Several other important characteristics of "networked flow" are stated, which strongly overlap with previous conceptions by Sawyer and Csikszentmihalyi: high concentration and involvement, a sense of control over the situation, clear goals, a balance between resources required and resources available, and a transformation of intention towards action (Csikszentmihalyi & Csikszentmihalyi, 1988; Gaggioli et al., 2011; Sawyer, 2007).

#### 5) *Creation of the artefact*

Through this process, some tangible product or artefact arises whereby a group is able to make judgements on the efficacy of their actions. The use or adoption of this tangible product characterises a group that is experiencing “networked flow”, while at this stage it is only the group that is aware of it.

#### 6) *The application of the artifact in social reality*

Finally, this tangible product or artifact is fed back into the social context of the group. Gaggioli and colleagues posit this a crucial stage (2011), through which individuals and social groups become aware of a group’s collective intention.

Overall, the “emergence” of the group that Sawyer refers to is, for the most part, the end result or product in “networked flow”, while it is in the ways that individuals self-organise themselves to allow for this to occur.

This model has been successfully applied towards a range of contexts, including educational settings and the creative arts (Gaggioli et al., 2011, 2015, 2017; Galimberti et al., 2015). In much of the work referenced here, empirical investigations into the relationship between social presence and “networked flow” have employed methods surrounding group-level structures in conjunction with related scales such as that of the Networked Minds Social Presence Inventory (Biocca et al., 2003), as is discussed in chapter 3. Overall, the Networked Flow model seemingly provides greater rigour and specificity than that of Sawyer’s theoretical framework in describing the cognitive nuances and stages of its phenomenological characteristics.

Yet, what is still seemingly lacking is testing of the entire model rather than parts of it (Pels & Kleinert, 2022). Furthermore, it largely pertains to the process of achieving networked flow, rather than the facets that networked flow encompasses. Therefore, while methods could be adopted to trace each stage of the model through to the “networked flow” stage, little detail is provided as to how networked flow is experienced as a group. The authors briefly describe key characteristics encompassing concentration, involvement or engagement, control, clear objectives, and motivation (Gaggioli et al., 2011), however, all of these are present in Csikszentmihalyi’s theory of individual flow (1990). This leads towards the assumption that there would be little



distinction between individual and shared flow experiences, beyond the way in which individuals organise themselves, which opposes many other concepts of shared flow.

### *2.1.2.3 van den Hout's theory of "team flow"*

For van den Hout, the conceptualisation of "team flow" describes an optimal team dynamic that occurs while interdependent tasks are executed (van den Hout et al., 2018). It stipulates that in the contexts of the workplace, individual flow is experienced concurrently and collectively, while multiple prerequisites and characteristics of a "Gestalt" team flow experience are fulfilled too. This perspective is multilevel: such prerequisites and characteristics of flow at individual and team levels supposedly affect one another.

Of the prerequisites, all are highly related to the theories that have been outlined so far. The first is "collective ambition", which is akin to the autotelicism and intrinsic motivation Csikszentmihalyi describes (1990). A "common goal" and "aligned personal goals" are then integral to any flow theory, yet in this context they are differentiated based on the individual-group divide, whereby individual goals should be compatible with and contribute to the group's goal. "High skill integration" extends the classic balance of challenge and skills, necessitating a distribution of skill sets amongst the group. "Open communication" describes ongoing feedback of Csikszentmihalyi (1975), and Sawyer's close listening (2007), yet it stems from that of the team, while "safety" goes hand-in-hand with Sawyer's potential for failure (2007). Lastly "mutual commitment" acknowledges the importance of complete concentration that both propose (Csikszentmihalyi, 1990; Sawyer, 2007).

Characteristics of "team flow" itself involve four interrelated emergent dimensions that connect the prerequisites with most outcomes seen in the flow theories described before now. A "sense of unity", which refers to cohesion and ego-blending, "joint progress", as a kind of sense of accomplishment, "mutual trust" akin to collective efficacy, and "holistic focus" as a feeling of group concentration and a resulting loss of time-consciousness. All are said to emerge once the prerequisites have been met.

The theory posits that several dimensions of "team flow" are collectively created and maintained, akin to that of Gaggioli and colleagues (2011), although there are aspects

of “team flow” that occur on a group level, detailing how this is consistent with the theories of Csikszentmihalyi and Sawyer (Nakamura & Csikszentmihalyi, 2005; Sawyer, 2007). Nevertheless, while Sawyer asserts that group flow may arise without all participating agents experiencing individual flow, van den Hout and colleagues insist that individual flow in its classical form (Csikszentmihalyi, 1990) is a necessitating condition for team flow to arise, in addition to these prerequisites and characteristics.

In contrast to the theories of Sawyer and Gaggioli, a dedicated questionnaire was developed based on all eleven elements of team flow described above (van den Hout et al., 2019). In spite of this, it has only been empirically tested in work-related environments (Aust et al., 2023; van den Hout et al., 2019). Furthermore, there are issues with the vagueness of constructs such as “holistic focus”, or specificity in terms of whether such constructs arise on individual or group levels of experience (Pels & Kleinert, 2022), given the bidirectional causal relationship between the two that the authors propose (van den Hout et al., 2018).

This distinction between “group flow” and “team flow”, despite the persistence from the authors that there are idiosyncrasies to the flow that arises in a team (van den Hout et al., 2018), is tenuous. As Pels and Kleinert argue, the only justification stems from the context being better suited to a “team” as opposed to a “group”, but this has no recourse for shared flow; the only requirement being that “the acting unit (i.e., the individual or the group/team) accomplishes a task (during which flow occurs) with goals” (2022, p. 8). Given the high degree of overlap between conceptualisations of flow provided so far, vast overcomplications seem to arise through debating the different characteristics and antecedents of shared flow resulting from contextual discrepancies. Instead, a key distinction between them is whether flow is experienced individually, or on a group level and whether the former is a necessary condition for the latter to occur.

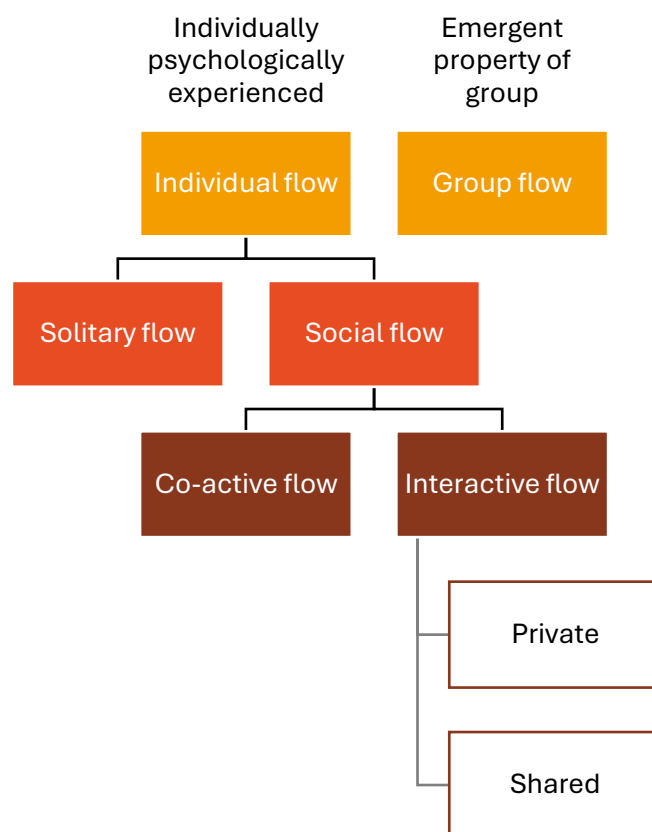
#### *2.1.2.4 Raettig and Weger’s “interactive flow” taxonomy*

Aside from discrepancies in how individual flow experiences relate to shared flow, there is little debate surrounding what the experience of shared flow entails. Many of the theories discussed so far detail similar principles in terms of what is required, while

there is an insistence on using new terms for old constructs based on differing contexts. Instead, what has been lacking in these theories is a greater level of clarity in distinguishing between individual and shared flow in group contexts and what separates the two. One such endeavour that attempts to rectify this is Raettig and Weger’s taxonomy of “interactive flow” (2018).<sup>2</sup> Although it presents yet another shift in nomenclature, it extends Sawyer’s concept of an emergent group-level flow, providing greater conceptual clarity by means of categorisation. This taxonomy is presented graphically in **Figure 3**.

**Figure 3.**

*Raettig & Weger’s Interactive Flow Taxonomy (2018)*




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<sup>2</sup> While this theory is adopted for now, further clarifications to the theory are provided by Hackert et al., (2022) which is introduced in chapter 5. This was published after the first empirical study of this thesis was carried out.

Starting with Csikszentmihalyi's state of individual flow (1990), the authors detail how this can arise in a setting where the agent is alone, or in settings where the individual is surrounded by others. One could think of a difference between experiencing "solitary flow" when running alone versus the "social flow" of running alongside others in a race. "Social flow" can then be thought of in terms of multiple tiers. In this example, there would be no interaction, and therefore the agents might be in "co-active flow", each experiencing flow individually, but the social context is subsidiary. If, instead, the race in question is a relay race, then the flow that the individual experiences would be a consequence of how well the team interacts together, leading to "interactive flow". This state can be felt in a "private" form, by any one member of the team, or "shared" by all of them (Raettig & Weger, 2018).

The states described above would be felt on an individual level, while group flow can only emerge as a state of the group. It is therefore proposed that all emergent group flow states that have been described by other authors can be treated as homogeneous (Pels & Kleinert, 2022). As theories often refer to this type of phenomenon in metaphorical terms, it is difficult to grasp how this may be empirically measured, particularly as Raettig and Weger do not detail how "group flow" arises (2018). Instead, they focus solely on "shared interactive flow" here, ascribing "group flow" to an emergent phenomenon that has no equivalent state on an individual level. For now, it is anticipated that the causal relationship between "shared interactive flow" and "group flow" state is bidirectional, dynamic and intertwined (Hackert et al., 2022). The group state may not arise even if all members are experiencing individual flow in a shared, interactive manner; contrarily, the group's state may induce individual flow in the individuals. It is this question of how such group-level interaction across members can be captured, beyond the sum of parts, which is of the greatest concern in this thesis.

#### *2.1.2.5 Summary*

Overall, it is clear where these theories intersect. All four theories contain notions of having clear objectives, concentration, and control. What is less evident, however, is the manner in which individual flow and a group-level emergent state of flow are distinguished.

Despite the importance of Sawyer's and Csikszentmihalyi's theories, the work of Raettig and Weger (2018) has been a major influence on the present work and inspired several key aspects of this thesis. This is because it presents a more clearly defined potential to empirically measure the experiences of individuals within a group setting, which avoids straying too far from that which flow is classically conceived to be. Antecedents, components and outcomes are more clearly distinguished from one another, unlike that of Sawyer's (2003, 2006, 2007). It is not without its shortfalls; for now, little attention is dedicated to how a group-level, emergent flow may relate to or be preceded by the "shared interactive flow" they describe. Such clarity is not provided until a later publication, introduced fully in chapter 5 (Hackert et al., 2022). Regardless, Raettig and Weger's taxonomic theory has been empirically tested in its entirety (2018), albeit in a limited context.

A source of contention between these theories is often the context in which they were conceived. Inevitably, each allows for differing degrees of individualised input and co-creation of a group artefact. In an effort to provide further clarity on this matter, the following section turns to one such context in which the individual- and group-level efforts and outcomes can be seen as two sides of the same coin. They are invariably distinguishable, yet also inextricably intertwined, depending on the success and the demands of the situation itself.

## **2.2 Flowing together through music**

Music is one context in which Csikszentmihalyi frequently exemplified flow states; whether through the autotelic nature of musical composition or the loss of self that stems from it (Csikszentmihalyi, 1975), or through the optimal levels of challenge that learning an instrument presents (Csikszentmihalyi & Csikszentmihalyi, 1988). In addition, music performance is often seen as conducive to flow as a result of its intrinsic continuous feedback potential, and the attentional processes it requires (Bakker, 2005; Harmat et al., 2021). While many have paid consideration to such flow that derives from the performances of individuals (Chirico et al., 2015; de Manzano et al., 2010; Fullagar et al., 2013), the meeting of musical minds and bodies in a group

setting presents unique opportunities in which the interactive qualities of shared flow can be captured.

The study of shared flow has often been trialled within musical contexts (Bishop, 2018; Gloor et al., 2013; Keeler et al., 2015) as music can be considered an intrinsically social phenomenon in its multiple manifestations (D'Ausilio et al., 2015; Schiavio et al., 2022; Turino, 2008). Sawyer's work on "group flow" has been applied to contexts of sports teams and workplace environments, but in actuality, a great deal of his writing on the subject is contextualised within that of theatre, music, and the improvisatory arts (Sawyer, 2003, 2006). The performances of improvising jazz groups are frequently credited as a conducive environment in which his emergent "group flow" occurs. The actions of individuals are highly interrelated across the group, and the resulting flow is therefore above any one player due to the social, dynamic and collaborative context in which it arises. In such contexts, individual flow experiences are difficult to disentangle from group flow experiences, due to the social context being the catalyst for flow.

The balance of structures and goals (2.1.2.1) that Sawyer described as a fundamental requisite for "group flow" to occur is largely described in the context of jazz improvisation. To expand further on this here, there are conceivably four structural lenses that can apply, where at least one needs to be adopted (Sawyer, 2003). Firstly, that of a general outline, or loose structure which all performers are privy to. Secondly, a repertoire of "ready-mades" with some prior knowledge of the ways in which they are performed. Thirdly, roles should be clearly defined within the group; this could apply to instrumentation specifically, or roles that are less overt. Finally, there should be shared conventions that guide the performances and interactions, weaving through like a common thread, such as chord progressions or solo lengths. Such structures are not just applicable to the realms of jazz, as it is conceivable that these are applicable to forms of music-making that are less flexible. Violinists in an orchestra should be aware of who has the role of the page-turner, of where a woodwind solo takes place and the dynamic should soften, or of what bowing has been agreed upon. Structure is intrinsic to all forms of music making, but some, more flexible ensemble opportunities, afford a greater degree of intrinsic interactivity in the music.

Situations in which the actions of one influence another as a series of causes and effects are seen as most favourable for shared flow to arise. Additionally, an individual's performance may be changeable. Musical material may vary over time in the level of challenge it presents, and so too might the individual's capacity or desire to meet such challenge (Csikszentmihalyi & Rich, 1997), and their ability to respond to the actions of others. As a result, the potential for shared flow to arise may fluctuate in accordance with the musical context and level of expertise. The importance of competence, or a balance of challenge and skill, emerged in most theories outlined in 2.1.2 and may play a large role in distinguishing between individual and shared flow in an ensemble when viewing flow as a taxonomy (Raettig & Weger, 2018).

Perhaps most fundamental in the relevance of shared flow to ensemble performance is a blending of egos in Sawyer's terms (2003), and a merging of action and awareness in Csikszentmihalyi's (1990). To play together with others requires a division of the senses and a state of constant and complete concentration: while performing, a musician has to be listening, simultaneously aware of the sounds you are producing and how they fit with the sounds of others (Sawyer, 2003). Such an awareness of self and other may not be so crucial in the performance of Western classical ensemble music, where providing each member performs their individual parts accurately, they should come together in the end. Nevertheless, attention should still be paid towards tempo changes and dynamic balance. Accordingly, whether playing with a score, without one, or improvising, each involves fundamentally different forms of social interaction (Hadar & Rabinowitch, 2023). Some prearranged forms of music performance, however, are not necessarily as concrete in their instruction as the compositions found in Western musical traditions. As we shall see, one striking example of this is found in gamelan music.

## **2.3 Finding shared flow in gamelan performance**

### **2.3.1 The tradition of Javanese gamelan music**

Since the 19<sup>th</sup> century, Gamelan music has been adopted and practised in Western cultures for its collaborative and communicative construction, and its otherworldly and parapsychological appeal. This began when composers and performers developed an

affinity with it for its “exotic” nature and as a novel source of inspiration (Sorrell, 1990). Only since the late 20<sup>th</sup> century however have educational practitioners recognised its potential to develop a greater sense of musicianship and improve personal and social attitudes (Diamond, 1979; Sanger & Kippen, 1987), through both musical features which will be explored in this section, and extramusical features. Respect for the instruments is paramount, to the point where polluting outside footwear is removed and instruments should not be stepped over (Sorrell, 1990). All emphasis lies on the notion of respectful detachment between players and instruments; this notion also relates to the behaviour of players towards one another and the way the music unfolds (Loth, 2014).

Gamelan is Indonesian in origin, although there are inter-regional distinctions between the gamelan cultures of Java, Bali, Sunda and Mandura, and even intra-regional variance between areas of Yogyakarta and Surakarta in Java (Pickvance, 2005). Nevertheless, most types of gamelan cross-regionally share the same fundamental basis: a core melody, punctuation of the melody, and drumming patterns (Loth, 2016). While there are some differences between gamelan practises specific to different regions, its conceptual basis of meaning, general instrumentation, tuning systems and structure varies minimally (Loth, 2014).

Within Javanese gamelan, both melodic and supportive roles are fundamental to the principle of gamelan being a group of instruments, as opposed to a combination of individualistic parts. Basic melodic lines are played by keyed instruments under the bracket of the *balungan*. Melodic instruments can be divided between “skeletal” parts (*slenthem*, *demung*, and *saron barung*), which play the basic *balungan* line, and “flowering” parts (*bonang*, *saron panerus* and *saron peking*), which play more complex and elaborate patterns building upon and anticipating the *balungan* line (Brinner, 1995). The supporter roles consist of “colotomic” or punctuating gong-type structure parts (*kethuk* and *kempyang*, *kempul*, *kenong*, *gong*), which are not considered as technically demanding, with a function in marking the subdivisions within larger cycles (Loth, 2014). These parts are significant, however, in their role of signalling subdivisions and meeting points within the structure for the rest of the players. Across most instruments, two tuning systems, or *laras*, exist; *sléndro*, being pentatonic, and *pélog*,



being heptatonic, each encompassing different characters and modal, or *pathet* variants (Sorrell, 1990).

In traditional pieces or *karawitan*, this melodic, or *balungan* line, consists of groups of four beats, known as *gatra*, where the strong beat lies on the fourth note of each *gatra*, named the *seleh* (Sorrell, 1990). *Karawitan* incorporates structures of cycles of series of *gatra* in which melodic parts play the continuous *balungan* line, and other structural instruments play interlocking beats punctuating the structure (Pickvance, 2005). The *seleh* at the end of each cycle is marked by a *gong*, which also acts as a signifier to return to the start. The structure of the piece is dictated by its title. Different structures encompass slightly different patterns, whereby in a cycle of 16 beats across four *gatra*, the interlocking of structural parts would look slightly different depending on whether it was a *lancaran* or a *ketawang*, for instance.

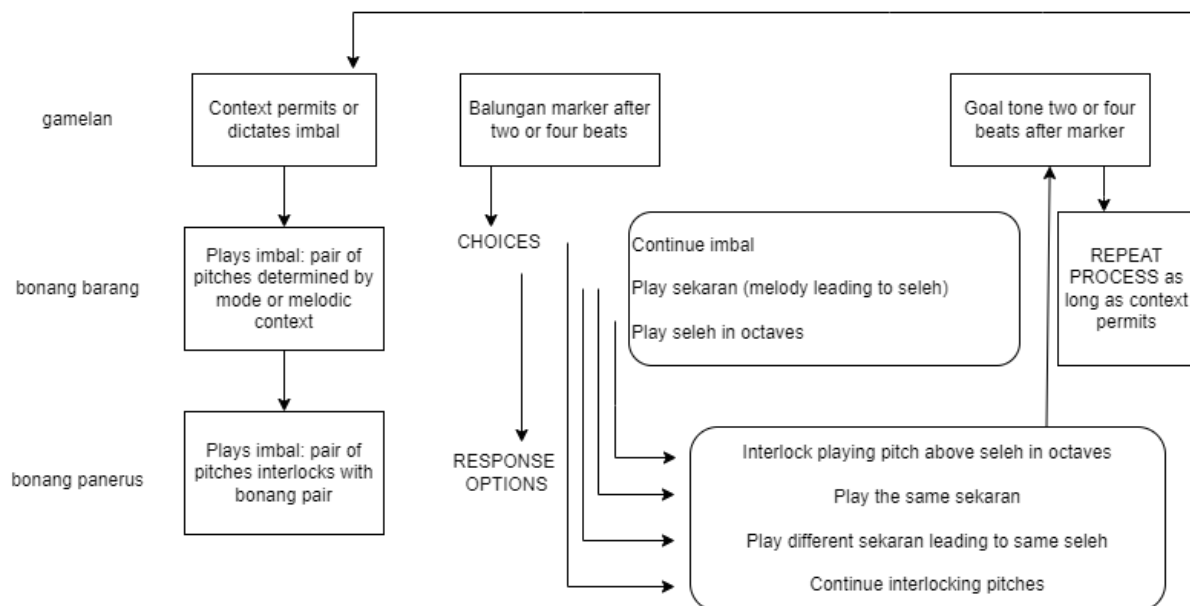
As a result of these prescribed structures and repeated patterns, most *karawitan* can be learnt through notation, or memorised with little challenge, though how *karawitan* is learnt is likely to affect the overall feeling of a piece (Benamou, 2010). Performances are usually led by a drummer (Brinner, 1995). Although, unlike the role of Western orchestral conductors, their role is largely to nurture a sense of cooperation and minimise hierarchy (Animawan & Soeparno, 2021; Tan et al., 2020), all the while providing structural cues and guiding changes in tempo and density. Such changes are closely linked in gamelan music under the bracket of the term *irama*, which concerns both time and space. In the simplest of examples, as the tempo may decrease from one variation into another, many instruments are required to double the density of their material; the result is that the tempo of the next variation is roughly the same as the previous in actuality, but the variation would take twice as long to perform (Benamou, 2010; Sumarsam, 2020).

Through changes in *irama*, some instruments are required to change their musical material. The *peking*, for instance, may add repetitions of coupled notes, while *bonang* players may change their material entirely (Sorrell, 1990). **Figure 4** depicts such decisions and response options that *bonang* players have as dictated by the context, in the form of *imbal* and *sekaran*. The former refers to the way in which *bonang panerus* and *bonang barung* perform pairs of notes that interlock to form a continuous scale,

while the latter refers to pre-set patterns based around the *seleh* note. Other elaborating instruments can be added, including the *suling*, a wooden flute, *rebab*, a two-stringed bowed instrument, and *gender*, a keyed instrument played with two soft mallets, all of which play more complex patterns with some variation (Sorrell, 1990); many of which follow similar decisions and response options to that of the *bonang* players.

**Figure 4.**

*Flow Chart Showing Interactions and Decisions Between Bonang Players in Typical Karawitan, from Brinner (1995, p. 225).*



The interaction of pre-composed structures and decision-making processes described above contribute to the reasons why some refer to gamelan as an improvisational form of music-making (Sawyer, 2003). While the building blocks are largely fixed, the manner in which they are arranged is determined by the performer. The most skilful of gamelan musicians will momentarily combine a designation of pre-existing units, or *cengkok* (elaborating patterns) akin to that of *sekaran*, in accordance with the decisions of other members of the group (Brinner, 1995). This concept is referred to as *garap*, or working out, and in contrast with the improvisation practices of other cultures, it is

implemented mostly by elaborating instruments (Pickvance, 2005). Players with lesser expertise may make such decisions in advance through much rehearsal. Meanwhile, the *balungan* and structural roles are permanent fixtures. As opposed to jazz, which allows for free solo-ing, it is incongruous with the attitudes of gamelan to draw attention to oneself. *Garap* is dictated by the structure, the *pathet* or mode, and the *seleh* note or strong beat, being the fourth note of each *gatra*. Elaborating instruments *garap* simultaneously according to what these musical parameters dictate, and therefore straying from such parameters would cause discordance that is distasteful in the context of *karawitan* (Brinner, 1995; Pickvance, 2005).

That being said, gamelan lends itself well to entirely free forms of improvisation as a result of the instruments being harmoniously tuned to one another (Loth, 2014). Though not traditional *per se*, it would be difficult to produce something as a group that sounds unpleasant, provided players allow for space and mutual listening, due to the limited harmonic potential of the instruments. Such improvisatory practises are becoming increasingly common in the UK and the West, where gamelan is adopted as an accessible form of group music-making in a variety of settings.

### **2.3.2 Gamelan in the West**

Across the UK, there are potentially more dedicated gamelan groups that come together regularly than in any other European country, and groups with no prior experience of playing gamelan can perform a basic piece of *karawitan* after only a two-hour workshop (Pickvance, 2005). For this reason, there has been a surge of gamelan interest in community, education, and therapeutic settings due to its technical and musical accessibility (Haddon, 2016; Henley et al., 2012; Loth, 2016). Reasons include, for one, its consideration as an egalitarian music system in terms of shared governance across the ensemble (de Bézenac et al., 2018), resulting from a lack of hierarchy of priority or value between instruments and a strong emphasis on intra-ensemble or “transactive” group communication. But on a more basic level, the technical skill required in playing gamelan instruments is generally undemanding (Loth, 2014; 2016). Its cyclical, and inevitably, repetitive nature allows for effortless memorisation and full absorption in the activity (Diamond, 1979), culminating in a highly accessible musical activity. Outcomes from studies in these contexts of community music, education, and

therapy, may reveal some of the ways in which gamelan performance is conducive to the experience of shared flow.

A large focus in the literature regarding the impact of playing gamelan centres on the work of a music-based charity, Good Vibrations (*Good Vibrations – Developing Life and Work Skills through Music*, 2024), and their outreach programmes that hold gamelan workshops in secure units and prisons. Gamelan was selected as a medium for the importance it places on communication, whereby the reduction of hierarchy between parts encourages positive social functioning (Henley et al., 2012). Numerous studies have aimed to explore the impact these programmes have on the different aspects of wellbeing specific to prison life (Caulfield, 2015; Caulfield et al., 2016; Henley, 2015; Henley et al., 2012; Mendonça, 2010; Okado, 2012; Wilkinson & Caulfield, 2017; Wilson et al., 2009). Positive emotional effects are common, whether affectual, such as a reduction of boredom and anxiety (Wilson et al., 2009), or in terms of emotion regulation. For some of the older offenders, the absorbing qualities of gamelan were treated as a means of meditation, where both during the project and after, using performance recordings in some cases, many participants felt more able to manage their emotions through meditation (Wilkinson & Caulfield, 2017).

Gamelan has also been used to promote more general educational goals. The non-hierarchical and egalitarian aspects of gamelan have been found to assist with the improvement of leadership qualities in health and social care education (Leonard et al., 2013). In gamelan workshops for children with special educational needs, the advantage of using gamelan is described using the term “transactive communication”, in which mutual collaboration between participants enhances learning environments (MacDonald & Miell, 2000). In a comparable context with autistic children, gamelan playing was found to help regulate volatile emotions, which in turn benefits communication skills (Bakan et al., 2008). In a higher education context, a consequence of playing gamelan with Western classical music students concerns the idea of losing ego. In this context, gamelan playing was found to reduce judgement of the self and others, promote intra- and inter-personal skills, and re-engage individuals in the ensemble as a whole (Haddon, 2016).

As a therapeutic tool, Loth has contributed some research into the application of gamelan playing in music therapy sessions (Loth, 2006, 2014, 2016). Through thematic analysis of interview data with each tutor, themes of gamelan's therapeutic potential were identified, including accessibility and engagement. Loth for the most part considers engagement in the form of a willingness to participate in and engage with a certain activity, as is the case with most of the studies conducted with offending populations (Henley, 2015; Wilkinson & Caulfield, 2017; Wilson et al., 2009). If considering a state of "optimal engagement", however, the idea of shared flow resurfaces.

### **2.3.3 Shared flow and *ngeli***

A recent systematic literature review of flow states in musical contexts recognised that research regarding flow states in gamelan ensembles would provide further insight into this discussion and that this is encouraged in the future (Tan & Sin, 2021). Indeed, the authors went on to explore this. In their aim of examining shared flow experiences in gamelan ensembles, Tan and colleagues identified a Javanese musical term used by a participant that is highly comparable to shared flow state (Tan et al., 2020). *Ngeli* is the feeling associated with the musical material of gamelan:

... in Javanese music, there is a term for it. It's called *ngeli*, 'to float' . . . it's that feeling of floating where you are carried along by the music, so it's like everything is happening and you move automatically with the music . . . So like you [are] familiar with the piece or you are familiar enough with what other people are doing so you can just go with it and you can listen and you can hear everything ... sometimes when you are performing when things are in a safe spot ... play in a relaxed way, you don't really have to think about it. Just float. (Tan et al., 2020, p. 8).

This quote captures several components of shared flow, including familiarity, safety and merging of action and awareness, that many of the findings highlighted too: a loss of ego (Haddon, 2016); reduction of boredom and anxiety, improved social functioning and leadership skills as a result of hierarchical absence (Henley et al., 2012; Leonard et al., 2013); close listening and communication (Bakan et al., 2008; Macdonald et al.,

1999; MacDonald & Miell, 2000). Moreover, one particularly prominent aspect of shared flow that is relevant to gamelan is a balance of challenge and skill. Gamelan provides a range of complexity across different instrumental parts and is especially suited to mixed-ability groups. If some parts do not meet the optimum level of challenge, more complex styles of gamelan playing could be adopted for those who are able (for example *imbal* playing that requires two parts to interlock) and players should take turns playing different parts ranging in complexity (Brinner, 1995; Loth, 2014, 2016). This, in turn, fulfils one key aspect of shared flow, whereby group members must participate equally (Sawyer, 2003), though not necessarily comparably in their level of challenge (van den Hout et al., 2018).

In Sawyer's view (2003), an emergent "group flow" can only occur when all agents are equally involved in the creative process, and consequently, may be unachievable if players do not have comparable skills. If this is the case, depending on individual ability and level of group training, which is seen to be paramount to fostering shared flow experiences (Pels et al., 2018; Salanova et al., 2014), a highly skilled gamelan group may achieve shared flow in playing a traditional piece, so long as all individuals are extremely familiar with their individual parts. This may not be the case with beginner groups. Conversely, if considering the idea of skill integration (van den Hout et al., 2018), it may not be necessary that all players must be of equal virtuosity, so long as their contributions are integral to the group's end product. Given the intrinsic nature of gamelan being formed by the group rather than the sum of parts, and the lack of hierarchy between them, it appears this requisite could be fulfilled. As with forms of participatory music (see Turino, 2008), gamelan relies on collective coordination and an absence of individual dominance, creating the ideal conditions for shared flow.

Within pieces of traditional gamelan repertoire, individuals are required to pay careful consideration to the roles of other members of the ensemble, listening and responding to subtle cues indicative of structural and temporal changes. Ultimately, the actions of one instrument influence another, spreading throughout the ensemble. For instance, how a change in drumming pattern might trigger rhythmic subdivisions for certain instruments, and how a change in register for those same instruments might trigger a change of section and melodic material for the entire ensemble. Such structures and

ensemble dynamics may allow for the potential rise and fall of flow through the fluctuations in shared attention. Where traditional pieces are often performed from notation, players may focus primarily on their individual roles, and intermittently be forced into an awareness of the changeable interactive setting. This may subsequently facilitate shared interactive flow, as this is related to individual experience of flow in an interactive setting, whereby individuals are focused on their tasks, or individual parts and their interaction with others (Hackert et al., 2022).

Improvised playing, on the other hand, involves a great degree of self-other merging and shared awareness, and therefore may lend itself more to an emergent group-level flow due to the entire focus being on the shared task as a result of the social interaction (Neuser, 2015). This sort of interpersonal coordination is facilitated by simultaneous self-other segregation and integration, allowing performers to adapt to and anticipate the actions and timings of others (Liebermann-Jordanidis et al., 2021). Improvisations are not so typical in *karawitan*. However, there are exceptions for elaborating instruments requiring a greater level of skill, where elaborations around the melody tend to have a degree of improvisatory character, as described in 2.3.1. Furthermore, gamelan lends itself well to group improvisation. Indeed, improvisation is a prevalent technique in both gamelan-based music therapy and community music groups in the United Kingdom, as the instruments are tuned to scales that allow for harmonies which form a cohesive sound with ease (Loth, 2014).

Given these contrasting underlying social dynamics involved between improvised and notated musical performances (Hadar & Rabinowitch, 2023), it is conceivable that the experience of shared flow may differ between the two, theoretically as a result of the varying degrees of interaction. It is understood that there may be distinctions between “solitary flow”, “co-active flow”, “shared interactive flow” and “group flow” between playing contexts (Raettig & Weger, 2018), for instance between improvised and prescribed playing, which may also depend on the level of musical experience. As traditional forms of gamelan performance are reliant on successful interaction, it is important to account for the influence of musical expertise. Beginner gamelan players may find greater ease of interaction if faced with free improvisation, providing them with

the optimal amount of challenge, while learning a piece of *karawitan* may bring about stress.

Gamelan is certainly not the only ensemble in which some of these flow-conductive parameters outlined may arise. Exploration of other ensembles or performance contexts beyond that of improvisation or jamming sessions which have been explored (Sawyer, 2003), such as that of samba (Monteiro, 2016), and taiko drumming (Haffner, 2020) may certainly be valuable.

## **2.4 Summary**

There are few studies centred around gamelan which adopt quantitative or mixed methodologies, and their primary aim has been to monitor and evaluate wellbeing outcomes that may arise through gamelan participation. Accordingly, many instead use thematic analysis of semi-structured interviews or learning diaries. An advantage of these methods is that they allow for more personal insights to be explored and can be easily adapted to observe longitudinal changes. Additionally, these methods are suitable for a wide variety of participant groups, including first-hand participant experiences or the observations of staff and support workers. Nevertheless, due to the subjective nature of these methods, they lack more replicable means of analysis, and the ability to look deeper into the mechanisms responsible for the benefits which have been highlighted.

As such, to the best of my knowledge, there has yet to be empirical research investigating the psychological processes, rather than outcomes, underlying gamelan performance. Furthermore, in addressing one primary aim of this thesis, gamelan is well suited as a context to explore more external units of analysis as a means to capture the interactive and group-level emergent qualities that may arise during shared flow. In doing so, not only may the understanding of how shared flow can be conceptualised and measured be improved, but so too would the empirical study of gamelan. Subsequently, it is necessary to explore suitable methods that may be employed to achieve this.



## Chapter 3. General Methods and Methodology

This chapter first outlines key epistemological and ontological considerations informing the design of the empirical work in this thesis. Following this, general methods are compared and selected. Shared flow may be measurable in part by qualitative insights or self-reports, as part of this chapter will outline. However, this only fulfils one piece of the puzzle. As Sawyer has remarked, a central issue in emergence is that of the level of analysis, where the focus should be on the collective or the group as opposed to the individual (1997). More external measures, such as physiological indicators of individual flow states may be extendable to a group level, and in turn the potential emergence of shared flow. Therefore, the latter portion of this chapter will discuss relationships between physiological synchrony resulting from coordination and interaction, and physiological parameters resulting from flow, to describe potential physiological indicators of shared flow within a setting of gamelan. Finally, discussions of ecological validity, ethics, and positionality are provided.

### 3.1 Epistemology and ontology

This thesis is not static in the methods it employs and continuously evolves as the missing pieces of the puzzle of shared flow become further identifiable.<sup>3</sup> The triangulation of multiple methodological streams, rooted in naturalistic, real-world settings, necessitated the guidance of an epistemological and ontological approach that balances notions of objectivity and subjectivity. Shared flow is by no means a straightforward phenomenon, and it is not an expectation of this thesis that a singular truth will be revealed. This is the intention of pragmatism, where rather than uncovering uniform causality, it “aims to interrogate a particular question, theory, or phenomenon with the most appropriate research method” (Feilzer, 2010, p. 8).

As has become increasingly more apparent in science, the arts, and the meeting point of the two, in striving for an “objective” truth, the phenomena we subject to enquiry are

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<sup>3</sup> It is worth noting at this point that research into theories and experiences of shared flow are still ever-evolving. Many of the key texts were published during the course of this thesis, and attempts have been made to consult the most current literature throughout.

bounded by contextual, social and cultural dependencies that are deeply embedded (Cross, 2024). Classic views of positivism as Comte put forward (see Crotty, 1998), have strived to identify reductive explanations of the world, proposing that an objective truth exists beyond that which surrounds it, thus reducing phenomena to its simplest of forms (Scotland, 2012). Constructivism, on the contrary, insists that reality cannot be disentangled from those who comprehend it (Hollway, 2008). Instead, through reconciling positivist and constructionist ontological approaches and more broadly their associated quantitative and qualitative lines of investigation, pragmatism welcomes mixed-methods exploration in a cyclical manner (Maarouf, 2019). Doing so allows for the unpicking of a phenomenon that is unlikely to be straightforward, from an epistemological position of utilising whatever methods may best serve the research objective at hand.

## **3.2 Measuring (shared) flow**

### **3.2.1 Interviews and observations**

Some of the first empirical work directly related to shared flow in musical collaborative contexts was conducted by Sawyer, extending his work on group creativity, of which he saw flow as one dimension of (2003). This investigation was largely qualitative, through an analysis of observational and interview data from work with jazz players. While this provided a comprehensive insight into the construct of group flow, observational methods have practical and logistical limitations in the study of larger groups (Tan & Sin, 2021). Further to this, regarding interviews, Sawyer himself highlights the limitations of such methods:

There are weaknesses associated with the interview method; after all, performers may not fully understand the mental and group processes that are involved in group creativity [...] when a phenomenon like group creativity is just beginning to be studied, an interview approach can provide an initial map of the territory (2003, p. 30)

Accordingly, qualitative observational and interview techniques may be useful in understanding how something as complex as flow may be broken down into more digestible components, rather than grapple with the underlying mechanisms involved.

Nevertheless, many studies on shared flow centre on qualitative investigation through means of grounded theory or phenomenology to further understand and gain subjective insights into the experience of such mechanisms in different settings.

Hart and Di Blasi (2015) and Hill and colleagues (2018) investigated shared flow by means of grounded theory, through semi-structured interviews and video observation analysis respectively. Both identified phenomenologically comparable features of shared flow to that of individual flow, with feelings of empathy as a so-called “by-product”. Again, their intentions were more focused on exploring how shared flow manifests in musical jam settings and collaborative composition, and the methods they employed were seen as a means to further understand the characteristics of shared flow.

To take this a step further, phenomenological techniques have been employed to gain insights into lived experiential aspects of flow occurrences and absorption, for instance with ballet dancers (Panebianco-Warrens, 2014), or string quartets (Høffding, 2023; Schiavio & Høffding, 2015). Within the context of gamelan and shared flow, one such study utilised phenomenological interviews (Tan et al., 2020). Using this method, the authors were able to gain rich qualitative insights concerning the cross-cultural nature of the Western concept of flow, enhancing theoretical understanding, but leaving space for further testing on the influence of social conditions and antecedents.

To some extent, mixed-methods approaches have reconciled qualitative investigation intending to explain how a phenomenon may arise and be experienced, together with quantitative approaches aiming to capture the extent to which such an experience is felt. Some examples of mixed-methods approaches take the form of questionnaires with both open questions and scales (Kaye, 2016; Walker, 2010), allowing for subjective insights alongside generalisable findings.

### **3.2.2 Self-reports**

In measuring flow quantitatively, the most common method by a clear margin is through the use of questionnaires (Tan & Sin, 2021). **Table 1** provides an overview of identified studies that utilise a scale across multiple disciplines, and is adapted and extended from similar overviews detailed in two relevant reviews (Pels et al., 2018; Tay

et al., 2021). Requirements for inclusion were primarily the use of a pre-validated measure or the validation of a measure comprising more than one item. Single self-constructed items were not counted, nor use of measures seemingly unrelated to shared flow. Similarly, studies that focused on individual experiences in the context of a social setting were not deemed relevant (Ryu & Parsons, 2012), nor those that propose untested theoretical methodologies (Galimberti et al., 2015).

**Table 1.**

*Overview of Flow Scales Used in the Measurement of Shared Flow, Adapted from Tay et al., (2021) and Pels et al., (2018)*

| Author(s) and year  | Shared flow-related scale                                                                                                      | Pronouns   | Resulting variable(s)                                                                                                                               | Measures used in combination                                                                                                                                                                                                                                          |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aust et al. (2023)  | Self-constructed based on the Flow Short-Scale (Rheinberg et al., 2003) and the Team Flow Monitor (van den Hout et al., 2019), | Plural     | Aggregated score per individual                                                                                                                     | <ul style="list-style-type: none"> <li>Stressors of teamwork in firefighting missions and Resources of teamwork during firefighting missions scales (Heinemann et al., 2024)</li> </ul>                                                                               |
| Akagi et al. (2022) | Flow State checklist (Ishimura & Kodama, 2006)                                                                                 | Individual | <ul style="list-style-type: none"> <li>Challenge to goals</li> <li>Confidence in skills</li> <li>Positive emotions and total involvement</li> </ul> | <ul style="list-style-type: none"> <li>The Unity Scale for Sports Teams (USST) (Yamada et al., 2013)(Yamada et al., 2013)</li> <li>The Multiple Mood Scale (MMS) (Terasaki et al., 1992)</li> </ul>                                                                   |
| Aubé et al. (2014)  | 9-item Flow-Scale (Martin & Jackson, 2008)                                                                                     | Individual | Group means calculated based on individual scores                                                                                                   | <ul style="list-style-type: none"> <li>Information exchange (self-constructed)</li> <li>Team goal commitment (Klein et al., 2001)</li> <li>Team performance (self-constructed)</li> </ul>                                                                             |
| Bakker (2005)       | Adapted WORK-reLated Flow (WOLF) scale (Bakker, 2001)                                                                          | Individual | <ul style="list-style-type: none"> <li>Absorption</li> <li>Work enjoyment</li> <li>Intrinsic work motivation</li> </ul>                             | <ul style="list-style-type: none"> <li>Balance between challenges and skills (French et al., 1982)</li> <li>Short scales on autonomy, performance feedback and social support (Bakker et al., 2003)</li> <li>Leader-Member exchange scale (Le Blanc, 1994)</li> </ul> |

**Table 1.***(Continued)*

| <b>Author(s)<br/>and year</b> | <b>Shared flow-<br/>related scale</b>                                             | <b>Pronouns</b> | <b>Resulting<br/>variable(s)</b>                                             | <b>Measures used in<br/>combination</b>                                                                                                                                                                                                                                                 |
|-------------------------------|-----------------------------------------------------------------------------------|-----------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gaggioli et al. (2015)        | Flow State Scale (Jackson & Marsh, 1996)                                          | Individual      | Nine dimensions of flow per individual and averaged over group level         | <ul style="list-style-type: none"> <li>• Creative Product Semantic Scale (O'Quin &amp; Besemer, 1989)</li> <li>• Social Network Analysis (SNA) of group structure using electronic communication logs</li> </ul>                                                                        |
| Gaggioli et al. (2017)        | Flow State Scale (Jackson & Marsh, 1996)                                          | Individual      | Group flow level calculated from the average of total flow individual scores | <ul style="list-style-type: none"> <li>• Level of expertise (self-constructed)</li> <li>• Team performance (self-constructed)</li> <li>• Networked Minds Social Inventory (Biocca et al., 2003)</li> <li>• SNA of group structure by means of eye gazes and verbal exchanges</li> </ul> |
| Gaggioli et al. (2020)        | Flow State Scale (Jackson & Marsh, 1996)                                          | Individual      | Group flow level calculated from the average of total flow individual scores | <ul style="list-style-type: none"> <li>• Networked Minds Social Inventory (Biocca et al., 2003)</li> <li>• SNA of group structure by means of eye gazes and verbal exchanges</li> </ul>                                                                                                 |
| Heyne et al. (2011)           | Flow State Scale-2 (Jackson & Eklund, 2002)                                       | Individual      | Nine dimensions of flow per individual and aggregated across group level     | <ul style="list-style-type: none"> <li>• Perceived complexity (self-constructed)</li> <li>• Team knowledge building (Fiore et al., 2010)</li> <li>• Perceived sharedness (self-constructed)</li> </ul>                                                                                  |
| Kaye (2016)                   | Adapted Flow State Scale-Short form (Jackson & Eklund, 2002) with plural pronouns | Plural          | Averaged score per individual                                                | <ul style="list-style-type: none"> <li>• Positive and Negative Affect Schedule (Watson et al., 1988)</li> <li>• Items related to group aspects of gaming contexts (self-constructed)</li> </ul>                                                                                         |
| Keeler et al. (2015)          | Flow State Scale-2 (Jackson & Eklund, 2002)                                       | Individual      | Group means calculated for each dimension and total scales score             | <ul style="list-style-type: none"> <li>• Measurement of plasma oxytocin and adrenocorticotrophic hormone (ACTH)</li> </ul>                                                                                                                                                              |
| MacDonald et al. (2006)       | Experience sampling forms (Csikszentmihalyi and Csikszentmihalyi, 1988)           | Individual      | Group means calculated based on individual scores                            | <ul style="list-style-type: none"> <li>• Consensual assessment technique (Amabile, 1982)</li> </ul>                                                                                                                                                                                     |

**Table 1.***(Continued)*

| Author(s)<br>and year      | Shared flow-<br>related scale                                                                                      | Pronouns   | Resulting variable(s)                                                                                                                                                                                                                               | Measures used in combination                                                                                                                                                                                                                                                                           |
|----------------------------|--------------------------------------------------------------------------------------------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oztop (2017)               | Adapted Flow State Scale-2 (Jackson & Eklund, 2002)                                                                | Individual | Nine dimensions of flow                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>Sports Motivation Scale (Pelletier et al., 2013)</li> <li>Empathy Quotient Scale (Baron-Cohen &amp; Wheelwright, 2004)</li> </ul>                                                                                                                               |
| Páez et al. (2015)         | Shared Flow Scale, based on Dispositional Flow Scale (Calvo et al., 2008; Jackson & Marsh, 1996)                   | Plural     | Aggregated score per individual                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>Spanish Collective Efficacy Questionnaire for Sports (CEQS) (Martínez et al., 2011)</li> <li>Perceived Emotional Synchrony Scale (PESS) (self-constructed)</li> </ul>                                                                                           |
| Pizarro et al. (2020)      | Shared Flow Short Form (Zumeta, Basabe, et al., 2016; Zumeta, Oriol, et al., 2016)                                 | Plural     | Aggregated score per individual                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>Compassion for Others Scale and Brief Measure (Amutio et al., 2018)</li> <li>Identity fusion (Aron et al., 1992; Swann et al., 2009)</li> <li>The Pemberton Happiness Index (Hervás &amp; Vázquez, 2013)</li> <li>PESS Short Form (Páez et al. 2015)</li> </ul> |
| Primus & Sonnenburg (2018) | Self-constructed experience sampling based on seven items of group flow theory by Sawyer (2008)                    | Plural     | <ul style="list-style-type: none"> <li>Importance of the activity</li> <li>Continuous communication</li> <li>Team listening</li> <li>Equal participation</li> <li>Sense of Unity</li> <li>Moving consistently forward</li> </ul> Full concentration | <ul style="list-style-type: none"> <li>Experience sampling for individual flow (Moneta &amp; Csikszentmihalyi, 1996)</li> <li>Experience sampling for creative flow (Larson &amp; Csikszentmihalyi, 2014)</li> </ul>                                                                                   |
| Raettig & Weger (2018)     | Interactive Flow Questionnaire, based on Csikszentmihalyi (1975) and Rheinberg Instrument (Rheinberg et al., 2003) | Plural     | <ul style="list-style-type: none"> <li>Absorption</li> <li>Smoothness</li> <li>Communication-specific aspects</li> </ul>                                                                                                                            | <ul style="list-style-type: none"> <li>None</li> </ul>                                                                                                                                                                                                                                                 |

**Table 1.***(Continued)*

| <b>Author(s)<br/>and year</b> | <b>Shared flow-<br/>related scale</b>                                                                                                                  | <b>Pronouns</b> | <b>Resulting variable(s)</b>                                                                                  | <b>Measures used in<br/>combination</b>                                                                                                                                                                                                                                                                                                 |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Salanova et al. (2014)        | Group task absorption scale (Salanova et al. 2003), Group task enjoyment scale (self-constructed), group challenge and group skills (self-constructed) | Plural          | <ul style="list-style-type: none"> <li>Aggregated score per individual</li> </ul>                             | Collective Efficacy Beliefs (Salanova et al., 2003)                                                                                                                                                                                                                                                                                     |
| van den Hout et al. (2019)    | Team Flow Monitor                                                                                                                                      | Plural          | <ul style="list-style-type: none"> <li>Prerequisites</li> <li>Characteristics</li> <li>Total score</li> </ul> | <ul style="list-style-type: none"> <li>Team positivity (self-constructed)</li> <li>Team performance (self-constructed)</li> <li>Happiness (self-constructed)</li> </ul>                                                                                                                                                                 |
| van Oortmerssen et al. (2022) | Adaptation WOLF scale (Bakker, 2001) with third subscale, “team interaction”                                                                           | Plural          | <ul style="list-style-type: none"> <li>Absorption</li> <li>Enjoyment</li> <li>Interaction</li> </ul>          | <ul style="list-style-type: none"> <li>Perceived proximity of team members (Hoegl &amp; Proserpio, 2004)</li> <li>Team goal commitment (Aubé &amp; Rousseau, 2005)</li> <li>Collective efficacy beliefs (Salanova et al., 2003)</li> <li>Challenge-skill balance subscale (Jackson and March 1996) adapted to the team level</li> </ul> |
| Zumeta, Basabe, et al. (2016) | Shared Flow Scale, based on Dispositional Flow Scale (Calvo et al., 2008; Jackson & Marsh, 1996)                                                       | Plural          | <ul style="list-style-type: none"> <li>Nine dimensions of flow in line with subscales</li> </ul>              | <ul style="list-style-type: none"> <li>Pemberton Happiness Index (Hervás &amp; Vázquez, 2013)</li> <li>Spanish CEQS (Martínez et al., 2011)</li> <li>Verbal identity-fusion (Gómez et al., 2011)</li> <li>Feeling of Relatedness Scale (Richer &amp; Vallerand, 1998)</li> </ul>                                                        |
| Zumeta, Oriol, et al. (2016)  | Shared Flow Scale, based on the Dispositional Flow Scale (Calvo et al., 2008; Jackson & Marsh, 1996)                                                   | Plural          | <ul style="list-style-type: none"> <li>Global one-dimensional factor scores per individual</li> </ul>         | <ul style="list-style-type: none"> <li>In-Group Identification Scale (Leach et al., 2008)</li> <li>Verbal identity-fusion (Gómez et al., 2011)</li> <li>PESS (Páez et al., 2015)</li> <li>Spanish CEQS (Martínez et al., 2011)</li> </ul>                                                                                               |

The most frequently used scales are the Flow State Scale, Flow State Scale-2, or their shortened counterpart (Jackson & Eklund, 2002; Jackson & Marsh, 1996; Martin & Jackson, 2008), based on the nine-dimensional flow theory of Csikszentmihalyi (1975). Other individualistic scales adopted include the Flow State Checklist (Ishimura & Kodama, 2006, 2009), WOrk-reLated Flow scale (WOLF) (Bakker, 2001), or experience sampling forms (Csikszentmihalyi & Csikszentmihalyi, 1988). For the most part, these scales were designed to measure individual flow experiences and were validated in such a context. Yet, the sole reliance on self-report measures in measuring flow experiences altogether may be questionable when accounting for the concept of “transient hypofrontality”, where a reduction in prefrontal activity lends itself to diminished self-awareness in order to achieve task immersion (Dietrich, 2004). This creates implications for the sole reliance on self-reports, as the ability for individuals experiencing flow to reliably reflect on their experiences is brought into question.

In spite of this, some authors still assess flow individually using self-reports but adopt analytical methods to capture the social or interactive aspects expected during the experience of shared flow. One such example is that of Bakker (2005), who investigated the potential for flow to pass from music teacher to student in a manner akin to that of emotional contagion. Alternatively, scales have been used to assess the presumed level of shared flow by equating the individual’s experience to that of the group.

Typically, this seems to be achieved through at least one of the two following ways: 1) by calculating aggregate measures representing the groups’ overall flow score, as a total or average of the individuals; 2) using plural, as opposed to personal pronouns, so that “I” becomes “we”. In all senses, as mentioned, this may be problematic if treated as a sole means of capturing shared flow. Aside from the issues of reduced self-awareness in capturing flow via self-report questionnaires (Dietrich, 2004), there also seem to be qualities of shared flow that are distinct from individual flow experiences. To overcome these complexities, additional measures should be employed alongside self-reports.

With regards to the use of group-level, aggregated measures, Gaggioli and colleagues over a series of studies (Gaggioli et al., 2015, 2017, 2020) have utilised the Flow Scale in its original form (Jackson & Marsh, 1996), calculated aggregate totals within the



group, and analysed this in conjunction with both the Networked Minds Social Inventory (Biocca et al., 2003) and Social Network Analysis (SNA) of inter-group dynamics (Knoke & Yang, 2020). Assessing an aggregate measure of flow in groups together with additional indices of interaction supports the assertion by Sawyer, that an emergent “group flow” may only truly be capturable by incorporating an external perspective (Sawyer, 2006).

Nevertheless, such methods of SNA may not be suitable in other contexts. While this was tested within the context of workplaces and creative collaboration, in musical ensembles explicit indices of interaction such as gaze and verbal exchanges may not be applicable. Conversations typically arise in rehearsals rather than performances (Hill et al., 2018), and in many musical contexts are likely to be instigated by the leader of the ensemble in a one-sided manner, rather than equally among members. Instances of this can be found in the way a conductor provides feedback and direction to an orchestra. Meanwhile, aligning intentions through gaze is not always a necessary means through which social cohesion can arise in music (Høffding et al., 2023). Rather, players might be drawn to subtler body movements and gestures to coordinate their interactions that are difficult to detect through observational means (Eerola et al., 2018). A similar tactic to that of SNA was employed by Keeler and colleagues (2015), where instead they measured hormonal levels, citing the importance of oxytocin for social bonding. However, the scale used was still framed towards individual experiences of flow, and, as the review of the previous chapter highlighted, there are fundamental differences between how flow is experienced on individual and social levels (Walker, 2010). It seems fruitful to have an alternative measure of gauging the interactive or social aspects of shared flow, alongside a pluralised form of questionnaire. In doing so, there is the insinuation of a shared belief of others being in flow, or a subsuming of goals from the individual to the collective level (Tay et al., 2021). Instances of “we”-based adaptations to flow questionnaires, and the devising of new questionnaires based on a group context or group-based theories of flow outlined in the previous chapter, are plentiful. Examples include that of the “team flow” theory (van den Hout et al., 2019), or the “interactive flow” taxonomy (Raettig & Weger, 2018). Some target education or workplace settings, and working groups (Salanova et al.,

2014; van Oortmerssen et al., 2022), while others focus on sports teams and more active forms of teams (Aust et al., 2023; Zumeta, Oriol, et al., 2016).

While this thesis adopts the view that there may be taxonomic distinctions between individual flow and “shared interactive flow”, the self-report counterpart for such a theory has only been validated in an educational context (Raettig & Weger, 2018). There are of course cases in which a scale has been validated in multiple contexts. The Shared Flow Scale validated by Zumeta and colleagues (2016), is one such example of this, and as a result, it may be better suited as a starting point. It is highly comparable to Raettig and Weger’s “Interactive Flow Inventory” (2018) in that it is based on the flow dimensions of Csikszentmihalyi, but replaces individual pronouns of the widely-used original scale (Jackson & Eklund, 2002) with plural ones. Furthermore, it has been successfully implemented in different areas of study, including both sports and music performance (Pizarro et al., 2020; Zumeta, Basabe, et al., 2016; Zumeta, Oriol, et al., 2016). For these reasons, this scale is adopted in the first study of this thesis.

Still, Zumeta and colleagues pair the scale with further questionnaires to gain insights into perspectives on the group, for instance through the use of the Collective Efficacy Questionnaire for Sports. (Moritz et al., 2000) or the Perceived Emotional Synchrony Scale (Páez et al., 2015). There remains an important methodological limitation concerning positive bias in retrospective accounts of flow (Kaye, 2016), applicable to both qualitative and quantitative realms of retrospective subjective enquiry. Therefore, while both forms entail various limitations, the use of self-reports comes with an additional set of concerns. This thesis instead proposes that such interactive or group-based dynamics may be better assessed from an external perspective, akin to that of SNA, as multiple authors have concluded (Oztop, 2017; Pels et al., 2018; Tay et al., 2021).

### **3.2.3 Beyond internal perspectives**

In seeking more external, quantifiable measures of shared flow, some strides have been made through a variety of techniques. One study found that aligned energy levels in jazz musicians suggested a greater likelihood of achieving group flow (Gloor et al., 2013), although no related self-report was adopted. More explicit investigation may

require both direct measures of shared flow, and indirect measures aimed at grasping what underlying mechanisms are involved, such as that of coordination, interaction and synchronisation.

More recently, synchronisation has been seen to be highly related to the experience of shared flow, and it is theorised that this may occur through both synchrony of action and synchrony of physiological parameters (Gloor et al., 2022). Some techniques, such as motion capture may be able to detect some of the more subtle aforementioned movements and mechanisms aiding coordination among musicians (Goebl & Palmer, 2009), which could be appropriate in obtaining a more external measure of togetherness. Nevertheless, due to the costly nature of motion capture systems, the need for dedicated spaces, and their time-consuming set-up requirements (Jakubowski et al., 2017), assessing larger ensembles through these means in ecologically valid settings would be insurmountable.

Regarding physiology, several studies have looked towards hormonal measures. Cortisol as indicative of stress and arousal levels (Keller et al., 2011; Peifer et al., 2015; Tozman et al., 2017) has been found to relate to flow in the form of an inverted U-shape, while the results of incorporating oxytocin as a measure of social bonding in relation to shared flow are less clear as a result of low power (Keeler et al., 2015).

Notwithstanding, hormonal measures are static in that they are not able to measure synchronous patterns, or momentary changes between individual and shared flow that may be evidenced by more dynamic measures, such as those of the autonomic nervous system (ANS).

#### *3.2.3.1 Physiological indicators of individual flow*

Various studies have demonstrated relationships between ANS patterns and individual flow (Bian et al., 2016; Katahira et al., 2018; Peifer et al., 2014; Thissen et al., 2021; Tian et al., 2017). Interpretations typically account for such findings as a result of the co-activation of both branches of the ANS; the sympathetic branch, linked to the fight-or-flight response, and the parasympathetic branch, linked to rest and digestion (Tozman et al., 2015).

Much of the work on physiological indicators of flow state has assessed Heart rate variability (HRV) which has been associated with domains of flow linked to concentration or balanced challenge and skill. This has been observed through both a linear relationship with parasympathetic activation (Thissen et al., 2021; Peifer et al., 2014; Tozman et al., 2015; Bian et al., 2016), and moderate sympathetic activation (Peifer et al., 2014; De Manzano et al., 2010). Taken together, these findings form a varied understanding of how cardiovascular activity might be related to flow, but generally, it is agreed that HRV is indicative of co-regulation of sympathetic and parasympathetic activity (Ullen et al., 2010; Tian et al., 2017; Thissen et al., 2021) potentially in the form of an inverted-u-shape (Peifer et al., 2014; Bian et al., 2016). Such studies indicate the substantial potential of HRV to measure potential flow experience. However, the necessity to calculate such variance over at least five minutes (Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology, 1996) does not allow for the ability to observe momentary changes in parasympathetic and sympathetic activation, reflecting a similar limitation of hormonal measures. While heart rate (HR) changes as indicators of flow activity may be confounded by physical exertion (Jaque et al., 2020), there still seems to be potential to relate HR changes to changes in flow experience in the context of music performance (Horwitz et al., 2021; Jha et al., 2022). Ultimately this is due to the potential for sympathetic and parasympathetic activity to increase or decrease HR respectively (Pérez et al., 2021).

In addition to cardiovascular activity, skin conductance (SC), is also prevalent in studies on physiological responses and flow state due to it being indicative of arousal in the sympathetic nervous system (Bian et al., 2016), and flow requiring a moderate level of arousal between boredom and stress (Peifer et al., 2014; Csikszentmihalyi and LeFevre, 1989). Supporting this notion, Tian et al., (2017) found moderate levels of SC as being related to flow experience compared to that of stressful states. SC changes have also been linked to mental effort associated with planning and execution in piano improvisation (Dean & Bailes, 2015), which could, in turn, suggest an important role for SC in the study of flow in dynamic music performance.

### 3.2.3.2 *Potential physiological correlates of shared flow*

While the outlined studies show relationships between physiology and individual flow states, considerations are now made towards how shared flow experiences may be reflected by shared physiological patterns. Making music as a group has been shown to induce physiological and neural synchrony (Delius & Müller, 2023; Khalil et al., 2022; Kohler et al., 2022; Ruiz-Blais et al., 2020). Explanations as to how and why are typically through the form of joint attention, joint action, and interaction, while even individuals processing the same music, film, or story can experience some degree of physiological alignment (Czepiel et al., 2021; Golland et al., 2015; Pérez et al., 2021). In musical settings, rhythmic entrainment may occur between audience members in terms of bodily movements and physiological levels (see Clayton et al., 2005).<sup>4</sup> Nevertheless, such physiological alignment in group music performance has yet to be explored in shared flow research.

One study that attempted to assess the relationship between general physiological levels and flow in chamber musicians was conducted by Horwitz and colleagues (2021). In this work, however, no significant relationship between synchronised flow experiences and overall HR means was observed. As shared flow experiences often encompass synchronised movements (Gloor et al., 2013), and shared flow is reliant on levels of interaction present within a group (Sawyer, 2003), it is relevant to also consider physiological parameters related to synchrony and interaction more specifically.

The coordination of actions and alignment of emotional experiences has been related to the coupling of physiological measures (Gordon et al., 2020; Palumbo et al., 2017; Tomashin et al., 2022; Vanutelli et al., 2017). Meanwhile, HR has been found to synchronise in response to shared cognitive processing of video stimulus (Madsen & Parra, 2022), and audio narratives (Perez et al., 2021), but also in response to co-ordinated action in group drumming (Gordon et al., 2020) and togetherness in improvised movement (Noy et al., 2015). Tomashin et al. (2022) found that synchrony of

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<sup>4</sup> Where the concept of entrainment is often used to describe the alignment of listener and performer, such as through tapping to the beat of a song (see Clayton et al., 2005), synchronisation is a more appropriate term to adopt in the context of group performance, where musicians are simultaneously coordinating with one another. For this reason, this thesis adopts the terms synchrony or synchronisation as opposed to entrainment.

HR could predict group cohesion, resulting from both levels of coordination in drumming, and group decision-making, supporting the work of Gordon and colleagues (2021).

Few studies situated in social contexts have adopted a measure of SC, which has been found to synchronise across audiences of live concerts alongside the synchrony of HR (Czepiel et al., 2021). Vanutelli and colleagues (2017) found that coupling of such electrodermal measures may be indicative of increased engagement and quality of interaction. These findings suggest that synchrony of SC could be expected in relation to shared flow, although research incorporating SC into group music-making paradigms is scarce. Nevertheless, where SC changes surrounding transitional moments have been identified in solitary performance contexts (Dean and Bailes, 2015), such changes could be expected to occur on a shared level, provided musicians are experiencing similar levels of mental effort and planning.

Taken together, the findings of these studies provide persuasive support for the inclusion of physiological synchrony, or more specifically of SC and HR, as an external measure reflecting the interactive, collaborative, and coordinating aspects of shared flow to supplement the use of self-reports. Nonetheless, there seemingly has yet to be any study of synchrony of continuous physiological signals in music performance contexts in relation to shared flow. Given the highly interactive nature of the gamelan ensemble, it is anticipated that such physiological synchrony would be highest across members of the ensemble when their experiences of shared flow are also at their highest.

On a final note: up until now, the term “physiological synchrony” has been used quite loosely. There are, indeed, various ways in which measures of physiological synchrony have been derived. Several studies that have implemented such a measure in musical contexts, or across group sizes of more than two, have done so using inter-subject correlation (ISC). This technique was made popular by Hasson and colleagues (2004), which is commonly adopted as a means to measure shared neural responses among participants (Abrams et al., 2013; Madsen & Parra, 2022; Nastase et al., 2019). ISC is particularly favourable in ecological research designs prone to signal interference and noise, as it is assumed that when segmenting and correlating multiple time-

dependent signals across participants, a synchronised response resulting from noise would be improbable (Czepiel et al., 2021; Dauer et al., 2021). A variant of ISC is that of inter-subject cross-correlation (ISXC) which accounts for a potential lag, resulting from inter-individual differences in physiological stimulus responses (Boucsein et al., 2012), through shifting the segments and assessing their commonality. While several studies have adopted ISXC in similar settings (Gordon et al., 2020; Tschacher et al., 2023), unconservative interpretations of them can result in misleading findings (Dean & Dunsmuir, 2016).

There is no unanimous approach to ISC, as various calculation methods have been adopted for a range of purposes and group sizes. One of the most common methods is to calculate ISC in a dyadic fashion before taking an overall mean across dyads per individual (Czepiel et al., 2021; Dauer et al., 2021; Pérez et al., 2021). It is this method that this thesis adopts.

To summarise, this thesis intends to measure the elements of group cohesion and interaction from a physiological perspective. Therefore the initial focus is on the potential that shared flow states may be captured in gamelan performance by pairing self-reports, using the Shared Flow Scale (Zumeta, Basabe, et al., 2016), with synchronised heart rates (HR) and skin conductance (SC), through inter-subject correlation (ISC).

### **3.3 Ecological validity**

As shown so far, numerous methodological designs have been employed in the study of flow, though one key facet in which they differ is in how closely a naturally occurring phenomenon is represented. There is a need to extend our understanding of physiological synchrony through quantitative naturalistic experimental designs (Chabin et al., 2020), and the outlined literature above indicates links between physiological mechanisms and flow states. Some flow-related studies centred on physiological inquiry have been undertaken in more controlled laboratory settings (Bian et al., 2016; de Manzano et al., 2010). Arguably there is a balance to be struck between experimental rigour and ecological validity, where signal quality is upheld while

ensuring that the phenomenon being captured is representative of real-world paradigms.

Developments in physiological technologies have afforded the opportunity to study such phenomena in settings more closely aligned to that of the real world (Tervaniemi, 2023), with the potential of continuously monitoring flow-related mechanisms without disruption. The successful implementation of such measures has allowed for valuable insights into musical performance contexts with regard to EEG (Dolan et al., 2018; Farrugia et al., 2021), and similar designs have been successful in assessing physiological synchrony within naturalistic concert-listening contexts (Czepiel et al., 2021; Tschacher et al., 2023). As Pels et al. (2018) recommended, studies should investigate conditions under which shared flow may occur. As a result, there is little reason that implementing such measures in an ecologically valid context for gamelan players – that of their usual rehearsal spaces - would be overly detrimental to the quality of data obtained. Moreover, the benefits of the insights such a context affords may outweigh the impact of signal interference or diminished experimental control.

### **3.4 Ethical and practical considerations**

Through the emphasis on ecologically valid settings, balanced with a focus on gaining insight into the subconscious experience, some ethical and practical considerations must be made.

The research incorporated into this thesis adheres to common practice standards of research ethics, including the Nuremberg Code (1947), the Belmont Report (1979) and The Declaration of Helsinki (1964), and was approved by the University of York School of Arts and Creative Technologies Ethics Committee. Some key principles these conventions share are the importance of informed consent, the right to withdraw, minimised risk and avoidance of harm. As such, the methods utilised were selected in accordance with the level of researcher competency and the balance between risk and reward.

Particularly with regard to psychophysiological enquiry, many methodological possibilities have been highlighted. Teams of researchers will often be involved in experiments involving multiple physiological measurements (Gordon et al., 2020; Pérez



et al., 2021). As such resources were not possible in the endeavour of this thesis, the methods adopted represent a balance between quality and feasibility. The selection of HR and SC was deemed optimal with this in mind, and due to the minimally invasive forms of associated measurement. While non-invasive forms of neuroimaging such as EEG, mentioned above, carry with them less of a financial burden than they once did (Biondi et al., 2022), in the current state of technology it may be impractical to monitor multiple active players simultaneously. Hormonal measurements also do not come without some level of invasiveness, even with methods of salivary collection as opposed to blood cortisol (Tozman et al., 2017), and such studies are typically conducted by experts in psychopharmacology or clinical sciences. The use of skin-surface electrodes, utilised in this thesis, presents near to no risk to participants. To further minimise any discomfort, participants are guided to attach electrodes themselves if desired, avoid undressing, and are provided a separate space to set up if needed.

### **3.5 Positionality statement**

As a practising Javanese gamelan musician, and with a Master of Arts in Music Psychology, I am uniquely positioned to undertake research into the experience of shared flow in the context of gamelan from an empirical lens. Nevertheless, it is important that I do so with an awareness of my position as a researcher. First and foremost, I am a white, British woman. I have no Indonesian heritage, nor have I ever resided there. My interest in Javanese gamelan was born in 2017 when I first joined Gamelan Nogo Abang at Cardiff University in the third year of my undergraduate degree. I was enticed by its accessibility, and intrinsic sociality (described in Chapter 2). This was particularly at a time when as a musician, my feelings of inadequacy in Western classical traditions were heightened, and my experiences of performing in the Western ensembles that I was accustomed to felt isolating and segregating. I was privileged with the opportunity of visiting Surakarta with Nogo Abang in 2018, learning from experienced Javanese musicians in the Indonesian Institute of the Arts, and attending dozens of public and private performances and rehearsals. I continued my involvement with gamelan upon joining the University of York for my MA and have been performing and practising regularly with Gamelan Sekar Petak ever since. For these reasons, I

consider myself as having both insider and outsider status in the practise of gamelan, because the majority of my experiences have been in the UK.

I am conscious not to be a voice for a tradition that is not strictly my own, nor treat gamelan as an “exotic” phenomenon that requires Western sensemaking to give it value. British gamelan has largely shaped my identity as a musician, albeit, as a much less well-established cultural tradition than that of Javanese gamelan. I make efforts to uphold values of respect to the instruments and other players that are engrained within the Javanese tradition and adopt native terminology where possible. Nevertheless, I still see myself as a beginner, a feeling which I have heard remains even after several decades.

This research has been informed and shaped in large measure by conversations with experienced British and Javanese gamelan musicians, and where possible, the sources I have used to inform the theoretical background are from both Western and non-Western authors. I adopt gamelan as a context in which shared flow seems to naturally lend itself to (Tan et al., 2020), while I aim to improve the ways in which shared flow is empirically measured and theoretically understood. This is not to say that the methods I adopt are intended only for gamelan, nor that gamelan is a means to an end. While some of the work in this thesis presents some of the first insights into psychological and physiological mechanisms underlying gamelan playing, it is my intention that all methods and conceptual insights are transferable to other forms of group music-making, and other collaborative or interactive environments both within and beyond the arts.

### **3.6 Summary**

While individual flow has been related to physiological signatures (de Manzano et al., 2010; Thissen et al., 2021; Tian et al., 2017), and degrees of social interaction and cohesion have been related to physiological synchrony (Gordon et al., 2020; Tomashin et al., 2022), to my knowledge, no study yet has directly investigated these links between physiological synchrony with shared flow. Investigating such parameters without any self-report at all, however, runs the risk of treating shared flow as an inevitable consequence of physiological synchrony. Accordingly, an optimal starting

point for the empirical work of this thesis is to assess self-reported shared flow using a plural-form scale, based on one of the most frequently and widely used dimensional theories of individual flow state, validated in a musical and group-based setting (Jackson & Marsh, 1996; Zumeta, Basabe, et al., 2016). While the antecedents and resulting qualities of “interactive flow” that Raettig and Weger describe are not made explicit in this scale, they are accounted for to some degree through the nature of Csikszentmihalyi’s multi-dimensional classical conceptualisation of flow that underlies it.

In any case, one key requirement of flow will be accounted for, by acknowledging that there may be distinctions between different levels of expertise and their qualities of interaction, depending on the type of performance context, if they perceive themselves to be in flow. To supplement self-reports and account for potentially diminished self-awareness, and the interactive, group-level, and potentially emergent components of shared flow, they will be analysed in conjunction with measures of ISC of HR and SC. The selection of these measures is based on i) the prevalence of their applications to research on individual flow, ii) the potential for them to be measured in a manner that minimises disruption and iii) their robustness to inevitable losses of signal quality resulting from the ecologically valid context.

## Chapter 4. Study 1: Relating physiological synchrony to shared flow in gamelan playing<sup>5</sup>

### 4.1 Aims

The synchronised, interlocking, repetitive, and egalitarian aspects of gamelan described in chapter 2, yield an optimal opportunity to empirically measure the more interactive elements of shared flow. As described in chapter 3, self-reported measures in flow research are often used to assess an individual's perceived shared flow experience, but such interactivity is likely to be better assessed from an external measure. Here, this is assessed by combining self-reports on flow with physiological measures; the assumption being that a greater sense of collectivism or cohesion would lend itself to greater physiological togetherness (Gordon et al., 2020) and in turn potential shared flow. Ultimately, this is due to an optimal setting for shared flow being when individuals are working together on a task involving great interactivity and interdependence, resulting in the highest level of interpersonal connectedness.

Since coordinated action, such as in musical ensembles, is associated with synchronised physiological responses (Hoehl et al., 2021; Ruiz-Blais et al., 2020), it was of interest to determine whether such an effect emerges more in a setting facilitating greater momentary interaction (improvised playing) than in a setting comprising more explicitly shared goals (traditional playing). Furthermore, as described in chapter 2, expertise is fundamental to the potential for successful interactions in which shared flow experiences may arise (Salanova et al., 2014; Pels et al., 2018). Shared flow is more likely to occur when there is collective competency, and by the same token, may be unachievable if agents have unequal contributions or incompatible skills (Raettig & Weger, 2018; Walker, 2021).

Consequently, this study aimed to test whether there are differences in the level of significant physiological synchrony that arises among groups of different levels of

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<sup>5</sup> An article based on this chapter entitled "Physiological synchrony and shared flow state in Javanese gamelan: positively associated while improvising, but not for traditional performance" was published in *Frontiers in Psychology* (Gibbs et al., 2023). Data and code contributing to the analysis of this study have been uploaded to a repository on Open Science Framework <https://osf.io/4g8r5/>.

expertise. In addition, whether there are associations between measures of physiological synchrony and self-reported shared flow states; and whether performing traditional gamelan or improvising has any influence on these potential associations. The following research questions will therefore be considered:

**RQ 1** Is the Shared Flow Scale in gamelan playing valid and reliable in its proposed factor structure?

**RQ 2** Is there a difference in significantly correlated windows of physiological synchrony between participants when playing traditional gamelan music compared to improvising as a group, and does this differ between levels of expertise?

**RQ 3** How does self-reported shared flow relate to average physiological synchrony in traditional and improvised playing?

## **4.2 Materials and Methods**

### **4.2.1 Participants**

Participants with varying experience levels of playing gamelan were invited to one of three recording sessions. The first recording session consisted of participants with prior experience of gamelan playing recruited from the current members and tutors of Gamelan Sekar Petak, a gamelan group based at the University of York, U.K. ( $N = 13$ , age  $M = 29.6$ ,  $SD = 10.2$ , 61.5% female). The second and third recording sessions consisted of participants with no, or very minimal, prior experience of playing gamelan ( $N = 16$ , age  $M = 24.75$ ,  $SD = 5.58$ , 62.5% female) and were students recruited from the University of York, mostly from the music department. This latter group was divided into two equal-sized groups for two recording sessions, due to limitations in the number of instruments available. All participants were provided information sheets and completed consent forms (**Appendix A**).

For both groups, players' instrumental parts encompassed different instrumental groups: structural instruments of *gong* and *kempuls* (shared by one player in the beginner group and played by two players in the advanced group); *kethuk* and *kenongs* (similarly shared by one player in the beginner group and played by two players in the advanced group); *bonang barung* and *bonang panerus* parts; and metallophone

*balungan* instruments of *sarons*, *slenthem* and *demung*. The advanced group included: *kempyang*, played alongside the *kethuk* by the same player; an added *peking*, a slightly more elaborating *balungan* instrument; *kendhang*, a set of drums playing intricate patterns that use a variety of techniques; and *gender*, a complex metallophone playing elaborate patterns weaving around the *balungan* line with both hands.

#### 4.2.2 Procedure

Both experience groups played two pieces: one traditional gamelan piece, or *karawitan*, from central Java that was selected to suit their collective ability and were asked to improvise a piece as a group spontaneously. Before the session, and after playing both the traditional and improvised pieces, participants completed questionnaires (detailed below, see **Appendix B** for full questionnaires), while physiological measures were taken throughout the performances. The entire sessions were video recorded. The recording sessions, including the set-up of devices, lasted around 90 minutes each. Due to measurement error, physiological data from two participants for each group was removed completely (total  $N = 25$ , advanced  $n = 11$ , beginners  $n = 14$ ).

The advance group played *Ladrang Pangkur laras pélog pathet barung* (12 minutes and 56 seconds),<sup>6</sup> which had been rehearsed for several months in preparation for a concert and a dance performance. The beginner groups were taught the principles of gamelan playing and learnt their traditional piece the same morning under the guidance of a tutor, which was *Lancaran Baita Kandas laras pélog pathet nem* (5 minutes and 5 seconds for the first beginner session, and 5 minutes and 51 seconds in the second beginner session due to an additional repetition of the opening cycle). *Baita Kandas* was largely learnt aurally due to the unfamiliarity of gamelan notation for beginners, while many players of *Pangkur* relied on the notation to varying degrees. Notation for both pieces is provided in **Appendix C**. Little instruction was given on how to navigate

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<sup>6</sup> For most *karawitan*, full titles encompass the structure at the beginning - in this case, *ladrang* - and the tuning system and *pathet*, which can be thought of as a mode, at the end. Here this is given as *pélog pathet barung*. The middle portion is the actual name of the piece, *Pangkur*. In this thesis, once names are introduced in full, where they are re-referred to, it is only by their name, for the sake of brevity.

improvisations; players were simply asked to leave space for others, not feel pressured to play constantly and be mutually responsive to one another.

### **4.2.3 Measures**

#### *4.2.3.1 Self-report measures of flow state*

As the study was exploratory, a wide variety of pre- and post-experiment measures were taken. Several of these measures encompassed items relating to the nine dimensions of flow state theorised by Csikszentmihalyi (2000). Although both the Dispositional Flow Scale (DFS-2) and the CORE Flow State Scale (Martin & Jackson, 2008) were used, the analyses in this chapter just focus on the experience of shared flow, using the Shared Flow Scale (SFS), a 27-item 5-point Likert scale (Zumeta, Basabe, et al., 2016). This scale is based on a Spanish version of the original DFS (Jackson & Marsh, 1996) and an adaptation (Calvo et al., 2008), in line with the nine dimensions of flow outlined above. It assesses the experience of flow after participation in an activity, and rather than measuring the individual experience as the DFS-2 does, it instead focuses on shared flow by replacing singular personal pronouns of “I” with “we”. Several other measures were also attained due to the ambitious and exploratory nature of this study from the outset, including the Goldsmiths-Musical Sophistication Index (Gold-MSI) (Müllensiefen et al., 2014), the Positive and Negative Affective Schedule (PANAS) (Watson et al., 1988), the Perceived Emotional Synchrony Scale (PESS) (Włodarczyk et al., 2020), and the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Tennant et al., 2007). However, as the research questions were further refined, this chapter and associated research questions are focused solely on the intersections of shared flow and physiological synchrony, these are not included in the analyses.

#### *4.2.3.2 Physiological measures*

Skin conductance (SC) and electrocardiogram (ECG) measures were recorded using Shimmer Sensors, where measurement areas for pre-gelled sensor electrodes were prepared using 70% alcohol swabs. ECG was measured via a four-lead configuration from the chest. From these measures, heart rate (HR) and skin conductance (SC) were

extracted to reflect an individual's physiological arousal. SC was measured via the inside of the right foot along the abductor hallucis muscle, which is a comparable anatomical recording site to that of the typical hand configuration (Hossain et al., 2022; Sanchez-Comas et al., 2021). This method was also selected due to having greater ecological validity, as it allows for the participant to play gamelan freely with both hands and because players traditionally remove outer footwear regardless as a way of showing respect to the instruments. A one-minute baseline was recorded before the first performed piece.

#### **4.2.4 Data analysis**

##### *4.2.4.1 Physiological pre-processing*

Physiological data, recorded at 256 Hz, were pre-processed using custom-made scripts for MATLAB. ECG data were pre-processed using a Butterworth bandpass filter with 0.2 and 12 Hz cutoff points, and 4th order zero-phase filtering. ECG was extracted from the standard lead II configuration (Golland et al., 2015; Gordon et al., 2021). Following this, inter-beat intervals (IBIs) were calculated from the peaks of the ECG. Continuous HR was then calculated from the IBIs using the *interp1* in MATLAB (with the “nearest” method specified) and lowpass filtered at 0.05 Hz. Only HR values between 40-140 beats per minute, typically associated with normal resting and light activity-induced HR for adults,<sup>7</sup> were used in subsequent analyses. This step was taken to ensure the exclusion of any inaccurate data resulting from measurement error ( $n = 3$ ). SC data were pre-processed using Butterworth lowpass filtering with a 0.5 Hz cutoff point. The whole SC signal was used in the analyses, rather than decomposing the data into tonic and phasic levels. The rationale for this was the lack of interest in solely event-related responses or levels of arousal, but instead the combination of arousal and relaxation resulting from the simultaneous activation of the parasympathetic and sympathetic nervous systems underlying flow (Bian et al., 2016), and to what extent such processes would be shared across the group. Any further SC signals observed to be inaccurate

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<sup>7</sup> This cut off was determined as an arbitrary means of excluding data that appeared to be well below or well above feasible heart rates given the context.



were discarded ( $n = 7$ ). This resulted in  $n = 9$  SC and  $n = 10$  HR remaining signals for the advanced group, and  $n = 9$  SC and  $n = 12$  HR remaining signals for both beginner groups combined.

#### 4.2.4.2 ISC of physiological signals and statistical significance

Both HR and SC signals were segmented into musically meaningful bins per bar, or *gatra* in Javanese terminology. A *gatra*, as described in chapter 2, typically encompasses a set of four notes for the *balungan* or melody line, which forms a part of a whole cycle, often in multiples of four or eight punctuated by structural instruments, and repeated.<sup>8</sup> *Karawitan* is generally constructed from these blocks of four-note *gatra* (Pickvance, 2005), and in this context, a *gatra* ranges from three to a maximum of seven seconds in length depending on the tempo of the section. For the improvisation, the signals were segmented into bins of equivalent duration to that of the traditional pieces, of around three seconds. Physiological synchrony was obtained from instantaneous SC and HR signals with inter-subject correlation (ISC) analyses. Pearson's  $r$  values were calculated between all possible dyads within groups, within windows of 8 *gatra* overlapping by 4, which was decided on due to the gamelan cycles in the pieces selected working largely in structures of 8 *gatra* which are repeated. Details of segmentation are provided in **Appendix D**. The ISC procedure follows that of Pérez et al. (2021) and was calculated using their provided MATLAB scripts. Fisher's  $z$ -transformation was applied to each dyadic ISC for each segment, before calculating the mean for each set of dyadic combinations per subject. Following this, the inverse Fisher's  $z$ -transformation was applied.

The statistical significance of ISC was assessed by comparing ISC calculated with original, time-locked data with control data that was computed using circularly shifted segment shuffling. This yielded a control ISC for each dyad, repeated for each group for both HR and SC. The filtered continuous signal for each subject and section was

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<sup>8</sup> In *balangun mlaku* style refers to a *gatra* with density of four notes, however *balangun nibani* style refers to a half-density *gatra* of two notes interspersed with rests, as described by Pickvance (2005). The pieces played in this study featured both styles, and so for the analysis, two *nibani* style *gatra* were equivocated with one *mlaku* style *gatra*, which were comparable in duration.

circularly shifted by a random amount 10000 times, producing control signals for each subject and section. The same ISC procedure was followed as above. Significance was determined by calculating the proportion of control ISCs above the threshold of the actual ISC for each subject, in both traditional and improvisational pieces.

For RQ1, a confirmatory factor analysis was conducted on the original Shared Flow Scale (Zumeta, et al., 2013), followed by an exploratory factor analysis and confirmatory factor analysis to assess whether there was a more appropriate solution for the observed data. For RQ2, points of significance were observed across all pieces visually, before conducting Fisher's exact tests to determine whether the proportion of significant ISCs differed between traditional and improvised playing, and between experience groups. Lastly, for RQ3, overall ISC-SC and ISC-HR variables were calculated by averaging all ISC across sections, to produce a global ISC average across the piece per participant,  $ISC-SC_{mean}$  and  $ISC-HR_{mean}$ . This was calculated for traditional and improvised pieces separately. Linear mixed models were fitted using the R *lme4* package to analyse potential relationships between physiological synchrony and self-report shared flow factors across conditions. These were selected as they are robust to small sample sizes and non-normal distributions (Bates et al., 2015; Winter, 2013).

## **4.3 Results**

### **4.3.1 RQ1: Validity and reliability of the Shared Flow Scale in its proposed factor structure**

Confirmatory factor analysis (CFA) was conducted for all 27 items of the Shared Flow Scale (Zumeta et al., 2013) across the 29 participants, to test whether the original model of nine dimensions was a reasonable fit for the observed data. This original model was not admissible, as the covariance matrix of latent variables was not positive definite. Therefore, it was necessary to seek another more appropriate solution for the data. Exploratory Factor Analysis (EFA) was then conducted using parallel analysis based on factor analysis, a maximum likelihood estimation method, and oblimin rotation. This resulted in a two-factor solution. CFA was repeated on the model provided by the EFA to gain additional measures of fit (Matsunaga, 2010), using the highest loading items and a maximum likelihood restricted estimation. The model was

fitted using *lavaan* in R. This confirmed a two-factor solution of 11 items with a reasonable fit for the observed data, given the small sample size,  $\chi^2(43, N = 29) = 58.790$ , CFI = 0.906, TLI = 0.880, robust RMSEA = 0.102, SRMR = 0.095. Cronbach's  $\alpha$  for this solution was given at 0.854 and 0.835, demonstrating very good internal consistency for each factor. This model is outlined in **Figure 5**, and parameter estimates are given in **Table 2**.

**Figure 5.**

*Factor Loading Plot Showing Standardised Estimates of the Two Factors Labelled Awareness and Absorption.*

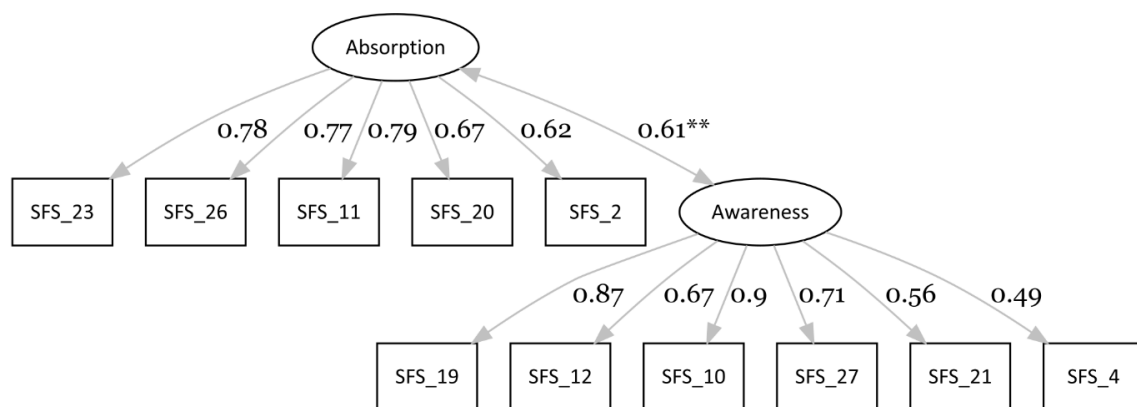


**Table 2.***Confirmatory Factor Loadings for SFS Factors.*

| Factor            |        | Item                                                                          | Est. | SE   | z value | p     |
|-------------------|--------|-------------------------------------------------------------------------------|------|------|---------|-------|
| <i>Awareness</i>  | SFS_19 | "We felt we were competent enough to meet the high demands of the situation." | .867 | .209 | 3.504   | <.001 |
|                   | SFS_12 | "We knew clearly what we wanted to do."                                       | .668 | .080 | 5.240   | <.001 |
|                   | SFS_10 | "Our abilities matched the high challenge of the situation."                  | .904 | .205 | 3.544   | <.001 |
|                   | SFS_27 | "The group experience left us with a good impression, a good taste."          | .708 | .211 | 2.421   | .015  |
|                   | SFS_21 | "We knew what we wanted to achieve."                                          | .559 | .086 | 3.602   | <.001 |
|                   | SFS_4  | "It was really clear to us that we were doing well."                          | .494 | .082 | 3.175   | .001  |
| <i>Absorption</i> | SFS_23 | "We felt totally absorbed by what we were doing."                             | .776 | .195 | 2.934   | .003  |
|                   | SFS_26 | "We felt like time stopped while we were performing."                         | .766 | .158 | 5.155   | <.001 |
|                   | SFS_11 | "We felt that things were happening automatically."                           | .785 | .126 | 4.226   | <.001 |
|                   | SFS_20 | "We performed automatically."                                                 | .669 | .244 | 2.326   | .020  |
|                   | SFS_2  | "We were doing things spontaneously and automatically."                       | .616 | .127 | 3.216   | .001  |

**Note:** N=29

Labels of *Awareness* and *Absorption* were given to each of the factors, to reflect items that encompassed elements of flow holding a great deal of awareness, in comparison to those that were absorbing and automatic. The average variance extracted (AVE) was

calculated using the *semTools* package (Jorgensen et al., 2022), which was 0.581 for *Awareness*, and 0.536 for *Absorption*, while the covariance between the factors was 0.612. For further analysis, composite scores for each of these factors were taken.

Data from two participants were removed for all subsequent analyses due to anomalous extreme values that could not be accommodated in further model specifications.

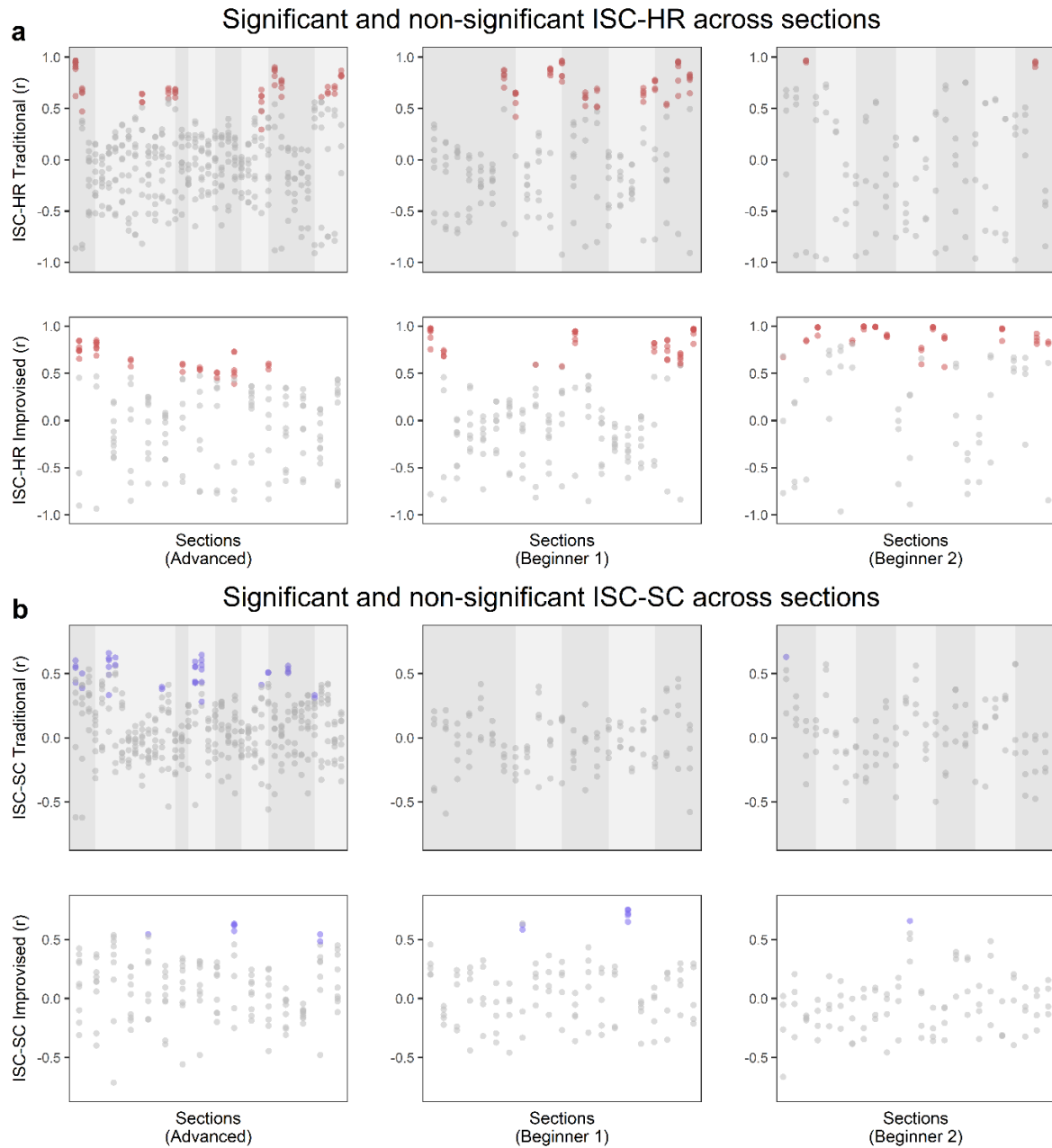
#### **4.3.2 RQ2: Differences in significantly correlated windows of physiological synchrony between traditional gamelan music compared to improvising as a group, and between levels of expertise**

To test for significant ISC of instantaneous SC and HR signals, pairwise ISCs for each participant were computed across 8 *gatra* sections for traditional pieces and an equivalent section in length of 24s for improvised pieces, before averaging across pairs to produce one ISC-SC and one ISC-HR value per participant and section. These values were then compared to values resulting from randomly shuffled signals.

**Figure 6** displays these ISC values across each of the playing sessions, whereby statistically significant values are denoted via coloured dots. This shows that sections yielding significant ISCs are observed to some degree across both playing conditions and for both SC and HR, albeit more so for ISC-HR than for ISC-SC.

**Figure 6.**

a) ISC-HR and b) ISC-SC Computed for Each Participant and Each Section Across Traditional and Improvised Gamelan Playing.



**Note:** Significance is denoted via coloured dots, using an FDR of 0.05.

Shaded regions indicate changes in musical material (i.e., where the section changes or more elaborating material is added) or tempo changes.

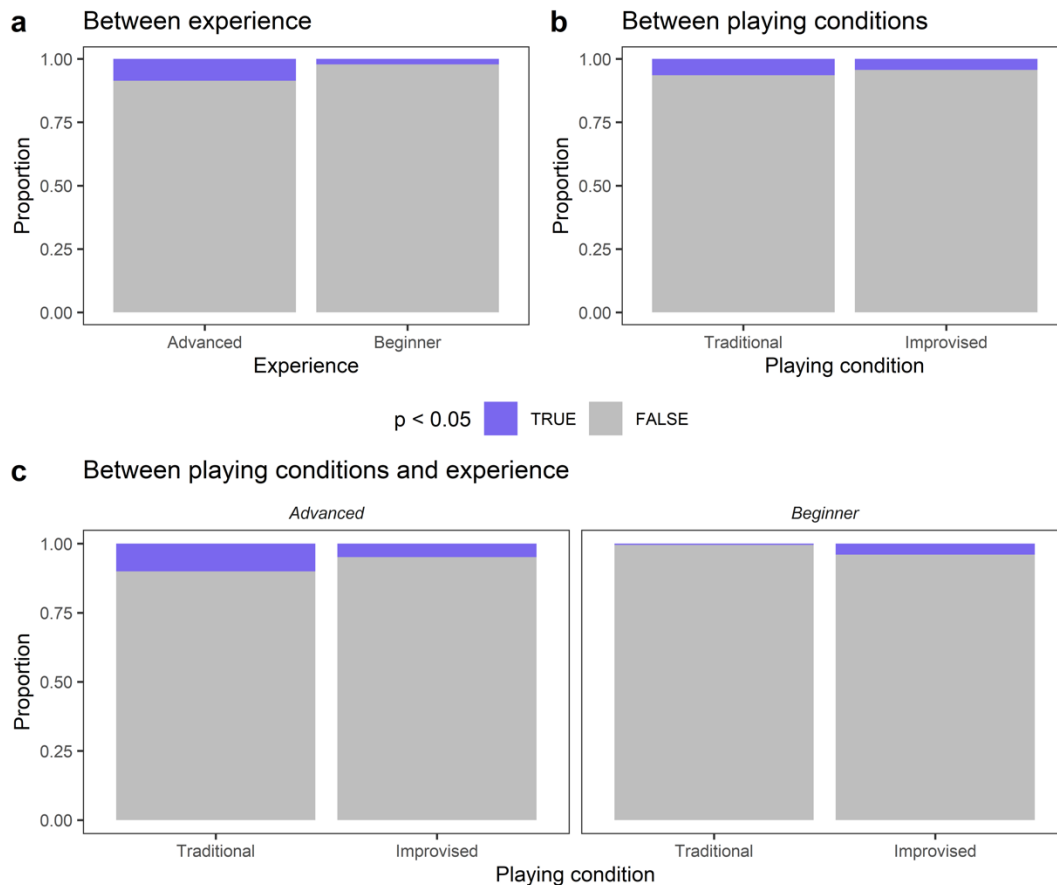
Fisher's exact tests were used to assess differences in the proportion of significant to non-significant values between the two levels of experience, with both beginner recording sessions combined, and between playing conditions. The significance here was determined by measuring the proportion of synchrony values calculated from the original data compared to control data attained through circular shuffling, using an FDR of 0.05.

For ISC-SC in traditional playing, there was a significant difference in the proportion of significant ISC-SCs between beginner and advanced experience groups ( $p < .001$ ), a greater proportion of significant ISC-SC occurred for the advanced group than the beginner group in traditional playing. No significant difference in experience groups was found for improvised playing. The data was then split to isolate experience groups and account for differences between playing conditions within them. For beginner players, a significant difference was found in the proportion of significance between improvised and traditional playing ( $p = .015$ ). Here, the proportion of significant ISC-SC seemed to be greater in improvised playing than in traditional playing for the beginner group. For the advanced group, a non-significant trend level difference between traditional and improvised playing was found for the advanced group ( $p = .078$ ), whereby contrary to the beginner group, the proportion of significant ISC-SCs may have been slightly greater in traditional playing than in improvised playing. These results indicate that the proportion of significant ISC-SC values was greater overall for advanced players, at least in traditional playing, and that the proportion of significant ISC-SC between playing conditions when isolating beginner and advanced groups seemed to be opposing. **Figure 7** displays these proportions of significance for ISC-SC graphically.



**Figure 7.**

*Proportion of Significance For ISC-SC Displayed in Coloured Regions Between Conditions and Experience Groups.*



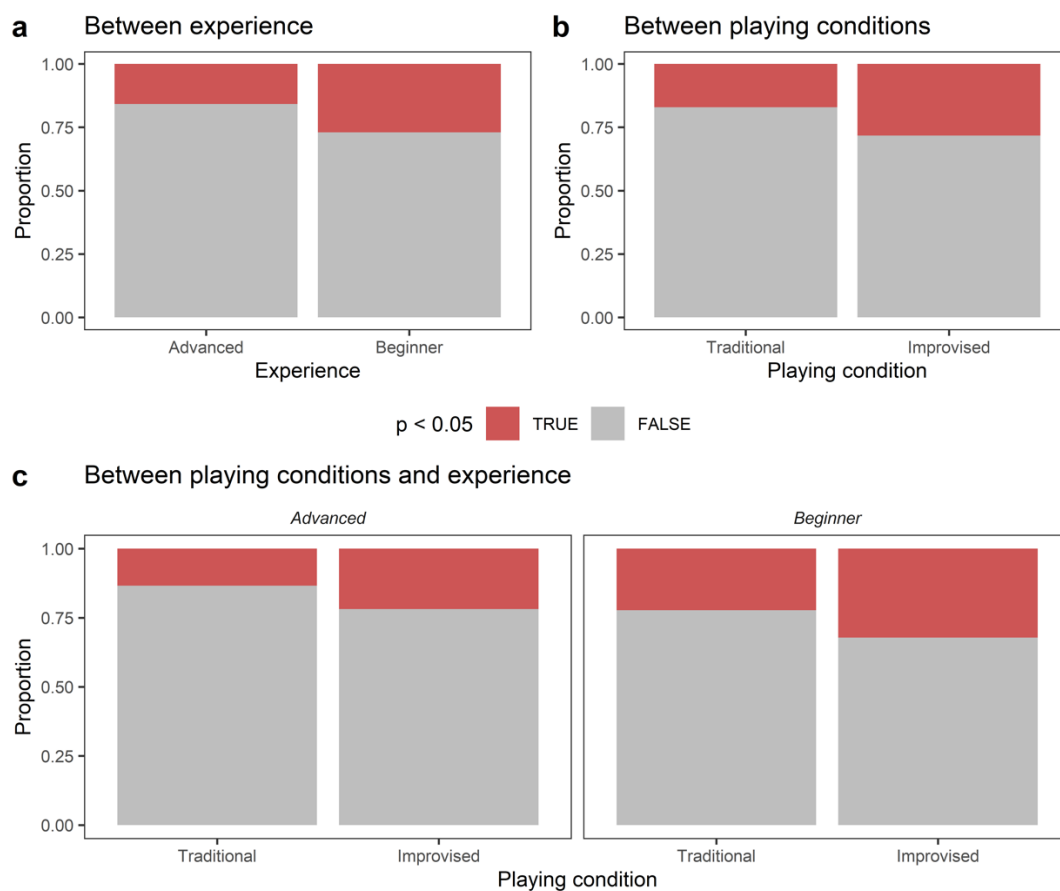
**Note:** a) Between experience levels across both playing conditions, b) between playing conditions across both experience groups, and c) between both playing conditions and experience. Significance determined using FDR of 0.05.

For ISC-HR, a significant difference was found between the beginner and advanced experience groups and the proportion of significance in traditional playing ( $p = .006$ ) and in improvised playing ( $p = .026$ ). Within these, beginners yielded a greater proportion of ISCs across both playing conditions. The data was then split to account for differences between playing conditions for each experience group separately. Overall, the proportion of significant ISC-HRs was significantly greater in improvised playing than in traditional playing for both the advanced group ( $p = .030$ ) and beginners ( $p = .009$ ). These results suggest that the proportion of significant ISC-HR values was greater

overall for beginners, and overall for improvised playing. **Figure 8** displays these proportions of significance for ISC-HR. Average significant ISCs were also compared between groups and playing conditions to assess differences in values (see **Appendix E**)

**Figure 8.**

*Proportion of Significance for ISC-HR Displayed in Coloured Regions Between Experience Levels and Playing Conditions.*



**Note:** a) Between experience levels across both playing conditions, b) between playing conditions across both experience groups, and c) between both playing conditions and experience groups. Significance determined using FDR of 0.05.

### 4.3.3 RQ3: Relationships between self-reported shared flow and average physiological synchrony in traditional and improvised playing

For the following analyses, all significant and non-significant ISC values were averaged across all sections, providing overall measures of average physiological synchrony denoted by  $ISC-HR_{mean}$  and  $ISC-SC_{mean}$ . Two separate linear mixed models were fitted for  $ISC-HR_{mean}$  and  $ISC-SC_{mean}$ . For each of these, we investigated the fixed effects of playing conditions (improvised vs. traditional) and the shared flow factors, identified in response to the first research question of *Absorption* and *Awareness*. A random effect was only assigned to experience level, as subject-level variance was negligible, and therefore did not warrant an additional subject-level random effect to explain the observed variance. Results for each indicated that the optimally fitting models involved an interaction between a shared flow factor and the playing condition.

#### 4.3.3.1 Dependent variable $ISC-HR_{mean}$

For the first mixed model comparisons, detailed model comparisons are listed in **Table 3**, while full fixed effects results for these most optimally fitting models are provided in **Table 4**.

**Table 3.**

*Dependent Variable: ISC- HR<sub>mean</sub>; Independent Variables: Condition (Traditional, Improvised), Shared Flow Factors (Absorption, Awareness).*

| Model                                               | AIC  | BIC | Marginal<br>$R^2$ | Conditional<br>$R^2$ | Improvement in<br>Model Fit |                   |
|-----------------------------------------------------|------|-----|-------------------|----------------------|-----------------------------|-------------------|
|                                                     |      |     |                   |                      | $\chi^2(1)$                 | $p$               |
| ISC- HR <sub>mean</sub> Null Model                  | 0.8  | 6.0 |                   | 0.136                |                             |                   |
| ISC- HR <sub>mean</sub> ~ Condition                 | -2.2 | 4.7 | 0.099             | 0.239                | 4.9991                      | .025              |
| ISC- HR <sub>mean</sub> ~ Condition +<br>Awareness  | -0.7 | 8.0 | 0.108             | 0.253                | 0.5083                      | .476              |
| ISC- HR <sub>mean</sub> ~ Condition ×<br>Awareness  | -3.5 | 6.9 | 0.190             | 0.339                | 5.3242                      | .070 <sup>a</sup> |
| ISC- HR <sub>mean</sub> ~ Condition +<br>Absorption | -0.4 | 8.3 | 0.103             | 0.233                | 0.1569                      | .069 <sup>a</sup> |
| ISC- HR <sub>mean</sub> ~ Condition ×<br>Absorption | -4.4 | 6.0 | 0.207             | 0.342                | 6.1872                      | .045 <sup>a</sup> |

**Note:** Linear mixed-effects model between ISC-HR<sub>mean</sub> values and shared flow factors. Condition is given as a fixed effect, and experience group as a random effect. Null model:  $HR \sim 1 + (1 | \text{experience})$ .<sup>a</sup> As compared to  $HR \sim \text{Condition}$ .  $\chi^2(1)$  increases to  $X^2(2)$  for two fixed effects, and  $\chi^2(3)$  in interaction models.

$N_{HR} = 21$

**Table 4**

*Fixed Effects Results for the Most Optimally Fitting Interaction Models with ISC- $HR_{mean}$  as a Dependent Variable*

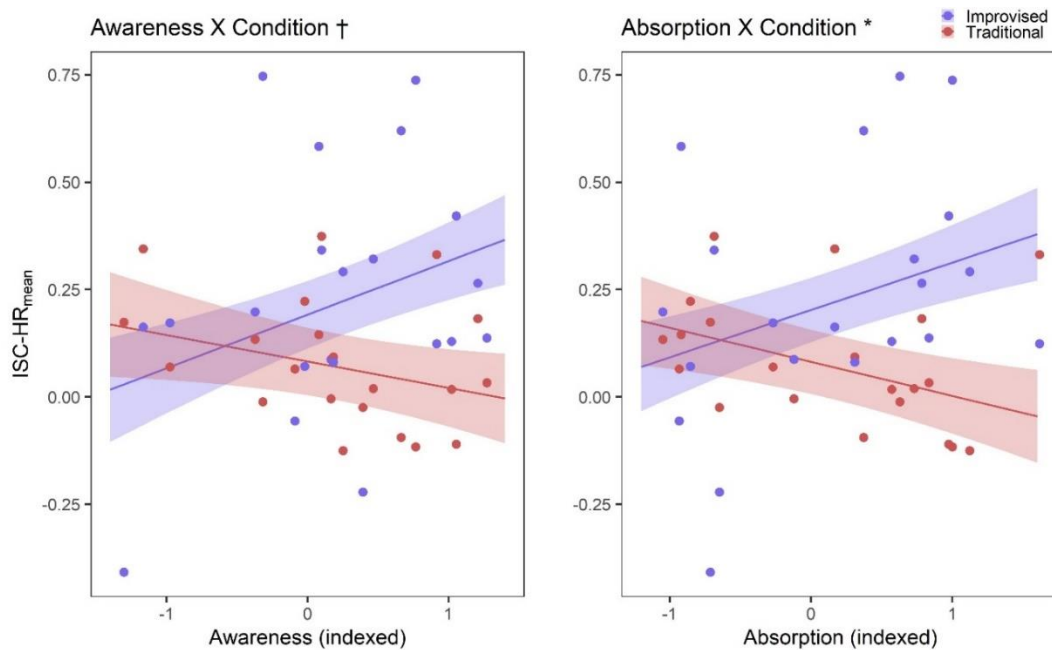
| ISC- $HR_{mean} \sim \text{Condition} \times \text{Awareness} + (1   \text{experience})$  |        |       |        |        |      |
|-------------------------------------------------------------------------------------------|--------|-------|--------|--------|------|
| Dependent                                                                                 | Est.   | SE    | df     | t      | p    |
| (Intercept)                                                                               | 0.191  | 0.078 | 2.870  | 2.441  | .096 |
| Condition (traditional)                                                                   | -0.109 | 0.062 | 39.993 | -1.758 | .087 |
| Awareness                                                                                 | 0.125  | 0.058 | 40.023 | 2.140  | .039 |
| Condition (traditional) $\times$ Awareness                                                | -0.186 | 0.082 | 39.993 | -2.262 | .030 |
| ISC- $HR_{mean} \sim \text{Condition} \times \text{Absorption} + (1   \text{experience})$ |        |       |        |        |      |
| Dependent                                                                                 | Est.   | SE    | df     | t      | p    |
| (Intercept)                                                                               | 0.202  | 0.075 | 2.784  | 2.707  | .080 |
| Condition (traditional)                                                                   | -0.120 | 0.060 | 39.946 | -2.010 | .051 |
| Absorption                                                                                | 0.110  | 0.053 | 40.424 | 2.073  | .045 |
| Condition (traditional) $\times$ Absorption                                               | -0.190 | 0.074 | 39.946 | -2.551 | .015 |

**Note:**  $N = 21$ .

An interaction model revealed that ISC- $HR_{mean}$  may be significantly predicted by shared *Absorption* as an overall fixed effect in improvised playing, though ISC- $HR_{mean}$  may decrease with *Absorption* specifically within traditional playing. An interaction model with shared *Awareness* demonstrated a trend-level fit above that of the condition model, and the findings of this were similar to that of shared *Absorption*. ISC- $HR_{mean}$  may be predicted by an overall fixed effect of shared *Awareness* in improvised playing, while ISC- $HR_{mean}$  seems to decrease with shared *Awareness* for traditional playing. Graphical figures are provided in **Figure 9**. These graphical figures suggest that contrary to the traditional playing condition, there may be a positive association between ISC- $HR_{mean}$  and both shared *Absorption* and *Awareness* for improvised playing.

**Figure 9.**

*Results for RQ3. Graphical Depiction of Predictions of  $ISC-HR_{mean}$  by Shared Flow Factors Interacting with Music Condition.*



**Note:** Shaded areas represent standard error. Predictions for  $ISC-HR_{mean}$  in improvised playing are represented in blue, while traditional playing is represented in red. † Denotes trend-level model fit improvement at  $p \leq 0.10$ , \*denotes significant model fit improvement at  $p < 0.05$ .

#### 4.3.3.2 Dependent variable $ISC-SC_{mean}$

For the second mixed model comparisons, a comparable pattern emerged. Detailed model comparisons are listed in **Table 5**, while full fixed effects results for this model are provided in **Table 6**.

**Table 5.**

*Dependent Variable: ISC-SC<sub>mean</sub>; Independent Variables: Condition (Traditional, Improvised), Shared Flow Factors (Absorption, Awareness).*

| Model                                           | AIC   | BIC   | Marginal<br>$R^2$ | Conditional<br>$R^2$ | Improvement in<br>Model Fit |                   |
|-------------------------------------------------|-------|-------|-------------------|----------------------|-----------------------------|-------------------|
|                                                 |       |       |                   |                      | $\chi^2(1)$                 | $p$               |
| ISC-SC <sub>mean</sub> Null Model               | -66.8 | -62.2 |                   | 0.201                |                             |                   |
| ISC-SC <sub>mean</sub> ~ Condition              | -64.8 | -58.7 | 0.002             | 0.203                | 0.0639                      | .800              |
| ISC-SC <sub>mean</sub> ~ Condition + Awareness  | -65.5 | -57.9 | 0.065             | 0.254                | 2.7614                      | .251 <sup>a</sup> |
| ISC-SC <sub>mean</sub> ~ Condition × Awareness  | -67.0 | -57.8 | 0.139             | 0.332                | 6.2524                      | .100 <sup>a</sup> |
| ISC-SC <sub>mean</sub> ~ Condition + Absorption | -62.8 | -55.2 | 0.002             | 0.207                | 0.0766                      | .962 <sup>a</sup> |
| ISC-SC <sub>mean</sub> ~ Condition × Absorption | -65.1 | -56.0 | 0.098             | 0.309                | 4.3746                      | .224 <sup>a</sup> |

**Note:** Linear mixed-effects model between mean ISC values and shared flow factors. Condition is given as a fixed effect, and experience group as a random effect. Null model:  $SC \sim 1 + (1 | \text{experience})$ . <sup>a</sup>As compared to SC Null Model.  $\chi^2(1)$  increases to  $\chi^2(2)$  for two fixed effects, and  $\chi^2(3)$  in interaction models. SC:  $n = 17$ .

**Table 6.**

*Fixed Effects Results for the Most Optimally Fitting Interaction Model with ISC-SC<sub>mean</sub> as a Dependent Variable.*

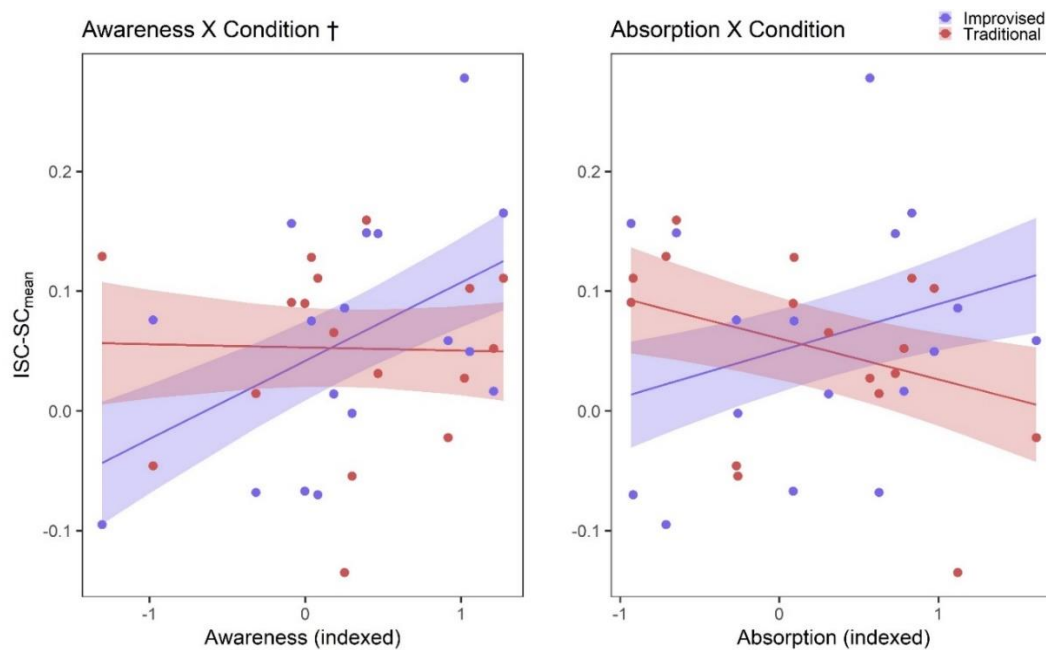
| ISC-SC <sub>mean</sub> ~ Condition × Awareness + (1 experience) |        |       |        |        |      |
|-----------------------------------------------------------------|--------|-------|--------|--------|------|
| Dependent                                                       | Est.   | SE    | df     | t      | p    |
| (Intercept)                                                     | 0.042  | 0.033 | 2.954  | 1.264  | .297 |
| Condition (traditional)                                         | 0.011  | 0.026 | 31.995 | 0.424  | .674 |
| Awareness                                                       | 0.065  | 0.025 | 32.028 | 2.605  | .014 |
| Condition (traditional) × Awareness                             | -0.068 | 0.035 | 31.995 | -1.921 | .064 |

**Note:**  $N = 17$

An interaction model indicated that  $ISC-SC_{mean}$  may be predicted by an overall fixed effect of shared *Awareness* in improvised playing, while  $ISC-SC_{mean}$  decreases with *Awareness* on a trend level in traditional playing, in the most optimally fitting model. Figures illustrating these predictions between factors of playing condition, shared flow factors, and ISCs are provided in **Figure 10**. Graphical visualisation shows that while the relationship between shared *Awareness*  $ISC-SC_{mean}$  may be negligible in traditional playing, it seems to be positively associated in the context of improvised playing. Although the  $ISC-SC_{mean}$  interaction model with shared *Absorption* did not show any significant improvement in the model fit, the related figure is still included for the sake of consistency.

**Figure 10.**

*Results for RQ3. Graphical Depiction of Predictions of  $ISC-SC_{mean}$  by Shared Flow Factors Interacting with Music Condition.*



**Note:** Shaded areas represent standard error. Predictions for  $ISC-SC_{mean}$  in improvised playing are represented in blue, while traditional playing is represented in red. † Denotes trend-level model fit improvement at  $p \leq .10$ .



## 4.4 Discussion

In furthering knowledge of mechanisms of joint music-making, this exploratory study is the first of its kind to investigate the experience of shared flow and physiological correlates in the context of Javanese Gamelan. The primary aims were to explore aspects of self-reported shared flow (RQ1) and synchronised physiological parameters of heart rate (HR) and skin conductance (SC) via inter-subject correlation (ISC) (RQ2) while participants played Javanese gamelan pieces. Potential differences in significant mean ISCs were assessed between the experience levels of the players and between improvised or traditional pieces. Finally, the extent to which physiological synchrony was related to self-reported flow was assessed (RQ3). Shared flow has scarcely been studied in group music contexts. Where it has, potential physiological patterns underlying the experiences have not been measured. Additionally, gamelan has had little attention from psychologists and presents an opportunity to study such effects in a highly ecologically valid setting, where interaction and egalitarianism meet in instrumental form. The findings revealed a complex picture of the differences in ISC-HR and ISC-SC underlying traditional playing and improvised playing between experience groups. In most instances, on at least a trend level shared flow factors and ISCs were positively associated with each other for improvised playing, and negatively for traditional playing.

The first research question concerned whether the Shared Flow Scale (SFS) (Zumeta et al., 2016) was valid and reliable in its proposed factor structure, in order to further explore aspects of shared flow in the context of gamelan. The SFS was initially selected for two reasons. First, the scale had previously been used in a comparable context of a drumming march at a festival. Second, the SFS adopts plural pronouns and aligns with classic flow theories. However, in its original form, the confirmatory factor analysis of the Shared Flow Scale (Zumeta et al., 2016) did not yield an admissible model. This could have been due to the interactive setting. Shared flow experiences in situations of music-making might be fundamentally different from the classic nine-factor conceptualisation shared with Csikszentmihalyi's flow (2000). In turn, the context in which Zumeta and colleagues validated the scale may have been more representative

of a “co-active” flow (Raettig & Weger, 2018). For that reason, it may be difficult to measure more interactive forms of shared flow experience using such a scale.

Instead, the final factor solution encompassed factors that were labelled as *Awareness* and *Absorption*, reflecting both the absorbing and challenging nature of gamelan playing. These factors may be potentially comparable to the need for simultaneous self-other integration and separation in group music performance, highlighted by Liebermann-Jordanidis et al. (2021). It is also possible that the resulting factors here of *Awareness* and *Absorption* are more strongly linked with the *Absorption* and *Smoothness* factors that the Interactive Flow (IF) scale of Raettig and Weger (2018) proposes, or that of Collective Efficacy, Absorption and Enjoyment developed by Salanova and colleagues (2014). Such scales suggest that a lower-order factor structure may be fruitful, particularly in this case where sample size may pose an issue for a factor structure that requires so many dimensions (Matsunaga, 2010). On another note, the SFS does not clearly distinguish between potential antecedents and outcomes of shared flow, as the IF does (Raettig & Weger, 2018). It may be worth, therefore, involving self-reports on shared flow experiences that contain a simpler factor structure and explicitly differentiate between antecedents and outcomes through the use of separate scales or groups of items, in accordance with the IF theory.

With regards to the second research question concerning whether there are differences in significantly correlated windows of physiological synchrony between performance conditions and levels of expertise, findings regarding the proportions of significant ISCs and the overall value of significant ISCs were mixed. A greater proportion of significant ISC-SC was found for advanced players compared to beginner players, while the opposite was true for ISC-HR. When splitting the data by experience, the proportion of significant ISC-HR seemed to be greater for improvised playing than traditional across both experience groups, while for ISC-SC, the difference in the proportion of significance between the two playing conditions was opposing for each experience group, at least on a non-significant trend level. Potentially this could indicate differences in required effort associated with levels of expertise and resultant physiological parameters. Furthermore, beginners were taught their parts aurally, while

many of the advanced players still relied on written notation. This distinction may have also accounted for these inconsistencies between measures.

HR indicates the activity of both the sympathetic and parasympathetic branches of the ANS, while increases in SC is an indicator of sympathetic activation. Accordingly, the differences in findings between experience levels and playing conditions are not necessarily surprising. Levels of attention may not affect parasympathetic activity (Pérez et al., 2021), while the degree of challenge and associated effort facilitating flow experience might (Thissen et al., 2022). Further to this, sympathetic activation as an indicator of arousal appears to form an inverted U-shape relationship with flow (Peifer et al., 2014; Tozman et al., 2015). For that reason, it seems plausible that a greater proportion of significant ISC-HR was present for beginner players who may have felt more of a fluctuating shared sense of challenge overall. Nevertheless, when observing the differences between playing conditions for each experience group separately, improvised playing yielded a greater proportion of significant ISC-HR for both groups. This perhaps instead relates to improvisation leading to greater levels of togetherness, enhanced engagement, and enjoyment (Noy et al., 2015), which may also be supported by a greater proportion of significant ISC-SC in improvised playing compared to traditional playing for beginners. Meanwhile, the finding of a greater proportion of significant coupling in traditional playing for advanced players may be attributed to heightened arousal levels, in that their piece involved more temporal and structural changes than the beginner piece. These findings must be taken with great caution, however, as the number of significant data points for ISC-SC was far fewer than for ISC-HR, and the sample is small overall. As such, it should be acknowledged that these findings are limited in their power and form merely a starting point in a novel area of research. There is a necessity to further disentangle the roles of shared sympathetic and parasympathetic activity in relation to shared flow experiences in differing contexts. Future studies with greater power may therefore find it worthwhile to explore such effects of expertise and playing style further.

Crucially, in addressing the final research question concerning relationships between self-reported flow and physiological synchrony, it was found that overall physiological synchrony underlying flow seems to be fundamentally different between improvised

and traditional playing. Through the use of linear mixed effects models, the shared flow factors seemed to negatively predict mean ISCs in traditional playing, and positively predict mean ISCs in improvised playing, on at least a trend level. These findings support the notion that ISC might not only occur in situations involving joint listening settings (Czepiel et al., 2021; Dauer et al., 2021; Pérez et al., 2021), but also in joint music performance settings. Extending knowledge of how more successfully coordinated action may result in greater physiological coupling on some level (Gordon et al., 2020; Ruiz-Blais et al., 2020), the results demonstrate a novel contribution of shared flow experiences. Tightly coordinated actions are necessary for the successful performance of music, which in turn is often found to involve some degree of shared flow experience (Cochrane, 2017; Magyaródi et al., 2022; Tay et al., 2021).

Contrary to a previous study that did not find a relationship between shared flow and overall mean HR (Horwitz et al., 2021), a relationship was observed between mean physiological coupling and shared flow. As this relationship seems to differ between improvised and prescribed playing conditions, there seem to be differences between physiological behaviours underlying shared interactive flow and group flow. This finding may support the potential for improvised playing and associated flow to result in greater physiological connectedness. As Raettig and Weger (2018) theorise, “shared interactive flow” arises from a context in which it relies on the interactivity of the ensemble. “Private interactive flow” experiences are rather experienced on the individual level, as the occurrence of flow is not solely dependent on interactivity. The differences between these might be evident in the differences between traditional and improvised gamelan playing. In the former, many participants in the advanced ensemble were playing from notated music, especially the less experienced advanced players. Similarly, although the beginners were taught aurally initially, there was not enough time in the workshop dedicated to ensuring all players were aware of the inner workings of all parts with fluency. The resultant piece may have therefore been played successfully without much awareness towards the group, aside from the occasional tempo change or section change. For improvised playing, on the contrary, interactivity and awareness of the group is fundamental.

## 4.5 Limitations

It should be emphasised here that almost all players in these ensembles were Western university students. The results may have looked quite different for more experienced gamelan players, especially those residing in Java who rehearse in more traditional ways. Something integral to the practice of gamelan is the focus on the group as a whole, rather than an individual's role within it. This notion may be difficult for Western players to fully resonate with, and therefore their engagement with traditional playing may still come from their Western ensemble experiences. The advanced group, Gamelan Sekar Petak, is comprised of players who have been learning gamelan for many years, with some having studied in Java, alongside students who may have only been learning gamelan for less than a year at the university. Further to this, Gamelan Sekar Petak does not typically improvise in their rehearsals. It would, therefore, be fruitful to replicate the study with more experienced groups, groups in which members are comparably experienced, or groups that are more accustomed to improvisation. It is anticipated that for groups with comparable traditional playing expertise to that of Gamelan Sekar Petak, and perhaps more experience with improvisation, similar results may arise. However, for more experienced gamelan groups, with comparably little improvisation experience, shared flow experiences may be positively associated with physiological synchrony in the context of traditional playing. Subsequently, the degree to which the results presented here are generalisable is unclear.

On that note, differences in the relationship between self-reported shared flow and synchronised physiological measures as a result of expertise were not explored. Here, it is plausible that the degree to which synchronised physiology is associated with shared flow is dependent on the level of expertise. Exploration of this could shed greater light on the varying degrees of interaction underlying a shared flow taxonomy (Raettig & Weger, 2018). Future studies should certainly explore this; however, another cause of omission here was the sample and associated power, which restricted the number of interactions it was possible to incorporate.

The most prominent limitation is the small sample size of the study and unequal group sizes. In gamelan, the number of players is restricted due to the number of instruments, and thus the only way of increasing this sample is by studying the experience of

multiple groups or multiple sessions with each group. The consequences of our sample comprising only two groups of varying experience levels, and recorded over three experimental sessions, may have had implications for every stage of the analysis. The beginner players were separated into two experimental sessions, due to the number of instruments available, and therefore the experience of these beginners may have been different between groups. The familiarity between group members was also not considered. Aside from differences in the experience of gamelan between the advanced group and the beginner group, they also differed in the amount of time in which they have been playing together and have known one another. Some beginner players may have known one another due to how they were recruited, but this was not accounted for in the data.

To tailor the potential for flow experiences to arise and improve compatibility between participants' skills and level of potential challenge, different pieces were selected for the beginner group and the advanced group. The beginners' piece was particularly repetitive and featured a short amount of musical material with only one melodic variant, and few tempo changes. This allowed players to learn the piece from memory in a short amount of time. To suit the ability of the advanced players, their piece was lengthier, with more variations to the structure and tempo and more complex instruments. The differences in instrumentation, style, structure, and form of these pieces could have led to quite different flow experiences between groups. Furthermore, although the advanced players' piece had been rehearsed for several months beforehand, many players were still reliant on the notation, while some had been familiar with the piece for years. Discrepancies in the learning style (i.e., aurally or written) were therefore present on both inter-and intragroup levels. Overall, a limitation of any quasi-experimental study design is that not all inter-individual differences, including and beyond those described, can be accounted for and controlled for. Future work may wish to improve experimental control, however as this is the first exploratory study in this area, its naturalistic study design necessitated compromises.

With regards to physiological measurement, SC sensors attached via the foot seemingly have not been used in an experiment of this kind before. Similar sensors monitoring SC attached to the hand have been used to monitor shared physiological

responses in response to a stimulus, rather than active activity, such as listening or group decision-making tasks (Czepiel et al., 2021; Dauer et al., 2021; Gordon et al., 2021). Furthermore, participants' body hair was not removed to minimise discomfort and invasiveness as much as possible, and as a result, the preparation of the area for recording ECG was not at an optimum. To that end, much of the data loss and signal interference may be associated with participants' continual movement and changing of sitting position, resulting in poor contact between the electrodes and the skin or disconnected leads.

Lastly, yet crucially, in an effort to improve ecological validity and reduce disturbance to the natural playing environment, post-performance questionnaires were only completed before and after the entire playing session, meaning any self-reported flow experience that differed between improvisation and traditional playing cannot be discerned. Further to this, the questionnaire was completed following the improvised session for both groups, and the experience of that may have been at the forefront of participants' minds when responding to the SFS which asked for the overall experience of both traditional and improvised playing.

## **4.6 Conclusions**

This study demonstrates the potential for shared flow experiences to be reflected by physiological synchrony and contributes to the sparse research into physiology in group music-making. Importantly, in diversifying our understanding of music performance not just in Western music making, ensemble performance in Javanese Gamelan was explored.

Within this study, two groups of differing levels of experience played traditional gamelan pieces and improvised as a group, while physiological parameters of SC and HR were continuously measured. After playing, participants completed a self-report measure of shared flow (SFS). First, the potential for the SFS to be valid and reliable in the context of gamelan playing was assessed, and a potential two-factor solution was proposed. Following this, the findings surrounding differences in significant moments of physiological synchrony between levels of experience, and between traditional and improvised playing were unclear. However, relationships were identified between

physiological synchrony and shared flow. More specifically positive associations were found between shared flow and average physiological synchrony within improvised playing and negative associations within traditional playing.

This finding may reflect the high degree of collectivism and collaboration required to participate in a group improvisation, whereas a group playing a traditional piece of gamelan music may still focus on their individual parts. Further research could reflect this potential difference in shared flow experience through a different self-report measure, assessing both antecedents and outcomes, as well as potential differences between individual- and group-level experiences of shared flow. Additionally, the findings reported here are specific to the paradigm of Western participants playing Javanese gamelan music; future work in further understanding such mechanisms could be assessed in more hierarchical Western ensembles, for example. These suggestions, in combination with the current findings, may provide valuable contributions towards a greater understanding of the experience of shared flow dynamics in ensemble music settings.



## **Chapter 5. Extending and adapting the methodology**

Results from the preliminary study indicate a relationship between physiological synchrony and shared flow state dimensions, and that the direction of this relationship appears to differ between traditional and improvised playing. However, the results of this were not entirely clear-cut, where the sample lacked power. Furthermore, as one aim of this thesis overall is to try to look beyond individualistic questionnaires to capture what underlying mechanisms may occur when a group is in shared flow, it may be productive to incorporate an additional variable. One possibility that is already known to be directly related to flow is that of the perception of time.

### **5.1 The pertinence of time perception to flow state**

The way in which time is perceived to pass by has much to do with the degree to which you are truly absorbed in a task or activity. An entire Sunday can pass by while you are crafting or playing a new video game, and suddenly it is dark outside. Or a compulsory hour-long work meeting may feel more like three if you feel some contempt towards the chair. These examples capture the implications of enjoyment and attention on time perception, and in turn why time distortion is such a predominant feature of flow state. That being said, little attention has been paid towards the temporal effects of shared flow explicitly.

Items related to time perception and temporal distortion are prevalent in the study of individual flow. Previous research indicates a relationship between participants' experience of downward time distortion (i.e. time flying by), and flow state via moderate attentional demands (Im & Varma, 2018). Furthermore, studies have revealed that the consciousness, affective experience, and performance components of flow state are correlated with time perception (Hancock et al., 2019). No study has seemingly assessed such components on a group level. As time perception is possibly the only characteristic of flow state that can be captured from more external means (Hancock et al., 2019), a fruitful avenue of exploration lies in examining shared perceptions of time alongside shared physiological patterns, extending the methods of the first empirical study of this thesis. Accordingly, the next three empirical studies (Study 2, Study 3.1 and Study 3.2) aim to further the methods explored in Study 1 (chapter 4) by

incorporating an additional measurement of subjective time distortion in their exploration of shared flow experiences. By providing quantitative, qualitative and mixed methods perspectives, these studies aim to investigate the potential for a consensus of time distortion, and the directionality in any potential temporal distortion resulting from shared flow experiences.

This chapter first introduces the concept of time perception as being pertinent to the study of flow, and its methodological constraints. Starting from theoretical conceptions contrasting inner time from objective and measurable time, the applicability of time perception to shared flow, music, group music making, and gamelan are then discussed. Subsequently, the latter portion of this chapter describes a shift in methodological approach based on the self-report findings of the first empirical study in chapter 4, and on recent conceptual developments in the field. The implications of these methodological and conceptual shifts are then described in terms of materials used and expansion of the performance context in the later studies of this thesis.

### **5.1.1 A brief history of subjective time perception**

In Western philosophy, early accounts of perceived time are thought to have begun with Aristotle, who defined time as sense perception, undefinable by itself; rather, it is a number in motion, grounded on a perception of the before, and after. This idea was echoed by numerous scholars. For Albertus Magnus, time is not an object of permanence, but is successive, both losing and gaining simultaneously (Snyder, 1994). His student, Thomas Aquinas, noted that while it is indeed fixed in motion, observable through the transitions of the stars, it is based upon one universe, one first motion from which all others are derived, and accordingly one objective time (Steven, 2000).

Understanding of time perception later gained nuance as philosophers paid considerations to the contextual factors alluded to before. John Locke noted that through intense absorption and focus on a singular object or instance, the resultant perception of time passed is short (Roedelein, 2008). Conversely, Thomas Reid described how if great levels of focus were given to the perception of pain, the perception of time is lengthier, and it is in the experiences of joy and cheerfulness in which time is shortest (Whitrow, 1980).

Such notions of perceptual and objective differences were well-defined by the end of the 19<sup>th</sup> century, particularly in the work of Henri Bergson in 1889. For him, time is divided into two meanings: objective, scientifically measurable time, referred to as *temps*, and subjective, unmeasurable, perceived time, or *durée* (Bergson, 2004). *Durée* is not based on *temps*, but on a continuous flow of subjective durational experience. Reconciling Aristotle's notion of motion, with Reid's and Locke's ideas on experiential and contextual influences, Bergson argued that perceived time is guided by emotions, memories, and worldly perceptions. Forming somewhat of a rivalry, Einstein's relativity theories, also grounded in the idea of divergent temporal judgements between observers and resultant time dilation phenomena, were instead explained in terms of the physical properties of the universe (D.A.P, Encyclopaedia, 1994). For Bergson, Einstein's theories may have gone so far as to explain why clocks exist, but *durée* was something entirely different (cf. Canales, 2015). With references to "lived time", Bergson's ideas are seen as phenomenological precursors. And, like Bergson, phenomenological philosopher Edmund Husserl saw time as both complex and subjective, where temporal sensemaking was dependent on objects of consciousness. His theory of internal time consciousness describes subjective temporal experiences as an interplay between phases, namely between past, future, and present perceptions (P.K.M, Encyclopaedia, 1994).

Fast forward, and we have a clearer picture of contextual factors influencing our perception of time through empirical study, though one that is not too dissimilar from Reid's, Locke's and Bergson's theories outlined above. Such factors usually include, but are not limited to, extensive concentration and enjoyment (Wittmann & Butler, 2016), self-awareness (Wittman, 2015), attention and memory (Block & Gruber, 2014), and emotional states (Droit-Volet & Gil, 2009; Droit-Volet & Meck, 2007; Grommet et al., 2011). Another mystery has also come into focus over the last half century or so; as well as *why* we experience time distortion, scholars have questioned *how* we perceive and estimate time, and what the brain and body might have to do with it. Arguments for the more straightforward pace-maker accumulator model or internal clock (Macar et al., 1994; Zakay et al., 1983) have been in dispute against the potential for some neural basis for the perception and estimation, demonstrated by the cortico-thalamic-basal

ganglia circuit (Buhusi & Meck, 2005; Merchant et al., 2013). While such theories go so far as to explain interval timing, which might be important in determining the correct moment to execute a task, the *how* and *why* of time distortion over longer passages or periods of time, such as in musical activity, is far more difficult to disentangle. Yet these questions may be useful in the context of this thesis, in unravelling ways in which group interactions may be captured.

### **5.1.2 Flowing through time alone and together**

When discussing the topics outlined above of subjective time perception, experience, and contextual factors such as absorption, attention, and pleasure, the concept of flow state might immediately spring to mind as the common link. However, in most methods of measuring flow, subjective time perception is usually determined by arguably loose and ambiguous references to losing track of time (Hancock et al., 2019; Jackson & Eklund, 2002), and few studies have explicitly assessed the relationship between flow and time perception using a quantitative measure. Those that have incorporated a quantitative measure have focused on one particular facet of flow, typically via moderate attentional demands, challenge-skill balance, or optimal concentration, whereby evidence of subjective temporal contraction has been acknowledged (Im & Varma, 2018; Rutrecht et al., 2021; Saiki & Inoue, 2011). However, little attention has been paid towards other facets of flow, or shared flow, and their relative consequences for time perception.

Typically, time perception within flow questionnaires is assessed by simply asking whether time passed differently from normal (Jackson & Ekland, 2002; Zumeta et al., 2016). This does not, however, ascertain the direction of estimation, whether subjective time is flying by, or slowing down, and the underlying reasons for temporal modulation are unclear (Wearden, 2015; Tanaka & Yotsumoto, 2017). Addressing this largely rests on a distinction between judging the duration of a single stimulus or event, and a sequence of stimuli or period of time, which involve different cognitive processes (Block & Zakay, 2001).

It may be that both temporal contraction and expansion are equally applicable for those experiencing flow. Events of shorter objective duration may feel extended, for

instance, in the length of time a javelin player feels they spent preparing to throw (Jackson, 1995). One such study on temporal order judgements of stimuli presented a task to musicians and athletes and found that those who reported higher flow state prior to the task performed better in judging the temporal order of stimuli appearing within milliseconds of one another (Sinnott et al., 2020). Meanwhile, judgements of duration across a period of time while in flow, or states of reduced self-awareness, are typically underestimated, as is the case with video games (Rutrecht et al., 2021) or meditation (Linares Gutiérrez et al., 2022). Both momentary stimuli and periods of time can be distorted when in flow, though each seems to rely on a different cognitive process (Sinnott et al., 2020). Moreover, of interest in this research is the concept of temporal distortion over a period of time in the context of shared flow.

While individual factors of flow state are often extended to shared experiences (Salanova et al., 2014; Zumeta, Basabe, et al., 2016), little work has been done to explore the subjective temporal consequences of shared flow at a group level (Pels et al., 2018). It is treated as a given, where imprecise references are made to time flying (Gloor et al., 2013), as an attempt to clarify or define the experience of shared flow. In relation to the phenomenon of “team flow” in the workplace, van den Hout et al. (2018) define a characteristic of holistic focus as an extension of individual flow. Within this, they discuss how for “team flow” to arise, all members of a team must focus on a common goal, to the point where the team’s sense of time passing is contracted. Measurement tools, again, primarily involve questionnaires, and there is a need for new methods of assessment for instances of temporal distortion in shared flow context to gain further, more specific, insights (Pels, 2018).

Few studies have addressed whether there might be a shared experience of overestimated or underestimated perceived time duration resulting from something experienced on a group level. This temporal experience is often theorised to consist of a collective loss of time consciousness resulting from a shared point of focus, for instance when reflecting on a successful ensemble performance (Gloor et al., 2013; Sawyer, 2015; van den Hout et al., 2018). Notwithstanding, an empirical basis in shared flow research remains lacking. On a more general level, it could be argued that timing is largely contagious. For instance, Conway III (2004) investigated the potential for

perceptions of time to converge when participants complete word puzzles in interactive and non-interactive groups and found a reduction of variance as a consequence of interactivity. In a similar manner to theories of emotional contagion underlying empathy (Chakrabarti & Baron-Cohen, 2006), humans are influenced in their perception of time and pace of movement both socially and emotionally (Chambon et al., 2008; Conway III, 2004; Droit-Volet & Gil, 2009; Effron et al., 2006). The contagion of time perception as representative of joint attention and interaction could, in fact, go hand-in-hand with the theories of flow contagion leading to experiences of shared flow, as discussed earlier (Bakker, 2005; Hatfield et al., 1993; Salanova et al., 2014). Given the cross-over between shared flow and shared time perception, this seems a promising avenue of investigation. Yet there has been a distinct lack of research not just from the standpoint of flow, but also from within the realm of music performance.

### **5.1.3 Perceived time, musical time, and gamelan time**

Discussions of time have often arisen when considering music listening. Knowles (2022) suggests two cognitive facets to temporal distortion during a period of listening. The first is that of complexity, whereby higher musical complexity may result in temporal contraction, and vice versa. However, the relationship is not linear, and subsequently excess complexity may lead to greater overwhelm, and in turn temporal dilation. The second facet is that of attention. In instances in which attention is distracted from temporal aspects of music, subjective perception of time is contracted. On the contrary, where our attention is directed towards time, it is expanded, relating to the earlier theories of Locke and Reid (Whitrow, 1980).

As well as the cognitive aspects of music listening, musical qualities themselves may influence the perception of time by means of arousing emotions (Agostino et al., 2008) or through temporal structures (Fascher, 2011; Pasoulas, 2020). Music contains multiple degrees of temporality which are hierarchically structured (Hammerschmidt & Wöllner, 2020), ranging from beat perception, to phrases, to large-scale musical structures. As such, hierarchical models of temporal perception can shed some light on the complexities of how perceived time is structured (see Pöppel, 1997). The implications of metrical hierarchies and tempos have had some attention from the standpoint of studies on music listening or more active tasks of tapping in time to

music (Hammerschmidt & Wöllner, 2020; Hammerschmidt et al., 2021; Wang et al., 2024; Wöllner & Hammerschmidt, 2021). Yet, neither the time-warping cognitive aspects of listening to music, nor the temporally hierarchical implications of musical features, seem to have had any consideration in the context of naturalistic music performance. One obvious reason for this is that for those who involve themselves in musical performance, time, in a sense, bears little importance.

This is where musical activities may differ from others in the studies of perceived time. Duration and beat-to-beat time are a wholly different phenomenon from that of more general understandings of time perception. Arguably most musicians are concerned with the amount of time between beats, though when looking at the larger picture, few are interested in the actual duration of a piece in minutes and seconds. Of course, an awareness of timing is important while pieces are prepared for a concert programme with strict scheduling requirements, but it would be absurd – musically - to presume a piece should be performed at a faster tempo if it was found that a concert programme would be too long.

While there are clear justifications for the relevance of time perception to the experience of shared flow during music performance, there are also potential confounds. If the experience of time distortion is experienced during an ensemble performance where musicians appear to be in flow together, is the distortion a result of the flow experienced, the focus on *timing* rather than clock time, or a combination of the two? Consider the differences between outer and inner time, Bergson's notion of *durée*, and music's relation to this. If musicians must synchronise perspectives on inner and outer time in order to produce a successful performance (Tay et al., 2021), described by Schütz as a "mutual tuning-in relationship" (1951, p. 79), can this be captured and consciously described by the musicians?

Regardless of these confounds, something missing in the recent emergent interest in the state of shared flow is an investigation as to whether this quality of time distortion is shared amongst a group in flow together. Time perception is strongly influenced by task-difficulty (Block et al., 2010), while motor movement potentially has some influence on time estimation through an increased demand in attentional resources (Castellotti et al., 2022; D'Agostino et al., 2023). Accordingly, if shared attention arises

as a result of shared flow in group music-making, it may follow that associated perceptions of time are also shared. It may be fruitful to consider whether congruity or the direction and extent of time distortion contributes to the potential for shared flow to arise. This would advance prior research that has subsumed individual flow states, where group members may have possessed very different conceptions of subjective time.

Returning to the musical context of focus within this thesis of gamelan, loose attitudes towards time are intrinsic within Indonesian society. *Jam karet*, meaning “rubber time”, is used in everyday language to describe how time expands and shrinks, akin to that of rubber, and reflective of a laid-back societal belief (Naidu, 2023). Issues of timing in gamelan itself have had some attention due to the simultaneous tensions on coordination and flexibility (McGraw, 2008; Roberts, 2022). Meanwhile, shared flow itself is deeply engrained within gamelan, through the concept of *ngeli*, interpreted as flowing together and being carried by the music (Tan et al., 2020). Extending these ideas beyond *irama* - the concept of density and tempo in gamelan that is intrinsically intertwined (see 2.3.1) - musical metre, and metric timing, towards ideas of time distortion and flow in gamelan is somewhat inescapable.

#### **5.1.4 Methods in determining perceived time durations**

Typically, subjective time perception within flow questionnaires is assessed by simply asking whether time passed differently from normal (Jackson & Ekland, 2002; Zumeta et al., 2016). This does not, however, ascertain the direction of estimation, whether subjective time is perceived to be flying by, or slowing down, and the underlying reasons for temporal modulation are unclear (Tanaka & Yotsumoto, 2017; Wearden, 2015). Instead, reproduction or verbal estimation methods may be applied.

Reproduction is more commonly used in replicating shorter stimuli, and while thought to be more reliable than verbal estimations which are confounded by memory (Castellotti et al., 2022; Hammerschmidt et al., 2021), verbal estimations are better suited to judgements of longer passages of time such as during music (Wöllner & Hammerschmidt, 2021). Particularly, as is the case here, in a naturalistic context where flow may arise, retrospective estimations may be less disruptive (Im & Varma, 2018). Nevertheless, only so much can be deduced from the performance context (i.e. the



level of challenge, complexity, and memorisation) that may influence such retrospective judgements. To account for this, it is important to acknowledge subjective perspectives and factors that players may be consciously aware of.

To summarise, no study to the best of my knowledge has yet identified whether any subjective time effects found in individual flow settings may be shared effects within shared flow experiences. Neither have they investigated, with greater specificity, whether distorted subjective experiences of time that are relevant to individual flow may also be found in settings where shared flow may arise. It is therefore useful to adopt a measure of subjective time perception in both senses; shared, and distorted, and to ascertain the factors in group settings that may be attributed to subjective time distortion.

## **5.2 Developing the theoretical foundations**

Since the research of chapter 4 was carried out, significant developments in the study of shared flow have been made. Such developments provide further ways to frame and contextualise the findings of the first study, while also providing further suggestions for how the experimental design may be improved.

### **5.2.1 Emerging theories of shared flow**

One such development is the Integrative Group Flow Theory proposed by Pels and Kleinert, (2022). It highlights the importance of balanced group action as a fundamental facet of “group flow”. Distinctions are made between the lower level, or individual, and higher level, or group-level systems. Individual behaviours, skills and states of mind contribute towards their counterparts on a superior group level, resulting in “group flow”, which retroactively influences the function and manifestations of the subordinate level. Several other propositions of their theory support the approach that this thesis has adopted so far; primarily that of the use of physiological parameters complementing questionnaires as a more “objective” measure (Pels & Kleinert, 2022), citing developments in neuroscience (Shehata et al., 2021). While this theory furthers the previous research to understand the ways in which individual and group-level experiences co-occur, many facets are described in metaphor. Some specificity is missing with regards to the relationship between the subordinate and superior levels of

group action that they describe, whereby there is little consideration towards how the middle ground might be understood.

At the same time, Hackert and colleagues (2022) extended the previous theory adopted in the first study of Raettig and Weger (2018) by providing greater specificity. The general theory encompasses a taxonomic approach to understanding how individual and shared flow experiences may be conceptualised and provides greater insights into distinctions between “shared interactive flow” and “group flow”. The former can arise where there is some shared attention on the task and some social interaction, but flow state is experienced individually by those involved. By extension, the experience of “group flow” may occur where social interaction is necessary for the task itself, and accordingly, flow emerges on a group level.

Two further clarifications have also arisen since Raettig and Weger’s proposition (2018). The first is that individual flow, “shared interactive flow” and “group flow” may occur in alternation, due to the dynamic and changeable nature of flow (Hackert et al., 2022; Pels & Kleinert, 2022). Secondly, underlying, measurable aspects that may distinguish between the two are the level of joint attention, self-other overlap and social interaction present.

Self-other overlap, typically measured via the visual scale of Inclusion of Other in the Self scale (IOS) (Aron et al., 1992), is related to social bonding, perspective-taking, cooperation and coordination (Galinsky et al., 2005). While the popularity of the IOS is irrefutable, issues have been raised with its most basic, static form as being too coarse, where participants often demonstrate avoidance bias of the no-overlap score (Castillo, 2021; Robson, 2021). Further to this, the self-report nature of the IOS still adopts a focus towards the beliefs of the individual and not the group. There remains the potential that social interaction and joint attention (Sebanz et al., 2006; Wolf et al., 2016), and their potential representation of the highest level of shared flow experienced on a group level, may be better assessed from an external, or implicit perspective (Hackert et al., 2022). To explore this option, two further categories are adopted: shared physiology, as introduced in the first study, and shared time, as described in 5.1.2. These categories may enable a deeper understanding of this phenomenon, enabling us

to consider the social nuances and potential group-level emergence of shared flow more rigorously.

### **5.2.2 Furthering the ways in which expertise and musical contexts are accounted for**

While the first study of this thesis suggested that shared physiology underlying shared flow may be dependent on the level of interactivity and joint attention present, other recent developments have demonstrated the potential for shared physiology (by means of cardiac synchrony) underlying shared absorption to be influenced by the level of expertise (Høffding et al., 2023). No such conclusion was drawn from the first study of this thesis, however, a confounding factor that may have had an influence is the level of in-group familiarity present in the beginner group that was formed for the purposes of the study. As other scholars have highlighted, within-group familiarity is a fundamental antecedent for the presence of shared flow to be possible (Sawyer, 2003), and therefore this may have hindered the degree to which musical expertise could be considered.

Further to this, Høffding and colleagues (2023) investigated multiple experimental conditions, differing in the degree of visual communication that was possible between players. It was found that for the group of greater expertise, no difference between experimental conditions was found, leading the authors to assume that visual communication was not necessary for shared physiology in experts. The first study of this thesis may have an additional confound, aside from that of in-group familiarity, within the performance of a traditional piece. Specifically, there were within-group discrepancies in the degree to which they relied on the use of notation. As Zielke and colleagues (2023) observed, in individual musical performances some of the most conducive environments for flow to arise may be memorisation or improvisation. The social dynamics between whether music is played or learnt from notation or without vary considerably (Hadar & Rabinowitch, 2023). One factor that may be attributed to such variation may be due to lower individual mental effort required in memorised performance (de Manzano et al., 2010; Keller et al., 2011). It is also conceivable that performing a piece of music from memory as a group encourages greater awareness towards the actions of others, and less concern for individual accuracy.

The subsequent studies extend the foundations of the first. They aim to overcome these unaccounted-for confounds, by incorporating an additional musical context and ensuring a sample of pre-established gamelan groups. Furthering the methodological toolkit, these studies also incorporate an additional externally capturable measurement through the perception of time, as described earlier in this chapter.

### **5.3 Summary**

There is potential for shared flow to be reflected by three facets: 1) participants have self-reported flow experiences within a group setting, 2) participants are joined in their experience of perceived temporal distortion, and 3) there is a degree of physiological togetherness. The interplay between these facets may combine to reflect experiences of shared flow more fully than scales, interviews, or observations alone can. This discussion supports further study attempting to isolate these parameters, and investigate this potential interplay, and a third to further untangle the temporal aspects of shared flow.

Study 2 will follow a similar procedure to that of Study 1 while improving experimental control and incorporating a novel measure of time perception. Overall, this will form an investigation into potential relationships between self-reported shared flow state and physiological parameters, and self-reported time perception in gamelan players performing three pieces: one pre-composed piece from notation, one from memory and free improvisation. Studies 3.1 and 3.2 aim to examine temporal distortion during shared flow in a group music-making context in two parts. This may be complex; as the experience of time as a result of flow may be confounded by the experience of time as a result of music itself. And, while a state of flow might be characterised by a degree of subjective time distortion, this may be difficult for performers to specify if asked to estimate.

Study 3.1 aims to investigate performers' attitudes towards shared flow, time perception, and the factors that may influence them. Study 3.2 combines quantitative measures with qualitative insights, aiming to ascertain the degree to which subjective time distortion is associated with experiences of shared flow state, and incorporating those factors that performers describe as influencing time perception and shared flow.

## **Chapter 6. General procedure and methods for Studies 2, 3.1 and 3.2<sup>9</sup>**

### **6.1 Overview**

The following studies are based on the same procedure, adopting quantitative, qualitative and mixed-methods approaches, which was repeated for four pre-established gamelan groups across the UK and Ireland. While a convergent design was adopted during data collection, the order in which the studies are presented was selected was based on how analytical choices were informed. Study 2 explores a triangulation of internal perspectives and externally capturable methods, to provide a more complete picture in evidencing shared flow. More specifically, internal perspectives were obtained by means of self-reported shared flow and self-other overlap (IOS). Meanwhile, more externally-capturable methods involved the degree to which individuals reach a consensus on their experienced time distortion, and measures of physiological synchrony, furthering insights yielded in Study 1. Study 3.1 consists of focus group interviews, where the aim was to gain insights into participants' views of the temporal and flow-related experiences after playing gamelan, and how such experiences could be accounted for through contributing factors and antecedents. These contributing factors and antecedents then informed the analysis of Study 3.2, which relies on questionnaire and individual follow-up survey data, collected during and after the experiment respectively.

### **6.2 Procedure**

The general procedure consisted of a repeated measures design, whereby each group was invited to perform traditional gamelan pieces from notation and memory, and an improvisation. Participants were asked to remove watches, and any clocks and phones were kept out of sight, which participants were told was to avoid distractions. The

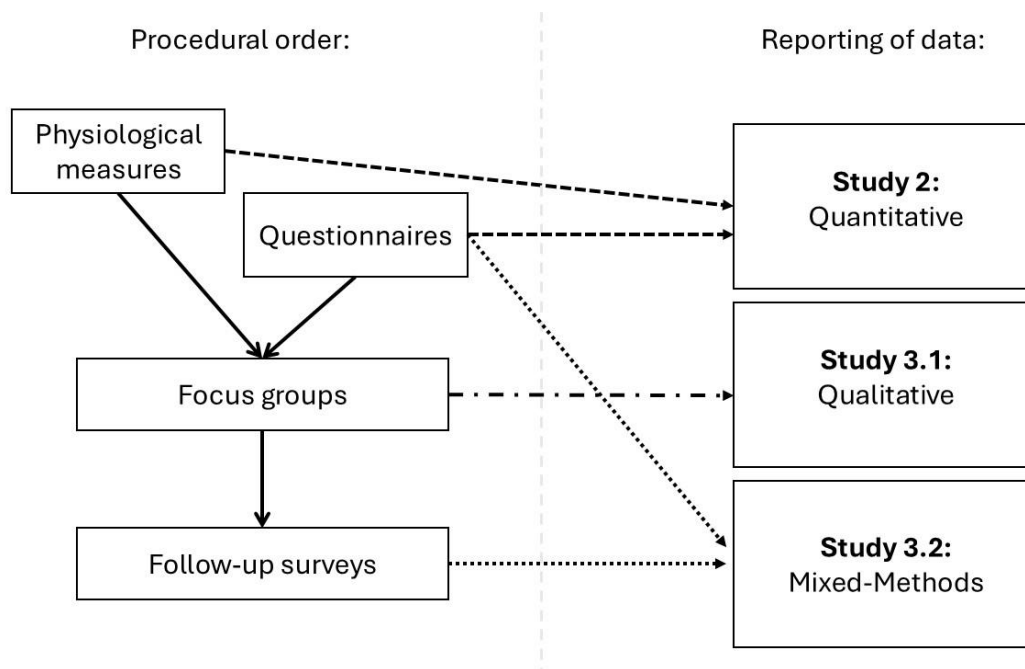
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<sup>9</sup> Methods sections from two articles were based on this chapter, entitled “Triangulation of self-other overlap, shared time, and shared physiology best predicts shared flow in music ensembles” (Gibbs & Schiavio, 2025a) and “Flowing between gongs: mixed-methods insights into shared flow and temporal distortion in music performance” (Gibbs & Schiavio, 2025b). The first is currently in peer review

performances were interspersed with paper versions of questionnaires, while physiological measures were recorded throughout. Immediately following the final questionnaire, a focus group interview was carried out with each group while their experiences were fresh, and a follow-up personalised online survey was administered to all participants to complete individually several days later. **Figure 11** provides an overview of the chronology of the procedure, and how the data is incorporated into the three resulting studies. Participant information sheets and consent forms are provided in **Appendix G**.

**Figure 11.**

*Procedural Design*



**Note:** Diagram adapted from Gibbs and Schiavio (2025b). Solid lines indicate the order of data collection and reporting, while dashed lines indicate how each category of data collected is incorporated into Studies 2, 3.1 and 3.2 of this thesis.

## 6.3 Participants

As with the first study of this thesis, the first group consisted of 12 members of Gamelan Sekar Petak (GSP) a gamelan group based at the University of York. This group

consisted of several students who had only begun playing at the start of the year, others who had played throughout their degree and were in the final stages, and three long-standing members of the group, who had many years of experience playing and teaching gamelan. However, all members studied or had studied music and had a moderately high level of musical training (according to the Gold-MSI MT subscale). Repertoire typically consists of traditional and more modern gamelan pieces, as well as new compositions created by members of the group. For the purposes of the study, they played *Gendhing bonang Tukung laras pélog pathet barung* from notation, and *Ladrang Mugi Rahayu laras sléndro pathet manyura* from memory.

The second group involved seven members of Southbank gamelan players (SBGP) a group based in London. The group consisted of highly experienced gamelan players, most of which had spent some time learning techniques in central Java, and had a moderately high level of musical training. Since the COVID-19 pandemic and because of other commitments, they have met less regularly than most groups, but typically perform pieces from memory. For the study, they played *Gendhing Gambirsawit laras pélog pathet nem* from notation, and like GSP, also chose to play *Mugi Rahayu* from memory.

The third group involved eight members of Dublin's National Concert Hall Gamelan (NCH). The group is initially a community group, though most of its members have been involved for several years, while others had recently been invited from the level two group. This group also had the highest average level of musical training, though this was more variable in comparison to SBGP. For NCH's notated piece, they played *Lancaran Singanebah laras pélog pathet barang*, while *Ladrang Rujak Jeruk laras sléndro pathet sanga* was played from memory.

The fourth and final group involved nine members of Gamelan Spréacha Geala (GSG), a community group based in West Cork. The group in general had the least amount of gamelan playing experience, the lowest average level of musical training and the greatest variability across members, but typically meet on a weekly basis. GSG chose to play *Mugirahayu* from notation, while *Lancaran Manyarséwu laras sléndro pathet manyura* was played from memory. **Table 7** provides demographic information and instrumentation for all participants, while notation is provided in **Appendix H**.

**Table 7.***Demographic Information for Each Group, and Across the Total Participant Sample*

|                    |                                  | <b>Gamelan<br/>Sekar Petak</b>                                                                                                               | <b>Southbank<br/>Gamelan<br/>Players</b>                                             | <b>Dublin<br/>National<br/>Concert Hall<br/>Gamelan</b>                                       | <b>Gamelan<br/>Spréacha<br/>Geala</b>                                                                        | <b>Total</b> |
|--------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------|
| <b>Sample</b>      | N                                | 12                                                                                                                                           | 7                                                                                    | 8                                                                                             | 9                                                                                                            | 36           |
|                    | Male                             | 6                                                                                                                                            | 4                                                                                    | 6                                                                                             | 3                                                                                                            | 19           |
|                    | Female                           | 6                                                                                                                                            | 3                                                                                    | 2                                                                                             | 6                                                                                                            | 17           |
|                    | Ages (years)                     | 20 – 45                                                                                                                                      | 39 – 67                                                                              | 33 – 67                                                                                       | 42 – 75                                                                                                      |              |
|                    |                                  | 29.17 ± 8.16                                                                                                                                 | 54.71 ± 9.98                                                                         | 46.75 ± 11.09                                                                                 | 56.33 ± 11.06                                                                                                |              |
| <b>Training</b>    | N reports                        | 12                                                                                                                                           | 6                                                                                    | 8                                                                                             | 9                                                                                                            | 35           |
|                    | MT subscale<br>score             | 20 – 38<br>31.08 ± 4.98                                                                                                                      | 26 – 38<br>33.33 ± 4.37                                                              | 26 – 42<br>33.88 ± 5.67                                                                       | 12 – 37<br>26.33 ± 7.78                                                                                      |              |
|                    | MT<br>percentile                 | 60                                                                                                                                           | 66                                                                                   | 68                                                                                            | 46                                                                                                           |              |
|                    | Gamelan<br>experience<br>(years) | 0.8 – 25<br>7.42 ± 9.69                                                                                                                      | 18 – 43<br>33.43 ± 9.13                                                              | 4 – 20<br>8.88 ± 5.08                                                                         | 1.5 – 24<br>7.57 ± 6.46                                                                                      |              |
| <b>Instruments</b> |                                  | <i>Bonang B<br/>Bonang P<br/>Demung<br/>Gender<br/>Gong<br/>Kempuls<br/>Kendhang<br/>Kenong<br/>Kethuk<br/>Peking<br/>Saron<br/>Slenthum</i> | <i>Bonang B<br/>Bonang P<br/>Gender<br/>Gong<br/>Kendhang<br/>Rebab<br/>Slenthem</i> | <i>Bonang B<br/>Gong<br/>Kendhang<br/>Kenong<br/>Peking<br/>Saron<br/>Slenthem<br/>Suling</i> | <i>Bonang B<br/>Bonang P<br/>Gongs<br/>Kempuls<br/>Kendhang<br/>Slenthem<br/>Kenong<br/>Kethuk<br/>Saron</i> |              |

**Note:** Musical training (MT) was calculated as the sum of the musical training factor of the Gold-MSI, with corresponding percentiles provided. Years and training scores are indicated as a range with mean ± SD.



## 6.4 Methods

### 6.4.1 Questionnaires

A copy of all questionnaires presented to participants is provided in **Appendix I**.

#### *6.4.1.1 Self-report pre-validated questionnaires*

Musical training was assessed within the pre-experiment questionnaire via the musical training (MT) subscale of the Gold-MSI (Müllensiefen et al., 2014). This questionnaire also encompassed demographics, questions related to their experience of gamelan playing in general, and four items on shared flow antecedents (Raettig & Weger, 2018), adapted for the context of group music making (Pr1). These items were rated on a seven-point semantic differential scale and related to level of engagement, familiarity with the group, and perceived competence:

(Pr1) I think the pieces today are (boring/engaging)

(Pr2) I know the other members of my group (not well/very well)

(Pr3) I think my own competence is (low/high)

(Pr4) I think the competence of my group was (low/high)

After each piece, participants were asked to estimate how much time had passed while playing that piece and rate their confidence in their estimate. Interactive flow was assessed via the Interactive Flow (IF) Questionnaire (Raettig & Weger, 2018). The IF questionnaire encompasses 10 items of the Rheinberg instrument (Rheinberg et al., 2003), measuring the underlying components of flow in accordance with factors of absorption and smoothness and reworded to refer to the group level of flow, while four additional items assessed the quality of the group's interactions (IF1, IF2, IF13, and IF14). All 14 items were rated on a seven-point Likert scale from "completely disagree" to "completely agree". Some items were reworded to suit the musical context (IF2, IF4, IF9, IF14). This post-questionnaire was repeated after each of the three pieces.

(IF1) We interacted like a well-rehearsed team.

(IF2) We had a stimulating performance.

(IF3) We felt the level of challenge was optimal.

- (IF4) Our playing was fluid and smooth.
- (IF5) We felt that time was flying by.
- (IF6) We had no difficulty concentrating
- (IF7) We had our wits about us.
- (IF8) We were completely absorbed in what we were doing.
- (IF9) We had a mutual understanding of our musical intentions.
- (IF10) We always knew what we had to do next.
- (IF11) We felt like we had everything under control.
- (IF12) We forgot everything around us.
- (IF13) Communication in our group went smoothly.
- (IF14) We inspired each other.

The final section of the questionnaire also encompassed post-session outcomes designed by Raettig & Weger (2018), again adapted for the context (Po1 and Po2) with one original item removed for lack of suitability (Po3). The four items were rated on a seven-point semantic differential scale:

- (Po1) I am (dissatisfied/satisfied) with the performance of my group
- (Po2) Overall, the pieces we played were (boring/engaging)
- (Po4) I think my own competence was (low/high)
- (Po5) I think the competence of my group was (low/high)

The IF questionnaire was used in combination with the Inclusion of Other in the Self scale (IOS) (Aron et al., 1992), measured via its original 7-point pictorial Likert scale form. This was implemented to determine the potential for shared flow according to Hackert and colleagues (2022), more explicitly than the first study of this thesis did following Raettig and Weger (2018). This post-questionnaire was repeated after each of the three pieces.

#### 6.4.1.2 *Perceived time estimation*

Following each performance of a piece, participants were asked to estimate how much time had passed while playing that piece to the nearest minute and second and rate their confidence in their estimate. This verbal estimation paradigm was selected as the most ecologically valid option for measuring time distortion in the context of flow (D'Agostino et al., 2023).

#### 6.4.2 **Physiological measures**

The procedure of obtaining physiological measures was largely similar to that of Study 1 in this thesis where skin conductance (SC) and electrocardiogram (ECG) measures were recorded using Shimmer3 GSR+ Sensors and EXG Sensors respectively at 256Hz. ECG was measured via a four-lead configuration from the chest using Biopac EL503 pre-gelled electrodes. SC was measured via the inside of the foot along the abductor hallucis muscle (Boucsein et al., 2012; Payne et al., 2013; van Dooren et al., 2012), this time using Biopac EL507 dry electrodes and 0.5% NaCl electrode paste, rather than pre-gelled electrodes, in an effort to improve signal quality. Demonstration of this set-up is provided in **Figure 12**. From these measures, continuous heart rate (HR) - extracted via inter-beat intervals - and skin conductance (SC) were obtained to reflect an individual's physiological arousal. Rather than preparing all necessary areas of the skin with 70% alcohol swabs, only the torso was prepared for ECG, while the foot was not pre-treated before electrode placement (Boucsein et al., 2012). Additionally, a three-minute baseline measure was taken before any playing, in which participants were asked to relax with their eyes closed or focus their gaze on a single point in the room.

**Figure 12.**

*Demonstration of Shimmer Devices Set Up on a Saron Player.*



#### **6.4.3 Focus Group Interviews**

A semi-structured focus group interview was conducted for each group after the experiment on the same day, each lasting around 25 minutes. There were three broader themes underlying the questions asked. Firstly, participants were invited to provide their understanding of flow state and shared flow theories, before they were clarified to the group. Secondly, participants were invited to contextualise these theories in their playing during the experiment and discuss factors that may influence their experiences of flow. Lastly, participants were invited to consider the role of time perception in their own experiences of flow. Overall, the purpose of the focus group was to gain subjective insights that could inform the analysis of quantitative data. As gamelan is intrinsically a group activity and the focus of the research is on shared flow, the approach of focus groups, rather than individual interviews, seemed more applicable to the context. All focus groups were recorded using a Zoom H4nPro and later transcribed verbatim. The

focus group protocol is provided in **Appendix J** and all transcripts are provided in **Appendix K**.

#### **6.4.4 Follow-up surveys**

For each group, several days after the aforementioned portions of the procedure, participants were sent a personalised electronic survey. The aim of this was to gather reflections on potential differences between participants' estimations of time duration while playing, and the actual time. For each piece, participants completed two seven-point Likert scales, assessing the level of surprise they felt about the potential variation in perceived time estimates, and how similar they felt their estimates were to the rest of the group. An open-ended item then presented participants with each of the estimated durations they provided during the experiment alongside the observed durations, and asked participants to account for the reasons for the potential difference between perceived and actual time, if there was any. A copy of an example survey is provided in **Appendix L**.

## Chapter 7. Study 2: Shared time, shared physiology and shared flow in gamelan performance<sup>10</sup>

### 7.1 Aims

The purpose of this study is to improve how shared flow is measured and understood by focusing on factors of self-other overlap, joint attention and social interaction that may help distinguish between different types of flow states (Hackert et al., 2022), in the context of gamelan performance. Delving beyond a self-reported internal perspective representing self-other overlap, (i.e., Inclusion of Other in Self Scale (IOS) – a standard tool used in previous research), the aim is to explore shared flow from a less individual viewpoint based on the concepts of shared time and shared physiology. In particular, the measures adopted are (i) an inferred external measure of consensus of time distortion ( $TD_{\text{consensus}}$ ) as a middle ground between the internal-external divide, and two physiological measures of externally measured togetherness. These are (ii) inter-subject correlation of heart rate (ISC-HR) and (iii) inter-subject correlation of skin conductance (ISC-SC), referred to here as physiological synchrony. The procedure and all measures used are described in detail in Chapter 6.

While the broader aim of this study is to improve how shared flow can be understood and empirically captured, the methodology may be particularly helpful in addressing three more specific research questions:

**RQ1** Is there a positive correlation between self-reported shared flow and IOS?

**RQ2** How is self-reported shared flow associated with both shared time ( $TD_{\text{consensus}}$ ) and shared physiology?

**RQ3** Can the level of joint attention and social interaction underlying shared flow resulting from condition and musical expertise be capturable via triangulation of the IOS, a measure of time consensus and measures of physiological synchrony?

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<sup>10</sup> An article based on this chapter, entitled “Triangulation of self-other overlap, shared time, and shared physiology best predicts shared flow in music ensembles” is currently in peer review. A pre-print is available on Research Square (Gibbs & Schiavio, 2025a). Data and code contributing to the analysis of this study have been uploaded to a repository on Open Science Framework <https://osf.io/tv7x9/>.

Following the theorised relationship between individually felt flow and group cohesion and interaction, it is anticipated that for the first and second objectives, the strength of these correlations is dependent on the type of performance condition and level of musical training. The hypothesis is that the relationship between shared flow and the IOS, time consensus, and physiological synchrony for players with the highest level of musical expertise would be strongest specifically in the performance of a memorised gamelan piece, compared with a notated piece or an improvisation, and those with lower levels of expertise. This is motivated by previous work indicating the necessity of joint attention, interaction, expertise, and familiarity with the goal, in achieving the highest level of shared flow (Bishop, 2018; Pels & Kleinert, 2022; Sawyer, 2006; van den Hout et al., 2018), and the context of the study, being that of Javanese gamelan performance.

## **7.2 Data Analysis**

All analyses were conducted in R Studio (version 4.3.1) (R Core Team, 2023), except for physiological pre-processing and inter-subject correlation analyses which were conducted in MATLAB (version 9.13.0) (The MathWorks Inc., 2022).

### **7.2.1 Factor analysis**

As opposed to Study 1 (chapter 4), factor analysis of the Interactive Flow (IF) Questionnaire (Raettig & Weger, 2018) was not approached as a research question. This is due to the scale informing components of both this present study, and the analysis of Study 3.2 (chapter 9). First, confirmatory factor analysis was conducted for all 14 items of the IF questionnaire (Raettig & Weger, 2018) across the 36 participants and 105 observations, after three non-responses were removed, to test whether the original model of three dimensions was a reasonable fit for the observed data. Two, “absorption” and “smoothness” derive from the Rheinberg inventory (Rheinberg et al., 2003), and an additional factor of “communication” relates to the intragroup dynamics. This original model was not admissible, as the covariance matrix of latent variables was not positive definite.

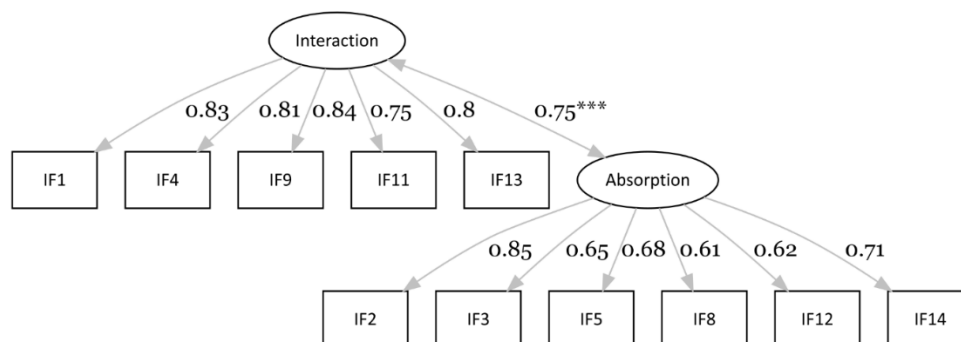
Due to the poor fit of the known factor structure, a more appropriate solution for the data was explored (Schmitt et al., 2018). Exploratory Factor Analysis (EFA) was

conducted using parallel analysis based on factor analysis, a maximum likelihood estimation method, and oblimin rotation. This resulted in a two-factor solution. Confirmatory factor analysis (CFA) was repeated on the model provided by the EFA in order to gather additional fit indices (Matsunaga, 2010), using the highest loading items and a maximum likelihood restricted estimation. This model was fitted using *lavaan* in R. As the survey was repeated across the three playing conditions, the survey design was clustered by case, using the *lavaan.survey* package (Oberski, 2014). This confirmed a two-factor solution of 11 items with a reasonable fit for the observed data, given the small sample size, scaled  $\chi^2(43, N=105) = 75.169$ , robust CFI = 0.922, robust TLI = 0.901, robust RMSEA = 0.103, SRMR = 0.059. Cronbach's  $\alpha$  for this solution was given at 0.833 and 0.900, demonstrating very good internal consistency for each factor. This model is outlined in **Figure 13** and parameter estimates are given in **Table 8**. Labels of *Interaction* and *Absorption* were given to each of the factors, to reflect items that encompassed elements of flow grounded in a great deal of group awareness, in comparison to those that were absorbing and automatic. The *semTools* package (Jorgensen et al., 2022) was used to calculate the average variance extracted (AVE), which was 0.475 for *Absorption*, and 0.644 for *Interaction*, while the covariance between the factors was 0.754. For further analysis, latent variables for each of these factors were calculated.



**Table 8.***Confirmatory Factor Loadings for IF Factors.*

| Factor             |       | Item                                                     | Est. | SE   | z value | p     |
|--------------------|-------|----------------------------------------------------------|------|------|---------|-------|
| <i>Absorption</i>  | IF_2  | We had a stimulating performance                         | .854 | .128 | 7.971   | <.001 |
|                    | IF_3  | We felt the level of challenge was optimal.              | .654 | .152 | 5.545   | <.001 |
|                    | IF_5  | We felt that time was flying by.                         | .680 | .142 | 6.573   | <.001 |
|                    | IF_8  | We were completely absorbed in what we were doing.       | .615 | .101 | 6.632   | <.001 |
|                    | IF_12 | We forgot everything around us.                          | .624 | .132 | 7.150   | <.001 |
|                    | IF_14 | We inspired each other.                                  | .714 | .127 | 6.509   | <.001 |
| <i>Interaction</i> | IF_1  | We interacted like a well-rehearsed team.                | .829 | .108 | 10.518  | <.001 |
|                    | IF_4  | Our playing was fluid and smooth.                        | .811 | .140 | 7.959   | <.001 |
|                    | IF_9  | We had a mutual understanding of our musical intentions. | .843 | .171 | 7.128   | <.001 |
|                    | IF_11 | We felt like we had everything under control.            | .754 | .145 | 8.950   | <.001 |
|                    | IF_13 | Communication in our group went smoothly.                | .796 | .136 | 7.649   | <.001 |

**Note:** N=36, 105 observations**Figure 13.***Diagram of CFA Factor Loadings*

### 7.2.2 Time distortion consensus

A measure of consensus of time distortion (i.e. the degree to which perceived time distortion was similar to that of the group) was calculated by first calculating a measure of perceived time distortion (TD) where for each observation, the actual length of time passed was subtracted from the estimated time passed, then this difference was divided actual time passed (Im & Varma, 2018). For each condition and each group, absolute differences in TD were calculated for every combination of pairs. The mean of all pairwise differences was taken for each participant within each condition and group and z-standardised using the mean and standard deviation of each condition within each group. The resulting values indicate the degree to which perceived time distortion was similar to the rest of the group, referred to as  $TD_{\text{consensus}}$  whereby values closest to 0 represent the highest degree of similarity.

### 7.2.3 Physiological pre-processing

Both electrocardiogram (ECG) and skin conductance (SC) signals were inspected before processing for indications of excessive artefacts or poor signal quality, which if present were subsequently discarded. Custom-made scripts, adapted from Study 1 (Gibbs et al., 2023), pre-processed the remaining ECG data through a Butterworth bandpass filter (0.2 and 12Hz cut-off points) and 4<sup>th</sup> order zero-phase filtering. Inter-beat intervals were extracted from the standard lead II ECG configuration (Golland et al., 2015; Gordon et al., 2021). Lastly, continuous heart rate (HR) was calculated from inter-beat intervals (IBIs) via the *interp1* function for MATLAB, specifying the *nearest* method. A low pass filter was applied at 0.05Hz.

Butterworth lowpass filtering with a 0.5 Hz cutoff point was used to pre-process SC data. As with the first study, the whole SC signal was used in subsequent analyses.

Whole signals that were excessively noisy were discarded (ISC-SC  $n = 23$  out of  $N=108$ , ISC-HR  $n = 16$  out of  $N=108$ ) while shorter segments deemed overly noisy were omitted from pre-processing and analysis.

#### 7.2.4 Inter-subject correlation

Inter-subject correlation (ISC) was selected as a means of determining levels of physiological synchrony across each group of players for its suitability in naturalistic experimental design (Czepiel et al., 2021). Pre-processed HR and SC signals were segmented into musically meaningful bins for the traditional pieces, where eight bars, or *gatra* in Javanese terminology, of four beats make up one cycle of material that repeats, with an overlap of four *gatra*. For improvisations, the average length of a traditional cycle for each group was taken as an equivalent length. Using the same ISC method as that of Pérez and colleagues (2021), dyad-wise correlations were then calculated from segmented instantaneous signals, downsampled to 4Hz, and Fisher's z-transformed. These were then averaged by means of the inverse Fisher's z-transformation across dyads to produce a series of ISC-SC and ISC-HR values equivalent to the number of cycles or equivalent time for each participant within each piece, separately for each group. A maximum of the first 15 segments was set for each participant in each condition to increase comparability between groups. The smallest number of segments present was 5. A summary of the segmentations used is provided in **Appendix M**. To produce an average ISC-SC and ISC-HR value per condition and per participant, labelled  $ISC-SC_{mean}$  and  $ISC-HR_{mean}$ , Fisher's z-transformation was again applied to each segment for each participant, before calculating the mean across participants for each condition and each group. Following this, inverse Fisher's z-transformation was applied.

As opposed to the first study (chapter 4) significance of physiological synchrony was not of focus. Primarily, this is due to greater differences in the lengths of pieces performed by different groups, and the varying sizes of the groups. As a result, it is not possible to reliably compare such significance.

#### 7.2.5 Linear mixed-effects models

Using the R *lme4* package, linear mixed-effects models were fitted to analyse relationships, as they are able to handle small sample sizes, non-normal distribution, and account for interindividual differences via random effects (Bates et al., 2015; Winter, 2013). The experimental design was treated as crossed and nested, where

participants were nested within groups, and every participant within each group performed in all three conditions. Condition was then contrast-coded with weights, due to the need to now compare three conditions as opposed to two, which was the case in the first study. This involved first comparing improvisation with traditional pieces, before comparing memorised and notated traditional pieces. The IOS and musical training (MT) variables were scaled to improve balance among fixed effects in the linear mixed-effects models.

Linearity, homoscedasticity and normality of the residuals were checked for each model and found on almost every occasion a violation of assumptions. However, similar effects were found when transformations were applied to predictors and when attempting alternative methods of modelling. As linear mixed-effects models are robust to non-normally distributed data providing random effects are accounted for (Schielzeth et al., 2020; Winter, 2013), the analysis pursued with them using the “lmer” function (Bates et al., 2015), z-standardising where it was deemed appropriate.

For the first part of the linear mixed-effects models, model comparisons of fixed effects were conducted for each dependent variable: (i) IOS, (ii)  $TD_{\text{consensus}}$ , (iii) ISC-SC, and (iv) ISC-HR. During this stage, the focus was on investigating how self-reported shared flow may be associated with each as representative of self-other overlap, social interaction, and joint attention, as a function of performance condition and MT. As the fixed effects included interactions among variables measured on a range of scales, the IF factors and MT were z-standardised across all observations. The IOS was z-standardised to improve the positive response-biased scores. A random intercept of participant nested within group was included for each model, and further random intercepts of section nested within groupwise condition and group were included for ISC-SC and ISC-HR model comparisons due to the repeated observation structure. Models fitted with restricted maximum likelihood were compared using the “anova” function in the R core *stats* package (R Core Team, 2023) and fit improvements were assessed by means of likelihood ratio tests (Tang et al., 2014)

Within the final full model selection process, the maximal models included all possible fixed and random effects justified by the design and aims of the study (Barr et al., 2013), with all four of the dependent variables above now as fixed effects, interacting with MT

and condition, and dependent variables of IF Interaction and IF Absorption. During this stage, the focus was on how self-reported shared flow may be predicted by measures of self-other overlap, social interaction and joint attention combined, as a function of condition and MT, to evaluate the highest possible states of shared flow. All continuous predictors were z-standardised across all observations to improve the balance of the model estimates. The *buildmer* package for R was used to reduce the models to their most parsimonious form, by means of likelihood ratio tests (Barr et al., 2013; Bates et al., 2018; Voeten, 2023). Singularity was allowed for the sake of comparison, however, if final models resulted in singularity, random effects were further reduced. Model tables were produced using the R *sjPlot* package's "tab\_model" function (Lüdtke, 2023). All post hoc tests were performed using the "emmeans" and "emtrends" functions from the *emmeans* R package (Lenth, 2024). Benjamini-Hochberg correction was used for multiple comparisons.

**Table 9.***Descriptive Statistics of Self-Report Measures Between Groups and Conditions.*

| Group | Condition  | IF Interaction | IF Absorption | IOS         | Length | TD <sub>consensus</sub> | ISC-SC <sub>mean</sub> | ISC-HR <sub>mean</sub> |
|-------|------------|----------------|---------------|-------------|--------|-------------------------|------------------------|------------------------|
| GSP   | Notated    | 0.45 ± 0.57    | 0.20 ± 0.79   | 5.42 ± 1.24 | 704    | 2.40 ± 0.58             | 0.09 ± 0.06            | -0.01 ± 0.09           |
|       | Memorised  | 0.82 ± 0.56    | 0.70 ± 0.72   | 5.83 ± 1.47 | 518    | 1.67 ± 0.48             | 0.16 ± 0.08            | 0.04 ± 0.12            |
|       | Improvised | -0.53 ± 1.36   | -0.24 ± 1.25  | 4.67 ± 1.92 | 467    | 2.63 ± 0.42             | 0.13 ± 0.08            | 0.02 ± 0.14            |
| SBGP  | Notated    | 0.14 ± 0.57    | -0.10 ± 0.81  | 5.14 ± 2.34 | 1295   | 1.72 ± 0.65             | 0.30 ± 0.06            | -0.05 ± 0.13           |
|       | Memorised  | -0.01 ± 0.69   | -0.37 ± 0.88  | 5.14 ± 2.27 | 434    | 2.53 ± 0.49             | 0.15 ± 0.06            | -0.04 ± 0.06           |
|       | Improvised | -1.41 ± 1.02   | -0.76 ± 0.79  | 4.29 ± 1.80 | 276    | 0.89 ± 0.47             | 0.16 ± 0.09            | -0.22 ± 0.14           |
| NCH   | Notated    | 0.41 ± 0.76    | 0.25 ± 0.96   | 4.50 ± 1.93 | 465    | 1.15 ± 0.53             | 0.24 ± 0.12            | -0.13 ± 0.17           |
|       | Memorised  | 0.46 ± 0.47    | 0.45 ± 0.55   | 6 ± 0.76    | 373    | 0.81 ± 0.58             | 0.24 ± 0.08            | 0.07 ± 0.14            |
|       | Improvised | 0.03 ± 0.92    | 0.54 ± 0.67   | 5.25 ± 1.58 | 306    | 0.90 ± 0.38             | 0.04 ± 0.08            | 0.11 ± 0.28            |
| GSG   | Notated    | -0.32 ± 0.81   | -0.30 ± 1.05  | 5 ± 1.31    | 225    | 0.33 ± 0.37             | 0.52 ± 0.31            | -0.14 ± 0.09           |
|       | Memorised  | 0.04 ± 0.59    | -0.21 ± 0.74  | 4.88 ± 1.64 | 216    | 1.36 ± 0.39             | 0.62 ± 0.40            | 0.02 ± 0.16            |
|       | Improvised | -0.65 ± 0.73   | -0.71 ± 0.93  | 5 ± 1.51    | 568    | 1.37 ± 0.51             | 0.20 ± 0.12            | -0.07 ± 0.1            |

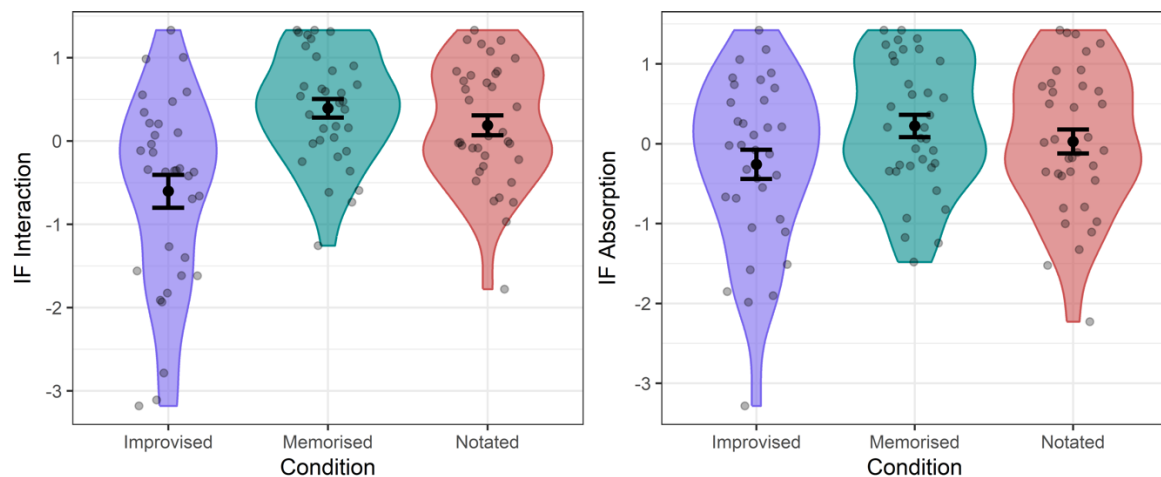
*Note:* All values are given as  $M \pm SD$ , except the length of the piece given in seconds.

### 7.3 Results

First descriptives of self-report variables were inspected (**Table 9**) before analysing potential differences in IF factors resulting from playing conditions and musical expertise. As an initial check of differences in shared flow arising from playing conditions, Kruskal-Wallis tests were used. These confirmed a significant difference in IF Interaction between playing conditions ( $\chi^2(2, 108) = 16.73, p < .001$ ). A Dunn Kruskal-Wallis multiple comparison test with Benjamini-Hochberg adjustment indicated significantly higher interactive flow for notated ( $z = -2.87, p < .001$ ) and memorised ( $z = -3.97, p < .001$ ) playing conditions compared to improvised. No significant differences were found for IF absorption. **Figure 14** depicts these differences in IF factors between playing conditions.

**Figure 14.**

*Violin Plots Displaying IF Interaction and IF Absorption CFA Standardised Scores between Improvised, Memorised, and Notated Playing Conditions.*



**Note:** Error bars denote the standard error of the mean.

Two initial regression analyses testing for the relationship between musical training and *Interaction* and *Absorption* found no significant associations for either factor.

Subsequently, models were built to assess the potential interactions between IF musical training, condition, and our dependent variables i) IOS, ii) TD<sub>consensus</sub>, iii) ISC-SC

and iv) ISC-HR. The “anova” function in R’s core package *stats* (R Core Team, 2023) was used to determine the most optimal fixed effects structure in each case by means of likelihood ratio tests. This began with a null, intercept-only model, before incorporating fixed effects of IF factors then covariates or interactions of condition, and MT. All model comparisons are provided in **Appendix N**.

### **7.3.1 RQ1: Correlating shared flow with the IOS**

For IOS, the optimal models for both factors of *Interaction* and *Absorption* involved no interactions or covariates (see **Table 10**). In both cases, the relationship was positive, whereby higher IF scores led to higher IOS ratings regardless of condition or musical expertise (*Interaction*:  $t(91.11) = 6.661$ ,  $p < .001$ ; *Absorption*:  $t(100.43) = 6.947$ ,  $p < .001$ ). Model predictions are displayed graphically in **Figure 15**. The amount of explained variance of the fixed effects, given by marginal  $R^2$ , was moderate at 27.5% and 31.8% respectively.



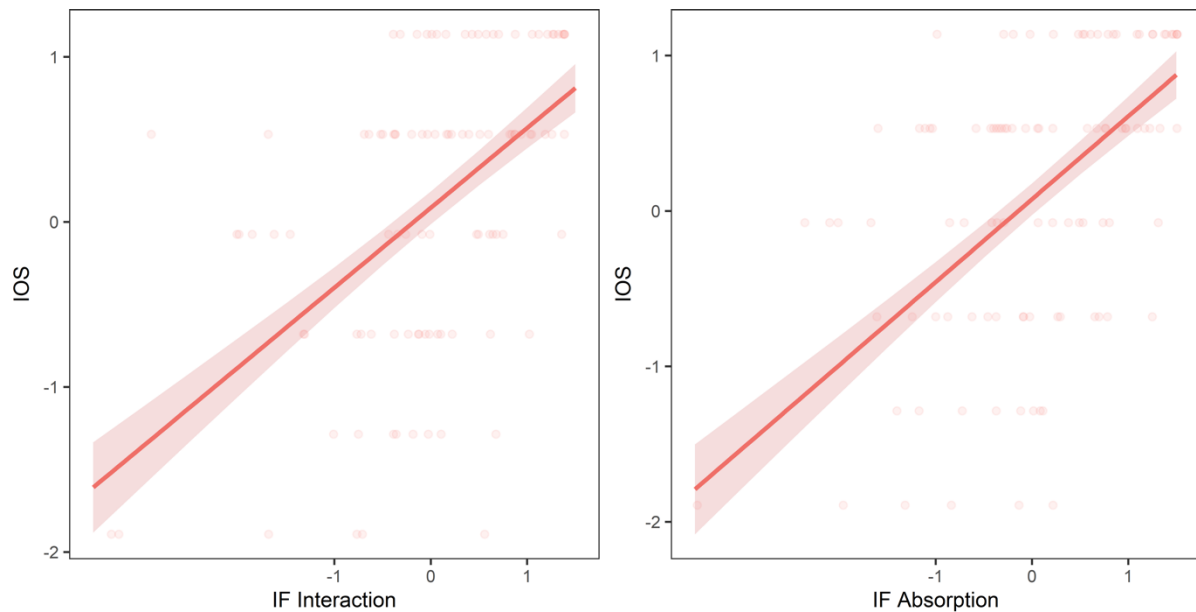
**Table 10.***Results from Linear Mixed Effects Models with IOS as the Dependent Variable*

| Predictors                         | IOS~ <i>Interaction</i> |                       |          | IOS~ <i>Absorption</i> |                       |          |
|------------------------------------|-------------------------|-----------------------|----------|------------------------|-----------------------|----------|
|                                    | Est.                    | 95% CI                | <i>p</i> | Est.                   | 95% CI                | <i>p</i> |
| (Intercept)                        | 0.09                    | -0.12 – 0.29          | 0.396    | 0.08                   | -0.13 – 0.28          | 0.460    |
| IF interact                        | 0.48                    | 0.34 – 0.63           | <0.001   |                        |                       |          |
| IF absorb                          |                         |                       |          | 0.53                   | 0.38 – 0.69           | <0.001   |
| <b>Random Effects</b>              |                         |                       |          |                        |                       |          |
| $\sigma^2$                         |                         | 0.42                  |          |                        | 0.40                  |          |
| $\tau_{00}$                        |                         | 0.20 case_id:group_id |          |                        | 0.22 case_id:group_id |          |
| ICC                                |                         | 0.32                  |          |                        | 0.35                  |          |
| <i>N</i>                           |                         | 35 case_id            |          |                        | 35 case_id            |          |
|                                    |                         | 4 group_id            |          |                        | 4 group_id            |          |
| Observations                       |                         | 101                   |          |                        | 101                   |          |
| Marginal $R^2$ / Conditional $R^2$ |                         | 0.275 / 0.505         |          |                        | 0.318 / 0.559         |          |
| AIC                                |                         | 242.716               |          |                        | 240.989               |          |

**Note:** Produced by the “tab\_model” function from the *sjPlot* package (Lüdtke, 2023). A random intercept was included for participant nested within groups (case\_id:group\_id). These models were selected as the most optimal fit, with only main effects of *Interaction* and *Absorption* as predictors, and no other fixed effects or interactions. All other model comparisons are provided in **Appendix N**.

**Figure 15.**

*Graphical Depiction of Predictions of IOS by IF Factors.*



**Note:** Shaded areas represent standard error.

### 7.3.2 RQ2: Investigating associations between shared flow and shared time, and shared flow and shared physiology

When comparing models with  $TD_{\text{consensus}}$  as the dependent variable, the most optimal fixed effects structure for *Interaction* and *Absorption* involved interaction effects with condition (see **Table 11**). It is worth noting that while the comparison of the optimal *Interaction* model yielded a significant likelihood ratio test, no models with a significantly better fit than the null model arose for *Absorption*. A model was selected which encompassed an interaction effect between *Absorption* and condition. While  $p = .053$  for the LRT, the AIC criterion was 239.71 compared to 240.63 for the null model.

**Figure 16** displays the graphical depiction of predictions for each model.

**Table 11.**

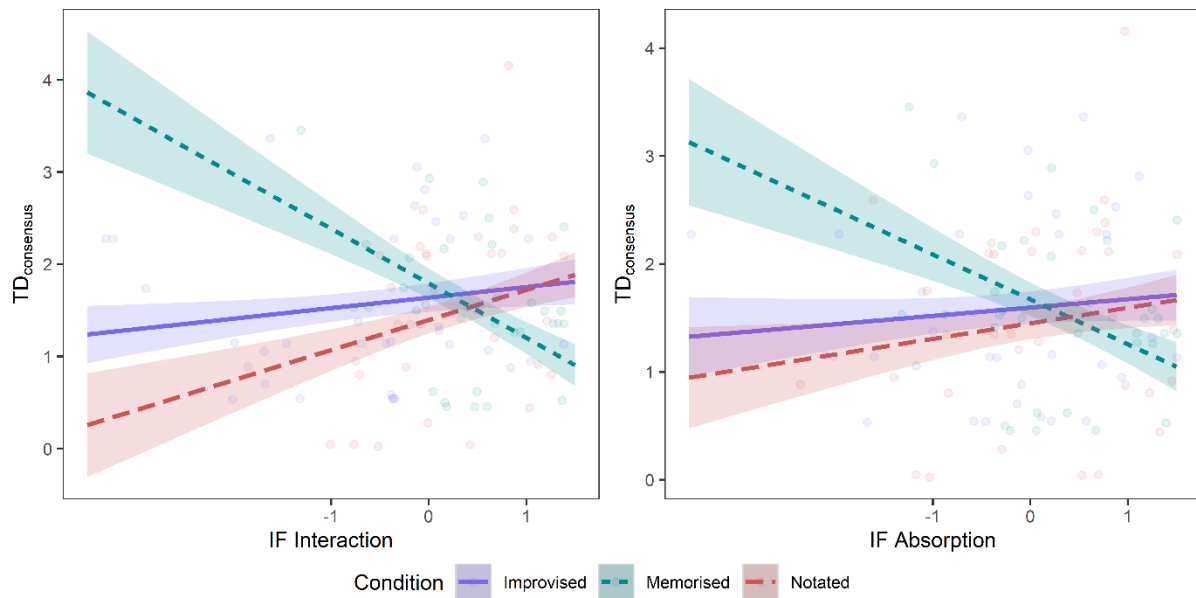
*Results from Linear Mixed Effects Models with  $TD_{consensus}$  as the Dependent Variable.*

| Predictors                                       | $TD_{consensus} \sim \text{Interaction}$ |                                  |       | $TD_{consensus} \sim \text{Absorption}$ |                                  |       |
|--------------------------------------------------|------------------------------------------|----------------------------------|-------|-----------------------------------------|----------------------------------|-------|
|                                                  | Est.                                     | CI                               | p     | Est.                                    | CI                               | p     |
| (Intercept)                                      | 1.61                                     | 1.36 – 1.86                      | <.001 | 1.57                                    | 1.33 – 1.82                      | <.001 |
| IF interact                                      | -0.05                                    | -0.22 – 0.12                     | .559  |                                         |                                  |       |
| IF absorb                                        |                                          |                                  |       | -0.06                                   | -0.23 – 0.10                     | .437  |
| condition <sub>improvTrad</sub>                  | -0.04                                    | -0.31 – 0.23                     | .745  | -0.04                                   | -0.29 – 0.22                     | .787  |
| condition <sub>memoryNotated</sub>               | -0.40                                    | -0.70 – -0.09                    | .011  | -0.22                                   | -0.52 – 0.08                     | .141  |
| IF interact × condition <sub>improvTrad</sub>    | -0.25                                    | -0.54 – 0.05                     | .102  |                                         |                                  |       |
| IF interact × condition <sub>memoryNotated</sub> | 0.92                                     | 0.51 – 1.32                      | <.001 |                                         |                                  |       |
| IF absorb × condition <sub>improvTrad</sub>      |                                          |                                  |       | -0.21                                   | -0.49 – 0.06                     | .130  |
| IF absorb × condition <sub>memoryNotated</sub>   |                                          |                                  |       | 0.56                                    | 0.22 – 0.90                      | .002  |
| <b>Random Effects</b>                            |                                          |                                  |       |                                         |                                  |       |
| $\sigma^2$                                       |                                          | 0.30                             |       |                                         | 0.34                             |       |
| $\tau_{00}$                                      |                                          | 0.38 <sub>case_id:group_id</sub> |       |                                         | 0.37 <sub>case_id:group_id</sub> |       |
| ICC                                              |                                          | 0.56                             |       |                                         | 0.53                             |       |
| <i>N</i>                                         |                                          | 34 <sub>case_id</sub>            |       |                                         | 34 <sub>case_id</sub>            |       |
|                                                  |                                          | 4 <sub>group_id</sub>            |       |                                         | 4 <sub>group_id</sub>            |       |
| Observations                                     |                                          | 100                              |       |                                         | 100                              |       |
| Marginal $R^2$ / Conditional $R^2$               |                                          | 0.109 / 0.610                    |       |                                         | 0.065 / 0.557                    |       |
| AIC                                              |                                          | 245.674                          |       |                                         | 253.388                          |       |

**Note:** produced by the “tab\_model” function from the *sjPlot* package (Lüdtke, 2023). A random intercept was included for participant nested within groups (case\_id:group\_id). These models were selected as the most optimal fit, with predictors of *Interaction* and *Absorption* separately, each interacting with playing condition. Condition is helmert contrast coded, first comparing differences between improvised and traditional pieces (condition<sub>improvTrad</sub>), then comparing the traditional pieces performed from memory and notation (condition<sub>memoryNotated</sub>). All other model comparisons are provided in **Appendix N**.

**Figure 16.**

*Graphical Depiction of Predictions of  $TD_{consensus}$  by Two-Way Interaction of IF Factors and Condition.*



**Note:** Predictions for improvised represented as blue, memorised as green, and notated as red. Shaded areas represent standard error.

Within the memorised condition, *Interaction* showed a significantly negative correlation with  $TD_{consensus}$  ( $t(87.2) = -3.441, p = .003$ ) indicating that higher shared flow related to greatest agreement, or less distance from the group mean, for time distortion. The effect did not reach significance in the notated condition ( $t(89.5) = 2.109, p = .057$ ), nor the improvised condition ( $t(85.2) = 1.157, p = .251$ ).

Post hoc pairwise contrasts showed significant differences in the effect between the memorised condition and both the improvised ( $t(87.0) = 3.533, p = .001$ ) and notated conditions ( $t(79.0) = -4.317, p < .001$ ). Both comparisons showed that the effect was significantly more negative in the memorised condition than the improvised or notated condition, meaning participants' experiences of shared flow in the memorised condition were more likely to have been associated with a greater consensus of time distortion.

For *Absorption* and  $TD_{consensus}$ , a significantly negative correlation was also found for the memorised condition ( $t(92.5) = -2.687, p = .026$ ), while no significant effects were found

for the other conditions. The effect in the memorised condition, was again significantly different from that of the improvised condition ( $t(84.6) = 2.719, p = .012$ ), and notated condition ( $t(76.8) = -3.132, p = .007$ ), whereby the same pattern emerged as that of *Interaction*.

Regarding shared physiology, three-way interactions between both *Interaction* and *Absorption*, together with condition and MT presented as the most optimal fixed effects structure in predicting ISC-SC (see **Table 12**).

**Table 12.**

*Results from Linear Mixed Effects Models with ISC-SC as the Dependent Variable*

| Predictors                                            | ISC-SC ~ <i>Interaction</i> |               |          | ISC-SC ~ <i>Absorption</i> |               |          |
|-------------------------------------------------------|-----------------------------|---------------|----------|----------------------------|---------------|----------|
|                                                       | Est.                        | 95% CI        | <i>p</i> | Est.                       | 95% CI        | <i>p</i> |
| (Intercept)                                           | 0.20                        | 0.11 – 0.29   | .005     | 0.20                       | 0.12 – 0.29   | .003     |
| IF interact                                           | -0.03                       | -0.05 – -0.00 | .038     |                            |               |          |
| IF absorb                                             |                             |               |          | -0.04                      | -0.06 – -0.02 | <.001    |
| condition <sub>improvTrad</sub>                       | 0.15                        | 0.08 – 0.22   | <.001    | 0.13                       | 0.06 – 0.20   | <.001    |
| condition <sub>memoryNotated</sub>                    | -0.02                       | -0.09 – 0.06  | .686     | -0.01                      | -0.09 – 0.07  | .830     |
| IF interact × condition <sub>improvTrad</sub>         | 0.01                        | -0.03 – 0.06  | .624     |                            |               |          |
| IF interact × condition <sub>memoryNotated</sub>      | 0.06                        | -0.00 – 0.12  | .070     |                            |               |          |
| IF absorb × condition <sub>improvTrad</sub>           |                             |               |          | -0.02                      | -0.06 – 0.02  | .409     |
| IF absorb × condition <sub>memoryNotated</sub>        |                             |               |          | 0.03                       | -0.02 – 0.08  | .183     |
| MT                                                    | -0.06                       | -0.10 – -0.02 | .004     | -0.06                      | -0.10 – -0.03 | .001     |
| IF interact × MT                                      | 0.04                        | 0.01 – 0.06   | .010     |                            |               |          |
| condition <sub>improvTrad</sub> × MT                  | -0.10                       | -0.15 – -0.06 | <.001    | -0.09                      | -0.13 – -0.05 | <.001    |
| condition <sub>memoryNotated</sub> × MT               | 0.04                        | -0.01 – 0.09  | .096     | 0.03                       | -0.02 – 0.08  | .206     |
| IF interact × condition <sub>improvTrad</sub> × MT    | 0.05                        | 0.00 – 0.09   | .030     |                            |               |          |
| IF interact × condition <sub>memoryNotated</sub> × MT | 0.01                        | -0.05 – 0.07  | .673     |                            |               |          |
| IF absorb × MT                                        |                             |               |          | 0.03                       | 0.00 – 0.05   | .036     |
| IF absorb × condition <sub>improvTrad</sub> × MT      |                             |               |          | 0.04                       | -0.00 – 0.08  | .052     |
| IF absorb × condition <sub>memoryNotated</sub> × MT   |                             |               |          | -0.02                      | -0.08 – 0.03  | .432     |

**Table 12.***(Continued)*

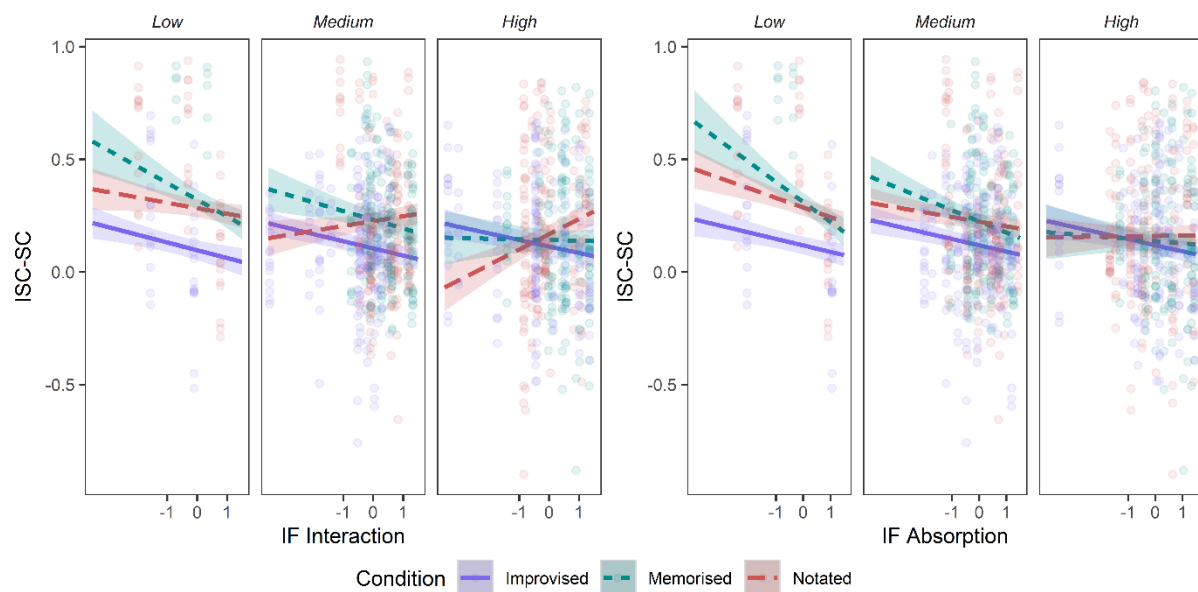
| Random effects                     | ISC-SC ~ IF Interaction | ISC-SC ~ IF Absorption |
|------------------------------------|-------------------------|------------------------|
| $\sigma^2$                         | 0.04                    | 0.05                   |
| $\tau_{00}$                        | 0.03 section:stim_id    | 0.03 section:stim_id   |
|                                    | 0.00 case_id:group_id   | 0.00 case_id:group_id  |
|                                    | 0.00 group_id           | 0.00 group_id          |
| ICC                                | 0.47                    | 0.45                   |
| $N$                                | 30 case_id              | 30 case_id             |
|                                    | 4 group_id              | 4 group_id             |
|                                    | 15 section              | 15 section             |
|                                    | 12 stim_id              | 12 stim_id             |
| Observations                       | 1111                    | 1111                   |
| Marginal $R^2$ / Conditional $R^2$ | 0.075 / 0.506           | 0.076 / 0.495          |
| AIC                                | 128.021                 | 136.480                |

**Note:** produced by the “tab\_model” function from the *sjPlot* package (Lüdtke, 2023). For these models, the ISC-SC was up to 15 values per participant per condition, with a Fisher’s z-transformed mean value per participant calculated across dyads per section, for a maximum of 15 sections. A random intercept was included for participant nested within groups (case\_id:group\_id), section nested within condition for each group (section:stim\_id), and group (group\_id). These models were selected as the most optimal fit, with predictors of *Interaction* and *Absorption* separately, each interacting with both playing condition and Gold-MSI musical training subscale score (MT). Condition is helmert contrast coded, first comparing differences between improvised and traditional pieces (condition<sub>improvTrad</sub>), then comparing the traditional pieces performed from memory and notation (condition<sub>memoryNotated</sub>). All other model comparisons are provided in **Appendix N**.

A significant main effect of the three-way interaction, involving *Interaction*, MT and contrast-coded improvised and traditional conditions, was found ( $t(736.80) = 2.17, p = .030$ ). While other fixed effects and two-way interactions also significantly predicted ISC-SC, these are interpreted with caution due to the presence of the three-way interactions. Overall, *Interaction* negatively predicted ISC-SC ( $t(644.01) = -2.08, p = .038$ ), although this also seemed to be a function of MT, with a positive two-way interaction effect ( $t(349.31) = 2.59, p = .010$ ). Graphical predictions of the three-way interaction models are provided in **Figure 17**.

**Figure 17.**

*Graphical Depiction of Predictions of Continuous ISC-SC by Three-Way Interactions of IF Factors, Condition, and MT Group.*



**Note:** For these predictions, MT was reduced to three predictions of low, medium and high based on  $M \pm SD$ . Predictions for improvised represented as blue, memorised as green, and notated as red. Each facet depicts differences in predictions resulting from MT. Shaded areas represent standard error.

Effect estimations were obtained for interactions, implementing the “cov.reduce” argument to improve interpretability for the continuous MT variable by calculating predictions based on  $M \pm SD$ .

For the two-way interaction between *Interaction* and MT, a negative relationship between *Interaction* and ISC-SC seemed to be significant for participants with the lowest level of musical training ( $t(691) = -2.68, p = .023$ ) which was significantly more negative than those with medium and higher level of musical training ( $t(430) = -2.51, p = .013$ ). With regards to the three-way interaction, for participants with the lowest level of musical training, a significantly negative correlation was found between ISC-SC and *Interaction* specifically within the memorised condition ( $t(654) = -2.505, p = .038$ ). However, post hoc contrasts revealed significant differences between the effects of MT for the notated condition ( $t(595) = -2.867, p = .004$ ), where, while no individual effects were significant, the effect for the highest level of MT in the notated condition seemed to be more positive ( $t(602) = 2.383, p = .052$ ).

Within the *Absorption* model, the main effect of the three-way interaction between the contrast-coded improvised and traditional conditions and MT did not reach the significance threshold ( $t(840.7) = 1.944, p = .052$ ), though the main effect of *Absorption* was significantly negative ( $t(318.2) = -3.524, p < .001$ ), and the two-way interaction effect between *Absorption* and MT was significantly positive ( $t(268.3) = 2.107, p = .036$ ). Simple effect estimations revealed that the correlation between IF Absorption and ISC-SC was significantly negative for those with the lowest ( $t(374) = -3.379, p = .002$ ) and medium levels of musical training ( $t(386) = -3.039, p = .004$ ), and significant differences in these correlations were found between MT levels ( $t(337) = -2.001, p = .046$ ), whereby the lower the experience level, the more negative the effect was.

Significant effects for the three-way interaction were found only for memorised condition, whereby the correlation was significantly negative for the lowest ( $t(1087) = 2.879, p = .012$ ) and medium levels of MT ( $t(1146) = 2.133, p = .0497$ ), although no significant difference in the effects of MT for the memorised condition were found ( $t(747) = -1.889, p = .059$ ).

For ISC-HR, no model was preferred in fit above that of the null model that involved significant effects of *Interaction* or *Absorption*. This result was checked using the *buildmer* package (Voeten, 2023), which in fact showed that the only significant predictors of ISC-HR based on the maximal model provided was MT and condition (see **Table 13**). For MT, there was a significantly negative correlation ( $t(31.63) = -3.107, p =$



.003). Meanwhile, significant differences were found between the memorised and notated conditions ( $t(138.71) = -2.824, p = .005$ ), whereby ISC-HR was higher on average in the memorised condition ( $M = 0.009, SE = 0.036$ ) than then notated ( $M = -0.079, SE = 0.036$ ). Nevertheless, the explained variance of marginal  $R^2$  was very small at 1.9%.

**Table 13.**

*Results from Linear Mixed Effects Models with ISC-HR as the Dependent Variable.*

| Predictors                         | ISC-HR                |               |             |
|------------------------------------|-----------------------|---------------|-------------|
|                                    | Est.                  | 95% CI        | p           |
| (Intercept)                        | 0.00                  | -0.11 – 0.11  | .998        |
| condition <sub>improvTrad</sub>    | -0.03                 | -0.08 – 0.02  | .274        |
| condition <sub>memoryNotated</sub> | -0.09                 | -0.15 – -0.03 | <b>.005</b> |
| MT                                 | -0.04                 | -0.06 – -0.01 | <b>.004</b> |
| <b>Random Effects</b>              |                       |               |             |
| $\sigma^2$                         | 0.12                  |               |             |
| $\tau_{00}$                        | 0.01 section:stim_id  |               |             |
|                                    | 0.00 case_id:group_id |               |             |
|                                    | 0.00 group_id         |               |             |
| ICC                                | 0.08                  |               |             |
| N                                  | 34 case_id            |               |             |
|                                    | 4 group_id            |               |             |
|                                    | 15 section            |               |             |
|                                    | 12 stim_id            |               |             |
| Observations                       | 1156                  |               |             |
| Marginal $R^2$ / Conditional $R^2$ | 0.019 / 0.101         |               |             |
| AIC                                | 940.900               |               |             |

**Note:** Produced by the “tab\_model” function from the *sjPlot* package (Lüdtke, 2023). For these models, the ISC-HR was up to 15 values per participant per condition, with a Fisher’s z-transformed mean value per participant calculated across dyads per section, for a maximum of 15 sections. A random intercept was included for participant nested within groups (case\_id:group\_id), section nested within condition for each group (section:stim\_id), and group (group\_id). The fixed effects were selected by the *buildmer* package as the most optimal fit (Voeten, 2023), with only a predictor of musical training subscale score (MT). All other model comparisons are provided in **Appendix N**.

### 7.3.3 RQ3: Evaluating the relationship between internal and external units of analysis through triangulation of the IOS, shared time and shared physiology

Finally, linear mixed-effects models were used to evaluate the relationship between IF flow factors, now as the dependent variables, and condition and musical expertise interacting with all fixed effects of interest together as predictors. This analysis was inspired by Czepiel and colleagues (2023). Two models were built, each predicting *Absorption* and *Interaction* respectively, starting from the most maximal random effects structures, and all fixed effects simultaneously. The *buildmer* package was used to reduce all fixed and random effects into the most parsimonious models (Voeten, 2023). Variance inflation factors (VIFs) were assessed for the final models using the *car* package in R (Fox et al., 2023), which confirmed that all were below 2. Each model is presented in **Table 14**.

**Table 14.**

*Results from Linear Mixed Effects Model with Interaction and Absorption as the Dependent Variables*

| Predictors                                                       | Interaction |               |                 | Absorption |               |             |
|------------------------------------------------------------------|-------------|---------------|-----------------|------------|---------------|-------------|
|                                                                  | Est.        | 95% CI        | p               | Est.       | 95% CI        | p           |
| (Intercept)                                                      | -0.08       | -0.32 – 0.17  | .537            | -0.00      | -0.59 – 0.58  | .988        |
| IOS                                                              | 0.29        | 0.02 – 0.57   | <b>.038</b>     | 0.49       | 0.20 – 0.78   | <b>.001</b> |
| condition <sub>ImprovTrad</sub>                                  | 1.08        | 0.63 – 1.54   | <b>&lt;.001</b> | 0.65       | 0.21 – 1.09   | <b>.005</b> |
| condition <sub>MemoryNotated</sub>                               | -0.09       | -0.62 – 0.44  | .730            | -0.10      | -0.58 – 0.39  | .689        |
| ISC-SC <sub>mean</sub>                                           | -0.31       | -0.57 – -0.06 | <b>.018</b>     | -0.50      | -0.76 – -0.23 | <b>.001</b> |
| ISC-HR <sub>mean</sub>                                           | 0.15        | -0.14 – 0.44  | .308            | 0.07       | -0.21 – 0.36  | .591        |
| MT                                                               | -0.18       | -0.52 – 0.16  | .282            | -0.26      | -0.66 – 0.15  | .203        |
| condition <sub>ImprovTrad</sub> × IOS                            | -0.85       | -1.32 – -0.38 | <b>.001</b>     | -0.45      | -0.97 – 0.08  | .092        |
| condition <sub>MemoryNotated</sub> × IOS                         | 0.06        | -0.51 – 0.63  | .837            | 0.57       | -0.08 – 1.23  | .084        |
| MT × IOS                                                         | 0.45        | 0.09 – 0.82   | <b>.017</b>     | 0.28       | -0.09 – 0.65  | .138        |
| condition <sub>ImprovTrad</sub> × ISC-HR <sub>mean</sub>         | 0.24        | -0.32 – 0.81  | .393            | 0.28       | -0.28 – 0.85  | .314        |
| condition <sub>MemoryNotated</sub> × ISC-HR <sub>mean</sub>      | 0.32        | -0.47 – 1.12  | .420            | 0.55       | -0.22 – 1.31  | .157        |
| condition <sub>ImprovTrad</sub> × MT                             | 0.02        | -0.57 – 0.61  | .949            | -0.04      | -0.62 – 0.54  | .887        |
| condition <sub>MemoryNotated</sub> × MT                          | 0.05        | -0.66 – 0.77  | .878            | -0.33      | -1.11 – 0.44  | .388        |
| condition <sub>ImprovTrad</sub> × ISC-SC <sub>mean</sub>         | 0.40        | -0.19 – 0.98  | .177            | 0.51       | -0.04 – 1.07  | .069        |
| condition <sub>MemoryNotated</sub> × ISC-SC <sub>mean</sub>      | 0.19        | -0.34 – 0.72  | .469            | -0.07      | -0.57 – 0.42  | .764        |
| MT × ISC-HR <sub>mean</sub>                                      | 0.13        | -0.22 – 0.48  | .466            | 0.12       | -0.26 – 0.49  | .531        |
| MT × ISC-SC <sub>mean</sub>                                      | 0.04        | -0.27 – 0.35  | .797            | 0.19       | -0.13 – 0.50  | .238        |
| condition <sub>ImprovTrad</sub> × MT × ISC-HR <sub>mean</sub>    | -1.03       | -1.79 – -0.27 | <b>.009</b>     | -1.07      | -1.88 – -0.25 | <b>.012</b> |
| condition <sub>MemoryNotated</sub> × MT × ISC-HR <sub>mean</sub> | -0.34       | -1.16 – 0.48  | .410            | -0.69      | -1.42 – 0.04  | .062        |
| condition <sub>ImprovTrad</sub> × MT × ISC-SC <sub>mean</sub>    | 0.41        | -0.23 – 1.05  | .200            | -0.11      | -0.75 – 0.52  | .716        |
| condition <sub>MemoryNotated</sub> × MT × ISC-SC <sub>mean</sub> | 0.81        | 0.12 – 1.51   | <b>.022</b>     | 0.59       | -0.02 – 1.21  | .059        |
| ztime                                                            |             |               |                 | -0.25      | -0.51 – 0.01  | .055        |
| condition <sub>ImprovTrad</sub> × ztime                          |             |               |                 | -0.38      | -0.76 – -0.01 | <b>.045</b> |
| condition <sub>MemoryNotated</sub> × ztime                       |             |               |                 | -0.26      | -0.74 – 0.21  | .261        |
| condition <sub>ImprovTrad</sub> × MT × IOS                       |             |               |                 | -0.81      | -1.60 – -0.02 | <b>.044</b> |
| condition <sub>MemoryNotated</sub> × MT × IOS                    |             |               |                 | -0.27      | -1.08 – 0.53  | .492        |

**Table 14.***(Continued)*

| Random Effects                     | Interaction              | Absorption                             |
|------------------------------------|--------------------------|----------------------------------------|
| $\sigma^2$                         | 0.40                     | 0.24                                   |
| $\tau_{00}$                        | 0.06 case_id:group_id    | 0.26 case_id:group_id<br>0.02 group_id |
| ICC                                | 0.13                     | 0.53                                   |
| $N$                                | 27 case_id<br>4 group_id | 27 case_id<br>4 group_id               |
| Observations                       | 67                       | 67                                     |
| Marginal $R^2$ / Conditional $R^2$ | 0.575 / 0.632            | 0.542 / 0.784                          |
| AIC                                | 194.920                  | 204.058                                |

**Note:** selected as most parsimonious by the *buildmer* package (Voeten, 2023), and produced by the “tab\_model” function from the *sjPlot* package (Lüdtke, 2023). A random intercept was included only for participant nested within group (case\_id:group\_id) for the *Interaction* model, and both participant nested within group, and group for the *Absorption* model (group\_id). Although a slope of ISC-HR<sub>mean</sub> on group was suggested for the *Absorption* model, this produced singularity errors. Condition is helmert contrast coded, first comparing differences between improvised and traditional pieces (condition<sub>improvTrad</sub>), then comparing the traditional pieces performed from memory and notation (condition<sub>memoryNotated</sub>). Note that the number of observations is reduced as a result of missing physiological data.

Both models seemed to favour all main fixed effects explored above, with the exception of TD<sub>consensus</sub>, which was only included in the model for IF Absorption. These models included some correlations that emerged in the previous models: the significantly positive correlation of IOS, the significant differences between conditions, the differences in TD<sub>consensus</sub> as a function of condition for IF Absorption, and the significantly negative correlation of ISC-SC<sub>mean</sub> as was the case with ISC-SC. Some, however, were not found previously, and therefore these are outlined here.

With regards to the IOS, two-way interaction effects with condition and MT both significantly predicted *Interaction*. Post hoc testing revealed that the correlation

between IOS and *Interaction* within the improvised condition was significantly positive ( $t(43.6) = 5.513, p < .001$ ), and significantly more so than both the memorised ( $t(45.0) = 3.026, p = .008$ ) and notated conditions ( $t(44.8) = 2.933, p = .009$ ).

For MT, significant positive correlations were found with the highest level of musical training ( $t(38.6) = 4.820, p < .001$ ) and medium level of musical training ( $t(45.0) = 3.892, p < .001$ ) and significant differences in the effect of MT on the correlation between IOS and *Interaction* overall (*Interaction*:  $t(44.9) = -2.398, p = .021$ ). More specifically, higher MT was associated with a more positive effect.

For *Absorption*, a significant three-way interaction was found between IOS, MT and condition<sub>improvTrad</sub> ( $t(36.39) = -2.091, p = .044$ ). Significant differences were only found in the improvised condition ( $t(31.6) = -2.745, p = .010$ ), whereby correlations were strongest for those with the highest level of MT (highest level:  $t(31.9) = 5.607, p < .001$ ; medium level:  $t(32.3) = 6.153, p < .001$ ; lowest level ( $t(31.8) = 1.879, p = .069$ ).

Lastly, significant three-way interactions were found between ISC-HR<sub>mean</sub>, MT and condition and both IF factors. Previously, no significant correlation was found between ISC-HR and shared flow in the form of main effects, or interactions, yet using the average ISC-HR value rather than continuous observations seemed to have made some difference. For both *Interaction* and *Absorption*, the only significant effect was found for the highest level of expertise specifically in the improvised condition (*Interaction*:  $t(43.9) = 3.051, p = .012$ ; *Absorption*:  $t(34) = 2.528, p = .049$ ). Significant differences were found between experience levels for the improvised condition (*Interaction*:  $t(43.8) = -2.479, p = .017$ ; *Absorption*:  $t(30.2) = -2.254, p = .032$ ). In both cases, higher MT led to more positive correlations in the improvised condition.

Marginal  $R^2$  for both models revealed that these fixed effects captured 57.5% and 54.3% of the explained variances for *Interaction* and *Absorption* factors respectively. Overall, the explanatory power of both models was moderate, providing notable evidence for the importance of triangulating combinations of measures in capturing shared flow experiences.

## 7.4 Discussion and limitations

Where an ensemble becomes more than the sum of its individual parts, so too should the strategies that are employed go beyond individual perspectives when studying the dynamics of ensembles. In this study, the aim was to explore means of capturing shared flow experiences beyond individualistic methods. To do so, a taxonomy of shared flow theorised by Hackert and colleagues was adopted (2022), whereby shared flow could be seen as the resultant state of both individually experienced and group-level properties in accordance with the level of self-other overlap, social interaction, and joint attention present. Three main categories of measures were utilised as respectively representative of such qualities: (i) the Inclusion of Other in Self scale (IOS), (ii) a measure of consensus of time distortion ( $TD_{\text{consensus}}$ ), and (iii) measures of physiological synchrony (ISC-SC and ISC-HR). Previous research has investigated shared flow in specific contexts, while rarely describing the nuances of those contexts; therefore, the aim of the study was to explore the connections between these underlying qualities and shared flow. More specifically, three performance conditions were adopted in the context of four Javanese gamelan ensembles, to see if the strength of potential associations between shared flow and its underlying social qualities, were a function of condition, and musical training.

Key findings, in accordance with the objectives, were as follows:

- 1) The IOS is moderately associated with factors of shared flow; nevertheless, on its own, it was not a function of condition or musical training.
- 2.1) Within the memorised condition, shared time, which we captured by means of measure  $TD_{\text{consensus}}$ , significantly negatively predicted shared flow, i.e. the higher the shared flow, the closer the perceived distortion of time was to that of the group.
- 2.2) ISC-SC, but not ISC-HR, was significantly negatively correlated with shared flow factors and was significantly more negative for those with lower musical training. Nevertheless, significant differences in this correlation were found in the notated condition for *Interaction*, and the memorised condition for *Absorption*.
- 3) The most optimally fitting model in predicting *Interaction* involved the self-reported IOS alongside  $ISC-SC_{\text{mean}}$ ,  $ISC-HR_{\text{mean}}$ , and interactions with condition and musical

training, while *Absorption* favoured the addition of  $TD_{\text{consensus}}$  alongside these. Overall, the proposed hypothesis of such indicators representing flow being strongest in the memorised condition for those with the highest level of expertise was only partially confirmed, as each of the findings contributes to a multifarious understanding of shared flow.

The association between the IOS and both IF factors was irrefutable in each analysis, however this did not appear to change with condition or expertise until the final maximal models. Overall, there was certainly a positive correlation, as the taxonomy proposes, yet the lack of distinction between condition and levels of musical training provides further justification for such a measure being restrictive, and inadequate in representing a range of shared flow experiences alone. This was further supported by the incorporation of the IOS alongside the other measures of joint attention and social interaction to predict shared flow, revealing that triangulation of internal, individually experienced, and external, group-level measures may be most rigorous.

There seemed to be minimal contribution of  $TD_{\text{consensus}}$  to the maximal model predicting *Absorption*. Even so, the findings from both the *Interaction* and *Absorption* basic models reveal marked insights into the association between shared time and shared flow, in what appears to be the first investigation of the group temporal effects of shared flow. Here, the correlation between  $TD_{\text{consensus}}$  and both IF factors was found to be significantly negative within the memorised condition. This aligns with previous research on time perception being socially contagious in interactive activity (Conway III, 2004). While the improvised condition arguably consisted of some degree of group interaction by its nature, the memorised condition had the added benefit of structure, and a clear goal, alongside the necessity for participants to be jointly attentive to cues and the unfolding of the musical material. This finding may be specific to the context of gamelan. Nevertheless, it is possible that one quality of the highest level of shared flow could be shared time, but further research is needed to explore this. In addition, while this study aimed to assess the extent to which participants' estimates of time, the directionality of any potential distortion of time perception, i.e. temporal contraction, or expansion, was not examined here. Studies 3.1 and 3.2 will therefore aim to provide

further understanding of the temporal properties of shared flow by investigating such specificity.

Few studies have explored synchrony of skin conductance in relation to shared flow; however, this measure was adopted as an extension to Study 1, and due to several previous studies having found a link between moderate SC and individual flow states, as a result of skills-demand compatibility (Peifer et al., 2014; Tian et al., 2017). Further to this, findings from Study 1 of this thesis suggested the potential for a relationship between ISC-SC and self-reported shared flow may be dependent on condition, though the significance threshold was not met. Therefore, synchrony of SC through the form of greater ISC-SC was expected where participants collectively felt skills-demand compatibility at similar musical moments or consciously responded to musical changes simultaneously, as was suggested in Study 1 (Gibbs et al., 2023).

The findings suggested a positive correlation between ISC-SC and *Interaction* only for those with the highest levels of musical training in the notated condition, while negative correlations were found in every other case. One plausible reason for this is that those who felt more comfortable with their musical material were more likely to have experienced comparable levels of mental effort surrounding similar moments of the notated pieces, while such comfort may have been more variable during memorised pieces as a result of varying time spent rehearsing for players within and between groups. Alternative speculation is suggested by Gordon et al. (2020), whereby synchrony of SC may point towards a negative effect of social cohesion, indicating stress extending amongst the group in a contagious manner. Further study is needed to understand whether the causes for synchrony of SC and synchrony of HR may be rooted in contrasting social dynamics.

Furthering the findings of the Study 1 that found a positive association between ISC-HR and shared flow (chapter 4) (Gibbs et al., 2023), the direction of the effect was found to be largely dependent on musical training, and this finding was only present in the maximal model. More specifically, for those with higher levels of musical training, a positive correlation between ISC-HR and *Interaction* was more likely in the improvised condition. Synchronised heart rates have been found in previous research to be a result of conscious processing of a shared stimulus (Czepiel et al., 2024; Fusaroli et al., 2016;



Keller et al., 2011; Madsen & Parra, 2022; Pérez et al., 2021; Ruiz-Blais et al., 2020) and perhaps the most conscious of performing conditions was that of the improvisation. The fact of this being specific to participants with the highest levels of experience may be a result of greater comfort with spontaneously improvising, with a greater inclination to be mutually responsive to one another's musical actions.

Nevertheless, it is worth highlighting here that the within-group level of musical training varied widely within groups, and what may be a more reliable metric is the level of collective musical training a group has. Furthermore, groups varied in size which in turn influenced the resulting ISC values as they were averaged across dyads. In addition to high or low expertise influencing shared flow, the degree to which expertise is compatible seems to be of greater importance, in line with many theories of shared flow covered in chapter 2 (Raettig & Weger, 2018; Sawyer, 2003; van den Hout et al., 2018).

This study is not the first to attempt to triangulate measurement techniques to reflect the complex social and interactive dynamics of shared flow. Links have already been identified between shared flow and the synchronised “swing” of a jazz band (Gloor et al., 2013), oxytocin levels of singers (Keeler et al., 2015), physiological arousal (Horwitz et al., 2021). All such techniques have shown promise; however, this empirical investigation furthers the implications of the first study, demonstrating the importance of acknowledging context and expertise when considering the potential insights such measurements can lend themselves to. Furthermore, by considering more than one measure beyond self-reports, e.g. temporal perception and physiological synchrony, one is able to gather a more complete picture of shared flow as a multifaceted phenomenon. What may be incomplete, though, is some indication of the affective qualities of flow, and how they may influence underlying measures. The use of a hormonal response such as oxytocin or cortisol, may be revealing in this endeavour as not only has it been shown to relate to flow by means of social bonding and skills demand compatibility (Keeler et al., 2015; Keller et al., 2011), increased oxytocin has already been related to subjective time expansion (Colonnello et al., 2016).

While triangulation may go some way to explain underlying aspects of shared flow experiences, self-reports cannot be disregarded altogether. The findings are largely

dependent on the use of the scale adopted, the Interactive Flow Questionnaire (Raettig & Weger, 2018), which was first validated in a non-musical context. This was chosen for its inclusion of items beyond the typical nine-dimensional flow factor model as others have done (Hart & Di Blasi, 2015; Zumeta, Basabe, et al., 2016), whereby aspects of interaction and communication were accounted for in addition to the use of plural pronouns. Nevertheless, its proposed three-factor structure was not admissible for the data. Proceeding with the two-factor structure instead did somewhat account for these social aspects, though admittedly the distinction between each was not clear-cut. The first factor was labelled *Absorption* due to its main focus on more individually felt aspects, such as feeling absorbed, the experience of time, and optimal challenge. Nevertheless, one item that loaded onto this factor involved inspiring one another, which would be theoretically more appropriate for the other factor *Interaction*. This scale was not validated in a musical, or even creative context, and that reason may account for why the original factor structure was not admissible. One suggestion is that a more universally appropriate shared flow scale is still missing, as various scales have been adopted in various contexts (Magyaródi et al., 2022; Tay et al., 2021), and perhaps one way to achieve this is by validating the same scale across multiple contexts.

Undoubtedly many of the models may have had improved power with a greater sample given some of the small effects that arose, particularly when assessing cross-level interactions (Meteyard & Davies, 2020; Scherbaum & Ferreter, 2009). Gamelan is restricted in the number of players that may participate at any one time, and as a naturalistic study design was adopted, pre-established groups were selected to participate. An additional unforeseen limitation though was the loss of observations with regard to physiological data, particularly skin conductance signals. While the foot is an optimal measurement site in this kind of activity where the hands can be left untethered (Payne et al., 2013; van Dooren et al., 2012), many participants' skin contact with the electrodes was not optimal given occasional detachment occurring when changing sitting position after some time. Further to this, the aim was to minimise any potential intrusion of the physiological measures, so participants were guided to attach their own ECG electrodes without removing clothing or body hair. This procedure may of course have had repercussions for the quality of the signals. It is recommended

that future studies adopt non-invasive physiological measurement possibilities by exploring the use of emerging technologies in more active settings, such as sports sciences.

A musical paradigm such as gamelan, which is an ensemble-based setting *a priori*, is an optimal paradigm to pilot the potential of measuring the social interaction and joint attention underlying shared flow experiences. Where other Western ensembles, such as a classical quartet or jazz trio, involve individual performers who may be very adept in solo settings, gamelan cannot be played alone. This chapter shows that this provides an optimal context for this research, although having demonstrated these methodological possibilities in understanding the social intricacies of shared flow, the use of them to be adopted in other musical, and non-musical contexts is encouraged.

## Chapter 8. Study 3.1: Qualitative findings on the role of subjective temporal distortion in shared flow in gamelan<sup>11</sup>

### 8.1 Aims

This study aims to further disentangle the subjective experience of time-related aspects of shared flow, by investigating participants' awareness of the influencing factors on time and shared flow. As such, participants' views of flow state and their subjective experiences of time in gamelan performance are explored, and so too are the reasons or influencing factors they could attribute to their experience of shared flow or subjective experiences of time.

### 8.2 Data Analysis

#### 8.2.1 Focus Group Analysis

With regards to the focus groups described in chapter 6, a hybrid approach to analysing data was implemented, which involved cycles of deductive and inductive techniques. Prior to coding, *a priori* codes and themes were generated in line with the aims of the study, by means of a deductive approach. The broader categories of these were the following:

Perspectives on flow and shared flow

Subjective time and musical time

Contextual influences on flow and time

Using MAXQDA software (VERBI Software, 2021), an inductive approach was then adopted, where data were reviewed line-by-line and coded *in vivo*. The *in vivo* codes were then refined and categorised for each focus group separately, and with deductive categories in mind, while still being open to unexpected insights. This allowed the

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<sup>11</sup> An article partly based on this chapter, entitled “Flowing between gongs: mixed-methods insights into shared flow and temporal distortion in music performance” has been published in PLOS ONE (Gibbs & Schiavio, 2025b). Focus group transcripts contributing to the analysis of this study have been uploaded to a repository on Open Science Framework <https://osf.io/tv7x9/>.

possibility of staying grounded within the aims while being fully immersed in the data. Quotes and excerpts are provided with both group acronyms and individual anonymous identifiers (the letter P and a number in accordance with the order of speakers within each focus group). This allows for the contextualisation of interpretations within each group's unique context. Code interrelations were explored visually by means of MAX Maps (Kuckartz & Rädiker, 2019), inspired by the recent work of Kruse-Weber and colleagues (2022).

### **8.3 Findings**

The iterative cycling of coding focus group transcripts led to five main categories, representing the main areas of enquiry, grouped into two overriding themes:

1) Primary understanding and experiences

- experiential qualities of flow
- group aspects of performance
- temporal experiences and estimations

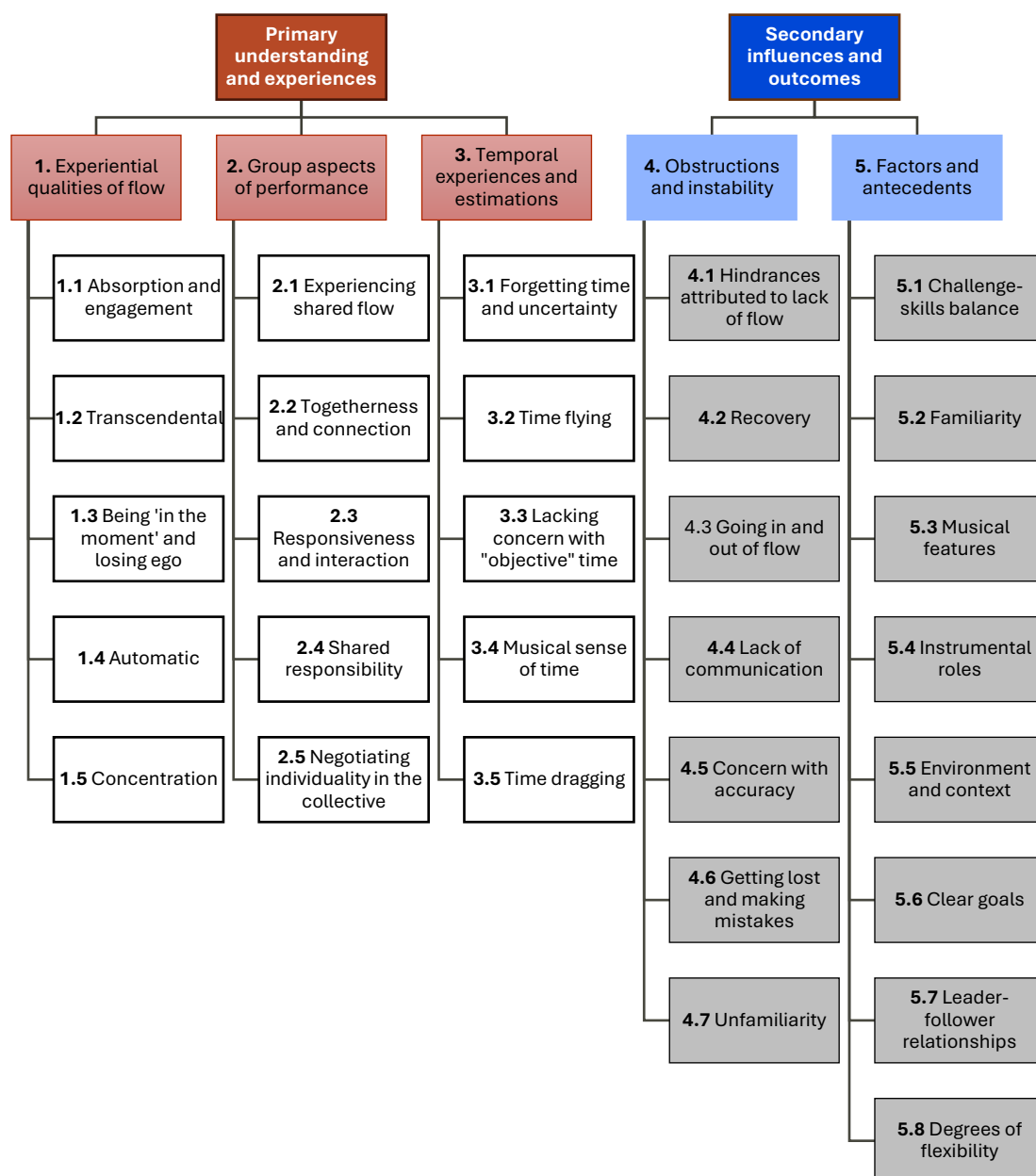
2) Secondary influences and outcomes

- obstructions, hindrances, and instability
- factors and antecedents

An extensive list of codes emerged from the data and were grouped into each category, detailed in **Figure 18**.

**Figure 18.**

*Coding Scheme from Focus Group Interviews*



In this section, each of the first three categories are explored separately under the theme of “Primary understanding and experiences”, while also discussing co-occurrences with any other codes. The final two categories under the theme of “Secondary influences and outcomes”, were primarily of interest in terms of where codes co-occurred with other categories and are therefore largely discussed in tandem. However, the intersections between the two underlying categories of this theme,

obstructions, hindrances, and instability (4) and influencing factors and antecedents (5), are also explored to gain a more complete picture of how the two categories overlap.

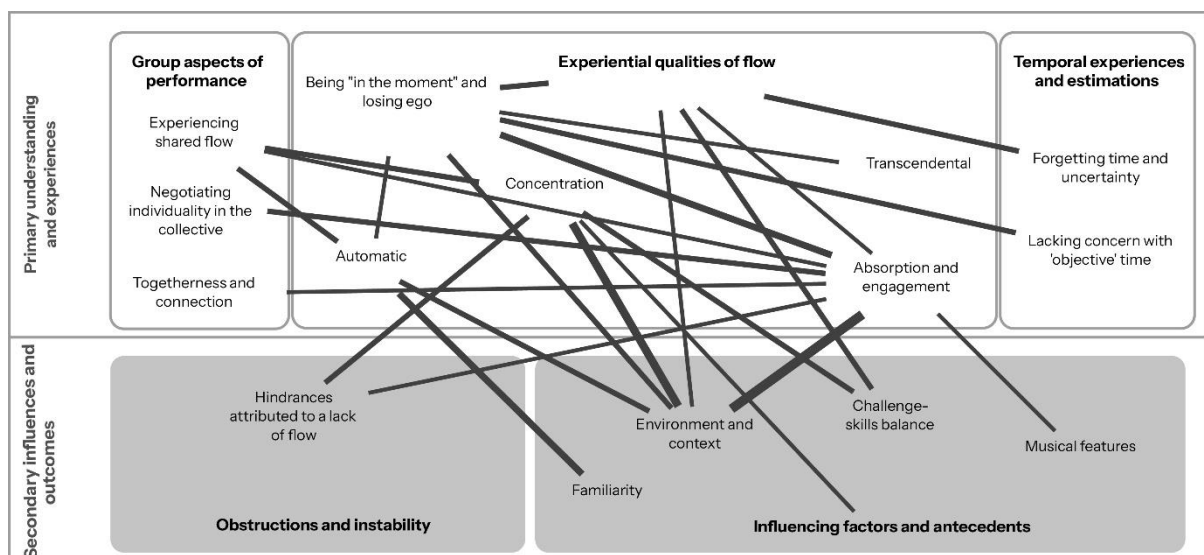
### 8.3.1 Primary understanding and experiences

#### 8.3.1.1 Experiential qualities of flow:

When players were first asked about their understanding of what flow state is, several made immediate reference to Mihaly Csikszentmihalyi, suggesting prior knowledge of flow theory. Greater interest from general audiences in the phenomenon seemed to have stemmed largely from growth in popular culture and social media. Regardless, fascinating insights were presented when participants were invited to describe their understanding of flow state. **Figure 19** presents code interrelations between the codes under this category, and codes of any other category.

**Figure 19.**

*Code Interrelations for “Experiential Qualities of Flow” Category and Codes.*



**Note:** Only those codes that co-occur a minimum of three times are included in this figure. Line thickness denotes the number of co-occurrences present.

Distinctions were often immediately made between characteristics of flow experience itself and the antecedents for flow to be achieved. The former commonly encompassed absorption and losing track of time, while the latter concerned prerequisites that must be in place in order to experience flow. Consider the following quote:

My understanding of it is it's something that you experience doing many different things ... where you become absorbed, and you lose a sense of time. But there has to be a certain level of competence involved. (NCH, P5)

Here, the potential for flow to be achieved is attributed to the antecedents of competence and *challenge-skill balance* (5.1) required, leading to a sense of *absorption and engagement* (1.1) in the moment, which they associated with the emergent property of *forgetting time and uncertainty* (3.1). From this perspective flow is something that you can achieve and experience providing the necessary criteria are fulfilled.

One member of the same group described their experience of flow outside of gamelan in a more out-of-body sense, coded as *transcendental* (1.2): “it was this weird feeling that the music was playing you, that was really strange” (NCH, P8). The distinction here is the potential control one can have over whether flow can be achieved, or whether flow arises, and in turn the level of suggested consciousness that might differentiate them. A similar view was also associated with *being in the moment and losing ego* (1.3):

For me. It's like not having to think about what I'm playing or worry if I'm playing it right ... like that point where you lose ego because actually worrying about what you're playing is an ego thing. (GSP, P4)

This sense of “being in the music” rested largely on the level of *familiarity* (5.2) a player had with the musical material. In addition to the level of *challenge-skill balance* (5.1) that must be in place for one to experience the absorbing aspects of flow, several noted on the level of *familiarity* (5.2), tied to flow occurring on an *automatic* (1.4) level.

Examples include the following two quotes: “I think when you know the next thing that's going to happen, the next thing just follows” (SBGP, P2); and “I don't have to think about it. The structure, you just feel it” (NCH, P2). These concepts were also tied to the kind of piece being performed and to the *musical features* (5.3) themselves.



The typical *musical features* (5.3) of gamelan, such as cyclical and repetition were frequently attributed to the potential for *absorption and engagement* (1.1), and fundamental to the potential for flow to arise. This is explained as follows by one participant:

Cycling or there are some motions which have that repetitive or expected quality that you are expected to be able to enter a kind of, I think when you know the next thing that's going to happen, the next thing just follows. (SBGP, P2)

Simultaneously, the same aspects of repetition may be regarded as *hindrances attributed to lack of flow* (4.1), often resulting in boredom depending on the level of *concentration* (1.5) and *challenge-skill balance* (1.1) in the moment. This is often specific to *instrumental roles* (5.4), as mentioned by one participant: “*Mugi Rahayu* is so easy for me I sometimes space out. So yeah, less challenge” (GSP, P2). Some players also found greater enjoyment in the improvisation as opposed to the traditional pieces. As the *gong* player put it: “it feels free for me to do what I want to do, instead of just waiting like after minutes after minutes and then falling asleep” (GSP, P3).

Nevertheless, participants often spoke of the experience of flow being a fine line between *absorption and engagement* (1.1), and *concentration* (1.5), whereby too much or too little of each would be seen as *hindrances attributed to lack of flow* (4.1). This was commonly dependent on the *environment and context* (5.5). On the topic of the improvisation, one participant stated “it's slightly more mentally engaged than what I think of as being flow. In that you are trying to find somebody, you're trying to find a sound to interact with” (SBGP, P1). As opposed to traditional pieces, where the goals are set from the start, this respondent felt that the level of conscious consideration and *concentration* (1.5) led to a loss of the potential for their playing to be *automatic* (1.4). In a similar vein, the level of challenge required for some parts during the traditional pieces led to overwhelm. This is captured well by the following statement: “I probably found the middle piece the hardest. So I don't think I was in flow state for that because I was a bit stressed because it's hard” (GSG, P1).

Interestingly, for several participants when asked about their understanding of flow state, their explanation was immediately surrounding a group context and *experiencing shared flow* (2.1). As one player admits “you're joining in with other people in it and

you're all in this thing together" (SBGP, P1). Due to the intrinsic importance of the group in gamelan playing, it appears that it is difficult for participants to understand flow in an individual capacity in such a context: "and it's like it's a group thing that no individual is really in charge of" (NCH, P4). While several were aware of facilitating contexts and conditions that may lead to individual flow, one participant explained the complexities of group performance:

I would find it hard to describe individual flow in the context of what we just did there. I'd find it hard to say that I experienced flow outside of the group ... it's very hard for musicians to say, I experienced flow, and it was only because of what I was doing. It was only within me, and it didn't involve any contamination from anybody else. (GSG, P2)

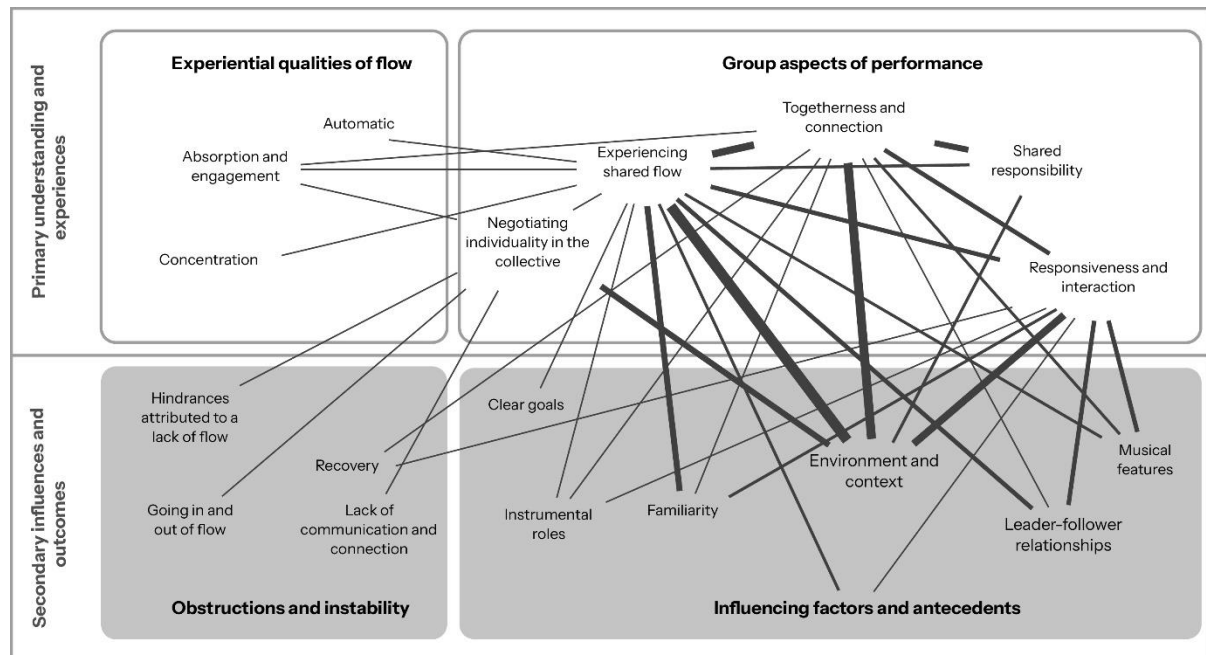
Accordingly, most groups felt that individual flow was far less applicable to their experiences of gamelan, and the focus turned to the group aspects of performance.

#### *8.3.1.2 Group Aspects of Performance.*

The experience of shared flow was discussed in much of the same terms as individual flow - including feeling absorbed, concentrating, and performing automatically – though these could only occur when other aspects of the group were present. **Figure 20** presents code interrelations between codes of this category and all others.

**Figure 20.**

*Code Interrelations for “Group Aspects of Performance” Category and Codes.*



**Note:** Only those codes that co-occur a minimum of three times are included in this figure. Line thickness denotes the number of co-occurrences present.

When the differences between shared flow and individual flow were explained to participants, most groups differentiated between their *experience of shared flow* (2.1) in gamelan based on the degree of *togetherness and connection* (2.2) present, the level of *responsiveness and interaction* (2.3) they felt towards others of the group, and the need for *shared responsibility* (2.4) in the performance of both traditional and improvised playing. In fact, they recognised that the experience of individual flow in the context of gamelan as a *hindrance attributed to lack of flow* (4.1) overall, in that it disconnected them from the group in traditional pieces, leading them towards *negotiating individuality in the collective* (2.5).

One player attributed a sense of individual flow to getting lost, where their experience of *negotiating individuality in the collective* (2.5) and *going in and out of flow* (4.3) was a result of excessive *absorption and engagement* (1.1) in their own part, yet eventually their recovery was prompted by a feeling of group *togetherness and connection* (2.2). This is stated explicitly by one participant:

I was really having fun with it on an individual level, because I knew exactly where I was and where everyone else was ... then I was like ... I don't know where I am now. That was definitely an individual flow state. I'm flowing with it, but sort of not necessarily in the right place ... then when again that *ciblon*<sup>12</sup> thing came back, there was this for me a kind of palpable sense of oh, group togetherness now. (SBGP, P1)

For this player in a group of collectively greater expertise, this occurred because they were at a level of gamelan musicianship where they were able to experiment with the material, regardless of it not being rehearsed. As with the general understanding of antecedents for flow, the importance of *familiarity* (5.2) was noted by several. As one player commented, with traditional pieces, a group may not need to have much familiarity with one another providing there is a mutual awareness of the intention and *clear goals* (5.6) in mind:

It feels like it might be easier with, say, a traditional piece ... where you could sit down with people that you've not played gamelan with before and probably fairly easily get into the same sense of flow because you know what it is you're aiming for. (GSP, P5)

Meanwhile, in certain *environments and contexts* (5.5) where the goal is less clear, such as in improvisation, the *familiarity* (5.2) among the group may hold more significance. One player noted that shared flow may be more difficult to enter in an improvisation, "unless you've been playing together for 20 years and you kind of get into some groove in your improvisation that you're used to" (SBGP, P5). Across most groups, the improvisation seemed to be one in which players felt an increased sense of *negotiating individuality in the collective* (2.5), whereby they were more likely to have experienced individual flow, rather than shared flow. This was attributed to the same sort of experimentation as that of the SBGP player, but also a *lack of communication* (4.4) and connection with others.

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<sup>12</sup> *Ciblon* refers to type of drum, or *kendhang*, that has strong implications for structure, whereby patterns on the *ciblon* are introduced at *iramas* of double density, for instance *irama wilet* (Pickvance, 2005). The move to *ciblon* often triggers *bonang* players to move to *imbal* and *sekaran* variations (Sorrell, 1990).

I felt in the improvisation, sometimes I was just in individual flow, doing my own little thing in a corner, not really caring what other people were doing. And other times I felt like I was in playing with the other people and whatever was happening was happening. So I kind of felt I was kind of flipping between the two in the improvisation. (NCH, P4)

*Leader-follower relationships* (5.7) and *instrumental roles* (5.4) were closely tied with *togetherness and connection* (2.2), *responsiveness and interaction* (2.3), and the potential for *experiencing shared flow* (2.1) overall. With the exception of SBGP, the directors of the ensemble all commented on conscious considerations inhibiting their potential for flow.

... it was just the improvisation for me that I was able to sort of get into that flow state. Because for the other pieces ... for me, personally, there were other very conscious considerations going on in my mind. I was thinking about form and structure ... whereas with the improvisation we didn't have to worry about what was right. (GSG, P2)

This pressure seemed to be particularly evident where there were less experienced members in the group, or members who were less experienced with their individual parts. The difference with SBGP is that they are comprised entirely of highly experienced players, and therefore the leadership “role” is changeable, perhaps most closely resembling the expert gamelan ensembles one would see in Java. Onus here was distributed across the group, and while they did not encounter the same pressures of singular leadership, there were still certain roles seen as crucial for others to rely on, which in turn had its own pressures that may inhibit flow, for instance, “if you're playing *balungan* ... I believe you have to be absolutely kind of rigid ... so it's a different kind of feeling of having to be there” (SBGP, P5).

As mentioned in relation to the category of *experiential qualities of flow* (1), excessive *absorption and engagement* (1.1) can be dangerous, and it is a fine line to draw.

This becomes particularly problematic if they are fulfilling structural *instrumental roles* (5.4) such as the *gong*, or *kenong*, which tend to provide cues for other members of the ensemble. Musically, instruments such as the *gong* could be thought of as less

demanding, and therefore less flow-inducing. Nevertheless, two participants of NCH argued for the contrary:

Could you get into a flow state if all you had to do was hit the *gong*? I would imagine that if you're part of a group and you're fully absorbed and everything, the group is happening ... I would say you could be in the flow state if it was just a one-note piece. (NCH, P1)

Theoretically, although the level of dextrous challenge may not be present for some instruments that would allow one to achieve the classic conception of flow, it is clear that such *instrumental roles* (5.4) still hold great importance, and the challenge is in how they provide the overarching form and structural significance. As another participant described, "it's a competence of listening, really. It's not a competence of playing the *gong* because that's easy. It's just knowing when to play it" (NCH, P4). Having a sense of a *clear goal* (5.6) is important for *togetherness and connection* (2.2), which comes naturally in prescribed pieces, and was often attributed to the *lack of communication* (4.4) in improvisation. Overall, this category seemed to insist on the importance of the group above all else. Little mention of temporal perception was given through discussions of shared flow explicitly, but as has already been seen, in the context of gamelan, the conceptual overlap between the two is great. At the start, several defined flow itself as contributing to a loss of time sense, and in turn, participants commented that shared flow is more applicable to gamelan due to the need for interaction; it follows that the same temporal experiences may be present in shared flow.

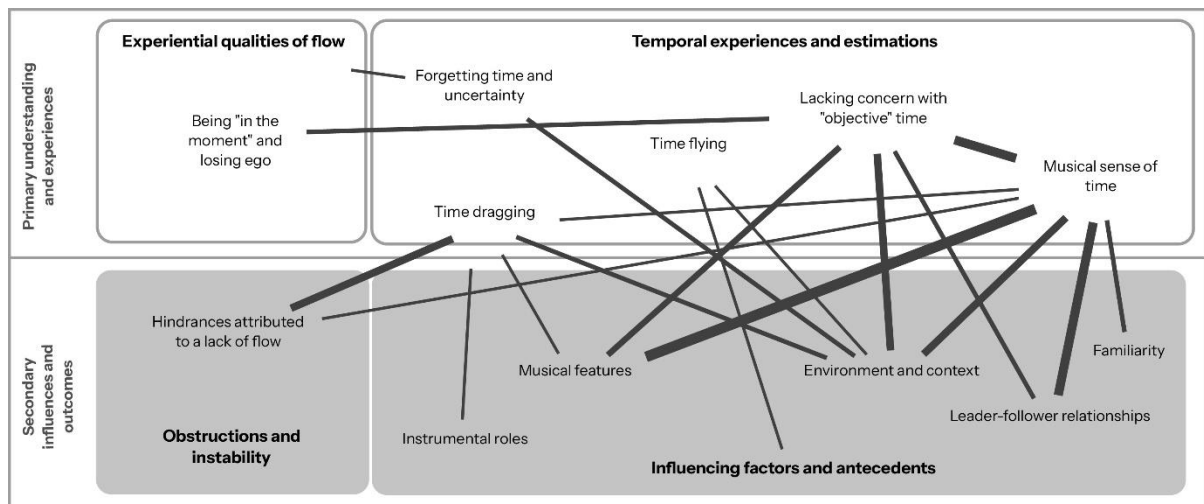
#### 8.3.1.3 Temporal experiences and estimations.

The subjective experience of temporal contraction is usually regarded as being closely tied to the experience of flow state. Nonetheless, the focus group findings highlighted that *time flying* (3.2) was more related to influencing *factors and antecedents* (5), and the *environment and context* (5.5), than it was to qualities of flow. While groups were aware that a sense of time supposedly flies by when in flow, they more typically associated *forgetting time and uncertainty* (3.1) with flow, with comments such as "I

think you forget time” (NCH, P2) and “I lose all track of time” (SBGP, P3). Code interrelations are presented in **Figure 21**.

**Figure 21.**

*Code Interrelations for “Temporal Experiences and Estimations” Category and Codes.*



**Note:** Only those codes that co-occur a minimum of three times are included in this figure. Line thickness denotes the number of co-occurrences present.

When asked to reflect more on their estimates given during the experiment, however, there were many who did not see the importance, *lacking concern with objective time* (3.3). One such participant stated: “It seems sort of irrelevant. I mean ... I’m not concentrated on my perception of time whilst I’m playing. All that I’m really concerned with is you know, where we are with the structure ... how it’s progressing” (GSP, P1). This participant, along with several others, found that the nature of the questionnaire – in which they were requested to provide an estimate to the nearest minute and second following each performance – was trivial. Others found that *musical features* (5.3) provided some sort of temporal framework. Although distinct from “objective” time, it separated the potential temporal consequences of flow experiences in music from other settings.

...with flow state in other things, like, say, creative writing or doing art, it's a lot harder to keep track of time. I think with music, you've got a little bit of a

framework in the back of your head. There's a beat and a pulse, and there's something there that helps you guesstimate how long it was. (NCH, P3)

For players who had roles that required leading tempo and structural changes, for instance, the drummer, the concept of metric, or a *musical sense of time* (3.4) was divorced from a sense of objective time even more:

The thing is, when you talk about perception of time, if you're talking about how long the piece is, that's a conception of time that I think probably we don't have when we're playing, well I don't. But I am very concerned with time. So it's like the time between two beats. It's like, is there enough time for *bonangs* to be doing *imbal sekaran*<sup>13</sup>? Is it like the optimum speed? So my brain is actually concerned with time constantly ... metric time and how that relates to the instrumental parts of the feel I want. (GSP, P4)

This participant commented on the role of time in the sense of it unfolding, and the importance of their awareness of that. A similar point of view was provided when time was a consideration in decision-making, related to *leader-follower relationships* (5.7):

But there's another facet of that, which is as a piece of music progresses, you have to make decisions ... so you can't entirely forget about time ... Whenever you have to make a choice to change in a piece, even in a flow state, you have to be sensing that it's the right time because enough time has passed. (NCH, P1)

Together, the above comments demonstrate a difference in temporal awareness depending on whether they hold a leadership role. Even though they may be *lacking concern with objective time* (3.3), especially in flow, all group directors, or those who had experience in facilitating groups and concerts had experience of timing pieces for the purposes of concerts, and several presumed this knowledge would influence their estimates of how long a performance takes to play:

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<sup>13</sup> *Imbal* and *Sekaran* are common interlocking patterns for the *bonang panerus* and *bonang barung* instruments that tend to occur in slower tempi, for instance in *irama dados* when the *balungan* line is at half speed, while other instruments double up. These patterns usually require *bonang* players to fit in twice the amount of material as they did in a faster *irama* (Pickvance, 2005).



I think there's probably a difference between people who are sort of estimating how long the *lancaran*<sup>14</sup> will take in this kind of situation or indeed, people who are used to timing how long a song is going to be ... and you rely on that rather than actually being like, in this moment, I'm experiencing this much time. (SBGP, P2)

More experienced players, particularly those in SBGP, described that their estimates of the duration of pieces were made in relation to lengths of cycles in traditional pieces, which was also described as the reason the improvisations were much more difficult to estimate in terms of duration. Therefore, participants assumed that *familiarity* (5.2) and expertise seemed to help make more accurate assumptions, and such antecedents also lend themselves to flow. Accordingly, the resulting experience is opposing the presumed temporal effect of time distortion.

Several other influencing factors on time perception were much the same as those related to flow, though more in line with the expected effects. One player noted how strongly *hindrances attributed to lack of flow* (4.1), namely boredom, is tied to the idea of *time dragging* (3.5):

There's been moments when I've been playing gamelan and I'm not enjoying it. And I'm completely out of flow and there's a boredom factor comes in where time seems to drag forever ... sometimes your flow does things to time, but so does boredom too. It's not the only thing that plays horrible games with your sense of time. (NCH, P4)

For some players and groups, the *environment and context* (5.5) were at the centre of this relationship. In particular, the improvisation was unanimously one in which there was a sense of *time dragging* (3.5), far more so than either of the traditional pieces, “When I first looked at it, it said estimate how long. My gut instinct was I wanted to write down three years” (GSP, P5). This may have been attributed to unfamiliarity with improvisation altogether, or lack of enjoyment and boredom.

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<sup>14</sup> A *lancaran* is one type of form of gamelan piece with 16 beats in each cycle (Sorrell, 1990), with its own particular pattern of which beats the structural instruments call on.

Lastly, another influencing context, like those found in the previous two categories, was that of *instrumental roles* (5.4). This code commonly intersected with *time dragging* (3.5) but seemed to be a result of two opposing reasons. The first was related to complexity, where one player insinuated that time may have dragged on for those with more complex parts in a traditional piece: “... *bonang panerus* during the last of *inggah*<sup>15</sup>. Really fast. He was like, ‘When will this end?’” (GSP, P2). Conversely, for instruments that are less complex or have the greatest gaps in metric division, the same may also be true. This seemed apparent with *gong* players earlier on, while this was also commented on for the only *balungan* player in SBGP, where another player pointed out “you have the longest period between beats” (SBGP, P2), where they had been describing other reasons for time dragging.

Akin to that of flow experiences, the potential for *time flying* (3.2) is also a balancing act. One needs to be familiar and comfortable with their part, but not so familiar with timing that they can calculate an *irama* cycle to the nearest second. One needs a part that is challenging enough, that neither is extremely busy, nor extremely bare. But aside from all of this, the participants largely questioned the use in referring to objective measures of seconds and minutes at all.

### 8.3.2 Secondary influences and outcomes

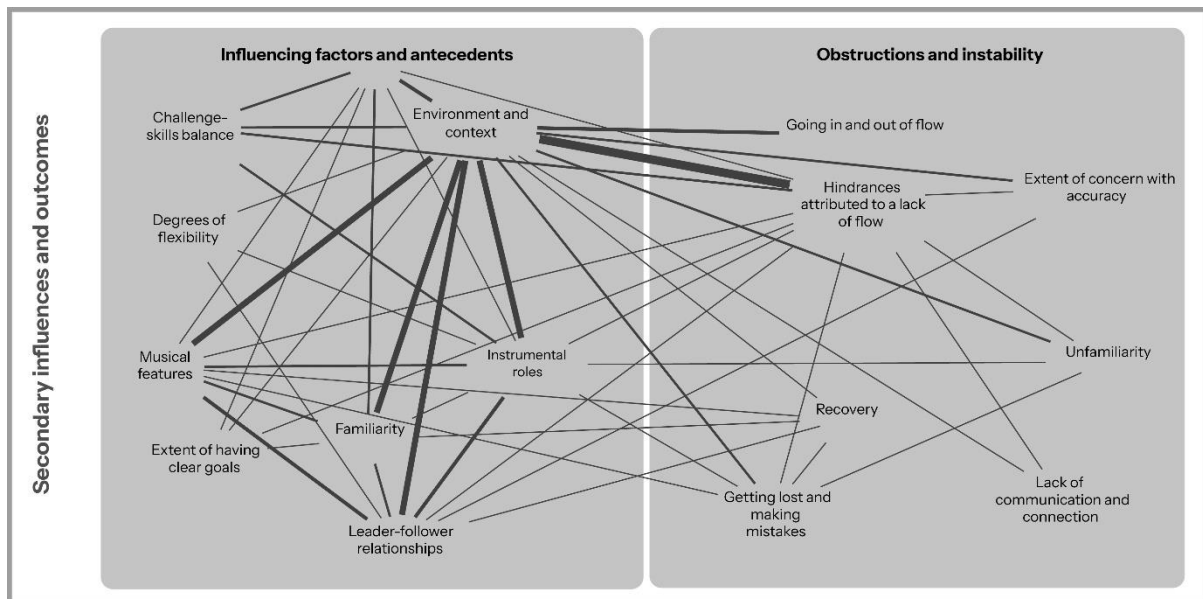
Although many of the codes within the theme of secondary influences and outcomes have been discussed in their co-occurrences with other categories, considerations are now made towards the intersections between its two underlying categories: *influencing factors and antecedents* (4), and *obstructions and instability* (5). Code interrelations are shown in **Figure 22**.

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<sup>15</sup> The *inggah* is usually the second section of typically longer form compositions, under the broad term of *gendhing* (Pickvance, 2005).

**Figure 22.**

*Code Interrelations Between Categories “Influencing Factors and Antecedents”, and “Obstructions and Instability” Under the Theme of “Secondary Influences and Outcomes”*



**Note:** Only those codes that co-occur a minimum of three times are included in this figure. Line thickness denotes the number of co-occurrences present.

Throughout all of the findings presented above, the *environment and context* (5.5) were key influences on temporal effects and the potential for flow experiences. Prescribed pieces, whether from notation or memory, were often related to *leader-follow relationships* (5.7) and *instrumental roles* (5.4), which in turn were ascribed to *hindrances attributed to lack of flow* (4.1). This was usually due to excessive pressure or responsibility for the group.

If I'm directing and the group isn't together, then I can't get into the flow at all. I've got to steer and give cues. *Kenong* player fell out at a bit. I gave a clear signal ... he spotted it and got back in. (NCH, P1)

The improvisation, on the other hand, was one context in which participants could be free from such pressures, lending to *degrees of flexibility* (5.8). This was typically associated with how confined a participant felt to their part, and co-occurred with *instrumental roles* (5.4), *environment and context* (5.5), and *leader-follower relationships* (5.7): “with the improvisation, we didn't have to worry about what was

right. Yeah, so for me. That was the one. If I didn't have that leadership role, I think I'd have a different answer" (GSG, P2). *Degrees of flexibility* (5.8) for members with greater expertise, however, were also relevant to traditional pieces.

When we went into the change of drum, I was like, I don't know where I am now. That was definitely an individual flow state. I'm flowing with it, but sort of not necessarily in the right place, but in my own way. (SBGP, P1)

In such instances, *concern with accuracy* (4.5) was somewhat diminished, even if they were *getting lost and making mistakes* (4.6). Where improvisation lends itself to mutual, momentary decision-making, traditional pieces that have been rehearsed have a clear structure that can be relied upon. For GSP, the *unfamiliarity* (4.7) and lack of *clear goals* (5.6) in improvisation led towards contexts that were difficult to compare in terms of shared flow, and potential *hindrances attributed to lack of flow* (5.1). One participant explained, "we haven't improvised together like that before, whereas we've practised *Mugirahayu* and *Tukung* a lot. So it's really tricky to compare things like group flow because you don't know what you're aiming for". (GSP, P4). Other participants described the other side of having such *clear goals* (5.6) in traditional pieces, especially where *leader-follower relationships* (5.7) were strongly tied to *instrumental roles* (5.4):

... some of the instruments you feel you might not be as used to or are a bit more complicated when you start to learn it. And that can be harder to get into the group flow. Yeah, or else if you're doing the *gong* or something, you can't get lost. Like you really have to pay attention then. (NCH, P5)

The result of this was an excessive *concern with accuracy* (4.5), and the potential implications of *getting lost and making mistakes* (4.6).

Overall, some of the main determinants of flow experiences and temporal distortion, or lack thereof, were the environment and context, instrumental roles and leader-follower relationships, familiarity, and challenge-skills balance. Several of these factors can be accounted for by variables obtained through questionnaires. Accordingly, Study 3.2 aims to identify if similar trends and patterns can be identified through a combination of quantitative and qualitative data, by means of peri- and post-experiment questionnaires and surveys.

## Chapter 9. Study 3.2: Mixed methods findings on the role of subjective temporal distortion in shared flow in gamelan<sup>16</sup>

### 9.1 Aims

For Study 3.2, the main point of interest was to see whether subjective time distortion as a standalone measure was associated with antecedents of shared flow and shared flow factors, and contributing factors outlined by participants in Study 3.1 (Chapter 8), in the context of gamelan performance. Through a mixed methods approach, a comparison of qualitative reasoning underlying time perception and shared flow with quantitative findings is provided. The procedure and all measures used are described in detail in Chapter 6.

### 9.2 Data analysis

#### 9.2.1 Quantitative measures

All quantitative measures and analyses were calculated and carried out using R Studio version 4.3.1 (R Core Team, 2023).

##### 9.2.1.1 Factor Analysis.

The same latent variables of the Interactive Flow (IF) questionnaire, calculated in Chapter 6 and used in Chapter 7, were adopted in this study. To reiterate, these two factors were labelled *Interaction* and *Absorption*, to reflect the items related to the more interactive and group-dependent aspects of the IF questionnaire, and those that were more absorbing and automatic.

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<sup>16</sup> An article partly based on this chapter, entitled “Flowing between gongs: mixed-methods insights into shared flow and temporal distortion in music performance” has been published in PLOS ONE (Gibbs & Schiavio, 2025b). Data and code contributing to the analysis of this study have been uploaded to a repository on Open Science Framework <https://osf.io/tv7x9/>.

#### 9.2.1.2 Time Distortion Measures.

Im and Varma's approach to measuring subjective time distortion (2018) was adopted, whereby the difference between participants' subjective time estimates and the objective performance time, measured by the experimenter based on video and audio recordings, was normalised by the objective performance time. This was calculated for each piece and each participant. The resultant values indicated underestimation (i.e., time flying) from negative values, and overestimation (i.e., time dragging) for positive values, and is referred to as time distortion, or TD. Repeated measures mixed ANOVAs were used first to assess potential differences in TD and flow factors resulting from the playing condition or gamelan group alone, followed by Kruskal-Wallis and Wilcoxon tests to identify pairwise differences. Following this, preliminary Kendall's Tau correlations were conducted between the measure of TD across all conditions simultaneously, and all variables that may have had an influence on time perception according to the findings of Study 3.1. Graphical representation was created by means of a generalised pairs plot using the *GGally* package in R (Emerson et al., 2013). Correlations that appeared to be most prominent were incorporated into the building of a linear mixed-effects model using the *lme4* package (Bates et al., 2015, 2018).

While initial tests indicated non-normal distributions of all continuous variables, linear mixed-effects models are robust to such violations (Schielzeth et al., 2020). Therefore, a parsimonious approach was implemented to select an appropriate random effects structure of a model containing all hypothesised fixed effects. However, due to the limited sample, in all instances, the only error-free model arose through the inclusion of no random slopes, and only a random intercept of participant nested within group. Following this, the fixed effects were reduced according to AIC criterion (Sutherland et al., 2023). All model comparisons of random effects, and subsequently fixed effects are provided in **Appendix O**, while only the final model in this study is presented using *sjPlot* (Lüdtke, 2023). Where necessary, variables that involved total scores (i.e. IF pre and post scales, and Gold-MSI musical training subscale) were scaled to improve model accuracy and balance amongst predictors.

### 9.2.2 Follow-up survey analysis

A similar approach to that of the focus groups was taken with the follow-up surveys (described in chapter 6), to primarily capture insights related to any contextual influences on time estimates that may not have been described in focus groups. Insights were gained through elicitation, providing participants with their estimates of time passed against the actual observed timings, as opposed to being blind to the potential difference between perceived and actual as they were in the focus group presented in Study 3.1. Codes were assigned to this broader theme of contextual influences deductively, while an inductive approach allowed for unexpected insights. These codes were then used to investigate potential differences in self-reported time estimates and shared flow states based on the presence of the codes. Due to non-normal distributions amongst the outcome measures, and unequal variances between groups, Wilcoxon-Mann-Whitney tests were carried out using the *coin* package in R (Hothorn et al., 2008).

In the following section the results are presented as follows: first starting with the questionnaire data, relationships are assessed between TD, shared flow factors, and variables identified to be of importance, in accordance with the findings of Study 3.1. Subsequently, mixed methods analyses are presented between subjective time perception and shared flow factors, and coded categories derived from follow-up surveys. The purposes of this were two-fold. Primarily, this was to substantiate relationships identified via separate streams of qualitative and quantitative data, through a consolidated mixed-methods approach. Secondary to this, was to observe how well participants' reflections of potential influences on their estimates of time and experience of flow - when these were evident to participants, and gathered by means of elicitation - aligned with the influences identified from focus groups when participants were not aware of the differences between their perceived and objective measures of time. While through focus group interviews, several may have said their estimates were merely guesswork, the mixed methods findings could shed light on the potential for an unconscious timekeeping mechanism, and the factors that might interfere with this.

## 9.3 Findings

### 9.3.1 Questionnaire results

Repeated-measures mixed ANOVAs with Greenhouse-Geisser sphericity corrections were used, assigning TD, *Absorption*, and *Interaction* each as the dependent variable, condition as the within-subjects factor, and group as a between-subjects factor, to explain the potential variance attributed to type of performance (i.e. traditional piece from notation or from memory, or an improvisation) between groups. Kruskal-Wallis tests were then used to identify significant differences. Distributions of variables between groups and conditions, with pairwise significance between conditions derived from Wilcoxon rank sum and signed rank tests, are provided in **Figure 23**.

No significant effect of condition alone on time distortion was found; however there were significant effects for group ( $F(3, 30) = 9.430, p < .001$ ), and for groups within conditions ( $F(4.93, 49.27) = 6.795, p < .001$ ). Kruskal-Wallis tests revealed significant differences in between groups for the notated ( $H(3, 36) = 17.6, p < .001$ ) and memorised conditions ( $H(3, 35) = 16.3, p < .001$ ), whereby generally GSP experienced significantly more time contraction in both conditions, while GSG experienced significantly more time expansion. GSG was the only group to demonstrate significant overall differences in time distortion between conditions ( $H(2, 26) = 9.52, p = .009$ ), whereby they reported time dragging the most in the memorised condition, compared to the improvised (see **Figure 23**).

For *Absorption*, there were significant differences between groups ( $F(3, 30) = 4.045, p = .016$ ) but no main effect for conditions overall, nor for groups within condition. Follow-up Wilcoxon rank sum tests revealed GSG reported significantly lower *Absorption* than both GSP ( $W = 546, p = .034$ ) and NCH ( $W = 99, p = .015$ ), while NCH reported significantly higher *Absorption* than SBGP ( $W = 392, p < .007$ ).

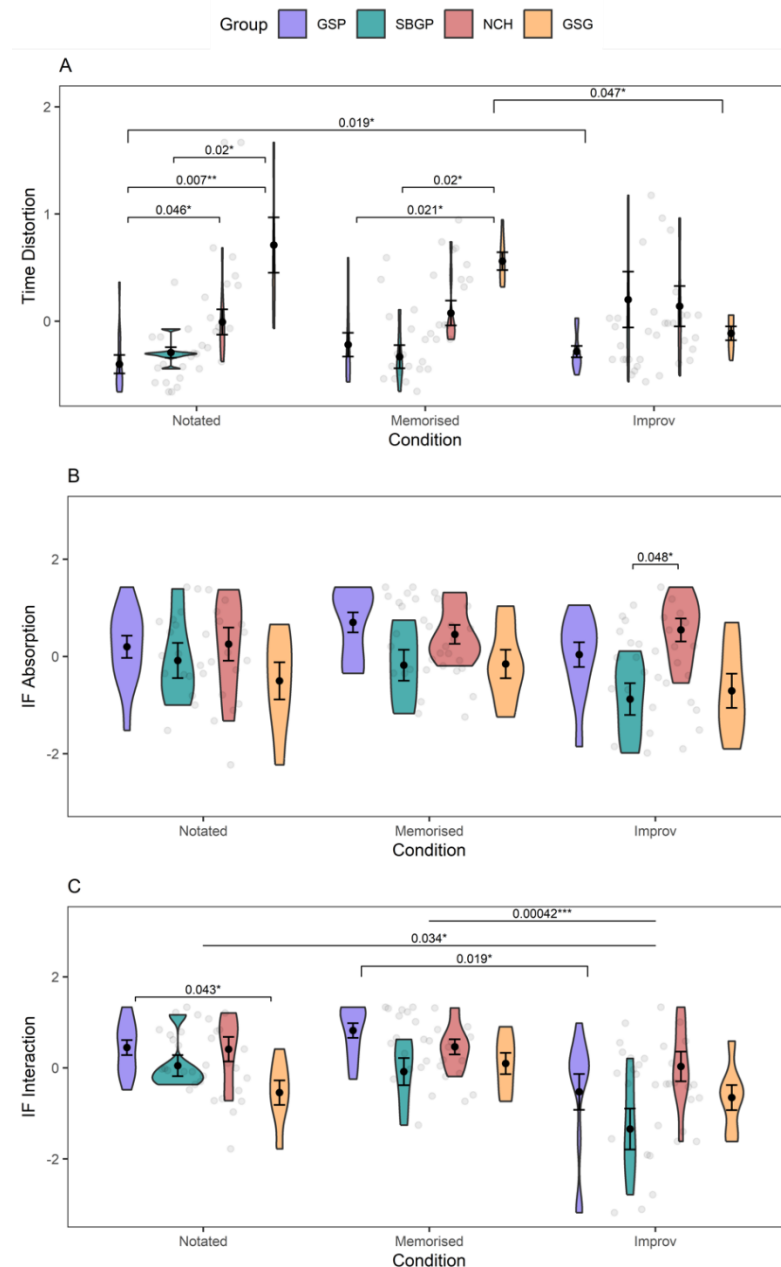
For *Interaction*, significant differences were found for both between groups ( $F(3, 30) = 5.419, p = .004$ ), and conditions overall ( $F(1.45, 43.38) = 13.348, p < .001$ ). There was no main effect between groups within condition. *Interaction* was generally lower in the improvised condition than in the memorised (see **Figure 23**). As with *Absorption*, GSG reported lower *Interaction* compared to GSP ( $W(21, 36) = 572, p = .008$ ) and NCH ( $W(21,$



24) = 381,  $p < .017$ , while GSP reported higher *Interaction* compared to SBGP ( $W(36, 18)=476$ ,  $p = .033$ ).

**Figure 23.**

*Violin Plots by Group, Split Between Playing Conditions, Showing Distributions of A) Time Distortion, B) IF Absorption, and C) IF Interaction.*

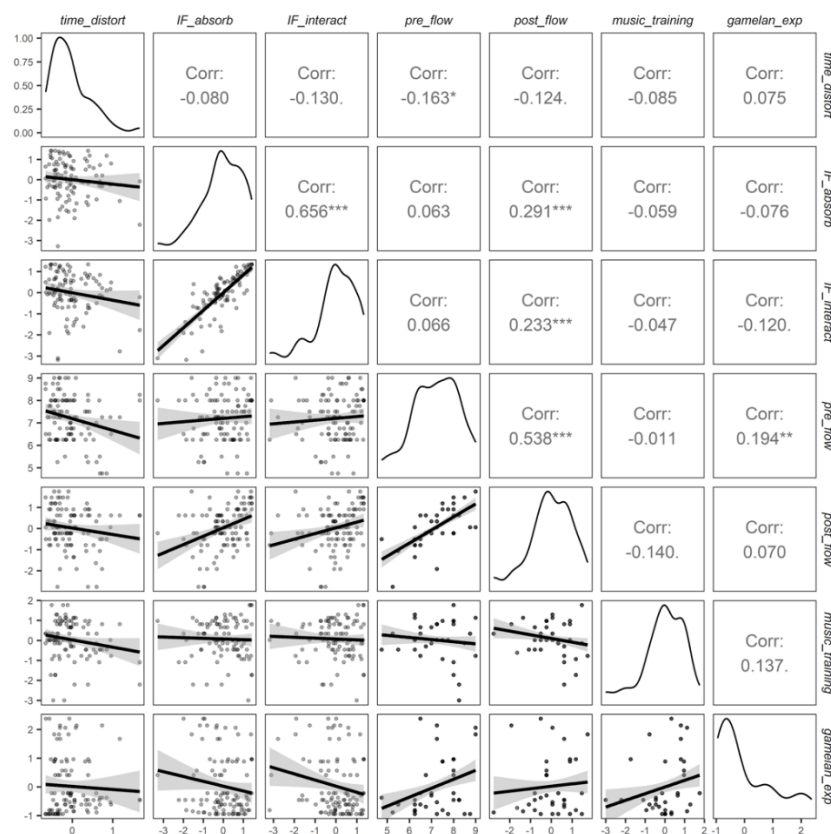


**Note:** Error bars show the standard error of the mean. Note: \*\*\* Denotes  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$ , .  $p < .10$ .

Preliminary correlations were examined between the measure of time distortion across all conditions simultaneously, and all variables that may have had an influence on time perception and flow, based on the review of the literature and focus group analyses. These involved, pre-, peri-, and post-experiment measures of interactive flow, Gold-MSI musical training total score, and years of gamelan playing experience, all of which are detailed in Chapter 6. Of these, the only variables which demonstrated significant correlations with time distortion were the pre- and post-flow antecedents, and IF interaction. **Figure 24** shows pairwise Kendall Tau correlation plots between all variables.

**Figure 24.**

*Pairwise Kendall Tau Correlations for Time Distortion, IF Factors and Antecedents, and Musical Training.*



**Note:** The top right triangle shows Tau coefficients with significance. The diagonal represents variable distributions. The bottom left triangle shows scatter plots with smoothed regression lines and 95% confidence intervals.

Note: \*\*\* denotes  $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ , . $p < 0.10$ .

A linear mixed effects model was then fitted to predict time distortion, according to variables that correlated with time distortion or presented indications of a relationship without reaching the significance threshold, and those that participants described as being influencing factors on their perception of flow, and subsequently time in Study 3.1. Therefore, as well as assigning fixed effects of the *Interaction* factor and playing conditions to address the core of the aims, musical training total scores and instrumental codes were incorporated according to metric density (i.e. elaborating instruments who played between the beats, melodic instruments who played every beat or more, and structurally punctuating instruments), as suggested by the focus groups. This was contrast-coded to compare the lowest metric density against the middle and highest density, then to compare the middle and highest density against each other. *Absorption* was also incorporated, as while the correlation was not significant, results from Wilcoxon rank-sum tests indicated differences between groups that may be controlled for through a random effect. **Table 15** presents the final model after a selection process reduced the fixed-effects structure based on AIC, while **Figure 25** displays the fixed effects estimates graphically. Full details of all model comparisons are provided in **Appendix O**.

*Interaction* and *Absorption* both significantly predicted time distortion in opposing ways. For the *Absorption* scores, more time was perceived to have passed for those who scored more highly (est. = 0.27,  $p = .004$ ). On the contrary, for *Interaction*, higher scores led to lower values of time distortion, interpreted as time contracting (est. = -0.32,  $p = 0.001$ ). Where condition was contrast coded, this effect was strongest in the notated condition, in comparison to both the memorised and improvised setting (est. = 0.26,  $p = .012$ ). However, planned contrasts with Benjamini-Hochberg adjustment for multiple comparisons did not reach significance when separately comparing the notated condition with the memorised (est. = -0.28,  $t(87) = -2.05$ ,  $p = .065$ ) and improvised (est. = -0.24,  $t(89.5) = -2.118$ ,  $p = .065$ ) conditions. IF post-session outcome scores presented a comparable relationship with time contracting as with that of IF interaction (est. = -0.15,  $p = 0.042$ ).

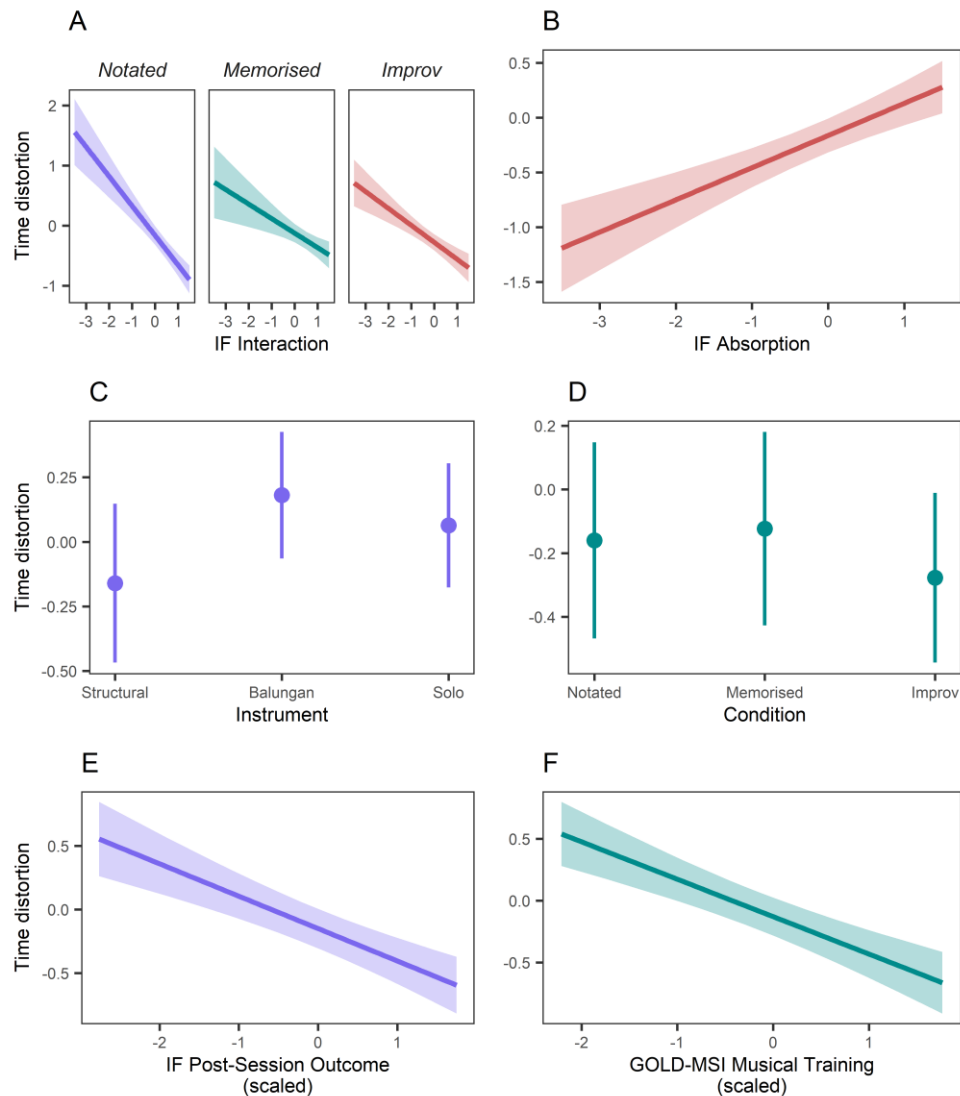
**Table 15.***Results from Linear Mixed Effects Model with Time Distortion as the Dependent Variable.*

| Predictors                                        | Time distortion |               |      |
|---------------------------------------------------|-----------------|---------------|------|
|                                                   | Est.            | 95% CI        | p    |
| (Intercept)                                       | -0.03           | -0.16 – 0.10  | .688 |
| IF interact                                       | -0.32           | -0.52 – -0.12 | .002 |
| condition (notation vs without)                   | -0.06           | -0.23 – 0.11  | .507 |
| condition (memorised vs improvised)               | -0.11           | -0.33 – 0.10  | .298 |
| IF absorb                                         | 0.27            | 0.08 – 0.46   | .007 |
| Instrument (structural vs elaborating)            | -0.25           | -0.48 – -0.01 | .040 |
| Instrument (balungan vs solo)                     | 0.08            | -0.15 – 0.31  | .510 |
| post flow                                         | -0.13           | -0.27 – 0.00  | .057 |
| music training                                    | -0.22           | -0.37 – -0.06 | .007 |
| IF interact X condition (notation vs without)     | 0.26            | 0.05 – 0.47   | .018 |
| IF interact X condition (memorised vs improvised) | -0.05           | -0.30 – 0.21  | .714 |
| <b>Random Effects</b>                             |                 |               |      |
| $\sigma^2$                                        |                 | 0.12          |      |
| $\tau_{00 \text{ id\_n:group}}$                   |                 | 0.08          |      |
| ICC                                               |                 | 0.40          |      |
| $N_{\text{id\_n}}$                                |                 | 33            |      |
| $N_{\text{group}}$                                |                 | 4             |      |
| Observations                                      |                 | 99            |      |
| Marginal $R^2$ / Conditional $R^2$                |                 | 0.230 / 0.537 |      |
| AIC                                               |                 | 155.455       |      |

**Note:** Fitted with restricted maximum likelihood estimation. A random effect was included for group, and participant within group. Model formula: time distortion ~ IF interaction X condition + IF absorption + instrument + post flow + music training + (1 | id:group)

**Figure 25.**

*Graphical Depiction of Each Fixed Effect Estimates Included in Final Linear Mixed Effects Model Presented in Table 15.*



**Note:** Fixed effects displayed are: A) Interaction effect of *Interaction* and Condition, B) *Absorption*, C) Instrument, D) Condition, E) IF Post-Session Outcome scores (scaled) and F) Gold-MSI Musical Training subscale total scores (scaled). Shaded ribbons denote the standard error of the mean, while error bars show 95% confidence intervals.

Musical training also had a similar effect, where those with the highest level of musical training were more likely to have experienced a feeling of time flying (est. = -0.22,  $p = .029$ ). With regards to the contrast-coded instrumental roles, elaborating, metrically

dense instrumental roles led to greater time contraction compared to structural roles such as the *gong* (est. = -0.25,  $p = .029$ ). When carrying out planned contrasts to compare the effects of each instrument grouping, no statistically significant effect was found. It is worth highlighting that there was no significant effect of condition alone on the degree of time distortion felt.

### 9.3.2 Mixed-methods findings

The final stage of analysis encompassed an investigation into whether participants' reflections, which arose through the follow-up surveys, could align with their estimates of time and self-reported shared flow experiences.

Through coding short segments of text provided in the follow-up surveys, participants' assumptions as to the reasons behind their estimates were grouped according to the context. The table below shows the most frequent reasoning codes, alongside the average quantitative variables for time distortion, and IF factors for participants where such codes were present.

Wilcoxon-Mann-Whitney tests were used to examine potential significant differences in participants' self-reported variables based on dummy coded qualitative codes, i.e. whether the qualitative codes were present or not. Codes that appeared the most and their associated test results are presented in the form of a joint display in **Table 16**. Despite the limited sample, several significant findings emerged.

**Table 16.**

*Joint-Display Table for Coded Segments Derived from Follow-Up Surveys, Compared with Measures of Time Distortion, IF Absorption and IF Interaction, Using Wilcoxon-Mann-Whitney Tests.*

| Condition | Code                | Exemplar quote                                                                                 | N  | Present | Time distortion |          |          |          | IF Absorption |          |          |          | IF Interaction |          |          |          |
|-----------|---------------------|------------------------------------------------------------------------------------------------|----|---------|-----------------|----------|----------|----------|---------------|----------|----------|----------|----------------|----------|----------|----------|
|           |                     |                                                                                                |    |         | <i>Mdn</i>      | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i>    | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i>     | <i>W</i> | <i>z</i> | <i>p</i> |
| Notated   | Optimal challenge   | “I didn’t feel like I was struggling ... I was enjoying the music we were making.”             | 10 | 1       | -0.34           | 304      | 0.87     | .383     | 0.59          | 263      | -1.01    | .313     | 0.36           | 265      | -0.92    | .359     |
|           |                     |                                                                                                | 19 | 0       | -0.20           |          |          |          | -0.08         |          |          |          | -0.02          |          |          |          |
|           | Enjoyment           | “I was fairly relaxed and enjoying playing my part”                                            | 8  | 1       | -0.29           | 317.5    | 0.12     | .903     | 0.82          | 276      | -1.90    | .057     | 0.80           | 282      | -1.61    | .107     |
|           |                     |                                                                                                | 21 | 0       | -0.25           |          |          |          | -0.18         |          |          |          | -0.05          |          |          |          |
|           | Excessive attention | “I think this piece is quite extensive and it takes a lot more focus since I played kendhang.” | 7  | 1       | 0.35            | 277      | -2.70    | .007     | -0.79         | 366      | 1.83     | .067     | -0.68          | 381      | 2.60     | .009     |
|           |                     |                                                                                                | 22 | 0       | -0.32           |          |          |          | .048          |          |          |          | .56            |          |          |          |
|           | Repetition          | “The piece is long though with many sections and repeats”                                      | 7  | 1       | -0.15           | 304      | -1.33    | .185     | -0.35         | 364      | 1.73     | .083     | -.30           | 375      | -2.29    | .022     |
|           |                     |                                                                                                | 22 | 0       | -0.32           |          |          |          | 0.48          |          |          |          | .66            |          |          |          |
|           | Familiarity         | “I probably lost track of time because Gambirsawit is another piece that I know well”          | 7  | 1       | -0.33           | 345      | 0.76     | .444     | 0.65          | 316      | -0.71    | .476     | 0.81           | 302      | -1.43    | .154     |
|           |                     |                                                                                                | 22 | 0       | -0.24           |          |          |          | -0.01         |          |          |          | 0.04           |          |          |          |

**Table 16.**

(Continued)

| Condition              | Code                      | Exemplar quote                                                                                         | N  | Present | Time distortion |          |          |          | Absorption |          |          |          | Interaction |          |          |          |
|------------------------|---------------------------|--------------------------------------------------------------------------------------------------------|----|---------|-----------------|----------|----------|----------|------------|----------|----------|----------|-------------|----------|----------|----------|
|                        |                           |                                                                                                        |    |         | <i>Mdn</i>      | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i> | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i>  | <i>W</i> | <i>z</i> | <i>p</i> |
| Notated<br>(continued) | Instrument                | “When I play the <i>suling</i> I do                                                                    | 7  | 1       | -0.10           | 297.5    | -1.66    | .098     | -.18       | 341      | 0.56     | .575     | .70         | 326      | -.20     | .838     |
|                        | Role                      | struggle with time because it is out of sync that the notes are played”                                | 22 | 0       | -0.31           |          |          |          | .27        |          |          |          | .08         |          |          |          |
|                        | Prior awareness           | “Usually when we play it, it clocks in around the three-minute mark”                                   | 6  | 1       | 0.15            | 306.5    | -2.074   | .038     | 0.24       | 347      | 0.11     | .914     | 0.32        | 349      | 0.22     | .829     |
|                        |                           |                                                                                                        | 23 | 0       | -0.31           |          |          |          | 0.08       |          |          |          | 0.10        |          |          |          |
|                        |                           |                                                                                                        |    |         |                 |          |          |          |            |          |          |          |             |          |          |          |
|                        |                           |                                                                                                        |    |         |                 |          |          |          |            |          |          |          |             |          |          |          |
| Memorised              | Familiarity               | “This is a piece I am familiar with, and I really enjoy playing it”                                    | 16 | 1       | -0.17           | 204      | 1.39     | .163     | 0.41       | 165.5    | -0.39    | .693     | 0.53        | 175.5    | 0.07     | .944     |
|                        |                           |                                                                                                        | 12 | 0       | -0.08           |          |          |          | 0.06       |          |          |          | 0.36        |          |          |          |
|                        | Prior awareness of timing | “I had recently timed the piece for our concert, so knew roughly how long it was (cheating, really!).” | 12 | 1       | -0.12           | 223      | -0.42    | .676     | 0.33       | 232      | 0        | 1        | 0.56        | 247      | 0.70     | .486     |
|                        |                           |                                                                                                        | 16 | 0       | -0.24           |          |          |          | 0.13       |          |          |          | 0.43        |          |          |          |
|                        | Optimal challenge         | “I didn't experience any difficulties and was aware of everyone's part”                                | 10 | 1       | -0.42           | 321      | 2.88     | .004     | 0.60       | 224.5    | -1.75    | .080     | 0.64        | 232.5    | -1.37    | .172     |
|                        |                           |                                                                                                        | 18 | 0       | -0.03           |          |          |          | -0.01      |          |          |          | 0.36        |          |          |          |
|                        |                           |                                                                                                        |    |         |                 |          |          |          |            |          |          |          |             |          |          |          |
|                        |                           |                                                                                                        |    |         |                 |          |          |          |            |          |          |          |             |          |          |          |



**Table 16.**

(Continued)

| Condition                | Code                                  | Exemplar quote                                                                                                                                   | N  | Present | Time distortion |          |          |          | Absorption |          |          |          | Interaction |          |          |          |
|--------------------------|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----|---------|-----------------|----------|----------|----------|------------|----------|----------|----------|-------------|----------|----------|----------|
|                          |                                       |                                                                                                                                                  |    |         | <i>Mdn</i>      | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i> | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i>  | <i>W</i> | <i>z</i> | <i>p</i> |
| Memorised<br>(continued) | Repetition<br>and structure           | “My part was very simple<br>indeed and repetitive, just<br>goes round and round so I<br>wasn't thinking so much<br>about it.”                    | 9  | 1       | -0.31           | 293.5    | 0.89     | .375     | 0.62       | 273.5    | -0.10    | .922     | 0.59        | 250.5    | -1.23    | .219     |
|                          |                                       |                                                                                                                                                  | 19 | 0       | -0.12           |          |          |          | 0.20       |          |          |          | 0.46        |          |          |          |
|                          | Excessive<br>attention                | “I had a task that involved a<br>high level of concentration,<br>memory and decision-<br>making, so my mind was very<br>active.”                 | 6  | 1       | 0.22            | 284      | -1.96    | .049     | -0.14      | 331.5    | 0.70     | .484     | -0.08       | 345.5    | 1.48     | .138     |
|                          |                                       |                                                                                                                                                  | 22 | 0       | -0.24           |          |          |          | 0.41       |          |          |          | 0.56        |          |          |          |
| Improvised <sup>a</sup>  | Lack of<br>direction and<br>structure | “I didn't know what to do ...<br>the whole time I was waiting<br>for the next part of the<br>process”                                            | 19 | 1       | -0.13           | 295      | -0.24    | .813     | -0.13      | 297      | 1.06     | .290     | -0.36       | 299      | 1.16     | .248     |
|                          |                                       |                                                                                                                                                  | 10 | 0       | -0.16           |          |          |          | 0.20       |          |          |          | -0.04       |          |          |          |
|                          | Active<br>Engagement                  | “I was deliberately more<br>active in the piece (I played<br>the <i>gong</i> , therefore in the<br>previous ones my activities<br>were limited)” | 9  | 1       | -0.18           | 303      | 0.83     | .408     | 0.06       | 256      | -0.24    | .811     | -0.18       | 263      | 0.10     | .924     |
|                          |                                       |                                                                                                                                                  | 20 | 0       | -0.09           |          |          |          | 0.04       |          |          |          | -0.35       |          |          |          |

**Table 16.**

(Continued)

| Condition                              | Code                     | Exemplar quote                                                                                                   | N  | Present | Time distortion |          |          |          | Absorption |          |          |          | Interaction |          |          |          |
|----------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------|----|---------|-----------------|----------|----------|----------|------------|----------|----------|----------|-------------|----------|----------|----------|
|                                        |                          |                                                                                                                  |    |         | <i>Mdn</i>      | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i> | <i>W</i> | <i>z</i> | <i>p</i> | <i>Mdn</i>  | <i>W</i> | <i>z</i> | <i>p</i> |
| Improvised <sup>a</sup><br>(continued) | Enjoyment                | “I was quite enjoying the improv, so it felt like it was over very quickly”                                      | 8  | 1       | -0.23           | 326      | 0.54     | .591     | 0.70       | 242      | -2.44    | .015     | 0.16        | 249      | -2.09    | .037     |
|                                        |                          |                                                                                                                  | 21 | 0       | -0.13           |          |          |          | -0.10      |          |          |          | -0.36       |          |          |          |
|                                        | Unfamiliarity            | “We have never played like this before in this group so we were very unaware of how we would all play together.” | 8  | 1       | -0.06           | 283.5    | -1.54    | .124     | -0.38      | 307      | 0.86     | .387     | -0.81       | 310      | 1.02     | .309     |
|                                        |                          |                                                                                                                  | 21 | 0       | -0.26           |          |          |          | 0.15       |          |          |          | -0.23       |          |          |          |
|                                        | Listening and responding | “My attention was so fixed on observing what others do and what I could contribute to the music”                 | 7  | 1       | -0.26           | 339.5    | 0.49     | .628     | 0.74       | 270      | -1.83    | .067     | -0.33       | 294      | -0.56    | .578     |
|                                        |                          |                                                                                                                  | 22 | 0       | -0.13           |          |          |          | -0.08      |          |          |          | -0.34       |          |          |          |

<sup>a</sup> **Note:** For the improvised condition, one less observation was available for the *Absorption* and *Interaction* factors due to missing data during the factor analysis. While there were 29 overall (28 in the 815 memorised condition due to one participant leaving early), 1 less absent code than stated is the case for IF results in the improvisation.

Within the notated condition, those who remarked that their parts require *excessive attention* levels seemed to significantly overestimate the time passed and were significantly more likely, alongside those who commented on *repetition*, to have had lower *Interaction* scores. Lower *Absorption* scores may have also related to both codes, however they did not reach the significance threshold. Participants who noted they had *prior awareness* of the amount of time a piece may have taken to play tended to significantly overestimate the amount of time. For comments related to *enjoyment*, the median of *Absorption* was greater than for those who did not report any enjoyable aspects, though this did not meet the significance threshold.

Regarding the memorised condition, the only finding that reached the significance threshold was for the *optimal challenge* code, whereby participants who commented on ideas relating to having a manageable task for their ability level underestimated the amount of time that had passed. While not meeting the significance threshold, the median *Absorption* score for these participants was also greater than for those where this code was not present. Similarly to the notated condition, participants who reported feeling they had held *excessive attention* levels may have overestimated the time passed on average, though this did not meet the significance threshold.

Few significant findings emerged in the improvised condition. Participants whose comments related to *enjoyment* reported significantly higher *Absorption* and *Interaction* during the experiment. Players who made attempts at *listening and responding* to others throughout the improvisation reported higher absorption on average, both compared to those for whom the codes were not present, although this did not meet significance.

## **Chapter 10. Study 3.1 and 3.2: Discussion<sup>17</sup>**

In these studies, an analysis of qualitative perspectives alongside quantitative data was provided. The primary aims were to understand how the subjective temporal effects of shared flow are experienced in the context of gamelan performance and participants' awareness of the factors that influence such effects. Gamelan is arguably under-researched in music sciences, and as an inherently group-based musical setting, it provides the optimal conditions in which shared flow can arise and be studied. While this research is novel in this context, it also presents, seemingly the first empirical enquiry into the temporal effects of shared flow in general.

### **10.1 Participants' understandings of shared flow, subjective experiences of time, and influencing conditions**

Through the qualitative findings in Study 3.1, the subjective temporal effects of flow seem to be common knowledge among participants, although a distorted sense of time was often treated as an outcome resulting from flow, rather than an experiential quality of flow itself. Flow was understood to be a state of complete absorption, whereby one loses a sense of self, is optimally challenged, and as a result, loses a sense of time. Following these preliminary definitions, participants felt that no explicit distinction could be made between shared flow and individual flow in the context of gamelan, as by definition, success depends on the group. Moments where participants commented on feeling as though they had entered an individual sense of flow, particularly in the improvisation, seemingly coincided with moments where they felt detached from the group.

The conditions for subjective temporal distortion appear to be similar to that of shared flow; a middle ground between boredom and challenge, but also between novelty and experience. As anticipated, many participants felt that assigning a numerical value to an estimate of how much time they felt had passed was arbitrary and that they rarely

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<sup>17</sup> The discussion section of an article based on this chapter, entitled "Flowing between gongs: mixed-methods insights into shared flow and temporal distortion in music performance" (Gibbs & Schiavio, 2025b).

paid any attention to how long a piece took in minutes and seconds. For some, they stated it was a complete guess. For others, their estimates were based on cyclical patterns within the structure and the tempo underlying it, or on several occasions, prior knowledge of how much time a particular piece takes to play through based on timing for concert programming. While some participants believed that those with prior knowledge of timing pieces and an understanding of temporal structures would be more accurate in their estimates, the analyses of Study 3.2 demonstrated that this was not the case. Perhaps what is instead supported is the presence of a pace-maker accumulator model or internal clock (Macar et al., 1994; Zakay et al., 1983) or neural basis for the perception and estimation (Buhusi & Meck, 2005; Merchant et al., 2013), each affected by levels of arousal and attention. Even where participants felt that little could be gained from their estimations, this previous work seems to support deeper subconscious mechanisms that may have informed them.

## **10.2 The influence of metric density and musical expertise, and dichotomous subjective temporal effects of shared flow**

Using a linear mixed effects model, three key findings are acknowledged. Firstly, the subjective experience of time appeared to contract more for those with greater levels of musical training. Possible explanations for this are merely speculative but could have to do with greater familiarity with the material and increased potential challenge-skill balance, which has been shown to also relate to time flying in flow-related studies (Hancock et al., 2019). Secondly, the experience of time flying was felt more for those playing structural instruments compared to the more metrically dense *balungan* or solo lines. This result was not surprising, and in fact, supports previous work related to the effect of metrical hierarchy, reduced cognitive load, and associated temporal effects (Merker, 2017; Wöllner & Hammerschmidt, 2021).

Thirdly, and perhaps one of the most fascinating revelations from the quantitative analysis, was a distinction between the relationship between time distortion and the two Interactive Flow (IF) factors assessed in this study. The first factor, *Interaction*, which encompassed the more responsive and active elements of shared flow, seemed to present a negative relationship with measures of subjective time distortion and

resulted in perceived time contracting. In turn, this effect was significantly stronger in the notated condition compared to others, potentially reflective of the importance of having clear goals for achieving shared flow (Hart & Di Blasi, 2015). Conversely, *Absorption*, relating to the more affectual and absorbing qualities of shared flow, and curiously, an item related to time “flying by”, both presented positive relationships with time distortion, resulting in a feeling of more time passing than actual. One potential reason, though purely conjecture, could be that the *Absorption* factor is related more to feelings of individual flow. In focus groups this was discussed as leading to a lack of communication and concern for the group, aligning with the possibility of a mismatch between individual and group intentions (Cochrane, 2017). While all items were worded with the use of plural pronouns, the *Absorption* factor seemed to most strongly encompass items that would be felt individually. Another theory this finding may lend support to is that shared flow may be experienced differently in accordance with the level of interaction, attention, and self-other overlap present (Hackert et al., 2022). Further research is certainly needed to explore this possibility, and while one intention was to account for multiple facets encompassing shared flow using the Interactive Flow Questionnaire used in this paper (Raettig & Weger, 2018), its original factor structure was not an admissible fit for the observed data. As a result, the ability to assess the multi-dimensionality of shared flow was limited. A suggestion is that future studies adopt a range of scales and methods, as was the aim here, to try and understand how best shared flow experiences can be reported and measured.

Nevertheless, this study is the first to my knowledge to evidence a difference in how subjective experiences of time differ according to the type of shared flow that is experienced. Where others before assessed the relationship between flow and the perception of time based on a singular measure of flow (Im & Varma, 2018; Rutrecht et al., 2021; Saiki & Inoue, 2011), this research supports the view that the temporal effects of flow are multi-faceted and complex, and should be treated as such.

### 10.3 Attributed reasons for temporal distortion, and associated shared flow effects

Contrary to the old adage, “time flies when you’re having fun”, and prior work supporting this (Gable & Poole, 2012; Pageau & Sorgan, 2015), no significant relationship was found between those who attributed their durational estimates to enjoyment in the notated, nor improvised conditions. However, enjoyment in the improvisation did seem to be associated with higher levels of both IF Absorption and IF Interaction, and it seems that those who did enjoy the improvisation were far less vocal about it in the focus groups. Rather, many participants discussed the improvisation as one they enjoyed the least and in turn least identified with the concept of shared flow. This typically was attributed to having unclear goals, especially in comparison to that of the traditional pieces. In follow-up surveys, reasons for time estimates coded as lack of structure and direction, in fact, had no significant relationship with time distortion, nor IF factors. Nevertheless, participants who perhaps felt overwhelmed by their parts in the traditional pieces may have found the improvisation a welcome respite.

Attention and optimal challenge are frequently cited as defining characteristics of flow (Csikszentmihalyi & Csikszentmihalyi, 1988; Fullagar et al., 2013), whether individual or shared (Hackert et al., 2022), and in turn temporal contraction (Im & Varma, 2018). Mixed methods findings reported in 3.2 support this, where reasons coded as optimal challenge in the memorised condition were significantly negatively correlated with temporal contraction. At the other end of the spectrum, participants who commented on feeling excessively challenged, or felt they had to focus very intensely, seemed to be significantly more likely to have reported an overestimation of time. In focus groups, several commented on the repetitive and cyclical elements of gamelan to be something that would encourage shared flow, but a negative relationship was observed between those who attributed their time estimates to repetition and the *Interaction* factor. In these instances, players may have felt under-challenged, bored or lost focus. Not only is this finding in keeping with flow theory, it also echoes the theories of Locke and Reid (Whitrow, 1980), and ideas of complexity in music listening (Knowles, 2022).

The findings also may lend support towards the effects of directing attention towards time in music listening (Knowles, 2022). Many in focus groups also remarked that they estimated durations based on their previous knowledge of the length of pieces and general structural durations, and accordingly, assumptions were made that the estimates of said players would be more accurate. However, in the notated condition, this code seemed to be associated with an overestimation of time, and players noted feeling surprised at the misalignment between perceived and objective time. These players may have experienced such slowing of time due to their attentional resources being directed towards time, especially where they were providing estimates in the second or third condition and were anticipating the question (Im & Varma, 2018).

It is also worth highlighting that a key distinction between the findings of the focus group discussions in Study 3.1 and the findings of the follow-up surveys in Study 3.2 may be a result of potential differences between reasoning gained through speculation and elicitation, as was a key distinction in the methods. Just as methods of retrospective estimation or reproduction of timings seemingly rely on differing cognitive processes (Block & Gruber, 2014), so too might participants' views of what may influence time distortion vary in accordance with elicitation techniques or anticipatory reasoning. While observing how the reasoning of participants may differ based on methodological distinctions was not the focus of this research, this possibility arose through the course of the analysis. Future studies may certainly wish to assess differences in reasoning under separate paradigms.

It is still unclear whether flow leads to temporal distortion, or the other way around; or if such causality bears any significance. More controlled experimental designs could seek to address this by manipulating flow-related factors – such as challenge-skill balance - across a set of conditions and measuring perceived durational estimates after each condition. However, this does run the risk of reducing flow to a unidimensional phenomenon and is unlikely to be feasible in naturalistic settings.

## **10.4 Limitations**

Despite the efforts made to maintain the naturalistic setting, inevitably the experimental context had several implications that were highlighted by participants as



detracting from their usual experience. One such aspect was a lack of vocals. As one endeavour of the research involved collecting physiological data, they had been asked to omit vocals from any pieces they selected, so as not to create confounds in the signals. For less experienced groups in the West, this is less of an oddity, as it is common for pieces to be rehearsed and learnt almost entirely without vocals. However, for more advanced players, particularly those who have spent time in Java such as those in SBGP, vocals become much more prevalent, and at the forefront of much *karawitan*.

Several limitations arose with regard to the measures used. Firstly, as acknowledged by Im and Varma (2018), when durational judgements are provided in a repeated-measures study, participants may treat prior estimates as an anchor towards their subsequent estimates. This confound was intended to be circumvented by allowing groups to decide on the order of pieces they chose, and requesting they not look through the questionnaire before starting so they were not aware they would be asked how much time they thought had passed for the first condition at least. Regardless, three out of four groups decided to end with the improvisation, which may have influenced their temporal judgement in comparing pieces they had prior structural awareness of, with something that was completely unstructured.

Secondly, a similar limitation to that of Study 1 (chapter 4) arose with regard to the pre- and post-measures of Raettig and Weger's IF questionnaire (2018), designed to measure flow antecedents. These were only completed once in an effort not to overwhelm participants with the amount of questionnaire items they were required to complete. As a result, any difference in antecedents related to each individual condition, particularly with regard to competencies, were not accounted for.

Thirdly, the use of the Gold-MSI musical training subscale (Müllensiefen et al., 2014) was commented on several times by our participants as not reflecting the type of musical expertise they had with gamelan playing. One such item that caused some confusion was regarding how many instruments they played; as gamelan encompasses many different instruments, some participants chose to define all gamelan as one instrument, while others considered each gamelan instrument separately. Further to this, one may not spend hours of individual practice time with a gamelan instrument as

one would with Western instruments, as it is only in the context of the group that some parts can be fully realised. For these reasons, this method of gaining data on musical expertise may not be fully appropriate in contexts outside of the Western musical tradition. As much of the groundwork in music psychology surrounds Western music (Jacoby et al., 2020), this limitation highlights the potential drawbacks of incorporating measures that have been validated with such a WEIRD (Western, Educated, Industrialised, Rich, and Democratic) focus. Of course, the participant pool in this research was largely Western even if the musical focus was not, and the consequence of the use of such a measure both in non-Western musical contexts and with non-Western participants could be all the more stark (Henrich et al., 2010).

## **10.5 Conclusion**

So, how do musicians experience time when in shared flow? While typically characterised by feelings of time flying, in these studies a far more complex picture of flow-related temporal effects has been unearthed. It is true that temporal expansion and contraction may both relate to flow, but seemingly this entirely depends on the type of flow one is experiencing. The more active, and *interactive* qualities do seem to lend themselves to time flying, while the more absorbing, perhaps even individualised aspects of flow do not. Of course, many factors may influence time in the same way they influence flow; challenge, arousal, and attention to name a few. All the while, this study has also shown that the influence of each is a middle ground, akin to the inverted U-shape that flow is famous for, or indeed, to early philosophical accounts and findings related to music-listening experiences. This study has shown how a quantitative measure of perceived time may be useful to understand the effects of flow, though little can be concluded through this alone. Future research may benefit from incorporating such a measure alongside self-reports and other methods to understand how truly interactive states of shared flow may differ from states that may be more individually experienced.

## **Chapter 11. General discussion and limitations**

The overriding objective of this thesis has been to address a fascinating puzzle in shared flow research; that of how the experience of the group in relation to flow can be best captured and measured empirically, and how this can contribute to a richer understanding of the concept of flow. In doing so, my aims have been not only to seek methodological improvements but also conceptual clarity. Throughout the literature review (chapter 2) and discussion of methods (chapter 3), it became apparent that previous empirical and theoretical research into the phenomenon of shared flow has been limited in its focus on individual units of analysis, as opposed to that of the group. Furthermore, in reviewing some of the theories relating to musical interaction in the gamelan ensemble, the ways in which it is a fertile environment for shared flow to arise were revealed. Each study devised from these notions dealt with its own, more specific research questions, reflecting the multi-faceted nature of gamelan and the multidisciplinary paradigm in which this thesis was rooted.

### **11.1 Summary of empirical studies**

Study 1 (chapter 4) provided a preliminary investigation towards the potential for measures of physiological synchrony (intersubject correlation of skin conductance and heart rate, ISC-SC and ISC-HR) to be reflective of the group-level aspects of interaction underlying self-reported shared flow (Zumeta, Basabe, et al., 2016). Two performance contexts and two levels of expertise were accounted for, in which both a group of experienced gamelan players and complete beginners performed a free improvisation and a piece of pre-composed traditional gamelan music. The research questions addressed were: 1) whether the Shared Flow Scale in gamelan playing was valid and reliable in its proposed factor structure; 2) whether there was a difference in significantly correlated windows of physiological synchrony between participants across expertise groups and conditions; 3) to determine how self-reported shared flow relates to average physiological synchrony in traditional and improvised playing.

As new theories emerged in the midst of this research, the guiding methodologies and theories were adapted accordingly in chapter 5, by means of an expansion to the underlying theory of a taxonomic view of shared flow states (Hackert et al., 2022;

Raettig & Weger, 2018), and through incorporating the additional variable of time perception. Subsequently, chapter 6 presented a revised procedure, in which these methodological advances were investigated in three distinct, but related studies.

Study 2 (chapter 7) extended the ambitions of Study 1 in multiple ways, with several fundamental improvements. The Shared Flow Scale (SFS) (Zumeta, Basabe, et al., 2016), was substituted for the Interactive Flow (IF) Questionnaire (Raettig & Weger, 2018), due to the use of the former suggesting a lower-order factor structure, and convincing clarifications to the theory underlying the latter (Hackert et al., 2022). More specifically, the clarifications suggested that differences between types of flow, including individual flow, “shared interactive flow”, and an emergent “group flow” may be distinguished taxonomically, in accordance with factors of self-other overlap, joint attention, and social interaction. The Inclusion of Other in the Self Scale (IOS) (Aron et al., 1992) was therefore incorporated as representative of the first. Meanwhile, joint attention and social interaction were captured from a more external perspective, delving beyond individual units of analysis towards measures of shared physiology and shared time. Study 2 explored the following research questions: 1) whether there is a positive correlation between self-reported shared flow and the IOS; 2) how self-reported shared flow may be associated with both shared time and shared physiology; 3) whether the level of joint attention and social interaction underlying shared flow as a result of condition and musical expertise be capturable via methodological triangulation.

The procedure surrounding the inter-subject correlation of physiological measurement largely stayed consistent, while a novel measure of a consensus of time distortion was incorporated. Its inclusion was intended to represent the potential for a shared sense of time to stem from the level of interaction that would be expected from the highest degrees of shared flow, as well as previous findings suggesting a contagious aspect of time perception (Chambon et al., 2008; Conway III, 2004; Droit-Volet & Gil, 2009; Efron et al., 2006).

In addition to these adaptations in measurement, some other confounds of the previous study were considered. The first of these was its sample pool. Four pre-existing groups of varying ability participated in Study 2, Study 3.1 and Study 3.2,

overcoming the confound of familiarity underlying the differences between the beginner and advanced groups of Study 1. In this, the beginner group was formed only for the purpose of the study. Contrarily, the four groups taking part in the subsequent studies still varied in ability and expertise but were at least somewhat familiar with the intricacies of their own group dynamics.

The second confound was in the extent to which participants relied on their notation, revealed in hindsight when considering the experimental design of Study 1. Indeed, members of the purpose-built beginner group were taught a traditional piece of gamelan music in the workshop aurally, while members of the advanced group varied in their choice of using notation or not. Several more experienced gamelan players were familiar enough with the music or with their *cengkok* and *garap*, that they felt no need to use notation. Instead, they relied on recognisable cues provided by other instruments and embedded in the structures. The processes of listening and responding to the rest of the group, and in turn, the fundamental interaction that should be present for shared flow to arise, may have been far more overt for them. That is, in comparison with others who were simply playing their parts as accurately as possible while immersed in their notation. This was particularly the case where players were assigned to instrumental parts that were unfamiliar to them as fundamental roles needed to be filled for the purposes of the study.

For this reason, the traditional performance condition was split into two for the subsequent studies. Groups were asked to play a piece from memory that they were well acquainted with, as well as a piece from notation. The latter was in some cases a piece that was still in the process of becoming familiar, or in the case of a highly skilled group, was a piece that most of the group was quite unfamiliar with, and yet possessed enough knowledge of how comparable pieces work that they were able to *garap* with little preparation. The intention here was to more explicitly account for this difference in where attention was directed, at least in comparison to the first study.

Where Study 2 (chapter 7) maintained the focus of physiological synchrony potentially underlying shared flow and incorporated a measure of shared time to complement this, both Studies 3.1 and 3.2 (chapters 8 and 9) homed in on the experience of time distortion underlying shared flow and the antecedents and necessitating influences

that underlie each. Time perception in Study 2 was analysed in terms of the group, in how closely aligned a member's reported passing of time was to the average of their group in an absolute manner. Studies 3.1 and 3.2 instead turned towards the directionality of this and whether temporal expansion or contraction may arise during shared flow. Doing so bridged a gap in previous research, whereby little attention has been given to the specificities of time perception in shared flow, and instead a general sense of time distortion is treated as a given (Tay et al., 2021).

Study 3.1 (chapter 8) involved a thematic analysis of the focus group interviews which took place after performances with each group. The purpose of this was to dissect participants' understanding of shared flow and their perception of time, and the factors they could attribute to influencing each. Findings informed the quantitative analysis of Study 3.2 (chapter 9), whereby variables that were related to attributions put forward by participants - including the level of musical expertise, experience with gamelan, instrumental parts, performance condition, and shared flow factors - were used to predict perceived time distortion. Finally, the study turned towards personalised follow-up surveys, which required participants to explain potential causes for their estimates by providing them with their reported judgements in comparison to the recorded length of time. Through a similar approach in thematic analysis to that of the focus groups, themes were correlated with self-reported shared flow factors and perceived time distortion, in order to determine potential antecedents, influences and obstructions of each.

Regardless of the flexibility of this thesis' methodological toolbox, and the plethora of measures that have been explored, the key underlying aims guiding this research remained the same. To re-iterate here, these were as follows:

- 1) To determine the most appropriate methodologies in assessing shared flow, going beyond individualistic self-reports.
- 2) To understand the implications of differing performance contexts to the experience of shared flow.
- 3) To assess the influence of expertise or musical training in how shared flow is captured.

- 4) To provide conceptual clarity to the notion of shared flow and its application towards a range of contexts.

The findings of each chapter are summarised under the bracket of each overarching aim below, in order to better synthesise and contextualise the richness of this thesis overall without repeating the discussion of previous chapters.

## **11.2 Determining the most appropriate methodologies**

As mentioned in the previous chapter, a scale to measure shared experiences of flow that applies to multiple contexts still seems to be lacking. While Zumeta and colleagues' Shared Flow Scale was originally selected for the first study (chapter 4) for the reason of its validation in both sports and creative contexts (Zumeta, Basabe, et al., 2016; Zumeta, Oriol, et al., 2016), it still appeared to fall short. In hindsight it perhaps was better representative of individual flow experiences within group contexts, lacking any further dimensions of shared flow that do not arise without interaction (Hackert et al., 2022). The incorporation of physiological measures was adopted to fulfil this lack, yet the factor analyses indicated a mismatch between the most optimally fitting structure and the theorised dimensions of the scale.

Substituting the Shared Flow Scale for the Interactive Flow Scale (Raettig & Weger, 2018) in subsequent studies aimed to resolve some of the previous issues. The proposed structure was simpler, meaning it may have still converged with a smaller sample. However, as with the factor solution of the Shared Flow Scale, the proposed factor structure did not align with the resulting solution, and the factors of this solution were not clearly defined. One possible recommendation could be to validate a scale that adheres to a dedicated theory of shared flow across multiple domains, however, it may also be the case that different conceptions of shared flow and the level of interaction it pertains to may be appropriate in different contexts. In any case, it has been emphasised that the use of self-reports in the study of shared flow should be treated as a starting point in triangulation, rather than as a means to an end.

In line with Hackert and colleagues' taxonomy (2022), the IOS (Aron et al., 1992) was incorporated as a means to represent the varying levels of self-other overlap that may underlie differences in types of flow. While it was found to correlate with self-reports

and shared flow, in line with the proposal that the highest degree of shared flow may encompass the highest degree of self-other overlap, it appeared to be narrow and static. Part of this was a limitation of the 7-point Likert scale variant used, adopted due to the use of paper questionnaires; instead, other online studies have implemented a sliding-scale version with many more increments (Kempf et al., 2024; Stupacher et al., 2020, 2022). Nevertheless, in aiming to capture some of the group-level mechanisms of flow, self-reports are limited in themselves.

The interactive qualities of shared flow, potentially uncapturable by self-reports alone, were first aimed to be captured by correlating self-reports with physiological measures related to the autonomic nervous system (ANS). Both heart rate (HR) (Jha et al., 2022; Keller et al., 2011; Tozman et al., 2015) and skin conductance (SC) (Bian et al., 2016; Tian et al., 2017) have been related to flow states in previous research, typically interpreted as a co-activation of both sympathetic and parasympathetic ANS branches. Meanwhile, the synchrony of HR between participants has been shown to be reflective of the coordination of action (Gordon et al., 2020; Noy et al., 2015), joint processing of stimuli (Czepiel et al., 2024; Madsen & Parra, 2022; Pérez et al., 2021), and group cohesion (Tomashin et al., 2022). Less attention has been paid to the synchrony of SC, however, this was incorporated as a measure potentially indicative of group-level cooperation, stress, arousal, planning, and execution (Dean & Bailes, 2015; Tian et al., 2017; Vanutelli et al., 2017). Physiological synchrony was calculated using inter-subject correlation (ISC), due to its robustness to noise and ecologically valid research designs (Czepiel et al., 2021; Dauer et al., 2021).

Findings surrounding physiological synchrony throughout the studies presented in this thesis were somewhat ambiguous. In Study 1,  $ISC-HR_{mean}$  was positively and significantly correlated with both shared flow factors of *Awareness* and *Absorption*, while with  $ISC-SC_{mean}$  the effect was only significant for *Awareness*. However, accounting for differences in performance conditions seemed to influence the direction of these effects. Of course, a prominent methodological limitation that may have had consequences for the interpretation of contextual differences is that the self-report was only completed once and reflected participants' experiences of shared flow following the performances of both improvised and traditional pieces. Therefore, in the



procedure that Studies 2, 3.1 and 3.2 were based on, self-reported shared flow was collected following each condition.

In Study 2, greater clarity was obtained on the potential for shared flow and physiological synchrony to be associated. For ISC-HR and shared flow factors, positive associations were dependent on levels of musical training, and performance contexts, as were negative correlations between shared flow factors and ISC-SC, which are discussed further in 11.3 and 11.4. Yet perhaps the most novel contribution of this thesis was its attention on time perception.

Few studies on flow have looked towards the intricacies of time perception in ways more specific than mere statements of time flying (Hancock et al., 2019; Im & Varma, 2018; Rutrecht et al., 2021). Fewer still are those that have assessed the shared effects of time (Conway III, 2004), while attention towards experiences of time during musical performances is scarce. This is not surprising given its complexities. In studies of music listening, factors influencing the effects of time perception include metre and metric density, rhythmic complexity, and tempo (Hammerschmidt et al., 2021; Wang et al., 2024; Wöllner & Hammerschmidt, 2021). Meanwhile, time perception is strongly influenced by task difficulty (Block et al., 2010), and motor movement through an increased demand of attentional resources (Castellotti et al., 2022; D’Agostino et al., 2023). Musicians in a group performing a piece of music will likely experience effects of distorted time perception, albeit effects that may be difficult to trace in origin. Regardless, several bridges have been constructed in this thesis to surpass these gaps in both performance and shared flow research.

Initially, subjective time perception was analysed in terms of a “consensus” of time distortion in Study 2, in order to reveal whether the potential interaction that arises through experiences of flow can be captured by observing shared effects of time (Conway III, 2004). This was indeed found to be true, but only within the memorised condition. For both shared flow factors, a significantly negative effect was found, whereby higher self-reported flow was correlated with closer reports of time distortion to the average of the group for memorised performance. For this study, however, the directionality of such temporal distortion was not accounted for; instead, estimates of time were treated in an absolute manner.

Such directionality was therefore of primary focus in Studies 3.1 and 3.2. Factors such as metric density and expertise were found to have prominent implications for flow-related temporal effects, potentially as a result of metric hierarchy and cognitive load (Merker, 2017; Wöllner & Hammerschmidt, 2021). Furthermore, no significant relationship was found between reports of temporal contractions and attributions of enjoyment, counteracting the potential for “time flying when having fun”. Correlations between time distortion and IF factors were opposing between them. *Absorption* seemed to be associated with time expansion, while *Interaction* related more to time contraction. In opposition to previous studies that look at flow as a unidimensional phenomenon (Im & Varma, 2018) or that are unspecific in stating temporal effects (Hancock et al., 2019), this finding may suggest that the temporal effects of shared flow are as multi-faceted as flow itself.

In seeking the most appropriate and fruitful methodological design, attention was placed largely on undisruptive measures that are directly related to shared flow. Qualitative insights provide a valuable basis through which a theoretical understanding of shared flow and its components may be gained, from which mixed-methods explorations can start to empirically capture. Some of the most revealing findings on the mechanisms underlying flow itself, however, were acquired through methodological triangulation, in assessing the influence of multiple measures simultaneously on shared flow reports.

The selection of subjective time perception and physiological measures as methods for capturing shared flow experiences is not necessarily without issues. As discussed, while retrospective assessment is the most appropriate technique for determining subjective time perception in ensemble settings due to being less disruptive (Im & Varma, 2018; Wöllner & Hammerschmidt, 2021), they are subject to confounds of memory (Castellotti et al., 2022; Hammerschmidt et al., 2021), leading to implications for reliability. As subjective time perception is also influenced by emotion (Droit-Volet & Gil, 2009; Droit-Volet & Meck, 2007; Grommet et al., 2011), stress and complexity (Knowles, 2022), metric density (Hammerschmidt & Wöllner, 2020) and tempo (Hammerschmidt et al., 2021), these may have implications for construct validity in determining the degree to which estimations of time passing are actually associated

with shared flow. Further efforts to control for these parameters could be made in selecting pieces to compare that are similar in density and tempo, and accounting for emotional states in the building of mixed-effects models.

Similar issues arise with the selection of physiological measures, whereby difficulty was encountered throughout the experiments in acquiring accurate signals due to inference and noise. Loss of data may have had implications for the degree to which the analyses would be reproducible, which may have been overcome through the use of alternative sensors or physiological methods (Cusack et al., 2024; Williams et al., 2024). Furthermore, as has been noted, physiological synchrony may also have occurred through shared stress or excitement rather than shared flow.

In adapting the methods used in this thesis to other contexts, several considerations may need to be made. While measuring skin conductance via the foot was an optimal method in the context of gamelan where players are largely static and without footwear, this would likely be inappropriate for ensembles in which players stand or move. In this case, alternative measurement sites or devices should be considered. In addition, the procedure of interspersing performances with questionnaires suited the length of the *karawitan* selected by groups. However, in contexts where longer performances would be expected, such as orchestral symphonies, or where breaking up sessions would be more likely to disrupt the trajectory of flow, such as with jazz improvisations, less reliance on self-reports and more on external measures should be adopted.

### **11.3 Distinguishing between performance contexts**

Investigations of shared flow in music performance contexts typically focus on one particular context and rarely compare them. Social dynamics are likely variable between such contexts (Hadar & Rabinowitch, 2023), for instance between a free-flowing and unstructured group improvisation, and that of a pre-composed piece of *karawitan*. These performance contexts were treated as conditions in a within-subjects study design, whereby both participant groups performed in both conditions of improvised and pre-composed gamelan music in order to identify differences in shared flow experiences and their relationship with external measures of interaction.

Differences in performance contexts yielded differences in the relationship between external measures of interaction and internal measures of self-reported shared flow in every study. In Study 1, negative correlations were found between both ISC-SC and ISC-HR on at least a trend level in traditional performance, while positive correlations seemed to occur in improvised performance. A potential interpretation of this was given as a difference in the level of interaction underlying shared flow between conditions, lending support to the taxonomic theories of shared flow, initially posited by Raettig and Weger (2018), and expanded on by Hackert and colleagues (2022).

For the successive studies, Study 2, 3.1 and 3.2, the context of pre-composed music was further categorised. An unexpected confound within the first study was variation in the degree to which players relied on notation. This was especially the case with *Tukung* - a *gendhing* which is extensive in its structure and melodic material - which some of the more advanced players were able to perform without over-reliance on notation due to greater knowledge of the rule-based notions of gamelan performance. Such variation was theorised to have implications in terms of the degree to which players attended to the dynamics of the group, as they may have solely been focusing on playing their own part with a high degree of accuracy. In turn, any flow they may have experienced may have been individualistic, and easily disrupted if a structural cue was given earlier than they had expected. Distinctions between memorised and notated pre-composed music were therefore specified, yielding three performance “conditions” or contexts, as opposed to two.

The influence of conditions on the internal-external measurement relationship in Study 2 were in line with some of the initial findings of Study 1. Significant differences in the correlations between self-reported shared flow and external measures, this time in both physiological synchrony and consensus of time distortion, were found between the three contexts. Stark contrasts between memorised and notated performance were of particular importance, as these were not accounted for in Study 1. Particularly with regards to consensus of time distortion, the improvised and memorised conditions seemed similar in effect, although only the memorised was significant, owing to more clearly defined shared goals and shared structures. The notated condition instead may

have led to more individualistic attitudes, particularly for more novice-level players who were more conscious of making mistakes.

Study 3.1 and Study 3.2 showed that differing contexts of notated, memorised and improvised music had repercussions for temporal distortion, enjoyment, challenge, and attention, while significant differences between conditions were found for the *Interaction* shared flow factor, but not for *Absorption*. Furthermore, the implications of instrument type were highlighted by participants, which little thought was given to previously. Such implications seem to be intertwined with expertise and levels of challenge.

Other ensembles that are less likely to feature notated parts, such as that of Taiko drumming or Samba, may be valuable to study, particularly as their parts may be more easily memorisable. As such, memorised performances could allow for less focus on accurate recall, and more on rhythmic engagement, timing, and interpersonal synchrony, and leading to less uncertainty in the confounding factors that may underlie both temporal distortion and physiological synchrony.

## **11.4 The influence of expertise**

Entangled with ideas of contextual differences in performance is the influence of expertise. Much of Sawyer's writings on "group flow" are paralleled with ideas of "group genius", whereby such emergent states are only possible for the most skilled of groups (Sawyer, 2007, 2015). As a result, empirical works on flow and shared flow typically focus on experts (Cohen & Bodner, 2019; Panebianco-Warrens, 2014). Some work has explored the implications of expertise in individual flow contexts and has found qualitative differences in accordance with expertise (Antonini Philippe et al., 2022; Canham & Wiley, 2003). Nevertheless, something highlighted by Hart and Di Blasi (2015), as well as several theoretical frameworks of flow in collaborative contexts (Sawyer, 2007; van den Hout et al., 2018) is the need for homogeneity of expertise and high skill integration when it comes to shared flow. Shared flow may only be possible if groups have comparable levels of skill, which is to say it could occur in groups of comparably novice-level musicians as well as those of a similarly high standard, providing in both cases the task at hand is suitable for their ability.

This idea motivated one of the methodological design features of Study 1, whereby two groups of expertise participated in the study. A beginner group was formed on the day of the experiment and split into two experimental sessions for reasons of practicality. Meanwhile, the advanced group consisted of players who participated in the regularly-meeting resident gamelan group at the University of York. The findings presented some differences in proportions of significant ISCs between levels of expertise overall. ISC-SC proportions were greater for advanced players compared to beginners, while the opposite was the case for ISC-HR. Furthermore, proportions of significant ISC-SC between performance conditions were found to be opposing as a result of expertise. These findings were interpreted as potentially indicative of differences in physiological indices of required effort facilitating flow experience (Thissen et al., 2022) and a fluctuating sense of challenge in relation to arousal (Peifer et al., 2014; Tozman et al., 2015). Implications overall were that physiological indices could present a valuable measure of flow experiences in conjunction with a focus on expertise. Nevertheless, the influence of expertise on relationships between shared flow and physiological synchrony was not explored, and limitations of this study design necessitated that these findings be interpreted with caution.

One further implication of the expertise groups not accounted for in Study 1 was the level of familiarity group members had with each other. For Sawyer, this is fundamental in knowing and understanding group dynamics, behaviours and patterns in order to respond in the moment to one another, particularly in the case of improvisation (Sawyer, 2003). Where the more advanced group pre-dated the study and rehearsed together regularly, the beginner group was formed for the purposes of the study and prepared for the experimental proceedings by means of a two-hour workshop. For that reason, findings surrounding expertise in the first study may have been confounded by this factor, and further attempts to control this were made for the second and third studies. More specifically, all groups were pre-existing; they ranged to a degree in terms of how long they had been a part of the group and how often they rehearsed. Nevertheless, it was presumed that amongst all groups of Study 2, Studies 3.1 and 3.2, there would be some familiarity that could not plausibly exist in the beginner group of Study 1. Expertise was therefore accounted for on an individual basis by means of the

Gold-MSI musical training subscale, and the number of years they had been learning gamelan.

In Study 2, relationships between physiological synchrony and flow as a function of expertise were further revealed. Indeed, the direction of the effect between ISC-HR and shared flow was found to be largely dependent on levels of musical training. ISC-SC negatively correlated with shared flow consistently, but the strength of this was stronger for lower levels of musical training. Findings relating to HR may relate to a greater inclination to be mutually responsive to one another's actions. Meanwhile, the findings of SC may hark back to what Gordon and colleagues describe as "the dark side of synchronisation" (2020); such synchronisation may reflect a contagious nature of stress-invoked responses, which SC is often reflective of. Therefore, it could be plausible that ISC-SC reflects a lack of flow-related group cohesion, and instead, togetherness facilitated by negative attitudes, affects, and stress.

Finally, in Studies 3.1 and 3.2, subjective experiences of time appeared to contract more with greater levels of expertise, in line with some previous findings comparing novices and experts in flow-related time perception (Canham & Wiley, 2003). This was also interpreted as being representative of a greater challenge-skill balance achieved by those with greater levels of musical training, compared to those with lower levels of musical training who may have experienced stress. The influence of expertise is complex and difficult to ascertain in the context of ecologically valid studies. Variation in skill amongst a group is a natural occurrence, as is the degree to which individuals may vary in their familiarity with one another. Implications of this variation for the extent that highly skilled players would be able to experience shared flow are highly plausible, given the need to rely on other parts in order to realise their own. For instance, in case with *gender* and *rebab* which require greater dexterity, may rely on cues and signals from more straightforward *balungan* lines or instruments such as the *kenong* emphasising the *seleh*. Any errors in the more straightforward parts would likely have implications for the whole ensemble. Nevertheless, accounting for expertise overall, whether in a group-wise or individualistic manner, seems to provide valuable insights into the study of shared flow.

It is also worth noting here that Western understanding of musical expertise may have had little consequence for their ability to perform gamelan well. As noted by Haddon (2016), competency in gamelan is in acquiring a collectivist mindset, while Western musicality favours individual virtuosity. Adopting the methods used in this thesis in Indonesian groups of different levels may overcome this distinction of expertise. In turn, it may be possible for both lower-level gamelan groups, such as those in schools, to experience shared flow as equally as expertise groups, providing both are equipped with musical skills rooted in collectivism.

### **11.5 Providing conceptual clarity to the notion of shared flow and its application towards a range of contexts**

In striving to provide conceptual clarity to the phenomenon of shared flow, it is appropriate to explore this with concurrent conceptual and empirical lenses, to see how findings of empirical study may provide a new perspective. This thesis has adopted the view that components of shared flow may be akin to the original theories of Csikszentmihalyi (1990) with some dimensions re-imagined and incorporated to suit the setting of the group (Gaggioli et al., 2011; Raettig & Weger, 2018; Sawyer, 2003; van den Hout et al., 2018). Such re-imagining is necessary for dimensions which assume an individualistic experience, for example how a “loss of ego” or “loss of self-consciousness” may be better thought of as a “blending of egos”. The goal of this thesis has not necessarily been to challenge the existence and necessity of such dimensions. Instead, its focus has been on the assumption that, in accordance with most theories, there must be a strong degree of interaction and group cohesion underlying the highest level of shared flow, which is unmeasurable through individual perspectives alone.

However, there remains a question of whether it is possible to measure Sawyer's concept of an emergent “group flow”. This might be particularly challenging, due to his assertion that individuals are not all required to achieve individual flow for the group-level experience of flow to emerge (Sawyer, 2003). Some studies have assessed this using higher-order measures, such as employing shared energy levels (Gloor et al., 2013), though arguably this only assesses the co-ordinating and cohesive aspects of an emergent “group flow”. Hackert and colleagues suggested that it may be possible to



capture an emergent flow without individuals having experienced flow, by combining the reports of individuals through qualitative and quantitative means together with external measures (Hackert et al., 2022). External measures are indeed fundamental in grasping the subconscious and cohesive aspects of shared flow, as this thesis has aimed to do by means of shared physiology and shared time. Nevertheless, such measures are designed to reflect only the interactive and attention-joining aspects of shared flow. All theories summarised in 2.1.2 maintain that shared flow, regardless of terminological and contextual heterogeneity, is multi-faceted. Integral dimensions of a “group flow” such as clarity of goals and familiarity may not be possible to assess without internal perspectives.

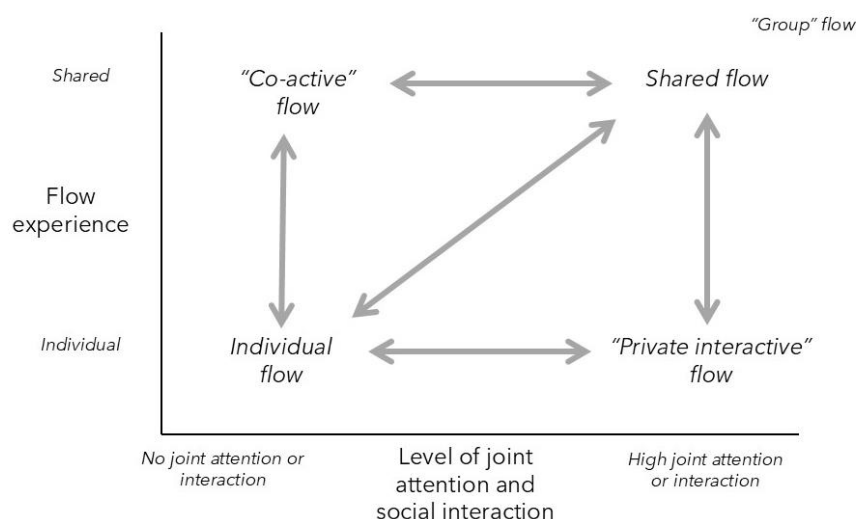
As the findings of the reported studies suggest, there are reasons to argue that such a phenomenon may not be sufficiently captured by external measures alone. Therefore, while the “group flow” that Sawyer conceived of may be used to describe the “magic” of a group, such a description may not be measurable empirically, akin to how scholars have been assessing individual flow states over the past few decades. Instead, it may pertain to an impenetrable force that scientific enquiry cannot resolve – for now. Many strides have been made over the past decade in determining how group behaviours, interactions and mechanisms can be studied, thanks to technological advances in measurement devices. As a result, it may be plausible for future studies to analyse the measures of shared time and shared physiology explored in this thesis, together with other external measures. One conceivable example is that of, EEG - which has been used in several studies on individual flow (Alameda et al., 2022; Katahira et al., 2018) - should there reach a point where it may be practical to monitor a group of musicians simultaneously. This may help to determine if there could be cognitive, physiological and neural patterns underlying “group flow” that may be distinct from individual flow experiences.

Alternatively, distinctions between types of individual and shared flow may be conceived taxonomically in accordance with factors representing self-other overlap, joint attention, and social interaction (Hackert et al., 2022; Raettig & Weger, 2018). As this thesis proposes, such a conception may in turn be examined by associating individual experiences with group-level mechanisms. Accordingly, shared flow is

realised as a property of this interplay. This begins with the assumption that the highest degree of shared flow does require at least the majority of individuals to be experiencing some sort of flow (van den Hout et al., 2018), contrary to the views of others who believe individual and shared experiences of flow are unconnected (de Moura Jr. & Porto Bellini, 2019). As one focus group participant put forward, “for everyone to be in a flow state, that does rely on individuals feeling that” (NCH, P6). The nature of shared flow arises from the level of interaction present amongst members of the group, which is the aspect measured from an external perspective. In this case, if self-reported flow is associated with measures of shared time and shared flow, members at the height of this interplay can be described as being in a state of shared flow. The stronger the effect, the closer that sense of shared flow may become to the emergent “group flow” state that Sawyer put forward (Sawyer, 2003). Alternatively, if members’ reports of flow negatively correlate with these indices of interaction, it can be assumed that there is a “co-active” flow present (Hackert et al., 2022); members of the group are flowing, but the level of interaction is negligible. **Figure 26** shows this hypothesised model of shared flow, based on the theories of Hackert and colleagues (2022) and Raettig and Weger (2018), yet re-imagined.

**Figure 26.**

*Hypothesised Model of Flow*



The terminology used throughout this thesis has largely settled on “shared flow” and “individual flow” respectively, unless explicitly referring to the theories of others. Motivating this decision was a desire to reduce complexities in codification. While other scholarly works have departed from the vocabulary of precursors as a result of contextual differences, the taxonomic theories have instead shed light on how flow might be conceptualised as distinguishable between the individual and the shared, based on the relationship between individual and external units of analysis. Ideas of “co-active” flow and “private interactive” flow may surround this relationship, but there is little need to form distinct definitions of them.

## **11.6 General limitations**

All studies are accompanied by their own set of limitations, many of which were not possible to overcome in the context of this thesis. Rather than repeat these, some of the most prominent general limitations that remained constant throughout this thesis are discussed and expanded on here.

First and foremost, the gamelan groups that participated in the set of studies presented here were all UK-based, and many of whom were British musicians. The potential for the studies to be reflective of gamelan in its native context is something this thesis cannot assume with any certainty. As opposed to many forms of Western instrumental learning, the focus of learning gamelan relies on collectivism as opposed to individual competencies (Diamond, 1979; Haddon, 2016). Therefore, as many of the musical backgrounds of the participants in these studies were of predominantly Western training, the mindset of collectivism that gamelan requires may not come as naturally as it might for natives. On a more general level, non-Western populations may be less individualistic in comparison to Westerners (Henrich et al., 2010), and therefore it may be fruitful to investigate shared flow experiences in non-Western paradigms.

Although differences in performance aimed to be accounted for through improvised or pre-composed music, one key aspect that was not captured or accounted for was that of the setting. It is conceivable that flow may be experienced in practice just as it is in concert performances, although whether these experiences may differ is something that was beyond the scope here. A multitude of variables were introduced, with the aim

of understanding the nature of shared flow from a variety of perspectives. Nevertheless, particularly with Studies 2, 3.1 and 3.2 (chapters 6 to 10) groups seem to differ in terms of how much they rehearsed, the repertoire they tended to rehearse, and whether they were preparing for - or had just performed in - concerts. Most groups chose to practice while equipment was being set up, but flow experiences that may have occurred during this practice or the potential impact practice had on their performances were not examined.

Furthermore, although efforts were made to improve ecological validity by carrying out the study in their usual rehearsal spaces, the performances held with them a degree of pressure, set apart from how practice may have looked. A usual rehearsal may have come with some stopping and starting, for instance, if mistakes are made and the group wish to tackle difficult corners through repetition or conversation (Hill et al., 2018). In this case, they were asked to play pieces through from start to finish. The result was a performance that was more akin to a concert than a practice session, albeit with an audience of one.

A prevalent weakness of the empirical work in this thesis, which has been highlighted in conjunction with all quantitative work, is the small sample size. Consequently, much of the significance should be interpreted with caution, particularly within the linear mixed effects models. Linear mixed-effects models were a technique chosen for being well suited to the crossed and nested experimental design, and for their robustness to various violations of assumptions that would be expected of more traditional analyses, including ANOVAs and regressions (Schielzeth et al., 2020). Smaller samples, however, bring with them a set of convergence issues in how random effects and slopes may be fitted, which in turn introduces concerns with model validity (Meteyard & Davies, 2020). Instead of attempting to increase the sample pool, which would likely be unfeasible with a focus on gamelan groups limited in their capacity, alternative analytical approaches could be considered. For instance, the approach of recurrence quantification analysis, bootstrapping and paired samples t-tests adopted by Høffding and colleagues (2023) seemed effective on samples even smaller than those highlighted here.

With regards to the methodology, the use of the Shimmer EXG and GSR+ units was adopted out of convenience and feasibility. Issues emerged in every study with signal loss and noisy data, which is an inevitability if working with wires, disposable electrodes, and humans who move, fidget and change posture, as would be expected in music-making settings. The ever-evolving market of smart wearable devices may present alternative possibilities that could overcome many of the drawbacks of more traditional electrode-based methods of physiological measurement (Cusack et al., 2024), but their high cost meant this was not an avenue that this thesis could explore. Another area of innovation is in novel means of acquiring heart rate data through video; a cost-effective method which has been successfully demonstrated in the context of music listening (Williams et al., 2024). Future research should investigate whether such measures are feasible in the performance of music, where participants would not be static.

## Chapter 12. Implications and recommendations

Drawing on the findings of this thesis and the above discussion, five key implications and associated recommendations are made for future research endeavours.

### *1) Shared flow is beyond the sum of parts, but not separate from them*

It is difficult to envisage how Sawyer's conceptualisation of an emergent "group flow" may be anything more than just a concept. While metaphorical depictions of a group in flow having "chemistry" or "clicking" or being "in sync" are apt, they are loose tropes that cannot be captured empirically. Rather, as other authors put forward, such emergence may stem from the experiences of individuals, yet be distinct from them in quality and content (Raettig & Weger, 2018; Tay et al., 2021; Walker, 2010, 2021). Findings particularly from Studies 3.1 and 3.2 support this, where participants described going between individual and shared flow. Where they felt they fell too far into the former, they felt detached from the group; contrarily, where they felt shared flow may have arisen, this was felt individually but with the group dynamic at the forefront of their consideration.

One common approach in research on shared forms of flow is to subsume the experiences of individuals and treat the result as the experience of the group. Yet as this thesis has argued, this is by far from enough. In turn, it is implausible to assume that the interactive dynamics of a group capturable using more external measures are solely caused by something as multi-faceted as shared flow. It is therefore recommended that future studies attend to the experiences of the individuals as a starting point, but not a means to an end, in order to grasp any potential emergence of the group.

### *2) Methodological triangulation is of paramount importance*

In line with the recommendations of other reviews highlighting the importance of external perspectives (Pels et al., 2018; Tay et al., 2021), external measures are fundamental to incorporate alongside an acknowledgement of individual perspectives (Hackert et al., 2022). Qualitative investigation may serve as a valuable starting point, in

which participants provide an understanding of flow, and descriptions of additional contributions to the experiences they had, uncapturable by rigid self-reports or external measures. This may then inform what variables and confounds should be captured and accounted for. Following this, internal perspectives by means of self-reports gauging flow or related aspects paired with external measures representative of interaction and group-level qualities of a group in flow, are an effective way of capturing the multi-faceted nature of flow in collaborative contexts. In this thesis, such external measures were implemented by means of physiological synchrony and time perception, however, there is scope for other innovative methods to be explored in future studies.

*3) The study of time perception and physiology presents novel methods of capturing shared flow*

The interactive aspects of shared flow, uncapturable by individualistic means, seem to be effectively capturable by means of physiological synchrony, whereby cardiac alignment has already been shown to reflect group cohesion (Gordon et al., 2020; Tomashin et al., 2022). Meanwhile, synchrony of skin conductance may be effective in complementing cardiac measures to reflect synchrony of stressful or arousing responses. As opposed to other measures that are either static in the case of hormonal measures, or retrospective in the case of self-reports, their advantages lie in monitoring such aspects of interaction during - what may be - a subconscious experience.

A more novel measure of time perception was introduced halfway through this thesis. It presents an opportunity to observe both the specificities of shared flow-related time distortion, as well as capture socially contagious effects of time in a more exact manner. Further study is needed to examine whether these measures can be applied to non-musical contexts and whether similar findings arise without confounds of musical structures, metric subdivisions, rhythms, and tempos.

*4) Flow experiences may only be capturable in ecologically valid settings*

The phenomenon of flow cannot be removed from the context in which it arises. As such it would be unproductive to assume that any findings that arise through attempts at capturing flow in a laboratory environment would be extended towards real-world

settings. This thesis is not the first work to posit this (Pels et al., 2018), however, attempts have been made to show how some of the more technical means of capturing interactivity can be implemented in ecologically valid settings.

Portable physiological sensors are one such way in which future studies may explore this initiative further, particularly if inventive means are explored to capture such measures in an undistruptive manner. In this case, measuring SC from the foot, in a setting where gamelan players would ordinarily be without footwear, allowed for minimal invasion and for participants' hands to remain free to play as usual. As technological advances in wearable monitoring devices and camera-sourced methods are ever-progressing (Cusack et al., 2024; Williams et al., 2024), future studies should utilise the fruits of these efforts in flow research. In these paradigms, the importance of minimising disruption, distraction, and any discomfort is paramount in ensuring that flow experiences are not impaired.

#### 5) *Gamelan provides valuable ways of exploring and understanding intra-ensemble dynamics*

Finally, the potential for gamelan to be representative of varying social dynamics in ensemble playing, in turn, yields possibilities for a range of shared flow experiences to be captured. As an intrinsically group-based paradigm, gamelan cannot be played alone. Nevertheless, the degree to which an individual is focused on their own role versus their contributions to the group may depend on the musical context. This has been explored by means of notated, memorised, and improvised contexts, which have shown to be potentially representative of the taxonomic conception of shared flow (Hackert et al., 2022; Raettig & Weger, 2018). An additional, and important contribution of this thesis has been in its empirical support for theoretical and qualitative findings that shared flow, and its native equivalent *ngeli* in the performance of gamelan (Tan et al., 2020). Through doing so, the underlying social dynamics and mechanisms have aimed to be captured.

The next steps of this thesis would be to explore the mechanisms of shared flow and gamelan performance in non-western contexts, for instance, in expert groups in Indonesia. On a more general level, future research may also find value in including a



focus on gamelan ensembles alongside studies on Western ensembles, to assess differences in the level of individualism and collectivism that may be present accordingly.

## Chapter 13. Conclusion

This thesis presented an ambitious endeavour in conceptually, contextually, and methodologically furthering the study of shared flow. Shared flow has been conceived of as the result of an association between classic flow dimensions and interaction, which may be exemplified through investigations of differing contexts, both in terms of performance and levels of expertise. Methods used have gone far beyond traditional approaches of subsuming individualistic perspectives towards that of the group. Instead, the degrees of interactivity at the heart of the shared flow taxonomy have been measured through external means. Physiological synchrony has provided some clarity on this, whereby synchronised heart rates may exemplify the necessity of togetherness and group cohesion to achieve group flow. Meanwhile, synchrony of skin conductance may have an opposing effect, evidencing a negative aspect of group cohesion, or an alignment between individuals in emerging from and re-entering a balance of challenge and skill. Finally, measures of time distortion and consensus have provided novel ways to capture subconscious flow-related insights from an external perspective. As a measure explicitly related to flow experience, time perception has provided insights into how perceptions of time may synchronise when a group is in flow and the factors that may influence time distortion.

This research has been situated within the context of the gamelan ensemble. As an intrinsically group-based practice, it provides unique ways of studying group dynamics in ensembles. One cannot perform a gamelan piece alone, in comparison with how a violin might be performed both within and outside of ensemble settings. An implication of this fact was revealed in focus group discussions, whereby an experience of solely individual flow is either inconceivable or unhelpful in the context of gamelan.

Successful playing requires that individuals are tethered to one another in a non-hierarchical manner, open to cues that may trigger structural and rhythmic changes in unexpected places.

A mystery of an emergent “group flow”, distinct from any individually experienced form of flow, remains. The discussion of this thesis has argued that such a conception, while unanimous amongst most theories and prevalent in the discourse surrounding shared flow, may simply be unmeasurable, and metaphorical at heart. Empirical work on

shared flow should be advancing beyond the sum of individual parts, but perhaps not straying from them completely. In doing so, the risk is that what makes flow, flow, is eluded.

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## Chapter 15. Appendices

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## **Appendix A -Participant information sheet and consent –**

### **Study 1**

#### Background

The University of York, Hannah Gibbs (PhD Student), and Dr Hauke Egermann (Supervisor), would like to invite you to take part in the following research project.

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or you would like further information.

What is the purpose of the study?

The experiment is designed to assess whether synchronisation is evident through physiological recordings while playing gamelan, and whether these correspond to measures of flow state and mood during gamelan playing.

The experiment requires you to play a piece of traditional gamelan music and improvise as a group. Physiological measures will be recorded using two different devices. One will measure your cardiovascular activity through four surface electrodes that will be stuck to your chest area. The other will measure your levels of skin conductivity through two electrodes on the inside of your right foot. You will be guided on how to place these electrodes correctly, however, you are welcome to have assistance with this if you wish. Before and after your play-through, you will fill in questionnaires that assess socio-demographic information (gender, education, age), and measures of mood and flow state.

Alongside both of these measures, video recordings will be made of all sessions in order to align physiological responses with the musical material. These video recordings may be used for future public dissemination, but faces will be blurred, and any other data shared will be fully anonymised.

Why have I been invited to take part?

You have been invited to take part because I am looking for University students with varying levels of experience playing gamelan.

Do I have to take part?

No, participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant consent form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

On what basis will you process my data?

Under the General Data Protection Regulation (GDPR), the University has to identify a legal basis for processing personal data and, where appropriate, an additional condition for processing special category data. In line with our charter which states that we advance learning and knowledge by teaching and research, the University processes personal data for research purposes under Article 6 (1) (e) of the GDPR:

*Processing is necessary for the performance of a task carried out in the public interest*

Special category data is processed under Article 9 (2) (j):

*Processing is necessary for archiving purposes in the public interest, or scientific and historical research purposes or statistical purposes*

Research will only be undertaken where ethical approval has been obtained, where there is a clear public interest and where appropriate safeguards have been put in place to protect data. In line with ethical expectations and in order to comply with common law duty of confidentiality, we will seek your consent to participate where appropriate. This consent will not, however, be our legal basis for processing your data under the GDPR.

How will you use my data?

Data will be processed for the purposes outlined in this notice. Analysed data will be included in articles that will be submitted to academic journals, conference presentations, as well as the PhD dissertation.

Will you share my data with 3rd parties?

No. Data will be accessible to the researcher (Hannah Gibbs) and supervisor (Dr. Hauke Egermann). Anonymised data may be reused by the research team or other third parties

for secondary research and/or teaching purposes. Segments of anonymised audiovisual material may accompany this.

How will you keep my data secure?

The University will put in place appropriate technical and organisational measures to protect your personal data and/or special category data. For the purposes of this project we will collect questionnaire data using iPads, or in paper form if you prefer, audiovisual data, and physiological data using the devices described. All data will be stored in password protected folders on a laptop and Google drive. Information will be treated confidentiality and shared on a need-to-know basis only. The University is committed to the principle of data protection by design and default and will collect the minimum amount of data necessary for the project. In addition, we will anonymise or pseudonymise data wherever possible.

Will you transfer my data internationally?

No. Data will be held within the European Economic Area in full compliance with data protection legislation.

Will I be identified in any research outputs?

No.

How long will you keep my data?

Data will be retained in line with legal requirements or where there is a business need. Retention timeframes will be determined in line with the University's Records Retention Schedule.

What rights do I have in relation to my data?

Under the GDPR, you have a general right of access to your data, a right to rectification, erasure, restriction, objection or portability. You also have a right to withdrawal. Please note, not all rights apply where data is processed purely for research purposes. For further information see, <https://www.york.ac.uk/records-management/general-dataprotectionregulation/individualsrights/>

Questions or concerns

If you have any questions about this participant information sheet or concerns about how your data is being processed, please contact Dr. Hauke Egermann ([hauke.egermann@york.ac.uk](mailto:hauke.egermann@york.ac.uk)) in the first instance. If you are still dissatisfied, please contact the University's Acting Data Protection Officer at [dataprotection@york.ac.uk](mailto:dataprotection@york.ac.uk).

#### Right to complain

If you are unhappy with the way in which the University has handled your personal data, you have a right to complain to the Information Commissioner's Office. For information on reporting a concern to the Information Commissioner's Office, see [www.ico.org.uk/concerns](http://www.ico.org.uk/concerns).

#### Contacts for further correspondence:

Researcher: Hannah Gibbs ([hannah.gibbs@york.ac.uk](mailto:hannah.gibbs@york.ac.uk))

Supervisor: Dr Hauke Egermann ([hauke.egermann@york.ac.uk](mailto:hauke.egermann@york.ac.uk))

Ethics: Mimi O'Neill ([mimi.oneill@york.ac.uk](mailto:mimi.oneill@york.ac.uk)) and Jonathan Finch ([jonathan.finch@york.ac.uk](mailto:jonathan.finch@york.ac.uk))

Please tick below if you are happy to proceed:

- ☐ I understand the purpose of this research and agree to the methods used.
- ☐ I am comfortable with the use of skin surface electrodes.
- ☐ I agree to audiovisual recordings, and potential use of segments of these recordings in dissemination, conferences and publication.
- ☐ Yes, I consent to participating in this study and allowing my data to be processed.

## Appendix B – Questionnaire – Study 1

What is your age?

---

What gender do best you identify with?

- ☐ Male
- ☐ Female
- ☐ Non-binary / third gender
- ☐ Prefer not to say

Do you have previous experience of playing gamelan?

- ☐ Yes
- ☐ No

If so, how long have you been playing gamelan?

---

I engaged in regular, daily practice of a musical instrument (including voice) for \_ years.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4-5
- ☐ 6-9
- ☐ 10 or more

At the peak of my interest, I practised my primary instrument for \_ hours per day.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 1.5
- ☐ 2
- ☐ 3-4
- ☐ 5 or more

I have had formal training in music theory for \_ years.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4-6
- ☐ 7 or more

I have had \_ years of formal training on a musical instrument (including voice) during my lifetime.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 2
- ☐ 3-5
- ☐ 6-9
- ☐ 10 or more

I can play \_ musical instruments.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6 or more

Rate the extent to which you agree with the following statements:

|                                                                                          | Completely<br>Disagree (1) | Strongly<br>Disagree<br>(2) | Disagree<br>(3)          | Neither<br>agree nor<br>disagree<br>(4) | Agree<br>(5)             | Strongly<br>Agree (6)    | Completely<br>Agree (7)  |
|------------------------------------------------------------------------------------------|----------------------------|-----------------------------|--------------------------|-----------------------------------------|--------------------------|--------------------------|--------------------------|
| I would not consider myself a musician.                                                  | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am able to judge whether someone is a good singer or not.                              | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I find it difficult to spot mistakes in a performance of a song even if I know the tune. | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I can tell when people sing or play out of time with the beat.                           | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I can tell when people sing or play out of tune.                                         | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| When I sing, I have no idea whether I'm in tune or not.                                  | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am able to hit the right notes when I sing along with a recording.                     | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am not able to sing in harmony when somebody is singing a familiar tune.               | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have never been complimented for my talents as a musical performer.                    | <input type="checkbox"/>   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Indicate to what extent you feel each of the following items, right here, right now?

|              | Very slightly or<br>not at all (1) | A little (2)             | Moderately (3)           | Quite a bit (4)          | Extremely (5)            |
|--------------|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Interested   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Distressed   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Excited      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Upset        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Strong       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Guilty       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Scared       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Hostile      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Enthusiastic | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Proud        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Irritable    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Alert        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ashamed      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Inspired     | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Nervous      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Determined   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Attentive    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Jittery      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Active       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Afraid       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



Below are some statements about thoughts and feelings. Please tick the box that best describes your experience of each over the last 2 weeks.

|                                                    | None of the time (1)                | Rarely (2)               | Some of the time (3)     | Often (4)                | All of the time (5)      |
|----------------------------------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| I've been feeling optimistic about the future      | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling useful                           | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling relaxed                          | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling interested in other people       | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've had energy to spare                           | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been dealing with problems well               | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been thinking clearly                         | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling good about myself                | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling close to other people            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling confident                        | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been able to make up my own mind about things | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling loved                            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been interested in new things                 | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I've been feeling cheerful                         | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Please answer the following questions in relation to your experience in playing gamelan. If you have no experience in playing gamelan, think about your experience in another form group music-making, and write what specifically you are referring to here:

\_\_\_\_\_.

These questions relate to the thoughts and feelings you may experience during participation in this activity. You may experience these characteristics some of the time, all of the time, or none of the time. There are no right or wrong answers. Think about how often you experience each characteristic during the activity, then circle the number that best matches your experience.

|                                                                              | Never<br>(1)                        | Rarely<br>(2)            | Sometimes<br>(3)         | Frequently<br>(4)        | Always<br>(5)            |
|------------------------------------------------------------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| I am challenged, but I believe my skills will allow me to meet the challenge | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I do things correctly without thinking about trying to do so                 | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I know clearly what I want to do                                             | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| It is really clear to me how I am doing                                      | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| My attention is focused entirely on what I am doing                          | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have a sense of control over what I am doing                               | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am not concerned with what others may be thinking of me                    | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Time seems to alter (either slows down or speeds up)                         | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I really enjoy the experience of what I am doing                             | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| My abilities match the challenge of what I am doing                          | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Things just seem to happen automatically                                     | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have a strong sense of what I want to do                                   | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am aware of how well I am doing                                            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                                                                                       | Never<br>(1)             | Rarely<br>(2)            | Sometimes<br>(3)         | Frequently<br>(4)        | Always<br>(5)            |
|---------------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| It is no effort to keep my mind on what is happening                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I feel like I can control what I am doing                                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am not concerned with how others may be evaluating me                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| The way time passes seems to be different from normal                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I love the feeling of what I am doing and want to capture this feeling again          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I feel I am competent enough to meet the demands of the situation                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I do things automatically, without thinking too much                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I know what I want to achieve                                                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have a good idea about how well I am doing while I am involved in the task/activity | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have total concentration                                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I have a feeling of total control over what I am doing                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am not concerned with how I am presenting myself                                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| It feels like time goes by quickly                                                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| The experience leaves me feeling great                                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| The challenge and my skills are at an equally high level                              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I do things spontaneously and automatically without having to think                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| My goals are clearly defined                                                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I can tell by the way things are progressing how well I am doing                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am completely focused on the task at hand                                           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                                                          | Never<br>(1)             | Rarely<br>(2)            | Sometimes<br>(3)         | Frequently<br>(4)        | Always<br>(5)            |
|----------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| I feel in total control of my actions                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I am not worried about what others may be thinking of me | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I lose my normal awareness of time                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| The experience is extremely rewarding                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

You have reached the end of the pre-experiment survey. Please stop here, and enjoy the experiment!

What instrument did you play?

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How long have you been learning the pieces for?

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Indicate to what extent you feel each of the following items, after playing gamelan?

|              | Very slightly or<br>not at all (1) | A little (2)             | Moderately (3)           | Quite a bit (4)          | Extremely (5)            |
|--------------|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Interested   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Distressed   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Excited      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Upset        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Strong       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Guilty       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Scared       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Hostile      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Enthusiastic | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Proud        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Irritable    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Alert        | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ashamed      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Inspired     | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Nervous      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Determined   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Attentive    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Jittery      | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Active       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Afraid       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Please answer the following questions in relation to your experience of playing gamelan just now. These questions relate to the thoughts and feelings you may have

experienced while taking part. There are no right or wrong answers. Think about how you felt whilst playing, then answer the questions using the rating scale below. For each statement, tick the box that best matches your experience.

|                                             | Strongly Disagree (1)    | Disagree (2)             | Neither agree nor disagree (3) | Agree (4)                | Strongly agree (5)       |
|---------------------------------------------|--------------------------|--------------------------|--------------------------------|--------------------------|--------------------------|
| I was 'totally involved'                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| It felt like 'everything clicked'           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I was 'tuned in' to what I was doing        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I was 'in the zone'                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I felt 'in control'                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I was 'switched on'                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| It felt like I was 'in the flow' of things  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| It felt like 'nothing else mattered'        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I was 'in the groove'                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| I was 'totally focused' on what I was doing | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |

Please answer according to your feelings towards playing gamelan just now.

|                                                                                                             | Not at all<br>1          | 2                        | 3                        | 4                        | 5                        | 6                        | All the time<br>7        |
|-------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We felt stronger emotions than those we normally feel.                                                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| It seemed like we could read each other's minds.                                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that we were one.                                                                                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt more sensitive to our emotions and feelings because we were surrounded by people who felt the same. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                                                                                | Not at all<br>1          | 2                        | 3                        | 4                        | 5                        | 6                        | All<br>the<br>time<br>7  |
|--------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We felt a strong shared emotion.                                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We performed as one, like a single person.                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We didn't need words to express the feeling between us.                        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt a strong rapport between us.                                           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt really united, almost melded into one.                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| What we were as a group was more important than what we were as individuals.   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt more intense emotions because we all went through the same experience. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I felt as if I was transported out of myself, becoming part of the group.      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| It seemed to me as if we were a single person.                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I felt a strong emotional bond between us.                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We let ourselves get carried away by our emotions.                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We communicated without words.                                                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Please answer the following questions in relation to your collective experience in playing gamelan just now. These questions relate to the shared thoughts and feelings you may have experienced while taking part. There are no right or wrong answers. Think about how you think the group felt whilst playing, then answer the questions using the rating scale below. For each statement, tick the box that best matches your experience.

|                                                                                  | Strongly Disagree (1)    | Disagree (2)             | Neither Agree nor Disagree (3) | Agree (4)                | Strongly Agree (5)       |
|----------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------------|--------------------------|--------------------------|
| We knew that our skills would allow us to meet the challenge we were faced with. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We were doing things spontaneously and automatically.                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| Our goals were clearly defined.                                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| It was really clear to us that we were doing well.                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| Our concentration was focused entirely on what we were doing.                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We shared a feeling of total control.                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We were not concerned with what others may have been thinking of us.             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that time was altered either speeded up or slowed down.                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We really enjoyed what we were doing.                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| Our abilities matched the high challenge of the situation.                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that things were happening automatically.                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We knew clearly what we wanted to do.                                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We were aware of how well we were performing.                                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We were completely focused on the task at hand.                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that we could control what we were doing.                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |
| We were not worried about what others may have been thinking of us.              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>       | <input type="checkbox"/> | <input type="checkbox"/> |



|                                                                             | Strongly<br>Disagree<br>(1) | Disagree<br>(2)          | Neither<br>Agree nor<br>Disagree<br>(3) | Agree (4)                | Strongly<br>Agree (5)    |
|-----------------------------------------------------------------------------|-----------------------------|--------------------------|-----------------------------------------|--------------------------|--------------------------|
| We felt that the way time passed was different from normal.                 | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We all found the shared experience extremely valuable and rewarding.        | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt we were competent enough to meet the high demands of the situation. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We performed automatically.                                                 | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We knew what we wanted to achieve.                                          | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We were sure that in that moment we were doing really good.                 | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt totally absorbed by what we were doing.                             | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt in total control of our bodies.                                     | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We were not worried about the image we were presenting to others.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt like time stopped while we were performing.                         | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |
| The group experience left us with a good impression, a good taste.          | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/>                | <input type="checkbox"/> | <input type="checkbox"/> |

How would you describe your experience of the sensors?

---

Please describe 3 positive things you felt about the experience.

---

Please describe 3 negative things you felt about the experience.

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## Appendix C – Notation – Study 1

### Advanced group - *Ladrang Pangkur* notation<sup>18</sup>

Ladrang **Pangkur**, laras pélog pethet barang

*Buka*

• 3 • 2 • 3 • 2 3 3 2 2 • 7 • ⑥

*Irama lancar*

[ 3 2 3 7 3 2 7 ⑥ 7 6 3 2 5 3 2 7  
3 5 3 2 6 5 3 2 5 3 2 7 3 2 7 ⑥ ]

*Irama ciblon*

[ • 3 • 2 • 3 • 7 • 3 • 2 • 7 • ⑥  
7 7 • • 6 6 7 2 3 2 6 3 • 2 • 7  
• • • 3 6 5 3 2 3 2 5 3 6 5 3 2  
6 7 3 2 6 3 2 7 • 3 • 2 • 7 5 ⑥ ]

*Ngelik*

• • • • 4 3 2 3 • • 3 5 • 6 7 5 ②  
2 2 • • 4 3 2 7 3 2 6 5 7 6 5 ③  
• • 3 5 6 7 5 6 3 5 6 7 6 5 3 2  
6 7 3 2 6 3 2 7 • 3 • 2 • 7 5 ⑥ ]

<sup>18</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)

Beginner group - *Lancaran Baita Kandas* notation<sup>19</sup>

**Lancaran BAITA KANDAS Slendro Manyura**

**Buka bonang:**

. 3 . 5      . 3 . 2      . 5 . 3

t t p b      p p

**Balungan (Slenthem & Peking):**

$$\begin{array}{cccc}
\begin{array}{c} + \\ \cdot 2 \cdot \hat{6} \end{array} & \begin{array}{c} + \\ \cdot \hat{2} \cdot \hat{6} \end{array} & \begin{array}{c} + \\ \cdot \hat{3} \cdot \hat{2} \end{array} & \begin{array}{c} + \\ \cdot \hat{1} \cdot (\hat{6}) \end{array} \\
\begin{array}{c} \cdot 2 \cdot \hat{6} \end{array} & \begin{array}{c} \cdot \hat{2} \cdot \hat{6} \end{array} & \begin{array}{c} \cdot \hat{3} \cdot \hat{2} \end{array} & \begin{array}{c} \cdot \hat{1} \cdot (\hat{6}) \end{array} \\
\begin{array}{c} \cdot 3 \cdot \hat{5}^2 \end{array} & \begin{array}{c} \cdot \hat{3} \cdot \hat{2} \end{array} & \begin{array}{c} \cdot \hat{5} \cdot \hat{3} \end{array} & \begin{array}{c} \cdot \hat{5} \cdot (\hat{6}) \end{array} \\
\begin{array}{c} \cdot 3 \cdot \hat{5}^2 \end{array} & \begin{array}{c} \cdot \hat{3} \cdot \hat{2} \end{array} & \begin{array}{c} \cdot \hat{5} \cdot \hat{3} \end{array} & \begin{array}{c} \cdot \hat{5} \cdot (\hat{6}) \end{array}
\end{array}$$

**Saron Counter Melody:**

$$\left\{ \begin{array}{cccc} \cdot & 2 & 6 & \cdot \\ 2 & 6 & \cdot & 2 \\ 6 & \cdot & 2 & 6 \\ 3 & 2 & 1 & (6) \end{array} \right\} \times 2$$

<sup>19</sup> Source Soosan Lolavar, <https://www.soosanlolavar.com/wp-content/uploads/2013/02/gamelon-notation.pdf> (accessed 12/09/2024)

## Appendix D – Segmentation information – Study 1

Table D1.

*Segmentation of Physiological Data for Heart Rate (HR) and Skin Conductance (SC) Between All Groups and Conditions.*

| Group      | Condition  | Length<br>(in s) | Total<br>segments | <i>N</i><br>segments<br>used | <i>N</i><br>participants | <i>N</i><br>discarded<br>signals<br>(HR) | <i>N</i><br>discarded<br>signals<br>(SC) |
|------------|------------|------------------|-------------------|------------------------------|--------------------------|------------------------------------------|------------------------------------------|
| Advanced   | Notated    | 776              | 41                | 41                           | 13                       | 3                                        | 4                                        |
|            | Improvised | 205              | 16                | 16                           | 13                       | 3                                        | 4                                        |
| Beginner 1 | Notated    | 305              | 23                | 23                           | 8                        | 0                                        | 3                                        |
|            | Improvised | 285              | 21                | 21                           | 8                        | 0                                        | 3                                        |
| Beginner 2 | Notated    | 351              | 27                | 27                           | 8                        | 4                                        | 4                                        |
|            | Improvised | 305              | 24                | 24                           | 8                        | 4                                        | 4                                        |

## Appendix E – Wilcoxon rank sum tests– Study 1

The mean of all significant ISCs for each measure (ISC-SC<sub>sig</sub> and ISC-HR<sub>sig</sub>) and each piece per participant was calculated in order to analyse and visualise differences in these values, and both beginner experiment groups were grouped together. As assumptions of normality were not met in the data, Wilcoxon rank sum tests were used to evaluate differences in the values of significant ISCs resulting from music conditions, and from experience groups. Detailed results are provided in Table E1, while Figure E1 shows the relationships graphically. ISC-HR<sub>sig</sub> across both experience groups was found to be higher in traditional playing (*mdn*=0.762) than in improvised playing (*mdn*=0.665). When isolating experience groups, the same was true for beginners, where ISC-HR<sub>sig</sub> in traditional playing (*mdn*=0.950) was higher than improvised (*mdn*=0.893), and ISC-HR<sub>sig</sub> for advanced players was higher in traditional (*mdn*= 0.721) than in improvised playing (*mdn*=0.648). The overall difference of ISC-HR<sub>sig</sub> between experience groups across both playing conditions was also significant, whereby ISC-HR<sub>sig</sub> for advanced players (*mdn*=0.684) was generally lower than ISC-HR<sub>sig</sub> for beginner players (*mdn*=0.920).

For ISC-SC<sub>sig</sub>, far few significant values were found overall, particularly for beginners. Across both groups, it is suggested that there was greater ISC-SC<sub>sig</sub> during improvised playing (*mdn*=0.590) than traditional playing (*mdn*=0.504). No significant difference was observed between playing conditions for beginners, and ISC-SC<sub>sig</sub> was found to be only slightly higher for improvised playing (*mdn*=0.559) than in traditional playing (*mdn*=0.501) for advanced players on a trend level. Overall, ISC-SC<sub>sig</sub> was significantly lower for advanced players (*mdn*=0.551) compared to beginners (*mdn*=0.645).

**Table E1.**

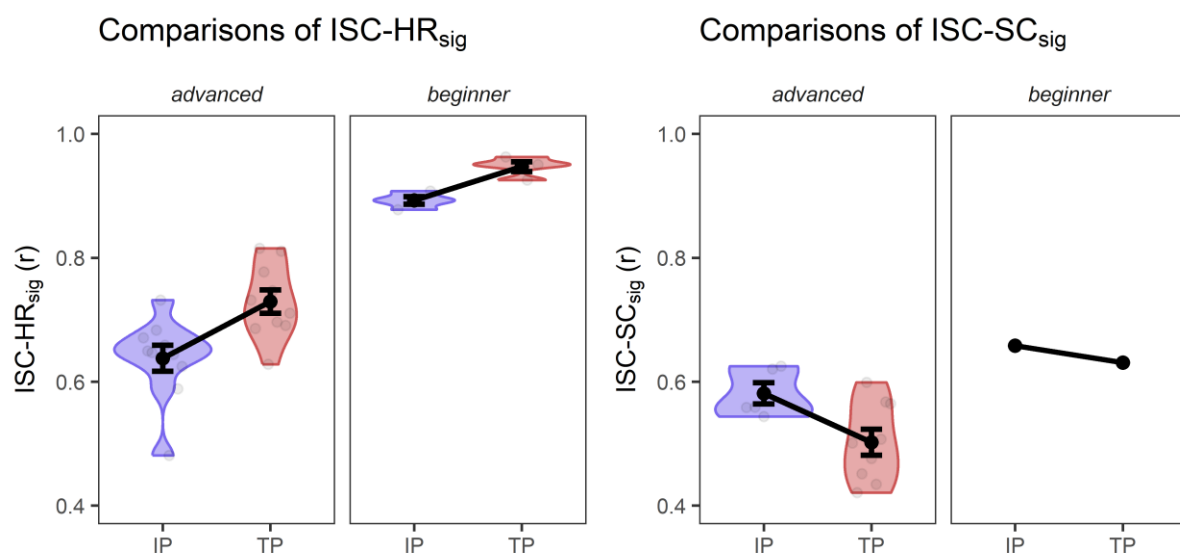
*Wilcoxon Rank Sum Exact Tests, Estimating Differences of Mean ISC-HR<sub>sig</sub> and ISC-SC<sub>sig</sub> Between Music Conditions (Traditional and Improvised Playing) and Experience Groups.*

| Dependent             | Factor                      | W  | p     | Effect size |
|-----------------------|-----------------------------|----|-------|-------------|
| ISC-HR <sub>sig</sub> | Music condition (Beginners) | 0  | .020  | -0.774      |
|                       | Music condition (Advanced)  | 11 | .002  | -0.688      |
|                       | Music condition (All)       | 51 | .031  | -0.408      |
|                       | Experience                  | 0  | <.001 | -0.941      |
| ISC-SC <sub>sig</sub> | Music condition (Beginners) | 1  | 1     | 0           |
|                       | Music condition (Advanced)  | 36 | .082  | -0.463      |
|                       | Music condition (All)       | 46 | .093  | -0.419      |
|                       | Experience                  | 0  | .017  | -0.598      |

*Note:* ISC-HR<sub>sig</sub> Advanced  $n = 10$ , Beginners  $n = 4$ , ISC-SC<sub>sig</sub> Advanced  $n = 7$ , Beginners  $n = 1$ .

**Figure E1**

*Violin Plots for ISC-HR<sub>sig</sub> and ISC-SC<sub>sig</sub> Showing Differences Between Music Conditions of Traditional Playing (TP) and Improvised Playing (IP), Grouped by Experience Levels.*



## Appendix F – Fixed effects results – Study 1

**Table F2.**

*Fixed Effects Results for the Most Optimally Fitting Interaction Models with ISC-HR<sub>mean</sub> as a Dependent Variable.*

| ISC-HR <sub>mean</sub> ~ Condition × Awareness + (1   experience) |        |       |        |        |       |
|-------------------------------------------------------------------|--------|-------|--------|--------|-------|
| Dependent                                                         | Est.   | SE    | df     | t      | p     |
| (Intercept)                                                       | 0.191  | 0.078 | 2.870  | 2.441  | .096. |
| Condition (traditional)                                           | -0.109 | 0.062 | 39.993 | -1.758 | .087. |
| Awareness                                                         | 0.125  | 0.058 | 40.023 | 2.140  | .039* |
| Condition (traditional):Awareness                                 | -0.186 | 0.082 | 39.993 | -2.262 | .030* |

| ISC-HR <sub>mean</sub> ~ Condition × Absorption + (1   experience) |        |       |        |        |       |
|--------------------------------------------------------------------|--------|-------|--------|--------|-------|
| Dependent                                                          | Est.   | SE    | df     | t      | p     |
| (Intercept)                                                        | 0.202  | 0.075 | 2.784  | 2.707  | .080. |
| Condition (traditional)                                            | -0.120 | 0.060 | 39.946 | -2.010 | .051. |
| Absorption                                                         | 0.110  | 0.053 | 40.424 | 2.073  | .045* |
| Condition (traditional):Absorption                                 | -0.190 | 0.074 | 39.946 | -2.551 | .015* |

Note: N = 21

**Table F3.**

*Fixed Effects Results for The Most Optimally Fitting Interaction Model with ISC-SC<sub>mean</sub> as a Dependent Variable.*

| ISC-SC <sub>mean</sub> ~ Condition × Awareness + (1   experience) |        |       |        |        |       |
|-------------------------------------------------------------------|--------|-------|--------|--------|-------|
| Dependent                                                         | Est.   | SE    | df     | t      | p     |
| (Intercept)                                                       | 0.042  | 0.033 | 2.954  | 1.264  | .297  |
| Condition (traditional)                                           | 0.011  | 0.026 | 31.995 | 0.424  | .674. |
| Awareness                                                         | 0.065  | 0.025 | 32.028 | 2.605  | .014* |
| Condition (traditional):Awareness                                 | -0.068 | 0.035 | 31.995 | -1.921 | .064* |

Note: N = 17

## **Appendix G - Participant information sheet and consent – Study 2 & 3**

### **Participant Information Sheet**

#### **Project background**

The University of York would like to invite you to take part in the following project:  
Gamelan, Flow, and Physiological Synchrony

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or you would like further information.

#### **What is the purpose of the project?**

This project is Hannah Gibbs ([hannah.gibbs@york.ac.uk](mailto:hannah.gibbs@york.ac.uk)), who is a doctoral student at the University of York, supervised by Dr Andrea Schiavio ([andrea.schiavio@york.ac.uk](mailto:andrea.schiavio@york.ac.uk)).

The work is being conducted according to restrictions that have been subject to approval by the ACT Ethics committee. The Chair of the ACT Ethics committee can be contacted on [ACT-ethics@york.ac.uk](mailto:ACT-ethics@york.ac.uk).

For this research project, we are interested assess whether synchronisation is evident through physiological recordings while playing gamelan, and whether these correspond to measures of flow state during gamelan playing.

Your participation in this project will involve you playing two pieces of traditional gamelan music (agreed prior with the leader of your group) and improvising as a group. Physiological measures will be recorded using two different devices. One will measure your cardiovascular activity through four surface electrodes that will be stuck to your chest area. A private room will be available, and you will be instructed on how and where you need to place these electrodes yourself. However, you are welcome to have assistance with this is you wish. The other will measure your levels of skin conductivity through two electrodes on the inside of your right foot, which you will be assisted with. The entire performance component of the experiment will be video recorded in order to align moments of interest with physiological data.



Before the experiment you will fill in questionnaires which assess socio-demographic information (gender, education, age), and following each play through you will complete a further component of the questionnaire assessing flow state.

After the experiment you will be asked to 1) stay to take part in a focus group interview which will be audio recorded, 2) be sent a personalised survey with open-ended questions based on some of your questionnaire responses. You will be asked for your email to pair with your anonymous identifier on a separate sheet in order to personalise your survey. At the end of the survey, you will also be asked if you would like to take part in an additional follow-up interview. If you would, your email address will be retained and stored securely in order to contact you at a later date. Any paper records of your email address will be disposed of through confidential waste.

From the start of set-up to the end of the focus group, the overall experiment should take no longer than 120 minutes. The follow up survey will take around 5 minutes to complete.

Please note that to comply with the approved Ethics requirements of this work, we do not intend to discuss sensitive topics with you that could be potentially upsetting or distressing. If you have any concerns about the topics that may be covered in the research study, please raise these concerns with the researcher. Your participation in this project is voluntary. If you wish, we will provide you with access to final report. If you would like to receive access to these, you can indicate as such on the consent form.

### **Why have I been invited to take part?**

You have been invited to take part because I am looking for gamelan groups across the UK with varying levels of gamelan expertise.

### **Do I have to take part?**

No, participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant consent form. If you change your mind at any point during the research activity, you will be able to withdraw your participation without having to provide a reason. To withdraw your participation, you need to keep note of the anonymous identifying code, and provide

this to the researcher as soon as possible in order for all of your associated data to be deleted.

### **Will I be identified in any outputs?**

No. Your participation in this research activity will be treated anonymously and you will not be identified in any outputs.

### **Privacy Notice**

This section explains how personal data will be used by the Gamelan, Flow, and Physiological Synchrony project at the University of York.

For this project, the University of York is the Data Controller. We are registered with the Information Commissioner's Office. Our registration number is Z4855807.

### **What is our legal basis for processing your data?**

Privacy law (the UK General Data Protection Regulation (GDPR) and Data Protection Act 2018) requires us to have a legal reason to process your personal data. Our reason is we need it to perform a public task.<sup>20</sup>

This is because the University has a public function, which includes carrying out research projects.<sup>21</sup> We need to use personal data in order to carry out this research project.

Information about your health, ethnicity, sexual identity and other sensitive information is called "special category" data. We have to have an additional legal reason to use this

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<sup>20</sup>This refers to UK GDPR Article 6 (1) (e): processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller

<sup>21</sup> Our charter and statutes states: 4.f. To provide instruction in such branches of learning as the University may think fit and to make provision for research and for the advancement and dissemination of knowledge in such manner as the University may determine.

data, because it is sensitive. Our reason is that it is needed for research purposes.<sup>22</sup> All research projects at the University follow our [research ethics policies](#).

### **How do we use your data?**

Data will be processed for the purposes outlined in this notice. Analysed data will be included in articles that will be submitted to academic journals, conference presentations, as well as the PhD dissertation.

### **Who do we share your data with?**

Anonymised data may be reused by the research team or other third parties for secondary research and/or teaching purposes. Segments of audiovisual material may also accompany this.

As well as this, we use computer software or systems to hold and manage data. Other companies only provide the software, system or storage. They are not allowed to use your data for their own reasons.

We have agreements in place when we share data. These agreements meet legal requirements to ensure your data is protected.

### **How do we keep your data secure?**

The University is serious about keeping your data secure and protecting your rights to privacy. We don't ask you for data we don't need, and only give access to people who need to know. We think about security when planning projects, to make sure they work well. Our IT security team checks regularly to make sure we're taking the right steps. For more details see [our security webpages](#).

### **How do we transfer your data safely internationally?**

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<sup>22</sup>This refers to [UK GDPR Article 9 \(2\) \(j\)](#): processing is necessary for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) based on Union or Member State law which shall be proportionate to the aim pursued, respect the essence of the right to data protection and provide for suitable and specific measures to safeguard the fundamental rights and the interests of the data subject.

If your data is stored or processed outside the UK, we follow legal requirements to make sure that the same level of privacy rules still apply.

### **How long will we keep your data?**

The University has rules in place for how long research data can be kept when the research project is finished. Your information will be kept for 6 months and after this time an anonymised version will be kept. As this will be fully anonymous, it will not be possible to identify you in any way from this data.

### **What rights do you have in relation to your data?**

You have rights over your data. This sheet explains how you can stop participating in the study, and what will happen to your data if you do. This information is in the section ‘Do I have to take part?’.

If you want to get a copy of your data, or talk to us about any other rights, please contact us using the details below.

### **Questions or concerns**

If you have any questions or concerns about how your data is being processed, please contact:

Andrea Schiavio ([andrea.schiavio@york.ac.uk](mailto:andrea.schiavio@york.ac.uk))

+44 (0)1904 32 2938

Sally Baldwin Building D022

Music – School of Arts & Creative Technologies

University of York, Wentworth Way

Heslington, York,

YO10 5DD

If you have further questions, the University’s Data Protection Officer can be contacted at [dataprotection@york.ac.uk](mailto:dataprotection@york.ac.uk) or by writing to: Data Protection Officer, University of York, Heslington, York, YO10 5DD.

### **Right to complain**

If you are unhappy with how the University has handled your personal data, please contact our Data Protection Officer using the details above, so that we can try to put things right.

If you are unhappy with our response, you have a right to complain to the Information Commissioner's Office. You can also contact the Information Commissioner's Office by post to Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF or by phone on 0303 123 1113.

## Participant Consent Form

Thank you for your interest in this project. This research activity will be used to understand how shared flow state might relate to physiological synchronisation across gamelan players, as part of my PhD in Music Psychology.

**Please read the following statements carefully and tick the appropriate box:**

|                                                                                               | YES                      | NO                       |
|-----------------------------------------------------------------------------------------------|--------------------------|--------------------------|
| I have read the information sheet about this project                                          | <input type="checkbox"/> | <input type="checkbox"/> |
| I agree to take part in this project                                                          | <input type="checkbox"/> | <input type="checkbox"/> |
| I consent to the performance being video recorded                                             | <input type="checkbox"/> | <input type="checkbox"/> |
| I consent to the use of physiological measurements via stick-on button electrodes             | <input type="checkbox"/> | <input type="checkbox"/> |
| I consent to the interview being video recorded                                               | <input type="checkbox"/> | <input type="checkbox"/> |
| I consent to the interview being audio recorded                                               | <input type="checkbox"/> | <input type="checkbox"/> |
| I consent to my anonymized data being deposited in data repository                            | <input type="checkbox"/> | <input type="checkbox"/> |
| I understand my right to withdraw and/or have my data destroyed from this project at any time | <input type="checkbox"/> | <input type="checkbox"/> |
| I understand that my participation in this project will be treated anonymously                | <input type="checkbox"/> | <input type="checkbox"/> |
| I am over the age of 18                                                                       | <input type="checkbox"/> | <input type="checkbox"/> |

Participant Name:

---

Researcher Name:

Hannah Gibbs

Participant Signature:

---

Researcher Signature:

---

Date: \_\_/\_\_/\_\_

Date: \_\_/\_\_/\_\_

## Appendix H – Notation - Study 2 & 3

### Gamelan Sekar Petak (notated)

#### *Gendhing bonang Tukung, laras pélog pathet barang*<sup>23</sup>

Gendhing bonang **Tukung** kethuk 4 kerep minggah 8, laras pélog pathet barang

*Buka*

• 2 • 2 • 7 6 5 • 2 • 2 • 7 6 5 • 5 • 5 • 5 • 5 6 7 2 7 6 5 3 ⑤

*Mérong*

[ 6 7 2 7 6 5 3 5 6 7 2 7 6 5 3 5 3 3 • 1 2 3 5 3 • 7 • • 5 6 7 6  
• 6 5 3 2 3 5 3 6 7 6 5 3 2 7 2 • • 7 • 5 6 7 2 • 7 • • 5 6 7 6  
• 6 5 3 2 3 5 3 6 7 6 5 3 2 7 2 • • 7 • 5 6 7 2 • 7 • • 5 6 7 6 \*  
5 4 • 2 4 5 4 2 1 4 1 • 2 4 5 6 5 • • • • 5 5 • • 6 7 2 7 6 5 3 ⑤ ]

*Umpak*

\* 7 6 • 6 7 2 3 2 7 6 • 6 7 2 3 4 3 4 • 4 3 4 • 4 3 4 6 4 3 4 ②

*Inggah*

[ 4 3 4 6 4 3 4 2 4 3 4 6 4 3 4 2 4 3 4 6 4 3 2 3 • 3 3 3 2 7 5 6  
3 5 6 7 6 5 6 3 6 5 3 5 6 5 3 2 5 3 2 5 3 2 5 3 • 3 3 3 2 7 5 6  
3 5 6 7 6 5 6 3 6 5 3 5 6 5 3 2 5 3 2 5 3 2 5 3 • 3 3 3 2 7 5 6  
• 7 6 • 6 7 2 3 2 7 6 • 6 7 2 3 4 3 4 • 4 3 4 • 4 3 4 6 4 3 4 ② ]

### Gamelan Sekar Petak and Southbank Gamelan Players (memorised) and Gamelan Spréacha Geala (notated)

#### *Ladrang Mugi Rahayu, laras sléndro pathet manyura*<sup>24</sup>

Ladrang **Mugi Rahayu**, laras sléndro pathet manyura

*Buka*

• 6 6 • 6 1 6 5 1 6 5 3 6 1 3 ②

*Ompak*

[ 3 6 1 • 3 6 1 2 3 6 1 • 3 6 1 2  
3 5 2 3 6 1 6 5 1 6 5 3 6 1 3 ② ]

<sup>23</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)

<sup>24</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)

## Southbank Gamelan Players (notated)

### *Gendhing Gambirsawit, laras pélong pathet nem*<sup>25</sup>

Gendhing **Gambirsawit** kethuk 2 kerep minggah 4, laras pélog pathet nem

|               |   |   |    |    |  |   |    |    |   |   |    |    |   |   |  |    |    |    |      |
|---------------|---|---|----|----|--|---|----|----|---|---|----|----|---|---|--|----|----|----|------|
| <i>Buka</i>   |   |   |    |    |  |   |    | 5  |   | • | 6  | 1  | 2 |   |  |    |    |    |      |
|               | • | 2 | •  | 2  |  | • | 1  | 2  | 1 |   | •  | 3  | • | 2 |  | •  | 1  | 6  | ⑤    |
| <i>Mérong</i> |   |   |    |    |  |   |    |    |   |   |    |    |   |   |  |    |    |    |      |
|               | • | 3 | 5  | 2  |  | • | 3  | 5  | 6 |   | 2  | 2  | • | • |  | 2  | 3  | 2  | 1̂   |
|               | • | • | 3  | 2  |  | • | 1  | 2  | 6 |   | 2  | 2  | • | • |  | 2  | 3  | 2  | 1̂   |
|               | • | • | 3  | 2  |  | • | 1  | 6  | 5 |   | •  | •  | 5 | 6 |  | 1̂ | 6  | 5  | 4̂   |
|               | 2 | 2 | •  | 3  |  | 5 | 3  | 2  | 1 |   | 3  | 5  | 3 | 2 |  | •  | 1  | 6  | ⑤    |
| [             | • | • | •  | 5  |  | 2 | 3  | 5  | 6 |   | 2  | 2  | • | • |  | 2  | 3  | 2  | 1̂   |
|               | • | • | 3  | 2  |  | • | 1  | 2  | 6 |   | 2  | 2  | • | • |  | 2  | 3  | 2  | 1̂ * |
|               | • | • | 3  | 2  |  | • | 1  | 6  | 5 |   | •  | •  | 5 | 6 |  | 1̂ | 6  | 5  | 4̂   |
|               | 2 | 2 | •  | 3  |  | 5 | 3  | 2  | 1 |   | 3  | 5  | 3 | 2 |  | •  | 1  | 6  | ⑤    |
| <i>Ngelik</i> |   |   |    |    |  |   |    |    |   |   |    |    |   |   |  |    |    |    |      |
|               | 6 | 6 | •  | •  |  | 6 | 6  | •  | • |   | 2̂ | 2̂ | • | • |  | 2̂ | 3̂ | 2̂ | 1̂   |
|               | • | • | 3̂ | 2̂ |  | • | 1̂ | 2̂ | 6 |   | 2̂ | 2̂ | • | • |  | 2̂ | 3̂ | 2̂ | 1̂   |
|               | • | • | 3̂ | 2̂ |  | • | 1̂ | 6  | 5 |   | •  | •  | 5 | 6 |  | 1̂ | 6  | 5  | 4̂   |
|               | 2 | 2 | •  | 3  |  | 5 | 3  | 2  | 1 |   | 3  | 5  | 3 | 2 |  | •  | 1  | 6  | ⑤ ]  |
| <i>Umpak</i>  |   |   |    |    |  |   |    |    |   |   |    |    |   |   |  |    |    |    |      |
| *             | • | 2 | •  | 1  |  | • | 6  | •  | 5 |   | •  | 6  | • | 5 |  | •  | 3  | •  | 2̂   |
|               | • | 3 | •  | 5  |  | • | 2  | •  | 1 |   | •  | 2  | • | 1 |  | •  | 6  | •  | ⑤    |
| <i>Inggah</i> |   |   |    |    |  |   |    |    |   |   |    |    |   |   |  |    |    |    |      |
| [             | • | 6 | •  | 5  |  | • | 1  | •  | 6 |   | •  | 1  | • | 6 |  | •  | 2  | •  | 1̂   |
|               | • | 2 | •  | 1  |  | • | 2  | •  | 6 |   | •  | 2  | • | 1 |  | •  | 6  | •  | 5̂   |
|               | • | 2 | •  | 1  |  | • | 6  | •  | 5 |   | •  | 1̂ | • | 6 |  | •  | 4  | •  | 2̂   |
|               | • | 3 | •  | 5  |  | • | 2  | •  | 1 |   | •  | 2  | • | 1 |  | •  | 6  | •  | ⑤ ]  |

<sup>25</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)



## Dublin National Concert Hall Gamelan (memorised)

### *Lancaran Singanebah, lara pélog pathet barang*<sup>26</sup>

Lancaran **Singanebah**, lara pélog pathet barang

*Buka*

|   |   |   |   |   |  |   |   |   |   |  |   |   |   |   |
|---|---|---|---|---|--|---|---|---|---|--|---|---|---|---|
|   | • | 5 | 3 | 2 |  | • | 5 | 3 | 2 |  | • | 6 | 5 | ③ |
| [ | • | 5 | • | 3 |  | • | 5 | • | 3 |  | • | 6 | • | ⑦ |
|   | • | 6 | • | 7 |  | • | 6 | • | 7 |  | • | 3 | • | ② |
|   | • | 3 | • | 2 |  | • | 3 | • | 2 |  | • | 5 | • | ③ |

*Tamban*

|   |   |   |   |   |  |   |   |   |   |  |   |   |   |   |
|---|---|---|---|---|--|---|---|---|---|--|---|---|---|---|
| [ | 7 | 6 | 5 | 3 |  | 7 | 6 | 5 | 3 |  | 7 | 6 | 5 | ⑦ |
|   | 3 | 5 | 6 | 7 |  | 3 | 5 | 6 | 7 |  | 3 | 5 | 3 | ② |
|   | 6 | 5 | 3 | 2 |  | 6 | 5 | 3 | 2 |  | 5 | 6 | 5 | ③ |

## Dublin National Concert Hall Gamelan (notated)

### *Ladrang Rujak Jeruk, laras sléndro pathet sanga*<sup>27</sup>

Ladrang **Rujak Jeruk**, laras sléndro pathet sanga

*Buka*

|   |   |   |   |  |   |   |   |   |  |   |   |   |   |  |   |   |   |   |
|---|---|---|---|--|---|---|---|---|--|---|---|---|---|--|---|---|---|---|
| 5 | 3 | 1 | • |  | 1 | 2 | 3 | 5 |  | 6 | 5 | 3 | 2 |  | 5 | 3 | 2 | ① |
|---|---|---|---|--|---|---|---|---|--|---|---|---|---|--|---|---|---|---|

*Irama tanggung*

|   |   |   |   |   |  |   |   |   |   |  |   |   |   |   |  |   |   |   |   |
|---|---|---|---|---|--|---|---|---|---|--|---|---|---|---|--|---|---|---|---|
| [ | 3 | 1 | 3 | 2 |  | 3 | 5 | 3 | 1 |  | 3 | 1 | 3 | 2 |  | 3 | 5 | 3 | 1 |
|   | 5 | 3 | 2 | 1 |  | 5 | 3 | 1 | 2 |  | 1 | 2 | 3 | 5 |  | 2 | 3 | 2 | ① |

*Tamban*

|   |   |   |   |   |  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|--|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [ | • | 3 | • | 1 |  | • | 3 | • | 2 |   | • | 3 | • | 5 |   | • | 3 | • | 1 |
|   | • | 3 | • | 1 |  | • | 3 | • | 2 |   | • | 3 | • | 5 |   | • | 3 | • | 1 |
|   | 5 | 2 | 3 | 5 |  | 6 | 1 | 6 | 2 | 1 |   | 3 | 2 | 1 | 6 |   | 5 | 3 | 1 |
|   | 5 | 3 | 1 | • |  | 1 | 2 | 3 | 5 |   | 6 | 5 | 3 | 2 |   | 5 | 3 | 2 | ① |

<sup>26</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)

<sup>27</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024)

## Gamelan Spréacha Geala (memorised)

### *Lancaran Manyarsewu*<sup>28</sup>

Lancaran **Manyarséwu**, laras sléndro pathet manyura

*Buka*

• 1 • 6 • 1 • 6 • 5 • ③

[ • 5 • 3̂ • 5̂ • 3̂ • 5̂ • 3̂ • 6̂ • ⑤  
• 6 • 5̂ • 6̂ • 5̂ • 6̂ • 5̂ • 3̂ • ②  
• 3 • 2̂ • 3̂ • 2̂ • 3̂ • 2̂ • 1̂ • ⑥  
• 1 • 6̂ • 1̂ • 6̂ • 1̂ • 6̂ • 5̂ • ③ ]

---

<sup>28</sup> Source Barry Drummond, <https://gamelanbvg.com/gendhing/index.php> (accessed 12/09/2024). A non-notated counter-melodic variant of the cycle is introduced and played in alternation with the version as written.

## Appendix I – Questionnaire – Study 2 & 3

### Pre-experiment section

What group are you playing with today? (Experimenter to fill in)

---

Model number of ECG device (Experimenter to fill in)

---

Model number of GSR device (Experimenter to fill in)

---

Please provide a unique anonymous identifier (a suggestion could be your birthday and the initials of your street, for instance 11th July and Wentworth Way would be 11WW, but anything else is fine so long as you remember it and it doesn't identify you).

---

What is your age?

---

What gender do you best identify with?

- ☐ Male
- ☐ Female
- ☐ Non-binary / third gender
- ☐ Prefer not to say

I engaged in regular, daily practice of a musical instrument (including voice) for ... years.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4-5
- ☐ 6-9
- ☐ 10 or more

At the peak of my interest, I practised my primary instrument for ... hours per day.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 1.5
- ☐ 2
- ☐ 3-4
- ☐ 5 or more

I have never been complimented for my talents as a musical performer.

- ☐ Completely disagree
- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree
- ☐ Completely agree

I have had formal training in music theory for ... years.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4-6
- ☐ 7 or more

I have had ... years of formal training on a musical instrument (including voice) during my lifetime.

- ☐ 0
- ☐ 0.5
- ☐ 1
- ☐ 2
- ☐ 3-5
- ☐ 6-9
- ☐ 10 or more

I can play ... musical instruments.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6 or more

I would not consider myself a musician.

- ☐ Completely disagree
- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree
- ☐ Completely agree

How long have you been playing with this group?

- ☐ Less than 1 year
- ☐ 1-2 years
- ☐ 2-3 years
- ☐ 3-4 years
- ☐ More than 4 years

How long have you been playing gamelan overall? (*You may have first experienced gamelan playing with a different group. Please estimate to the nearest year.*)

---

What instrument are you playing today? (*If you are switching instruments, please specify what instrument you are playing for each piece*)

---

Do you usually play this/these instrument(s) for both pieces? (*If you usually do for one piece and not for the other, then please elaborate.*)

- Yes
- Yes, but only for one of the pieces (please explain for which one)
- \_\_\_\_\_
- No

I think the pieces today are...

|        | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        |          |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|
| Boring | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Engaging |

I know the other members of my group...

|          | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        |           |
|----------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----------|
| Not well | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Very well |

I think my own competence is ...

|     | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        |      |
|-----|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------|
| Low | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | High |

I think the competence of my group is...

|     | 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        |      |
|-----|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------|
| Low | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | High |

Please use one word to summarise how you feel right now

\_\_\_\_\_

Please stop here, do not continue until you have played the next piece.

## Piece 1 section

Please give an estimate of how much time passed while playing that piece (to the nearest minute and second)

---

How confident are you that this estimate is accurate?

- ☐ Not confident at all
- ☐ Mostly unconfident
- ☐ Somewhat confident
- ☐ Mostly confident
- ☐ Very confident

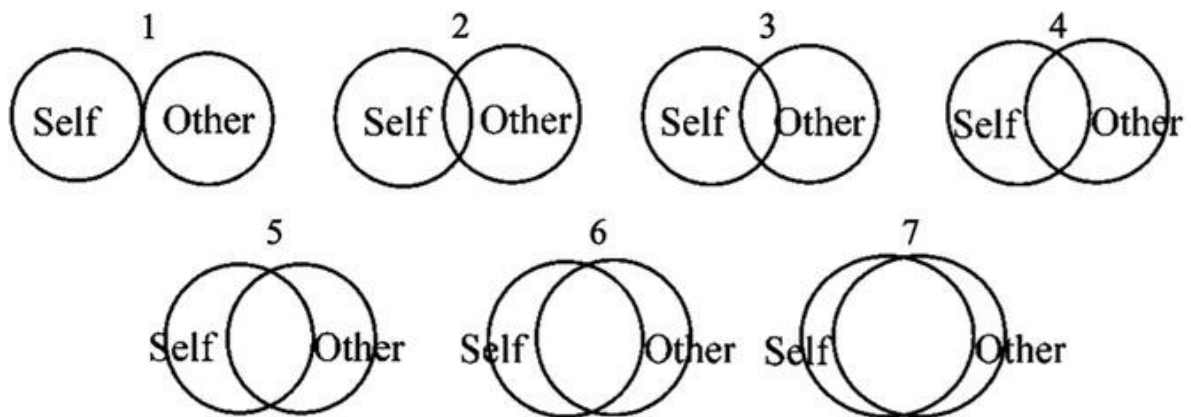
Please rate the following items in relation to how you feel about the piece you just played.

|                                             | 1<br>Completely<br>disagree | 2                        | 3                        | 4                        | 5                        | 6                        | 7<br>Completely<br>Agree |
|---------------------------------------------|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We interacted like a well-rehearsed team.   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a stimulating performance.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt the level of challenge was optimal. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Our playing was fluid and smooth.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that time was flying by.            | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had no difficulty concentrating.         | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

| (Continued)                                              | 1<br>Completely<br>disagree | 2                        | 3                        | 4                        | 5                        | 6                        | 7<br>Completely<br>Agree |
|----------------------------------------------------------|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We had our wits about us.                                | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We were completely absorbed in what we were doing.       | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a mutual understanding of our musical intentions. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We always knew what we had to do next.                   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt like we had everything under control.            | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We forgot everything around us.                          | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Communication in our group went smoothly.                | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We inspired each other.                                  | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



The image below represents the level of individuality or togetherness you feel, or the level of self-overlap you perceive there to be between you and the rest of the group.



Which image best represents your perceived self-other overlap while playing just now?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

How much did you look at your notasi? (Please skip this question if you improvised)

- ☐ Not at all
- ☐ Only some of the time
- ☐ Around half of the time
- ☐ Most of the time
- ☐ Constantly

Please use one word to summarise how you feel right now.

---

Please stop here until after you play the next piece.

## Piece 2 section

Please give an estimate of how much time passed while playing that piece (to the nearest minute and second)

---

How confident are you that this estimate is accurate?

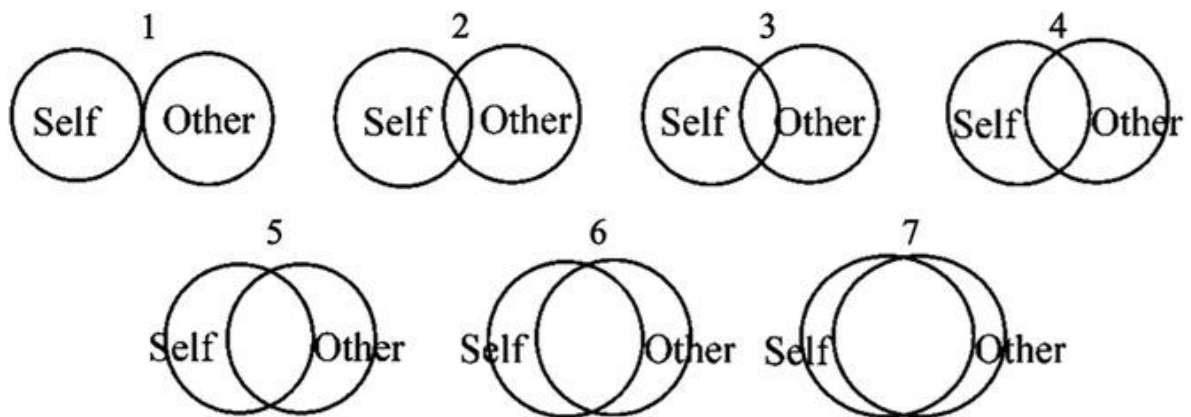
- ☐ Not confident at all
- ☐ Mostly unconfident
- ☐ Somewhat confident
- ☐ Mostly confident
- ☐ Very confident

Please rate the following items in relation to how you feel about the piece you just played.

|                                             | 1<br>Completely<br>disagree | 2                        | 3                        | 4                        | 5                        | 6                        | 7<br>Completely<br>Agree |
|---------------------------------------------|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We interacted like a well-rehearsed team.   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a stimulating performance.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt the level of challenge was optimal. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Our playing was fluid and smooth.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that time was flying by.            | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had no difficulty concentrating.         | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

| (Continued)                                              | 1 Completely disagree    | 2                        | 3                        | 4                        | 5                        | 6                        | 7 Completely Agree       |
|----------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We had our wits about us.                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We were completely absorbed in what we were doing.       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a mutual understanding of our musical intentions. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We always knew what we had to do next.                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt like we had everything under control.            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We forgot everything around us.                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Communication in our group went smoothly.                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We inspired each other.                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

The image below represents the level of individuality or togetherness you feel, or the level of self-overlap you perceive there to be between you and the rest of the group.



Which image best represents your perceived self-other overlap while playing just now?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

How much did you look at your notasi? (Please skip this question if you improvised)

- ☐ Not at all
- ☐ Only some of the time
- ☐ Around half of the time
- ☐ Most of the time
- ☐ Constantly

Please use one word to summarise how you feel right now.

---

Please stop here until after you play the next piece.

## Piece 3 and post-experiment section

Please give an estimate of how much time passed while playing that piece (to the nearest minute and second)

---

How confident are you that this estimate is accurate?

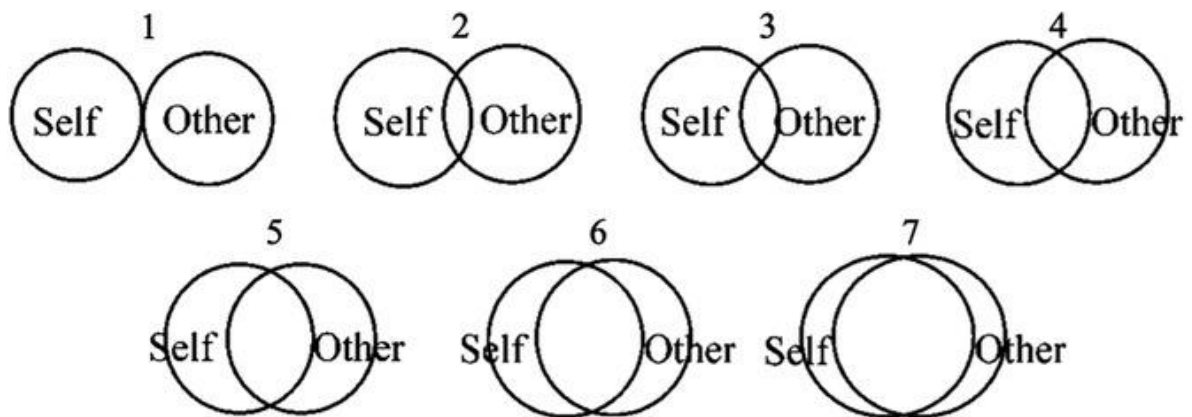
- ☐ Not confident at all
- ☐ Mostly unconfident
- ☐ Somewhat confident
- ☐ Mostly confident
- ☐ Very confident

Please rate the following items in relation to how you feel about the piece you just played.

|                                             | 1<br>Completely<br>disagree | 2                        | 3                        | 4                        | 5                        | 6                        | 7<br>Completely<br>Agree |
|---------------------------------------------|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We interacted like a well-rehearsed team.   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a stimulating performance.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt the level of challenge was optimal. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Our playing was fluid and smooth.           | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt that time was flying by.            | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had no difficulty concentrating.         | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

| (Continued)                                              | 1<br>Completely<br>disagree | 2                        | 3                        | 4                        | 5                        | 6                        | 7 Completely<br>Agree    |
|----------------------------------------------------------|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| We had our wits about us.                                | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We were completely absorbed in what we were doing.       | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We had a mutual understanding of our musical intentions. | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We always knew what we had to do next.                   | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We felt like we had everything under control.            | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We forgot everything around us.                          | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Communication in our group went smoothly.                | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| We inspired each other.                                  | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

The image above represents the level of individuality or togetherness you feel, or the level of self-overlap you perceive there to be between you and the rest of the group.



Which image best represents your perceived self-other overlap while playing just now?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

How much did you look at your notasi? (Please skip this question if you improvised)

- ☐ Not at all
- ☐ Only some of the time
- ☐ Around half of the time
- ☐ Most of the time
- ☐ Constantly

Please use one word to summarise how you feel right now.

---

And to finish....

In relation to the entire session:

I am ... with the performance of my group

|              |   |   |   |   |   |   |   |   |   |           |
|--------------|---|---|---|---|---|---|---|---|---|-----------|
|              | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |           |
| Dissatisfied |   |   |   |   |   |   |   |   |   | Satisfied |

Overall, the pieces we played were...

|        |   |   |   |   |   |   |   |   |   |          |
|--------|---|---|---|---|---|---|---|---|---|----------|
|        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |          |
| Boring |   |   |   |   |   |   |   |   |   | Engaging |

I think my own competence was...

|     |   |   |   |   |   |   |   |   |   |      |
|-----|---|---|---|---|---|---|---|---|---|------|
|     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |      |
| Low |   |   |   |   |   |   |   |   |   | High |

I think the competence of my group was...

|     |   |   |   |   |   |   |   |   |   |      |
|-----|---|---|---|---|---|---|---|---|---|------|
|     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |      |
| Low |   |   |   |   |   |   |   |   |   | High |

Did you notice any particular bodily sensations while you played? *(Related to your heart rate, breathing, or sweatiness?)*

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---

---

Would you like to leave any other comments on your experience of the experiment in general?

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## Appendix J – Focus group schedule – Study 3.1

Thank you so much for participating my study today. As may know by now, I was interested in how physiological responses might reflect feelings of flow state. This focus group will now investigate your perceptions of flow, and playing gamelan in general, as a group.

- What was your experience of playing in today's experiment?
  - *Did you play well, did it go as planned?*
  - *How would you compare the different pieces, and improvising?*
- What is your understanding of flow state?
  - *How might it be defined, and what might it involve?*

Flow state defined primarily as a balance between challenge and skills for a given task and moderate mental effort, but also includes ideas of clear goals, absorption and more. This results in being optimally challenged, so that you aren't bored but aren't stressed. You might have also heard about this being referred to as 'being in the zone'.

- What was your experience of flow state while playing in this experiment?
  - *Do any of you think you might have felt this at any point today? When?*
  - *If not, why not?*

Something I'm interested in is group flow. For some researchers, shared flow or group flow is often seen as an extension of individual flow state, where it typically arises through synchronous or coordinated action, and relates to the level of togetherness a group might feel.

- What was your experience of group flow state while playing in this experiment?
  - *Do any of you think you might have felt this at any point today? When?*
  - *If not, why not?*
- What was your experience of the differences between individual flow state and group flow while playing in this experiment?
  - *Do you think they might occur in alternation? How might this come about?*

- In general, what do you think about the relevance of group flow state to gamelan playing?
  - *How might it arise in gamelan playing?*
  - *Do you all agree? Does anyone have a different experience?*
- In general, do you think there's a difference in the potential for group flow between improvised and traditional playing? If so, how would you describe this?
  - *Do you all agree? Does anyone have a different opinion?*
- Please describe an instance outside of this session in which you have experienced group flow state.
  - *How was it experienced?*
  - *Do you all agree?*
  - *Do you think you are more likely to enter a feeling of flow or group flow when you are playing a certain instrument or kind of piece?*

One of the main focuses of this experiment is to isolate and assess one parameter of flow states, the perception of time.

- In general, how do you perceive time when you play? Can you describe this as a group?
  - *Can you reach a consensus that everyone agrees upon?*
  - *Does anyone disagree? Feel the opposite? Can you describe this?*
  - *Did you feel this today, is this how you usually feel?*
- How do you think time perception might relate to flow experiences?
  - *Do you think you might be more likely to be in flow if you perceive time as accurately, or faster or slower?*
- Is there anything about your experience of playing in this experiment that might have influenced any of these ideas we have discussed on time and flow?
  - *Do you think the electrodes were distracting?*
  - *Or do you think the experiment set-up might have interfered with the potential for flow to occur?*

I'll be sending out a very short, personalised survey to each of you. This will just ask if you have any comments on the overall experiment and purpose of the study and will also ask you to comment on the time estimates you gave in the study in comparison to the actual. I would like you to question why you think this might be, and what might have contributed to this.

## **Appendix K – Focus group transcriptions – Study 3.1**

### **GSP Transcript**

#### **Researcher (00:00)**

Thank you so much for participating in my study today. This focus group will now investigate your perceptions of flow, playing of gamelan in general, as a group. OK? So first question. What was your experience playing in today's experiment?

#### **Speaker 1 (00:31)**

It was fun.

#### **Researcher (00:32)**

It was fun? Yeah?

#### **Speaker 2 (00:33)**

Yeah, really exciting.

#### **Speaker 3 (00:35)**

Very exciting. Yeah.

#### **Researcher (00:38)**

Did you play well? Did it go as planned?

#### **Speaker 1 (00:40)**

Yeah. Mugirahayu was great. I think that was, like a really tight performance of that.

#### **Speaker 4 (00:46)**

Yeah [others show agreement].

#### **Researcher (00:46)**

Everyone agree? [Agreements]. No-one feels differently? [The group shakes their heads, and several say no].

#### **Speaker 5 (00:51)**

No, I definitely made mistakes in Mugirahayu. But I felt that we were coherent enough that it, it didn't feel very, very tense. It was like, oh, I'm in the wrong bit. There we go. I'm back in again. So yeah it felt very held.

**Speaker 3 (01:04)**

As a gong player, I lost concentration in many, many bits.

**Speaker 6 (01:09)**

Did you keep back in time?

**Speaker 3 (01:11)**

I kept back in time.

**Speaker 6 (01:13)**

That is the [inaudible].

**Speaker 3 (01:14)**

That's the key. Yeah.

**Researcher (01:15)**

That's what we want. What about Tukung?

**Speaker 3 (01:19)**

I was confused for two minutes and then [inaudible]

**Speaker 4 (01:20)**

I quite liked the way we had this sort of hairy start with the gong coming in too soon, but everyone just, like, you know people knew where the gong was and we all decided where it was and it just came right back together. And it didn't really affect things [verbal agreement from the group]. And in a lot of ways, that's better than, you know it's good to know you can do that, and that we feel it well enough to get back in.

**Researcher (01:42)**

Nice. So the next prompt I have is how would you compare different pieces? So, for example, the improvisation versus Tukung from notasi versus Mugirahayu, hopefully most of you from memory. How would you compare those experiences?

**Speaker 1 (01:58)**

Yeah, so the first one was I think all of us have to read from the sheet because there's so many notes, you know, you can't memorise all of that. If you can that's really impressive...

**Speaker 4 (02:10)**

Actually you don't need to because you can just listen to the bonangs. They're playing all the notes in advance.

**Speaker 1 (02:13)**

Right.

**Speaker 4 (02:15)**

That's the secret

**Speaker 6 (02:16)**

Now if the bonangs forgot to play [inaudible].

**Speaker 1 (02:19)**

Whereas Mugirahayu, that's all memorised now. So that was like completely different.

**Researcher (02:24)**

Okay. Does this side of the room feel the same? How did you find Mugirahayu?

**Speaker 2 (02:29)**

Yeah it's really relaxed and some times I space out and 'oy! My turn'.

**Speaker 6 (02:31)**

I think in the last couple of gotra, I kept doing mistakes because I was too relaxed.

**Researcher (02:38)**

That's a nice space to be in. Really.

**Speaker 3 (02:41)**

I didn't look at the sheet much

**Researcher (02:44)**

Really?

**Speaker 3 (02:45)**

Yeah, because I, I think I knew it by heart. I just don't know which number that is. But I knew the melody, I definitely knew the melody by heart. So that's really why it comes to that point, just like.

**Speaker 5 (02:56)**

That's really nice.

**Researcher (02:58)**

That's really nice to get into that space

**Speaker 7 (03:00)**

I didn't, I didn't need to see the note because I just [mimics playing].

**Speaker 6 (03:09)**

That is a state of flow.

**Researcher (03:12)**

Well, which brings me into almost as though I planned it. Flow state is actually what I'm looking at. So, what's your understanding of flow state is my question.

**Speaker 1 (03:24)**

When you're so engrossed in the activity that you lose track of time.

**Speaker 6 (03:29)**

I think I can describe this like this [waves arm] and for the audio I'm grabbing my hand and just waving it slightly up and down.

**Speaker 1 (03:38)**

Yeah, that's a flow state.

**Speaker 4 (03:42)**

For me. It's like not having to think about what I'm playing or worry if I'm playing it right. Like just feeling really situated in the music and with other people. And I kind of like that point where you lose ego because actually worrying about what you're playing is an ego thing and just like feeling that dissolve and just being in the music.

**Speaker 1 (04:04)**

Yeah, it's literally just like vibes.

**Researcher (04:10)**

Anyone else? Does anyone not have any idea about flow state? Have you ever heard of it?



**Speaker 3 (04:16)**

Yeah, I've never heard of it.

**Researcher (04:17)**

Never heard of it? Is that the same for you?

**Speaker 8 (04:20)**

Yeah, never heard but like having like the same idea.

**Researcher (04:23)**

Great. Cool. So I will give you the definition. Well, a loose definition. Flow state, defined primarily as a balance between challenge and skills for a given task, moderate mental effort, but it also includes ideas of having clear goals, being absorbed and more. This results are being optimally challenged so they aren't too bored but you're not too stressed. You might have also referred to this, heard this as being referred to being in the zone. So, when we're thinking about today's experiment, what was your experience with flow state?

**Speaker 5 (04:57)**

I was super not in the zone in the improvisation. Oh no. It was really strange for me going from Tukung where I felt kind of in the zone, but I was aware I was thinking about getting it right, what you were saying there that, there was a bit of that, 'Am I doing the right thing?' Mugirahayu I was totally in it, connected to everybody and then the improvisation straight after I was like, 'Wow, where's that communication gone?' I really felt I'd lost that.

**Researcher (05:27)**

That's so interesting. Do you all agree?

**Speaker 2 (05:30)**

I'm in the other way around in Tukung, because I'm [inaudible] in time I have like focus. Whereas Mugirahayu is so easy for me I sometimes space out. So yeah less challenge.

**Speaker 1 (05:43)**

With the improvisation, I found that there were moments where I was able to communicate with players and have a call and response. And there was other times where I would become aware of my surroundings and I'd go, 'Oh, I'm a bit lost now.' Or I

don't know how to contribute. I'd fall back for a moment and then I'd try and find my way back in.

**Researcher (06:09)**

Ah. That's really interesting.

**Speaker 4 (06:12)**

I felt in the improvisation very connected at the beginning, particularly there was this nice little rhythm that just got going, which is quite unusual.

**Speaker 3 (06:21)**

Yeah I heard you play the drum according to what rhythms I think I heard it in the, the uh, I don't know what it was called.

**Speaker 5 (06:31)**

Was it bonangs?

**Speaker 3 (06:33)**

It's the bonang, yeah.

**Speaker 4 (06:34)**

Yeah I was picking up on someone else [inaudible].

**Speaker 3 (06:35)**

Yeah first it was like bonang. And then there was articulation and dynamics that were getting really loud and you just follow that dynamic or articulation. It's quite fun to hear. But I just play very randomly so.

**Researcher (06:50)**

Okay. So how would you describe the moments in which it might have been lost along the way? I think, (Speaker 5), you were saying you felt a bit disconnected at times. What would you say was the reason for that?

**Speaker 5 (07:03)**

I think a lot of the time, I guess I probably looked up and out much more in the improvisation than I did in anything else. And yet somehow felt less connected. And I think I felt that people seem quite absorbed in their own thing they were playing. But only on some occasions were those things connected to other people. But a lot of the

time, it felt people were exploring their instrument for themselves rather than necessarily the whole group as an instrument. That's probably [inaudible]

**Researcher (07:35)**

That's a really interesting observation. No, no! Does anyone disagree with that? Does anyone feel like they were more connected during the improvisation than they were elsewhere?

**Speaker 6 (07:47)**

There were only moments where...

**Speaker 2 (07:50)**

Yeah, it's like on and off.

**Speaker 3 (07:52)**

Yeah. But I prefer the improvisation.

**Researcher (07:54)**

You preferred the improvisation? Okay. Dramatic. Do you like the drama?

**Speaker 3 (07:59)**

Not necessarily, but like as a, you know again, as a gong player, it feels more free for me to do what I want to do, except for just waiting like after minutes after minutes and then falling asleep [inaudible].

**Researcher (08:21)**

So is there potentially something to do with the instrument that you're playing?

**Speaker 3 (08:24)**

Yeah, probably. It's due to the instrument that I'm playing, yeah.

**Researcher (08:27)**

Okay, cool. So as you might have gathered, something I'm interested in is group flow. So for some researchers, shared flow and group flow, synonymous words, they're often seen as an extension of individual flow state, where it typically arises through synchronous or coordinated action such as playing a gamelan, and relates to the level of togetherness you might feel. So what was your experience, going on from the last question, what was your experience of group flow state while playing this experience?

**Speaker 5 (08:58)**

I definitely felt that the pickup after the gong in Tukung, the slow down to the gong and the pick back up. I might have got it wrong, but I think in that one, I felt like we really nailed that. We really got it. And it was like, oh, it's just a collection of people that just know how fast we're going to come back in and where it is. And it just felt like this unspoken communication connection.

**Speaker 2 (09:22)**

We did it even better than the concert.

**Speaker 5 (09:29)**

More experience then.

**Speaker 4 (09:30)**

Yeah. We hadn't been going round the merong for eternity.

**Researcher (09:37)**

Okay. Did anyone not feel like they're in group flow at any point?

**Speaker 4 (09:47)**

So there's something something that... It is group flow but a very different feeling. So for me, it was a very different feeling in Tukung where I was just playing peking and following the drum and you know, then Mugirahayu where I was drumming and I got a lot more excited. I could feel the adrenaline spikes, especially when I needed to speed things up or change the tempo. So yeah there was that difference between the kind of following flow state and the leading flow state.

**Researcher (10:22)**

Yeah. So something to do with leader follower roles that definitely has something to do with it.

**Speaker 5 (10:27)**

Yeah. Actually, I think in Mugirahayu that really helped me to be able to be really relaxed because I was just able to go, oh (Speaker 4)'s got this. Totally on this, I just follow and do what I'm told. So it just felt very held and safe.

**Researcher (10:42)**

Okay. So do you think there might have been an experience of potential differences, this is quite a tricky question, between individual flow states, what we're discussing before, and group flow state.

**Speaker 1 (10:57)**

I think in gamelan and it's really important to never be fully immersed in the individual flow because then you get you know separated from the group. So I think it's important to prioritise the group flow. But there is still you know... Because in Mugirahayu, I love my bonang part. You know. So I'm really enjoying that. I'm definitely in the flow of it. But it's still tethered by the group. You know I'm still paying close attention to what (Speaker 4) and the rest of the gamelan are doing.

**Researcher (11:34)**

Yeah. Yeah. Does anyone have anything to add to that?

**Speaker 2 (11:40)**

I think it's helpful to have a strong group flow state as well, because it helps you to recover and you lose yourself. Like in the beginning of Tukung, kinda like, we try to settle down, but once it's set, then it goes smoothly. So everyone kinda like helps, you know, to save everyone when they're lost. But we have a good group's flow state. Yeah.

**Speaker 5 (12:09)**

Sort of like the group flow has to be there for the individual flow to happen in a way.

**Researcher (12:16)**

Okay. So we've sort of answered this in relation to talking about how cohesive we felt in improvised versus the pieces that we play. But I'm going to ask it just in case anyone has any other reflections. In general, do you think there's a difference in the potential for group flow between improvised and traditional playing? So do you think group flow is experienced differently when you're improvising versus when you're playing from the notasi?

**Speaker 2 (12:46)**

Yeah, different experience.

**Speaker 3 (12:48)**

It's quite different.

**Speaker 6 (12:50)**

It's more that it feels like... [interruption] I think by design, you're playing by notation. You have to flow together. Whereas an improv? You can go out on a rant, not listen to anybody. Just be happy. Everybody can do it. Everybody can be in their own little world but it's not flowing or they can flow in its small groups.

**Speaker 1 (13:14)**

Yeah. There's a lot more individual flow in the improvisation. And I think that when you've got your traditional pieces, you've prepared and you've memorised, and that allows you not to be concerned so much with that aspect. That allows you to communicate more effectively with the group.

**Speaker 5 (13:38)**

Were you going to say something, (Speaker 3)?

**Speaker 3 (13:40)**

No, I forgot.

**Speaker 5 (13:44)**

Just thinking that it feels like it might be easier with, say, a traditional piece or traditional pieces where you could sit down with people that you've not played gamelan with before and probably fairly easy get into the same sense of flow because you know what it is you're aiming for. Whereas I felt like with us, because we haven't really improvised together before, it felt like that was quite different to if, say, we were a group that improvised together a lot, I think group flow would be a lot easier if we'd got experience on that. Speculating a bit there.

**Researcher (14:15)**

No, that's interesting. So would you say it's not necessarily about how well you know a group, but it's how much a group might be used to doing one thing? So you're saying you can maybe play the same as a different group that you don't know as well, but you all have the same experiences of playing those things? Whereas this group who know each other quite well aren't used to improvising

**Speaker 5 (14:37)**

Yeah. So I think it's perhaps related to that thing about a sense of what the goal is and what the ways of getting there are.

**Speaker 4 (14:46)**

They're not really directly comparable because as (Speaker 5) says, we haven't improvised together like that before, whereas we've practised. Mugirahayu and Tukung a lot. So it's really tricky to compare things like group flow because, you don't know what they're aiming for.

**Researcher (15:03)**

Nice. Okay, I'll move on. Next question. This is still in the same category and then another category of questions. Only short. Can you describe, any of you, or all of you an instance outside of this session, outside the experiment today, in which you'd experience group flow?

**Speaker 1 (15:26)**

In gamelan?

**Researcher (15:27)**

In gamelan.

**Speaker 6 (15:30)**

Pretty much every time we play.

**Researcher (15:31)**

Every time you play?

**Speaker 2 (15:32)**

Yeah, I think especially during our rehearsals before the concert.

**Speaker 3 (15:38)**

Exactly. When I first came to gamelan, I didn't have much group flow as well, because I don't know it feels very weird to me because I don't play in the other orchestra and I don't sing. I was just like, the piano is just like on my side. I haven't played with other people much of the time, but it gradually becomes better, especially for rehearsals from before the concert. So yeah.

**Researcher (16:07)**

Nice. Is there any one single experience, maybe more recently, that stands out?

**Speaker 7 (16:14)**

I think when we sang together. Warang Pojok

**Speaker 3 (16:20)**

Warang Pojok!

**Speaker 7 (16:21)**

Yeah, I did. Backstage. I think (another group member) started it and then everyone joined and it was fun. It's like, Okay, we had a good vibe now, let's bring it to the concert stage.

**Researcher (16:38)**

So there was an element of not just the music but also the feeling that you had that you shared?

**Speaker 7 (16:43)**

Yeah, the connection.

**Researcher (16:45)**

That's really nice.

**Speaker 1 (16:46)**

I love when we did that live as well because there was a lot of joy. The performance we're having a great time and I could see it in the audience as well.

**Researcher (16:55)**

They absolutely loved it.

**Speaker 7 (16:57)**

Some of them said that that was their favourite piece of the concert.

**Researcher (17:04)**

Nice. Okay, I'll move on to the final three questions. [Omitted]. As you might have been able to tell from the questionnaire, I was trying to hide it. One of the main focuses of this experiment was to isolate and assess one parameter of flow, which was the perception of time. So I was really interested in how time might relate to flow and relate to



gamelan. So without reeling on too much, over to you, how do you perceive time when you play gamelan? And can you describe this as a group? Can you reach some sort of consensus?

**Speaker 1 (17:38)**

It seems sort of irrelevant. I mean I don't, I'm not concentrated on my perception of time whilst I'm playing. All that I'm really concerned with is you know, where we are with the structure and how the shape, how it's progressing. I'm not going like, 'Oh, this is the three minute mark. This is the four minute mark.' I've never really paid attention to how long any of the pieces are. So I have no idea. When I have to write that down in the questionnaire, I have an idea, I'm making that up.

**Researcher (18:09)**

But when you reflect back on it, do you think maybe you're overestimating, underestimating?

**Speaker 2 (18:16)**

Don't really remember.

**Speaker 6 (18:18)**

I suspect it's mainly underestimated.

**Researcher (18:22)**

Okay.

**Speaker 5 (18:24)**

What I found ridiculous is I timed these pieces for the concert and I couldn't remember [inaudible].

**Speaker 4 (18:31)**

I put down the timing for Tukung based on how long we started before the doors were due to shut.

**Speaker 5 (18:37)**

Yeah! But I just realised I couldn't figure it out at all.

**Speaker 2 (18:41)**

Maybe you should be bonang panerus during the last of inggah. Really fast. He was like, 'When will this end?'.

**Speaker 4 (18:49)**

The thing is, when you talk about perception of time, if you're talking about how long the piece is, that's a conception of time that I think probably we don't have when we're playing, well I don't. But I am very concerned with time. So it's like the time between two beats. It's like, is there enough time for Bonangs to be doing imbal sekarang? Is it like the optimum speed? So my brain is actually concerned with time constantly.

**Researcher (19:14)**

Sort of rhythmic time and metric time.

**Speaker 4 (19:16)**

Metric time and how that relates to the instrumental parts of the feel I want. So it's like, you know, perhaps it's like that's the use that my time brain is going on and there's no space for duration.

**Speaker 5 (19:28)**

That's really interesting. And that sounds really familiar to me as well. Like, you're really interested in pace, timing, but actually how long it takes to play.

**Speaker 2 (19:40)**

It's not about duration.

**Researcher (19:43)**

It's not about duration? So when I'm trying to talk essentially about the subjective time, so not objective times in what the clock says, but subjective is in what you think time is, it sounds like you don't really care.

**Speaker 1 (19:58)**

Yeah. When you have novel experiences, new experiences, you're not paying attention to how, you know your sense of time then because it's all very new to you. I'm going to use the comparison of the [electric] scooters. When I started using the [electric] scooters, I was having a great time. So, I wasn't paying attention to how long the journey was and then I'd close the, I'd end the journey and go, 'Oh, that's how much time had

passed'. Whereas now I'm very aware of time progressing because it's like, 'Well, this is just what I do every day now. This is sludge.' I would say that that doesn't apply to gamelan. I've never gotten to that point where it's a sludge, like I'm waiting for it to end. So in that sense, yeah, I'm not really concerned about time.

**Researcher (20:42)**

Okay. Does anyone feel differently?

**Speaker 5 (20:46)**

I was really concerned about time in the improv. I was just like 'Oh. Come on!'

**Speaker 1 (20:49)**

Yeah. I thought there was going to be one place where we were going to end. I was like, I don't really love that, though. And then we got back into it.

**Researcher (21:00)**

So do you think the improvisation your time estimate could have been overestimated or underestimated?

**Speaker 5 (21:05)**

I don't really know. I mean, I kind of, when I first looked at it, it said estimate how long. My gut instinct was I wanted to write down three years [inaudible]. So yeah, I don't know.

**Speaker 3 (21:18)**

I felt for sure it was shorter than both pieces. I don't know.

**Speaker 1 (21:22)**

It was, yeah. It was.

**Speaker 3 (21:23)**

It was shorter because people were like, ran out ideas. People trying to come back and I put the gong in and everyone was silent.

**Speaker 4 (21:30)**

That's what you're waiting for. The other times, it nearly stopped.

**Speaker 2 (21:36)**

It's actually during the last part of the improvisation and I think that, 'Oh, you're starting to get into something and then it ends already.'

**Researcher (21:46)**

So, it sounds like it's something to do with boredom, the level of effort that's required?

**Speaker 1 (21:52)**

A bit.

**Researcher (21:53)**

Yeah? Okay, I'll move on. How do you think time perception might relate to flow?

**Speaker 4 (22:00)**

Again are we talking big duration, are we talking about time perception from beat to beat.

**Researcher (22:05)**

From the subjective sense, so how much time you think is passing, whether we're overestimating or underestimating, if you were to be asked, whether time is flying by or dragging?

**Speaker 6 (22:17)**

Flying by usually.

**Researcher (22:19)**

Flying by?

**Speaker 6 (22:20)**

Definitely with the improv not as much.

**Researcher (22:22)**

And does that apply to when you're in flow?

**Speaker 1 (22:27)**

I think it's difficult to measure the perception of time when you're in flow. That's what makes it so tricky to answer that.

**Researcher (22:32)**

But that's what I'm trying to do (Speaker 1).

**Speaker 1 (22:33)**

I know. I know. [Inaudible] That's why it's a good question to ask. But it's tricky. It's tricky to perceive that when you're in flow.

**Speaker 5 (22:46)**

I think it was like [interrupting]. Sorry. I was just, I think it's the level of caring about whether time is passing or not is really, really diminished. It's like I don't care how long I've been doing this. I'm having a great time.

**Speaker 2 (23:00)**

Exactly. That's what I wanted to say.

**Researcher (23:04)**

Okay. Nice. Final question. Anything about your experience of playing in this experiment today that might influence any of these ideas we've discussed on time and flow. We've sort of touched on this, but this is just basically your final chance to put extra comments in. Anything that I haven't said about flow, some prompts might be, do you think the electrodes were distracting at all? Do you think the setup might have interfered with the potential for flow?

**Speaker 3 (23:33)**

I think the electrodes were, on the other hand, made me more concentrated. It made me feel like I'm actually taking part very seriously in someone else's research. Not like playing a randomly, like a random concert or something. [inaudible]

**Speaker 6 (23:47)**

I think once you hit, I guess, one's perception of hitting the flow, you really don't notice it.

**Researcher (23:58)**

Does anyone feel differently? Did anyone get annoyed?

**Speaker 6 (24:01)**

Unless did they start tickling you or doing something funny, but for the most part...

**Speaker 5 (24:04)**

There were moments where I thought mine was falling off. That was a bit distracting. So

I was like, 'Oh, oh no.' But I found it much less distracting than last time we did the study. Yeah, the first time I was like, 'This is so weird.' But now I know what to expect which is nice.

**Researcher (24:19)**

And those that participated for the first time in my study, how does it feel?

**Speaker 2 (24:24)**

The devices are small, so it doesn't distract. [Omitted]

## SBGP Transcript

### **Researcher (00:01)**

So thank you so much for participating today. This focus group will investigate your perceptions of flow, playing today and in general. So first question is what was your experience playing in today's experiment? How do you think it went?

### **Speaker 1 (00:29)**

I enjoyed it.

### **Speaker 2 (00:31)**

Think it went quite well.

### **Speaker 1 (00:35)**

I think it was it didn't feel like it was any different from normal.

### **Speaker 3 (00:41)**

I thought it was at least to start with.

### **Speaker 1 (00:43)**

Did you?

### **Speaker 4 (00:44)**

Yeah, I thought it was slightly different.

### **Speaker 2 (00:48)**

I mean Mugirahayu felt different because we are all completely used to playing it with...  
To me, I've never done it without vocals. So that felt artificial

### **Speaker 3 (00:59)**

Both pieces felt weird without vocals to me.

### **Speaker 2 (01:02)**

Gambirasawit, because I'm less familiar with it was just kind of like, oh yeah, I'm playing a piece. I don't know, I'm familiar with this experience, but yeah, I think Gambarasawit didn't have that sense of artificiality, which I did in Mugirahayu where it was like at some point I was like, oh, if I listen up for (Speaker 1), she's going to play that cue that I would expect from a vocalist. That kind of thing.

**Speaker 1 (01:31)**

Yeah. Actually thinking about it, that was with me not having the vocalist.

**Researcher (01:35)**

Interesting because Mugirahayu is quite a vocal heavy piece. Well, not heavy, but vocal forward.

**Speaker 1 (01:43)**

And there's different garaps that you do on different instruments too. Like normally the rebab would either lead or follow the vocal things. I was following John when he changed the ciblon and it's like, okay, I have to remember not to do the gerong section that I would normally automatically do. You just out of habit, I suppose.

**Researcher (01:57)**

So it sort of changed the leader follower roles in way as well.

**Speaker 1 (02:01)**

A little bit. Yeah, I guess the roles were the same. It's just the order that we're used to doing things in was slightly different.

**Researcher (02:08)**

Sort of removed a stage there?

**Speaker 5 (02:09)**

Something missing

**Speaker 1 (02:11)**

Yeah, like we didn't do the first gerong.

**Speaker 5 (02:13)**

Missing bit, so I was having to adapt in the moment to the missing bit.

**Researcher (02:18)**

Yeah, I completely appreciate that. So how would you compare the different pieces today, for instance? And how would you compare playing from memory versus playing from notation, if you did, versus improvising?

**Speaker 5 (02:32)**

Thought the notation was the most stressful one.



**Researcher (02:34)**

Okay.

**Speaker 6 (02:34)**

I found that stressful too because I wasn't sure whether I should be looking at it. Then I sort of looked in it and then it was going between trying to remember without looking at because it felt like more normal under my fingers. And then I'd be looking at the notation and have a double take about.

**Speaker 3 (02:54)**

But you didn't have to look at it.

**Speaker 6 (02:56)**

No well I thought I was supposed to be looking at it.

**Speaker 5 (02:59)**

Had this conversation before about whether we knew the piece

**Speaker 3 (03:02)**

But if, (speaker 6), because you said, you know it so you wouldn't need to look at the notation.

**Speaker 6 (03:08)**

But on the other hand I was also quite rusty. So I guess.

**Speaker 1 (03:14)**

I thought it was different because again, the drumming was slightly different to how I'm used to maybe doing it because I think we did go into the inggah for a bit longer and then we changed in a different place. So at one point I had no clue where I was. I was looking at Helen going, I'm going to whiffle around and then if she lands for one, I'll play a one, and if she lands on a six, then I'm a six. And it wasn't until it sort of eventually settled in the irama that I was like, I still don't know completely know where I am, but I'm working with it and it's fine, but to me that feels really fun because that's what I do anyway. Okay. That wasn't until a recognisable pattern came in. Again, it's weird without, if I'd had the vocalist with me, I would have caught up quicker because I'd have known exactly where I was. But then it wasn't until a couple of recognized kecharian patterns came and said, oh yeah, great, I'm definitely in the right place, I can stop whiffing now.

**Researcher (03:58)**

So for you, being lost wasn't necessarily a stressful thing.

**Speaker 1 (04:02)**

it's a fun thing. I find. Because with rebab, although you're supposed to be leading some of the things, there's not a vocalist to lead, so you can sort of get away with it.

[Inaudible].

**Speaker 4 (04:15)**

Also, I'm just wondering, so I was okay because I was reading a drum notation. But you see, normally the ciblon drumming you'd have your kengsa and your [inaudible] and most musicians, those patterns tell you exactly where you are. But none of that was in there. That's what I mean. That hadn't even occurred to me until we were actually doing it..

**Speaker 1 (04:32)**

And I don't know the patterns well enough. I know the ciblon thing and I will go and I find myself moving and dancing along almost to the not really, but dancing along to the ciblon thing, but so without that, it's a bit like, oh, unknown territory this is quite fun. I'm not entirely convinced I know what irama I'm in but that's all good. Yeah. So I actually really enjoyed that.

**Speaker 5 (04:58)**

Whereas I find if you're playing slenthum and you get lost, it really matters. Because you're the only balungan really.

**Speaker 1 (05:06)**

Yeah, it matters. I think that's the hardest thing

**Speaker 2 (05:07)**

I was there, I only fell out once.

**Speaker 1 (05:11)**

No but I think that's harder than [inaudible]

**Speaker 2 (05:16)**

But there was the bonang, that was a reasonably solid cue.

**Speaker 5 (05:19)**

Yeah, he just shift around a bit though.

**Speaker 4 (05:23)**

I felt a bit like I'd set myself up to fail. Not in an unpleasant way, but like sort of think, oh yeah, it's the most peaceful calm...

**Speaker 5 (05:39)**

Oh yes, yeah I thought that was a bit funny.

**Speaker 3 (05:40)**

I felt calm.

**Speaker 4 (05:41)**

Did you feel calm?

**Speaker 1 (05:42)**

I felt really zen in Gambirasawit, I really liked it.

**Speaker 2 (05:43)**

I probably felt calmer than I did the last time I did it, when I was trying to sight read the singing part. Trying to mash the vocal in is a lot harder than following.

**Speaker 1 (05:55)**

And it's kind of weird doing it without a full gamelan as well, and without a vocalist.

**Speaker 3 (05:58)**

You really miss the kenongs.

**Speaker 1 (06:00)**

Yeah I really missed the kenongs. Because you don't have the point of reference so if you are really lost...

**Speaker 1 (06:07)**

I know, I thought, will somebody play kenong?

**Speaker 2 (06:09)**

So again, sort of having a smaller ensemble or having something missing, it makes you focus on something that you're not usually used to having to focus on.

**Speaker 1 (06:16)**

Or it makes you listen harder. Yeah.

**Speaker 5 (06:21)**

Which is a good thing You don't listen to the kenong, it's just there. You just listen when it's not there, don't you?

**Researcher (06:25)**

Interesting, thank you, but I will move on, because that was only the first question.

What's your understanding of flow state? Big question. I know. Don't worry, I'll explain.

You don't have an understanding. Does anyone have an understanding of flow state?

**Speaker 3 (06:46)**

It's when you're absorbed in an activity, not thinking about anything else, not thinking.

**Speaker 5 (06:50)**

And you're joining with other people in it and you're all in this thing together.

**Speaker 3 (06:55)**

Well, yeah, it doesn't necessarily have to be communal.

**Speaker 2 (07:02)**

Cycling or there are some motions which have that repetitive or expected quality that you are expected to be able to, enter, a kind of I think when you know the next thing that's going to happen, the next thing just follows.

**Speaker 2 (07:20)**

I think that's pretty robust definition there. I'll give you the sort of textbook definition. It's primarily a balance between challenge and skills for a given task with moderate mental effort. Also includes ideas of clear goals, absorption and a whole lot more. But this results in being optimally challenged, so you're not too stressed, you're not too bored. You might have also heard of it as being referred to being in the zone or something like that, usually referring to the same things. Do you think you experience flow state at any point today? In an individual sense?

**Speaker 3 (07:56)**

Yeah at a different points

**Speaker 4 (07:59)**

At different points.

**Speaker 5 (08:01)**

The first piece, I'm just getting stuck on the optimally challenge because it's very specific, meaning a definition of it, which was in the questionnaire before you defined optimally challenged, because it sort of stuck out a bit in the questionnaire.

**Speaker 2 (08:16)**

I don't think I did, but I don't know that I would ever very often enter what would be defined as a flow state. It's not a surprise to me.

**Researcher (08:29)**

So it can be a trait level thing as well. So some people are more likely to enter a flow state than others, so that's also perfectly fine. Forgive me if the following two questions don't necessarily apply to you as well. Something I'm more interested in is group flow. [Speaker 5] already alluded to it is that you can experience flow on a shared level in activities that require parts to be mutually responsive to one another. So you might have experienced it in sport, if you're a dancer, you might have experienced it in dance, playing chess. Also, musical ensembles are very much quite a breeding ground for something like group flow. So it arises through synchronous or coordinated action and relates to the level of togetherness a group might feel. Anyone had an experience of group flow in this experiment?

**Speaker 1 (09:24)**

Oh, I'd say definitely. I'd say in Gambirasawit, once the ciblon came in and everyone was like, oh, yeah, definitely know where we are.

**Speaker 4 (09:31)**

Yeah it felt like a relief didn't it. Even to me.

**Speaker 1 (09:35)**

I got really relaxed at that point. Because It was like oh I know where I am now.

**Speaker 4 (09:37)**

Because that was like sort of quite, what's the word, so it became more complicated and yet we all relaxed I felt, yeah, contradiction there.

**Speaker 1 (09:49)**

There were certain patterns that we were bonang patterns where, the rebab would play a thing, but it'd be played on the bonang or gender at the same time. And then I think you probably noticed us all looking up at certain points and smiling. It's like, oh, yeah, we're definitely [inaudible]. Then there are some things that I did a really funny wolf note at some point.

**Researcher (10:07)**

I noticed that, I noticed you smile. That was good.

**Speaker 1 (10:14)**

That was fun. And yeah there's bits like that. You find yourself like looking around a bit more and leaving the notation behind.

**Researcher (10:21)**

Nice. So it potentially brings a bigger level of comfort or something like that.

**Speaker 1 (10:28)**

Yeah, more like interaction because it's nicer to look at people rather than notation.

**Researcher (10:33)**

Did you experience potential differences between feeling flow state as an individual or feeling flow state as a group?

**Speaker 1 (10:42)**

Oh, yeah, I would say so.

**Speaker 4 (10:46)**

Not sure I understand the question.

**Researcher (10:49)**

Did you notice instances in which you felt flow state individually?

**Speaker 4 (10:53)**

Right.

**Researcher (10:55)**

And notice moments where you felt group flow state and do you feel that there might have been a difference between where those instances lay?

**Speaker 6 (11:03)**

Definitely different points, I think maybe points where I would be just more involved in what I was doing myself, enjoying that aspect of it. So it can go a bit in and out in that sense, I find.

**Speaker 1 (11:26)**

Yeah, I found that at the beginning Gambirasawit, I was really having fun with it on an individual level, because I knew exactly where I was and where everyone else was. And I was in my mind I don't know if it came across when I was actually playing, but in my mind, I was having fun, like, delaying certain things and playing with it. And that was great. And then I was like, oh, this is really cool. And then when we went into the change of drum, I was like, I don't know where I am now. That was definitely an individual flow state. I'm flowing with it, but sort of not necessarily in the right place, but in my own way. And then when again that ciblon thing came back, there was this for me a kind of palpable sense of oh, group togetherness now. I don't know if anyone else found that, but that's my little I think.

**Speaker 5 (12:06)**

I think there's a real difference if you're playing balungan and if you're playing something else because you have to be absolutely, well I believe you have to be absolutely kind of rigid or keep and everyone else [mimics playing] is farting about.

**Speaker 6 (12:23)**

And you don't have that flexibility of what you play.

**Speaker 5 (12:26)**

No. And so it's a different kind of feeling of having to be there.

**Speaker 1 (12:31)**

Yeah, but you can like in a gadon, when you haven't got a full gamelan, you can if you're playing sundan, you can delay, delays and things like that. But to align with the others, if you're really kind of then I think.

**Speaker 4 (12:42)**

You have to really know what each other's doing but I just think it's quite interesting, the difference between definitely where you're at.

**Speaker 2 (12:54)**

There's definitely something to that. I think potentially with that in consideration, do you think there's potential differences in how group play might arise between improvised or traditional playing?

**Speaker 3 (13:11)**

Yeah, I felt very different in the improvisation.

**Speaker 2 (13:14)**

Yeah.

**Speaker 1 (13:14)**

We haven't got any rules that you can't play wrong, but I suppose the improvisation hinges on communication. And I don't, so, it's slightly more mentally engaged than what I think of as being flow. In that you are trying to find somebody, you're trying to find a sound to interact with.

**Researcher (13:37)**

That's really interesting.

**Speaker 2 (13:38)**

So you are slightly more engaged, I think, than, like if it were, to me, flow implies much more of the unconscious,

**Researcher (13:46)**

More automatic.

**Speaker 2 (13:48)**

Whereas if you, unless you're like a master improviser

**Speaker 5 (13:52)**

Or you've been playing together for 20 years and you kind of get into some groove in your improvisation that you're used to. Yeah. I think we, well I was much more alert.

**Researcher (14:04)**

With potentially these ideas of freedom of your instrument in mind. Did you potentially feel more flexible playing your balungan part in the improvisation, potentially considering how that might influence flow



**Speaker 5 (14:21)**

Much more than [mimics playing].

**Speaker 4 (14:24)**

More interesting yeah.

**Researcher (14:27)**

Okay. Last question in this category, and then on to the last. Could you describe an instance outside of this experiment where you've experienced group flow together? I don't know how often you all play as a group or if you can.

**Speaker 4 (14:44)**

We're talking about this group outside of here, but with this group?

**Researcher (14:48)**

Yeah, or generally...

**Speaker 5 (14:52)**

In our lives?

**Researcher (14:54)**

Well, in gamelan. Southbank gamelan players contexts, not necessarily people in this room.

**Speaker 3 (15:00)**

But with other groups. Yeah, definitely.

**Speaker 5 (15:05)**

But with this group, I think in days gone by. I'm just thinking...

**Researcher (15:10)**

Any particular memories that come back?

**Speaker 5 (15:13)**

Yeah, I was thinking of that. What's the piece? I'm looking at [speaker 6] now. I was on the kenong. It was a piece that you'd written out. Very...

**Speaker 6 (15:32)**

Contemporary piece?

**Speaker 5 (15:33)**

Yeah. Vaguely contemporary or not recent.

**Speaker 2 (15:37)**

Okay.

**Speaker 1 (15:45)**

I say, like, when we do wayang quite a lot.

**Speaker 5 (15:47)**

Yeah. Well, I was thinking about that, wayangs can be very...

**Speaker 1 (15:51)**

Repeated things that we know the music backwards, but you're concentrating on the puppets or the puppeteer and listening out for cues, and you're like really, especially when it's like really sudden change. I think we're all really in the zone.

**Speaker 2 (16:07)**

There's also, there's some bits of singing, like there's some [inaudible] where you know where the notes are going.

**Speaker 1 (16:17)**

Yeah.

**Speaker 2 (16:17)**

You don't have to think about where the notes are going because they have that, I mean, you find it in gerong singing as well. There's some tunes you just know what the tune is going to do because that's the way that those tunes work. But I really feel it much more, I think, with [inaudible], where you just have this, like, this is where it's going to go, and then you have that sense of inevitability to it, which I think is in there. I also actually thought, this is not Southbank Gamelan Players, but didn't involve more than half people in this room. The Sunder gig that we did on Thursday, there were moments where things just worked.

**Speaker 3 (16:58)**

Oh, yeah. So many occasions, in my experience, not just Javanese, but Balinese , Sundanese

**Speaker 4 (17:07)**

Yeah. I think there's been some contemporary stuff we've done as well where it's just...

**Speaker 5 (17:13)**

Yeah, I can't think what the piece is, but yeah.

**Speaker 4 (17:14)**

The Amsterdam gig with [inaudible] there was just something about that because I remember I was barely in the first half and it was just all working like, clockwork is the wrong word, but couldn't stop just thinking, wow, that's amazing.

**Researcher (17:34)**

It's just working

**Speaker 5 (17:36)**

But I do think it's a lot about when the group's been playing together a lot, rehearsing a lot and really engaged in the music and that and we know it. And then we can do, I'm just thinking some of the old [inaudible] concerts. What's that piece? I can't remember names, in pelog where we start really slowly when people were coming in. Yeah. And people were coming in and then gradually got faster and faster and faster with that thing. And it's just I was loved because we just saw we were faster and faster and you moved along with it.

**Speaker 2 (18:23)**

[Inaudible] bonangs it happens a lot because of the shape.

**Speaker 6 (18:25)**

Thinking about the pieces we played actually, today. So that's the sort of thing which slowly builds up, isn't it, today? I have to say, the traditional pieces, it took me a while just to get into both of them. So starting them, each of them felt a bit of a jarring experience. And was that because of the slightly artificial nature of what we were doing?

**Speaker 4 (18:49)**

Yeah. I think for me, it was definitely.

**Speaker 5 (18:52)**

Felt a bit like, [gasp] we're on now.

**Speaker 4 (18:56)**

And for me what made it worse was having those three minutes.

**Speaker 3 (19:00)**

I know.

**Speaker 1 (19:02)**

Yeah.

**Speaker 4 (19:03)**

My mind just went completely mad in those three minutes.

**Speaker 1 (19:07)**

I was like, oh, I'm holding my rebab. Am I supposed to be holding my rebab?

**Speaker 6 (19:15)**

And you should have asked the question, how many minutes do you think that was?

**Researcher (19:21)**

It's interesting because different people feel differently about the baseline. Some people in York loved it.

**Speaker 5 (19:27)**

It's because they all meditate.

**Researcher (19:28)**

Yeah, maybe I do not.

**Speaker 3 (19:33)**

I didn't know if I was supposed to be thinking about the pieces or not thinking or I didn't know, but I was thinking. Couldn't switch my brain off.

**Researcher (19:39)**

I'll keep that in mind. Interesting. Okay, I'll move on. Last couple of questions. This is it. One of the main focuses, as you can probably tell from the questionnaire, was to isolate and assess one parameter of flow state, which is time. And I was trying to see whether potential differences in time perception might be shared depending on how

much in flow you might feel. Depending on how shared your physiological responses might be. How do you perceive time when you play gamelan generally?

**Speaker 3 (20:12)**

I lose all track of time.

**Researcher (20:14)**

You lose all time?

**Speaker 6 (20:15)**

Yeah. So in fact, when I was thinking about them, I was more thinking about how long would it take for a ladrang to go round in an irama dados? It's about minute, so that's cheating. It felt a bit like cheating.

**Speaker 4 (20:32)**

I did exactly the same.

**Speaker 3 (20:34)**

I didn't.

**Speaker 1 (20:35)**

I did for Mugirahayu.

**Speaker 2 (20:37)**

I just guessed a number.

**Speaker 4 (20:38)**

Gambirasawit I haven't got a clue. So do you know how long they were?

**Researcher (20:43)**

I will do, and I will let you know that's what the follow-up questionnaire is going to be on where I will send you the exact estimates compared with your estimates. For instance, the second one might be a million years, but we'll see. And on that note, how do you think your estimates might have compared to the actual times today? For each of them? Did some of them feel particularly short or some of them feel particularly long? Do you think your estimates are really far off?

**Speaker 1 (21:13)**

Probably really quite far off, but I've not idea

**Speaker 2 (21:17)**

I think there's probably a difference between people who are sort of estimating how long the loud range will take in this kind of situation or indeed, people who are used to timing how long a song is going to be, and like timing how long a piece is for the purpose of a concert, which just gives you a kind of working thing of like, this kind of piece of music will be this kind of length and you rely on that rather than actually being like, in this moment, I'm experiencing this much time.

**Speaker 4 (21:45)**

Yeah, that's good point.

**Speaker 1 (21:48)**

I think it's funny as well, because the rehearsal last week, we were all going, God, is it time's up already? It's quite chilled and stuff, but today it just felt like quite different. It didn't feel like time was dragging, but it didn't have that same, like, oh, gosh, we're at the end already kind of thing.

[inaudible]

**Researcher (22:08)**

Okay. Does anyone disagree with that?

**Speaker 5 (22:13)**

No I was just thinking. Again, it'll be on film I said to [speaker 6], 'what, again! We're going around again!' I think it depends what you're doing, if you're totally, I mean, obviously I could have been totally into it, but also I got cramp in my left leg. I was feeling, suddenly went and I was uncomfortable.

**Speaker 2 (22:33)**

And you have the longest period between beats.

**Speaker 1 (22:35)**

Yeah.

**Speaker 5 (22:35)**

And it's just like that's what you're doing and you're listening, but you're not having fun. But I was just thinking about in the Balinese piece, like if I'm playing rayon and

everything doesn't repeat endlessly the same, and then something different happens, something different, and we're playing my goal, it's 14 minutes or something, and you think, wow. So I was just comparing that difference of what I'm doing, how kind of involved and interesting my part is.

**Researcher (23:00)**

So there's definitely something about the complexity there.

**Speaker 3 (23:03)**

Yeah, definitely. I can get to the end of a complex piece in Balinese and think, oh, we've finished already, how did I get there?

**Speaker 5 (23:08)**

Yeah, but if it just goes on two, three, four, five, six, seven, eight.

**Speaker 2 (23:08)**

I think the fact that you had to count...

**Speaker 5 (23:14)**

Well I was counting because it freaks me out. If everyone's pulling it around.

**Researcher (23:22)**

Fabulous, that pretty much covers my questions. The only one left is just to say, is there anything about the experiment that we haven't covered in terms of it not feeling like you usually do, about how did you find the electrodes? Were they distracting? Did you notice them? Did they influence ...

**Speaker 2 (23:39)**

Ankle. The body one's fine notice them. But I think just the feeling of, like because I would normally adjust my position, I would normally probably fold my ankle behind me, and I couldn't do that because I had a thing on it. So I think that was quite also, I beat time with my big toes, and I didn't do that because I...

**Speaker 3 (23:54)**

I chose the foot that I wouldn't normally use to keep time with. I found myself doing that in Gambirasawit but not in Mugirahayu. Because there's time in between the notes.

**Researcher (24:10)**

Yeah. Any other comments on that?

**Speaker 5 (24:18)**

I mean. It's interesting, you're saying about anything different. I mean, the reality also is that we haven't played in this constellation for very long time.

**Speaker 2 (24:25)**

Yeah.

**Speaker 5 (24:28)**

But in terms of if you saying, like, the group that always plays sort of thing, the usual group, if you'd done this six years ago, we would have been playing together loads more. Sort of since COVID it's all been a bit...

**Researcher (24:45)**

I think this is something I'll be taking into account, obviously, because a lot of the groups in my studies are groups that rehearse regularly. Our group rehearses every week on a Friday. And this is something maybe we take for granted, but it could have a big difference and a big influence in how some of these things are felt and perceived.

**Speaker 5 (25:05)**

It's interesting how we could play, even though we don't...

**Researcher (25:09)**

Yeah, exactly. I thought Mugirahayu was beautiful.



## NCH Transcript

### **Researcher (00:33)**

Okay. Thank you so much for participating in the study today.

### **Speaker 1 (00:37)**

Thanks, [Researcher]. Thanks for coming all the way over.

### **Researcher (00:39)**

Thank you. It's very valuable for me. So the point of this focus group is now to look at your perceptions of flow state and how you think it might relate to some of the things I'm looking at. First question is, what was your experience playing in today's experiment?

### **Speaker 2 (01:06)**

Good.

### **Speaker 3 (01:07)**

Yeah, it was more fun than I expected.

### **Speaker 1 (01:11)**

Yeah, me too. Like from us, apart from.

### **Speaker 3 (01:19)**

Well apart from anything else, I usually spend more time being nervous about making a mistake. So the fact that there was only a handful of us here, there's less places to hide. So I was surprised how it actually flowed much quicker than if there would have been twice as many people because you can actually hear everybody, it's easy to...

### **Speaker 4 (01:39),**

Whenever I made a mistake, I thought, well, this is going to be great research material. She's going to really enjoy these mistakes. I could see her looking over at me delightedly, and I think, good, I'm getting positive feedback on all my mistakes.

### **Researcher (01:54)**

There's definitely things to work with there. So in terms of making mistakes, compared to sort of your usual rehearsal or usual performance, did it go well? Did it go as planned, mostly?

**Speaker 5 (02:05)**

Mostly I was less worried about making mistakes because we weren't preparing for performance. But then I was also, in another way, kind of more worried because it was like, being recorded.

**Researcher (02:17)**

Yeah. It tends to have the sort of dual effect, doesn't it?

**Speaker 5 (02:20)**

I think overall, though, yeah. I mean, I didn't mind that. I was like, okay, I'm just going to wait for the gong because yeah.

**Researcher (02:27)**

And how would you compare the different pieces in the improvisation? Do you think one went better than.

**Speaker 2 (02:31)**

The other first one, which one we did from memory, lancaran. That's the easiest. So it's very chilled. Kind of get into a groove with each other. Well, I find we're all locked into each other really easily.

**Researcher (02:49)**

Yeah.

**Speaker 2 (02:50)**

Whereas the other one's a bit more complicated. So you try not to get into the mind, but the mind does start to get involved a bit more...

**Researcher (03:00)**

Interesting. Does everyone feel the same?

**Speaker 1 (03:02)**

Yeah, totally.

**Speaker 3 (03:02)**

I was surprised how little I looked at the notation in the second piece, even though we weren't playing it from memory, because actually, you get into it much more if you don't look.

**Speaker 6 (03:16)**

I just found just being on the bonang on the Barong, just not having you're the bonang player because you're so used to being synced in with them. I found that a bit challenging. I'm not used to doing just by myself. No, it was grand. It was nice to fit in with the others. I listened to the others more than I would normally because I didn't have the other bonang beside me.

**Researcher (03:36)**

That's true. I suppose when you're used to just being part of like a duo, you can kind of lock into just yourselves and have a habit of not necessarily listening to the whole.

**Speaker 6 (03:48)**

Yeah, just tune into the drums [inaudible]

**Speaker 2 (03:53)**

I'd like to say as, although it's got a lot to with [Speaker 1] because he's very relaxed and that kind of like you don't feel like if you make a mistake, you know that he that.

**Speaker 3 (04:04)**

Was just today, wasn't it?

**Speaker 2 (04:05)**

No, but in general. Anytime we play, even if it's a pressurized situation, I don't think any of us have that feeling of like, oh my God, we're going to be dead if we...

**Speaker 3 (04:15)**

Well, yeah. I don't think it's not imposed from the outside. I definitely do spend a lot of time sitting on the stage staring at people going, what's the next note?

**Researcher (04:25)**

So your Zen is infectious.

**Speaker 1 (04:28)**

Excellent. Like I said, I learned from [GSP former director].

**Researcher (04:32)**

Who is the most Zen person in the world.

**Speaker 1 (04:35)**

But it's the kind of spirit, I learned how to teach gamelan from him, know like a child learns how to be a parent from how they were raised. He had the right attitude.

**Speaker 3 (04:45)**

I think the music has a lot to do with it. I mean, one of my biggest problems when I first started was that it would just sound so amazing and you would get into this Zen state and then it's like, when was the last time I played a note? Where are we? What's going on? I love that feeling. But you have to be constantly aware of the fact that you can actually get lost in that.

**Researcher (05:10)**

It's dangerous.

**Speaker 3 (05:12)**

Then you're gone. You might as well just sit back.

**Speaker 2 (05:14)**

And like a relaxed awareness. You have to try and stay aware of where you are or else you'll get lost even though you're relaxed.

**Researcher (05:22)**

Yeah.

**Speaker 1 (05:24)**

Now that this has reminded me and refreshed my sense of the importance of memorising stuff and this group tends to keep some busy with gigs and things. I often lean heavily on notation, but next year we're going to record this CD, so yeah, some of the pieces I think we should aim to do at least like Singa Nebah and KotheK from memory with all the variations because it really paid off. The spirit of what that does really came out.

**Speaker 2 (05:57)**

I think a lot of us do have the music in our memories, but we use the notes just as a safety thing.

**Speaker 1 (06:02)**

Exactly. So I think we'll do those couple of pieces without it for next year.

**Researcher (06:08)**

Cool. So talking about sort of that not being too relaxed, but being sort of aware sort of thing, what's your understanding of flow state? Has anyone heard of flow state before.

**Speaker 5 (06:20)**

Mihaly Csikszentmihalyi

**Researcher (06:22)**

There we go. He knows.

**Speaker 4 (06:24)**

What did he say?

**Speaker 5 (06:26)**

The flow theorist. Mihaly Csikszentmihalyi

**Researcher (06:29)**

So tell me more.

**Speaker 5 (06:33)**

My understanding of it is it's something that you experience doing many different things. Sports, could be cooking, could be, playing music is obviously a big one where you become absorbed and you lose a set of time. But there has to be a certain level of competence involved. So every activity can induce a flow state

**Researcher (06:58)**

Yeah.

**Speaker 1 (06:58)**

And not just the level of competence, but the level of challenge. So when you're doing something very complicated, you obviously have to be very competent to be able to get lost without losing your place. But the challenge has to be so demanding that the stuff you end up pulling off would surprise the hell out of you if you were aware of it. But you're in this state, so you're pulling off shit you wouldn't usually oh, that's great that just came together.

**Researcher (07:24)**

Exactly.

**Speaker 5 (07:25)**

So that it just draws you in, all of your focus. It has to be challenging enough that you have to be like, okay, I have to do this.

**Speaker 1 (07:31)**

Yeah. So I was thinking of all these issues while being aware that the only thing we'd do from memory is a lancaran with some variations. So it was somewhere in there, because I know who [suling player] and [siter player] were doing the variations, and it took a minute to so it was obviously enough of a challenge. So I was wondering if that would need.

**Speaker 8 (07:58)**

Well, not with gamelan, but with other instruments. On a couple of occasions, it was this weird feeling that the music was playing you that was really strange. You were almost sort of taken aback by this and sort of, oh, God, what's happening? Kind of thing, but hasn't happened in recent time. Not so much your gamelan, but otherwise.

**Researcher (08:16)**

So you also sort of slightly led into my, I didn't even need to give you the definition, which was wonderful. Thank you.

**Speaker 9 (08:23)**

Well, it's kind of on Instagram and TikTok.

**Speaker 5 (08:26)**

Oh, yeah.

**Speaker 9 (08:26)**

I don't know.

**Researcher (08:27)**

It's sort of trendy at the moment. I was into it before it was cool. So you sort of slightly got into this. But do you think you experienced flow, say, at any point today during this experiment?

**Speaker 1 (08:42)**

Yes, definitely.

**Speaker 5 (08:44)**

For me, more so in the first one, because it was just, I think, concentrating. It's, like, too hard to and then in the second one, it was much more difficult.

**Researcher (08:51)**

You were slightly sort of over challenged.

**Speaker 2 (08:53)**

Sometimes, if you think while you're playing, sometimes the first piece, I was like, oh, how many times am I doing this? And that kind of gets in the way. Whereas if I just feel it as a groove and I'm not thinking this is a number, it's a feeling, oh, the harmony is moving to there. So I'll move and then you feel really in the flow. Yeah. Whereas if you start thinking about the numbers.

**Speaker 1 (09:22)**

There is, in dealing with groups of various kinds, it's always easier to be heard when things are quieter. Sometimes if we have a large classroom, for example, we might shout over the group to be heard when the truth is, if you speak really quietly, suddenly everyone kind of leans in and you get their attention better. So I think having this small group, everything stayed quiet and mellow. So the level of listening, I think, was at a higher level than if we had all 20 people here playing every instrument where you.

**Speaker 3 (09:56)**

It was much easier to hear the music leading you to where you're going next. I could hear a lot of stuff really clear coming from the Bonangs and whatever, and it's like, oh, well, I'd stop and I think and I'd go, how many times have I played that two notes? And before I'd even had a chance to think about it, you'd hear it coming and then it's like, okay, yeah, we are going there.

**Speaker 5 (10:20)**

Yeah, I noticed that as well.

**Speaker 2 (10:23)**

Though. Isn't it like a self trust? Oh, yeah, I actually know this is fine. I don't have to think about it. The structure, you just feel it.

**Researcher (10:32)**

Yeah, that's a really nice way of putting it. So something I'm more interested in is the idea of group flow, which is an extension of some of Csikszentmihalyi's work. And it can be called numerous things shared flow, group flow, networked flow. But it's seen as an extension of individual flow. But it arises through synchronous or coordinated action. So, the sort of coordinated action needs to be necessary for flow to occur, say, for example, with a group ensemble. So do you think you experience group flow?

**Speaker 4 (11:07)**

I'd say so, yeah. I mean, sometimes our group, you get feelings some evenings when we don't and some evenings when we definitely do. And it's like it's a group thing that no individual is really in charge of. But today, I think I felt it yeah.

**Speaker 3 (11:20)**

I've noticed a lot well, this summer as well, especially with being back playing live and stuff, is that the rehearsals are way more stressful and messy than the gigs ever are. Sometimes you sit down, you're like, this has got to be awful. This guy I was like, I can't even remember it. And I know somebody else said the same thing to me. And it's like you blast through and you don't even know what happened. And it's almost like you want to burst out laughing after. It's just like, how did it happen? And it is just that you're there, you've got to do it, and you just go, all right. It's kind of almost just like breathing sometimes. I don't know. I have a terrible habit of forgetting to breathe if I get stressed, hold my breath. Whereas if you just go, just remember. It just happens, like, you know so.

**Researcher (12:09)**

Just forget about it. I can relate to that quite a lot.

**Speaker 2 (12:14)**

Is it like that if there's something coming up that puts a different pressure on the



playing, so then you're more in the mind trying to get it right. And then when we're under pressure, when we're playing, we forget.

**Speaker 3 (12:30)**

Yeah, I guess that's what it is. Everybody gets way more anxious thinking about the thing, and preparing for the thing and what if I do this, what if I do this wrong? Or what if we're not? And it's like once you sit down to actually play for an audience, you kind of go, well, too late now.

**Speaker 2 (12:49).**

I see, I think this is a relaxing thing because I have always come in straight from being with the kids. Well, so for me, I always feel really relaxed and I don't mind, I never really care if I make mistakes. Sorry guys, I'm just like I'm here to enjoy myself. It's not heavy.

**Researcher (13:11)**

No, that's nice. So do you think there are differences between feeling individual flow and group flow in the context of gamelan?

**Speaker 9 (13:22)**

Like, everywhere. Yeah, it's teamwork, right? And so the small pieces could be seen as in programming small pieces of work. So it applies the theory of the teamwork applies here as well.

**Speaker 1 (13:42)**

So I'm not sure there can be a difference for me. There can't be, like if I'm directing and the group isn't together, then I can't get into the flow at all. I've got to steer and give cues. [Kenong player] fell out at a bit. I gave a clear signal about here's the gong, and he spotted it and got back in.

**Speaker 9 (13:59)**

But if you're playing alone as a solo player, so you can be in the flow like.

**Speaker 1 (14:05)**

Oh, yeah. So they're different.

**Speaker 9 (14:08)**

This is like group work.

**Speaker 1 (14:10)**

Yeah. You can't get into your solo flow unless there's a group flow.

**Speaker 4 (14:14)**

I felt in the improvisation, sometimes I was just in individual flow, doing my own little thing in a corner, not really caring what other people were doing. And other times I felt like I was in playing with the other people and whatever was happening was happening. So I kind of felt I was kind of flipping between the two in the improvisation, but in the actual pieces, maybe with the suling it's a little bit make it up to you along. But I think in the pieces, because it's something for we've rehearsed together it's much more about group flow, I think.

**Speaker 6 (14:42)**

I think it is possible to feel flow individually and not everybody is feeling exactly the same thing. But I think for everybody to be in a flow state that does rely on all individuals also experiencing that.

**Speaker 9 (14:56)**

It's kind of tuning into each other. For me, it's easier when I tune in on a drum. What [leader]'s doing anyways. When I hear individual players, it's easier for me to find my own.

**Speaker 8 (15:11)**

Ways of sort of tuning in before even starting to play.

**Speaker 2 (15:14)**

Maybe having that quiet before helped us all to relax a bit as well.

**Researcher (15:22)**

So you kind of alluded to this, but do you think there are differences in the potential for group flow to arise between improvisation and between playing traditional gamelan music?

**Speaker 5 (15:36)**

I mean, I think the sense of group flow was it felt very evident to me in the first piece, much more so than the improvisation. There were points in the improvisation where it

felt like some things were coming together. I think we're mostly kind of like doing our own things.

**Speaker 2 (15:52)**

I thought we were all really listening.

**Speaker 5 (15:53)**

Really?

**Speaker 1 (15:55)**

Exactly, I think it's half and half.

**Speaker 3 (15:57)**

I think so, definitely once more people got involved and it sort of just developed its own trajectory, it definitely felt like we were all on the same page.

**Speaker 1 (16:10)**

Truth be told, a huge chunk of my career is in of improvisation ensembles and it's practically a rule, that, so I'm talking like entire rehearsals where you just improvise again and again over hours. And it's almost a rule where the first one is just the warm up, it doesn't count, it never goes well, and the second one's brilliant. So I was a little wary of the fact that we were only going to have one improv and I thought, oh, the first improv is always a dud. So I was actually very pleased with how much we got out of that, having never even improvised as a group before, never mind the fact that we didn't get to do one dud one before we got into the good stuff. I was actually very pleased that we got something out of a one off totally unprepared improv.

**Researcher (16:58)**

And do you think you're more likely to enter a feeling of flow or group flow if you're playing a certain instrument or performing a certain kind of piece?

**Speaker 2 (17:08)**

Do you mean in general or just gamelan?

**Researcher (17:10)**

In the context of gamelan.

**Speaker 5 (17:12)**

I don't think it matters what instrument I'm playing if I really know it. I think it doesn't depend on the instrument for me.

**Researcher (17:21)**

Does everyone agree?

**Speaker 5 (17:23)**

I don't know some of the instruments you feel you might not be as used to it or a bit more complicated when you start to learn it. And that can be harder to get into the group flow. Yeah, or else if you're doing the gong or something, you can't get lost. Like you really have to pay attention then.

**Researcher (17:39)**

But do you think you'd be challenged enough to be in flow if you're playing something like the gong?

**Speaker 6 (17:45)**

I think sometimes if I'm playing similar stuff, it's easier to get a bit lost. But if like the Bonangs, which if I'm feeling very confident and competent, then it's kind of almost easier to get into the flow with it. Because of that level of concentration that you need.

**Researcher (18:05)**

Yeah, I like that confident and competent.

**Speaker 1 (18:09)**

One thing gamelan can do when you have a full orchestra. I've often had this with like there's a particular experience I remember from [inaudible] and I was honestly moved to tears. It can be so overwhelming of the senses. When I remember this piece they did and laid out all the instruments and then it changed gears, so the soft instruments came in and then the voices came in doing [inaudible] and it just got more and more layered. And then the dancers came out and I just lost it. My senses were totally overwhelmed. So I would imagine, to answer your question about could you get into a flow state if all you had to do was hit the gong? I would imagine that if you're part of a group and you're fully absorbed and everything, the group is happening. Like in a scenario like that, even though you're only hitting one note, if you're carried all the way

through until the gong, I would say you could be in the flow state if it was just a one note piece.

**Speaker 4 (19:12)**

I think my problem with that, though, is that when it's all those complicated layers, I actually just lose track of what's going on. It's just this mush of sound. And then I've got the responsibility for playing the gong. Whereas if it's something where I feel I'm following it, then I can be in the flow on the gong.

**Speaker 1 (19:29)**

But not like what I was saying, how competent are you on your part?

**Speaker 4 (19:33)**

But it's a competence of listening, really. It's not a competence of playing the gong because that's easy. It's just knowing when to play it.

**Speaker 4 (19:40)**

But is the flow state an emotional state, though, or is that different? Because you can be it can by music.

**Researcher (19:47)**

It's a bit of both. It's both something that people say kind of rise or something that happens to you either willingly or not and can produce sort of emotions or it can also sort of encompass emotions. There's lots of different theories around it.

**Speaker 5 (20:05)**

It's funny because emotions we tend to associate as very internal, but flow state almost feels like external in a way.

**Speaker 8 (20:13)**

Is it a thing about letting go rather of the control and allowing the flow state to happen rather than

**Researcher (20:19)**

It can be. Yeah, absolutely.

**Speaker 1 (20:22)**

I think it's partly like losing your sense of self. Like you can't believe you're doing what

you're doing. I'm thinking of times when it's happened on guitar where I wouldn't be the best guitarist and then I'm suddenly pulling off stuff I wouldn't have thought I was capable of. And I'm kind of out of it watching it happen.

**Researcher (20:39)**

Yeah, great. I've just got a couple more questions and I'll need to bring it to a close. Okay. So as you might have been able to tell from the first question when you turned over the page, one of the main focuses of this experiment was actually trying to assess one parameter of flow states which hasn't seemed to be given much attention, which is the perception of time. So, in general, how do you think you perceive time when you play? And can you describe this as a group?

**Speaker 6 (21:06)**

I would say I definitely did a lot worse guessing how long the improvisation was. Because I'm used to playing those pieces. So I have a rough idea. Oh, that's how long we went through a few sections, and it was less than maybe ten minutes, whereas the improvisation, that could have been three minutes, or it could have been 20. And I couldn't have told you.

**Researcher (21:25)**

Really?

**Speaker 1 (21:26)**

Yeah.

**Speaker 3 (21:27)**

I do think there's something about that open ended kind of experience, though. There is no clear beginning or end. And you're just in it and it's. Like then when it finished, it was like, all right, yeah, we're done. Like you say, it could have been I said about eight or nine minutes, but it could have been a lot less. And felt like that just because there was so much happening.

**Speaker 8 (21:51)**

Something rhythmic would tend to give you a better sense of time, I suppose, rather than something that's completely flowing.

**Researcher (21:57)**

So you're sort of judging time based on the rhythm and the structure. Maybe.

**Speaker 8 (21:59)**

On the music, on how many times you've heard it

**Speaker 9 (22:06)**

It's a bit different if I'm kind of bored. It's longer.

**Speaker 3 (22:12)**

I think it's quite like flow state in other things, like, say, creative writing or doing art, it's a lot harder to keep track of time. I think with music, you've got a little bit of a framework in the back of your head. There's a beat and a pulse, and there's something there that helps you guesstimate how long it was, but you're kind of working it out from that. It's not really your actual perception of time, in a way.

**Researcher (22:38)**

No, that's really interesting.

**Speaker 2 (22:39)**

Depends on the environment as well, because here we're all playing and it's relaxed and you can just totally let go. Whereas, say, if you're doing a gig or something and you are more conscious of time, someone does actually have to physically keep track of the time. And you might feel more rushed because your heart might be going faster. So time, you can sort of forget time still, though, it feels like the thing's gone like that. I don't know. It's weird.

**Speaker 4 (23:08)**

Does heartbeat actually affect your perception of time?

**Researcher (23:11)**

There is mixed evidence so far. I'm hoping to contribute to that. I'll let you know.

**Speaker 2 (23:19)**

Sometimes you're paid for your time if you're a musician, so you'd be like, if I'm doing a gig or someone will be checking our time, and it can feel like and you'd be moving everything really slowly. You know what I mean? It's really weird. Yeah. Then if you pick

pieces you like, it goes really fast. I know, it's weird. Or if you're sight reading, so it changes the perception.

**Researcher (23:40)**

So how do you think time perception might relate to flow experiences?

**Speaker 2 (23:46)**

I think you forget time.

**Researcher (23:47)**

You forget time altogether?

**Speaker 3 (23:48)**

Yeah. I think it disrupts your perception of time completely. Well, certainly for me it does, yeah.

**Speaker 4 (23:53)**

But not in flow sometimes. I mean, there's been moments when I've been playing gamelan and I'm not enjoying it. And I'm completely out of flow and there's a boredom factor comes in where time seems to drag forever. So, like, yeah, okay, sometimes your flow does things to time, but so come boredom too. It's not the only thing that plays horrible games with your sense of time.

**Researcher (24:12)**

Absolutely.

**Speaker 1 (24:12)**

But there's another facet of that, which is as a piece of music progresses, you have to make decisions not just in terms of queuing changes in a gamelan group, but in other ensembles as well. So you can't entirely forget about time. Sometimes it's just the right time to do something. Let's say it's an improvisation and, you know, enough time has passed on that theme and you have to move on to a new one. Whenever you have to make a choice to change in a piece, even in a flow state, you have to be sensing that it's the right time because enough time has passed. Perhaps you can't quantify how much has passed.



**Speaker 9 (24:52)**

Because you don't see how people eat, actually, if you see how they eat. So, for example, I was kind of in Indonesia and they changed the music when they kind of saw change of course. So they kind of absorbed this. And when you don't see it, you kind of don't know when you are supposed to kind of change the music or something.

**Speaker 5 (25:22)**

[Speaker 1] was saying it's a lot to do with his role, like his role as a director means he is conscious of time in a different way to the way we are. Or like, say, if you're like the leader of an orchestra or somewhere, you have a different perception of time of the group because you have to bring in all the tempos and everything, whereas if you're in, we're more passive, so we're relying on him for everything so we can relax and go into a flow state. Whereas he is aware of all of us as not being the expert.

**Speaker 1 (25:58)**

So let's say in a concert we can all be in a good flow together and I'll still have a sense of like, one more cycle is going to be too much I'm going to queue the change this time. So I'm not necessarily counting the minutes, but we can be part of a group flow and still have enough awareness of the passing of time, or at least I can, to make those kind of decisions.

**Speaker 3 (26:20)**

It's a different sort of time, though, really, isn't it? It's not.

**Speaker 1 (26:25)**

Not clock time.

**Speaker 3 (26:26)**

Yeah, it's not clock time. Like you say, another cycle of the whole thing is going to be too much, whether it's just because you don't want to hear it again or whether you think the audience, reading the audience. It's kind of like...

**Researcher (26:39)**

Stretchy time.

**Speaker 3 (26:41)**

Yeah.

**Researcher (26:43)**

Great. I've got one more brief question, and I really must call it an end. Yes. But do you think there's anything about the experience of playing today that might have had an influence on the flow? Mainly I'm referring to the equipment and the electrodes. Was any of it distracting? How did you find it?

**Speaker 6 (27:02)**

We really noticed it when I was actually playing.

**Researcher (27:04)**

Yeah. Great. Fantastic.

**Speaker 5 (27:08)**

I couldn't feel my foot at one point.

**Speaker 8 (27:11)**

I was worried about my foot getting sweaty and the things falling off.

**Researcher (27:16)**

Great. Fantastic. Okay, we'll leave it there. And thank you.

## GSG Transcript

### **Researcher (00:00)**

My first question is what was your experience of playing in today's experiment? Did the pieces you played go well?

### **Speaker 1 (00:23)**

Yeah, I thought the improvisation was lovely

### **Speaker 2 (00:26)**

Yeah. I was pretty happy with how things went. I don't think, I hadn't played manyar sewu in a long time, so it was great to play that and get that back up and running. Yeah, I was very happy.

### **Researcher (00:47)**

Yeah? Does everyone feel the same? [Inaudible]

### **Speaker 3 (00:51)**

By the end.

### **Speaker 2 (00:53)**

By the end. [Inaudible]

### **Researcher (00:57)**

So as you might know from the information sheet, I'm interested in how feelings of flow state might be kind of represented through physiological signals. So the next question is what's your understanding of flow state? Are you familiar with it as a concept?

### **Speaker 4 (01:17)**

Is it the concept... Csikz....

### **Researcher (01:19)**

You've got it. So what's your understanding of that theory?

### **Speaker 4 (01:25)**

When you're so engaged in something that you're engrossed in what you're doing so. The world around you... that you really focus, that you're really engaged.

**Researcher (01:35)**

That's a really nice way of putting it. Anyone else heard of something similar?

**Speaker 1 (01:41)**

Yeah, just not thinking of anything else yeah. Just that you're engrossed in what you're and...

**Speaker 4 (01:46)**

Doing and being in the moment.

**Researcher (01:53)**

Nice. So I'll give you the classic definition. So flow state is defined primarily as a balance between challenge and skills for a given task, moderate mental effort, but it also includes ideas of having clear goals, being absorbed and more. So this results in being optimally challenged so you're not too bored and you're not too stressed. You might have also heard of it as being referred to as being in the zone or something like that. Generally similar concepts. So what was your experience with flow state today? Do you think you might have experienced flow state in this experiment at all?

**Speaker 4 (02:32)**

Yeah.

**Speaker 5 (02:35)**

I think so. And I think because you notice it when then we had to write something.

**Researcher (02:40)**

Yeah.

**Speaker 5 (02:41)**

And so you had to suddenly make a change.

**Researcher (02:45)**

So sort of on reflection?

**Speaker 1 (02:49)**

I probably found the middle piece the hardest. So I don't think I was in flow state for that because I was a bit stressed because it's hard. Maybe I haven't practiced it enough. So

there's a frustration there if something is too hard and maybe not as at ease. But the other two pieces were fine, I think.

**Researcher (03:15)**

Okay.

**Speaker 1 (03:16)**

Even though the third piece, maybe I felt like I didn't know as well, but I didn't mind, but the middle piece was just not, I was out of my flow space.

**Researcher (03:28)**

Did anyone else feel the same or does anyone disagree?

**Speaker 4 (03:34)**

I found the first piece took a while to get into, that it felt.

**Researcher (03:38)**

Was this the improvisation?

**Speaker 4 (03:40)**

Although that it just took a while to get by the end of it? It did, but it just took just took a while.

**Researcher (03:46)**

Okay.

**Speaker 3 (03:48)**

I like the improvisation. I like that.

**Researcher (03:51)**

Okay.

**Speaker 3 (03:54)**

That last piece we did, I think, stopped me because we haven't done it for a while. I enjoyed the first one we did. I like that one. But trying to memorise, it was a different story.

**Researcher (04:10)**

Yes, it's true.

**Speaker 2 (04:16)**

I feel like at the back of my mind, I know we've got a concert, so I'm in sort of rehearsal mode. So really it was just the improvisation for me that I was able to sort of get into that flow state. Because for the other pieces, I'm thinking we have to do this, we have to do that, now I'm not thinking bad things, and we have to go here and we have to, blah, blah, and this person needs to know when that beat is. So for me, personally, there were other very conscious considerations going on in my mind. I was thinking about form and structure and all those kinds of things and what's right. Whereas with the improvisation we didn't have to worry about what was right. Yeah, so for me. That was the one. If I didn't have that role, I think I'd have a different answer.

**Researcher (05:10)**

Okay. So depending on sort of leader roles, potentially, I can understand that sort of feeling responsible for the group in a way. So something I'm more interested in is the idea of group flow. So if you can understand what the experience of flow state might be like. Group flow is essentially flow state in situations in which it arises through synchronous or coordinated action. So essentially, the coordinated action is necessary for flow state to arise. And examples of this can be group dance, sports, playing games or in musical ensembles. So with that in mind, what was your experience with group flow in this experiment? Do you think you experienced group flow at any point?

**Speaker 4 (06:06)**

That last piece, I thought it was all together.

**Researcher (06:10)**

Yeah?

**Speaker 4 (06:13)**

I think that was the best one.

**Researcher (06:14)**

Okay.

**Speaker 1 (06:19)**

Probably towards maybe the end of the improvisation. Second half has been improvisation.

**Researcher (06:25)**

Yeah. Do you think potentially that's to do with not relying on your music?

**Speaker 6 (06:30)**

Or maybe, I thought it was the drum.

**Speaker 1 (06:35)**

The drum?

**Speaker 6 (06:37)**

When the drum came in on the second part of the improv,

**Speaker 2 (06:39)**

I think pulse has a bit to do with group...

**Speaker 6 (06:42)**

I think it brought us together. I certainly realized I was more engaged once the rhythm came in.

**Speaker 2 (06:51)**

Yeah. Think that sometimes it can be presence of the drum. So eventually, whether you fall into the same pulse of the drum and there was a lovely moment where I stopped or not stopped, but kind of slowed down and just to see what would happen. Because at that point, I knew that everyone was very, very focused and I knew that everyone was in this. We had created a sort of a sympathetic atmosphere amongst us, I think. And then there was this lovely moment of almost not wanting it to end, where I was like, I'm happy for it to end now. But it's like, also if I played one more note? Would someone else play one more note? And someone did. So there was a lovely kind of sense of focus around that. And I wonder I'm not sure it would have happened had we not fallen in with the beat, like you said.

**Speaker 6 (07:59)**

And playing with it, not just following the beat.

**Speaker 2 (08:03)**

Yes.

**Speaker 6 (08:03)**

Playing with the beat happened, and so it got a certain intensity or energy or involvement or whatever.

**Speaker 2 (08:17)**

And it's hard to start cold with a free improv as well, I think. Hard to just jump in there.

**Researcher (08:22)**

Yeah.

**Speaker 2 (08:23)**

So I wonder if we've been here for three or 4 hours and then we did that.

**Speaker 6 (08:28)**

because it would have been in the atmosphere. Something together would have been. I agree I thought the beginning of it was...

**Researcher (08:37)**

Or if you would have potentially done the improvisation last, maybe?

**Speaker 2 (08:40)**

Yeah, it might be. Different because we'd have already gone in. We'd already had kind of contributed the labour, I suppose, into creating the collective feeling.

**Speaker 6 (08:51)**

The field. That's it the field. And I didn't feel in the beginning there was a field, whereas later. Yeah, I agree. Because we would be playing with the field somehow or being able to rest into it, being able to relax more into where we were in ourselves. But first of all, you find yourself and find the sounds.

**Speaker 2 (09:11)**

And you're still outside in your day-to-day life where you're. Yeah.

**Researcher (09:18)**

So potentially easing into things a little bit more might have helped.

**Speaker 4 (09:23)**

Yeah, definitely. Think, as you're saying, starting with the improvise. I think that it's hard.



But the end was like you said, it was a love that you felt at the start. Think it's hard starting with an improv.

**Speaker 2 (09:36)**

But those group things it's like the group dynamic has a bit of inertia to it. So you need to spend some time, like pushing or dragging or whatever until creating. Yeah.

**Speaker 6 (09:49)**

Or just creating I think. Just being together, working. Just whatever happens in that being together and doing and being together, something is created. Something has moved in the field.

**Speaker 2 (10:05)**

And I wonder, would it be the same if we had sat down and talked for 15 minutes? No.

**Speaker 6 (10:12)**

Because our field was musical.

**Speaker 2 (10:15)**

Yeah.

**Speaker 6 (10:16)**

It's not verbal, really.

**Speaker 5 (10:18)**

Yeah.

**Speaker 6 (10:20)**

It's the sound, isn't it?

**Speaker 2 (10:21)**

Yeah, that's the [inaudible].

**Speaker 1 (10:26)**

Do you think there's a difference in how you might have experienced individual flow states? So what we're talking about before and how you experience group flow, do you think they're different things? In this context.

**Speaker 2 (10:46)**

I would find it hard to describe individual flow in the context of what we just did there. I'd find it hard to say that I experienced flow outside of the group.

**Researcher (11:00)**

Yeah.

**Speaker 2 (11:01)**

I think there's really only the group. That's my feeling. I often hear tennis players talk about flow, and I think, well, that's fair enough, because you're out there on your own yeah. Or but you got the audience, or whatever, the spectators. But it's very hard for musicians to say, I experienced flow and it was only because of what I was doing. It was only within me, and it didn't involve any contamination from anybody else.

**Researcher (11:33)**

That's really interesting words. Yeah. Contamination.

**Speaker 2 (11:36)**

Yeah.

**Speaker 6 (11:39)**

For me, when it was very simple like that Manyar Sewu

**Speaker 2 (11:43)**

Yeah.

**Speaker 6 (11:44)**

The part I was playing, because I kind of got it quick.

**Speaker 2 (11:48)**

Yeah.

**Speaker 6 (11:53)**

What my part was. And so I did feel my individual flow, but of course it's in relation to the group, but I feel there is a difference. I felt like there was a difference because when the group is flowing and you are in the group, it's just a different feel, kind of clarity and whatever. Whereas with this one no, I just thought, no, here I am. It didn't feel like we

were all together all the time, but something about, you know oh, yeah. Bonk [mimics part]. You know, '3, 5, 3, 5'

**Researcher (12:29)**

You know where your part is and where you fit in. That's nice.

**Speaker 6 (12:36)**

Yeah.

**Speaker 4 (12:37)**

You don't know your line or something. Just like there's that magic when every which is totally beyond you.

**Researcher (12:44)**

Exactly.

**Speaker 4 (12:45)**

And you can't get that on your own. In my experience, when we lock in, like we did on Saturday there are times where. It seems like you're just part of something, but like [Speaker 1] was saying, then it's kind of stressful if you don't know your part, you can't focus at all because you're so busy trying to, 'what am I doing again'.

**Researcher (13:09)**

You need that balance.

**Speaker 4 (13:13)**

Yeah sure.

**Researcher (13:14)**

Yeah. Cool. Okay, I'm going to ask a two-part question. These are separate questions, but I'm going to group them together. What do you think about the relevance of group flow to gamelan? And do you think it differs between when you're improvising with gamelan and playing traditional pieces? I can keep them separate, but I think they're quite nice together.

**Speaker 2 (13:40)**

What was the first part again?

**Researcher (13:42)**

I'll keep them separate. What do you think about the relevance of group flow to gamelan playing in general?

**Speaker 1 (13:51)**

Well, it can't happen on its own. You can't play gamelan on your own. Well, you could, but it's not.

**Researcher (13:59)**

Like a one man band.

**Speaker 1 (14:01)**

Yeah. It's not an individual thing.

**Researcher (14:04)**

Yeah. But what do you think about how structures might lend themselves to group flow, for instance?

**Speaker 2 (14:16)**

Yeah, well, microstructures like repetition, beat repetition and doing the same thing over and over again, which there's a lot of in gamelan. Does, it's a pathway, I think, towards flow. Also, I think the fact that the parts, some of them notwithstanding, are generally simple and repetitive. So you got that balance between not being too boring and not being too challenging. A lot of the instruments fall into that kind of sweet spot, I think. But it's just a personal philosophy of mine, is whenever we're playing music together, the point is to get into that state of group flow or whatever you, you know, whatever you want to call that sort of participatory thing where you're merging with someone else's intentions and your intentions. And as to the relevance, I think it's the whole point. And playing gamelan or playing music is just one way of being together in that way, and a way that I think is good, is a quicker way to get in group flow than like, I don't know, arguing with someone, or you know the talk. If we sat down and talked to each other, would we be in flow? Or maybe someone who does another art form might say, actually it's making sculptures together, dancing together.

**Researcher (15:57)**

It's contextual.

**Speaker 2 (15:58)**

Yeah.

**Researcher (15:59)**

So on that note, do you think group flow is experienced differently when you're improvising and when you're playing traditional pieces?

**Speaker 5 (16:12)**

You yeah, I think that traditional music is definitely so obviously collective. And so when suddenly improvisation, you have to watch that. You don't get too much thought into it.

**Speaker 3 (16:31)**

When you're improvising, even though you're playing an instrument, but there's everyone else around you and you have to listen to everyone else. You were all playing together, so we're all kind of become one, as it were. So you're not really on your own, but you're with, you're all together.

**Researcher (16:55)**

Yeah.

**Speaker 3 (16:57)**

And it's beautiful. All the different sounds really blend in really well together.

**Researcher (17:05)**

Yeah. Okay, I'll move on to my last set of questions, unless anyone has anything else to add? Okay, so as you might have been able to gather from the questionnaire, one of my main focuses was time, because time perception is one parameter of flow. So how do you usually perceive time when you play gamelan?

**Speaker 6 (17:37)**

Forget about it.

**Speaker 4 (17:38)**

Time goes really quickly, isn't it?

**Researcher (17:43)**

You feel it's quick?

**Speaker 4 (17:45)**

Like an hour will go past really quickly.

**Speaker 5 (17:48)**

Yeah.

**Researcher (17:48)**

And is that always the case?

**Speaker 1 (17:53)**

When you're really engaged? There was something we played there maybe on Saturday in here, and you were like, oh, that was eleven minutes. And it was like, that felt like two minutes.

**Speaker 2 (18:07)**

Yeah. Well, that's why I time things before concerts, because I don't have a concept of time, maybe for the traditional pieces. I know that for playing at a certain tempo, a lancaran is going to be a cycle. One cycle is going to be this. And so I have a kind of a sense of those with the traditional pieces, but generally not. So I always have to time things externally before concerts because I have no idea how long the pieces are.

**Speaker 1 (18:38)**

And maybe because like, a song is generally three or four minutes. So then when you're doing it, you don't expect a piece to be that long either maybe, or it doesn't feel like it's that long either.

**Researcher (18:50)**

Yeah. The last question is just is there anything about your experience of playing this experiment that might have influenced any of these ideas? So I'm mainly talking about the equipment and the setup. Do you think anything might have gotten in the way of anything that you might have otherwise felt.

**Speaker 6 (19:24)**

Definitely, it's imperceivable. But I mean, it's like and I guess I wanted to go back to that question about the improv and the traditional music, just to say something about that for me, anyway, with the traditional music, there's the form, the repetition or the form or that you're going to it is a lot about how many times you repeat it. This is just personal,

maybe, but psychologically has to do with my relationship to authority completely. Completely. And it's like in the improvisation, I don't have that. It's like the form is whatever, my sense of sensibility of music and whatever. And I imagine everybody brings that into the improv. So the form is just yourself in a funny way, do you know what I mean? Or your sense of shape or form, sound and all that. But in the traditional music, there's a bit of this for me anyway, it's a little more. Oh, God, am I getting it right or not. There's a bit more of that. And there's something about just having the whole set up where there's somebody monitoring your things, but it's imperceptible, I feel, because it's not necessarily a big influx, it's just something just something there.

**Speaker 5 (20:49)**

But it broke it up because I suppose that's my thing. It's something to do with because if I can learn something without having to look at a piece of paper, it's completely different. And so after everything, then having to write something down felt really odd to me because usually you have your 2 hours and you're talking about flow, so. Then one thing goes into another. So writing things down sort of broke it up in a different way, I suppose that was different.

**Speaker 3 (21:22)**

Actually. I think that's me. But just the whole experiment was a bit strange, but I got into it and I got used to it and I suppose I was very aware that I was actually kind of wired up but at the same time trying to be calm. You know? Yeah, but in a good way, though, obviously. In a good way.

**Researcher (21:47)**

Yeah.

**Speaker 8 (21:49)**

And then, as well as [speaker 5] was saying, having to write stuff down. Did kind of break stuff up a bit.

**Speaker 5 (21:56)**

Not in, it wasn't bad though.

**Researcher (21:58)**

I understand what you mean, yeah.

**Speaker 4 (22:06)**

I think you're always and there's equipment you're always a bit more, whether it's even unconsciously

**Speaker 5 (22:09)**

And we were flashing for goodness sake.

**Speaker 2 (22:20)**

I was very conscious of it. I was very conscious of not, you know, moving as much as I would have and normally I might move around the room a bit more yeah. And not wanting to disturb the machines or whatever. So, yeah, definitely I was aware much more of my movement and maybe I was a tiny bit less comfortable, I would say. If I sit like this, am I going to break something? If I shift onto my heels, are the things going to pop off?

**Researcher (22:57)**

Yeah.

**Speaker 4 (22:59)**

It just impinged physically on me.

**Researcher (23:03)**

I think that's the reason I asked this question is because although I'm trying to measure these things in your environment and trying not to interfere. It's always going to and it's just the extent, of that, really. So I just need to keep that into account. This is all really interesting to hear. Were there any final thoughts? Or we could leave it there?

**Speaker 2 (23:32)**

Congratulations.

**Researcher (23:33)**

Thank you.



## Appendix L – Follow up survey – Study 3.2

As discussed in the focus group, one of the primary focuses of the study was in fact time perception - you may have been able to deduce this from some of the questionnaire items! This survey is an opportunity for you to tell me more about this, and relate your questionnaire responses to your own perceptions of playing in the group.

Your anonymous identifier is <insert here>. Please confirm whether this is correct, and if not, please email me (hannah.gibbs@york.ac.uk) before continuing with this survey.

☐ Yes

### Piece 1 - Tukung

For the first piece you played, Tukung, you gave an estimate that the duration was 10 minutes. It was instead approximately 11 minutes and 44 seconds.

How surprising is this to you?

- ☐ 1 (Not surprising at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very surprising)

How similar do you think your estimate was in comparison with the rest of the group?

- ☐ 1 (Not similar at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very similar)

Please comment on your perceived time estimate for this piece in comparison with the actual duration, providing as much detail as possible.

*What do you think might have accounted for the difference, if there was any? Is there something about your familiarity with the piece or the difficulty of the part, or something else?*

## Piece 2 - Mugirahayu

For the second piece you played, Mugirahayu, you gave an estimate that the duration was 12 minutes. It was instead approximately 8 minutes and 38 seconds.

How surprising is this to you?

- ☐ 1 (Not surprising at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very surprising)

How similar do you think your estimate was in comparison with the rest of the group?

- ☐ 1 (Not similar at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very similar)

Please comment on your perceived time estimate for this piece in comparison with the actual duration, providing as much detail as possible.

*What do you think might have accounted for the difference, if there was any? Is there something about your familiarity with the piece or the difficulty of the part, or something else?*

### Piece 3 - Improvisation

For the third piece you played, the group improvisation, you gave an estimate that the duration was 8 minutes. It was instead approximately 7 minutes and 47 seconds.

How surprising is this to you?

- ☐ 1 (Not surprising at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very surprising)

How similar do you think your estimate was in comparison with the rest of the group?

- ☐ 1 (Not similar at all)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very similar)

Please comment on your perceived time estimate for this piece in comparison with the actual duration, providing as much detail as possible.

*What do you think might have accounted for the difference, if there was any? Is there something about your familiarity with the piece or the difficulty of the part, or something else?*

Please feel free to write any other comments about your experience of the study, including anything you may have wanted to say in the focus group but might not have had the opportunity.

As well as reviewing these survey responses, the focus group, the questionnaires, and the physiological data, I am also interested in carrying out individual interviews via zoom,

where I will show you moments of the video recording and ask you to comment on your experience of playing during that section. Would you be interested in taking part?

*If yes, then your email address will be retained alongside your anonymous identifier in order to contact you until the interview is carried out, and so that your interview responses can be related to the rest of the data collected. If no, then your email address will be deleted, and your data will only be stored together with your anonymous identifier.*

☐ Yes

☐ No

## Appendix M – Segmentation information – Study 2

**Table M1.** Summary of segmentation, detailing number of segments and signals discarded from each group.

| Group | Condition  | Length<br>(in s) | Total<br>segments | <i>N</i><br>segments<br>used | <i>N</i><br>participants | <i>N</i> discarded<br>signals (HR) | <i>N</i> discarded<br>signals (SC) |
|-------|------------|------------------|-------------------|------------------------------|--------------------------|------------------------------------|------------------------------------|
| GSP   | Notated    | 704              | 39                | 15                           | 12                       | 3                                  | 1                                  |
|       | Memorised  | 518              | 14                | 14                           | 12                       | 1                                  | 2                                  |
|       | Improvised | 467              | 19                | 15                           | 12                       | 1                                  | 2                                  |
| SBGP  | Notated    | 1295             | 31                | 15                           | 7                        | 3                                  | 0                                  |
|       | Memorised  | 434              | 13                | 13                           | 7                        | 0                                  | 0                                  |
|       | Improvised | 276              | 7                 | 7                            | 7                        | 3                                  | 1                                  |
| NCH   | Notated    | 465              | 32                | 15                           | 8                        | 0                                  | 1                                  |
|       | Memorised  | 373              | 28                | 15                           | 8                        | 0                                  | 1                                  |
|       | Improvised | 306              | 24                | 15                           | 8                        | 0                                  | 2                                  |
| GSG   | Notated    | 225              | 13                | 13                           | 9                        | 2                                  | 5                                  |
|       | Memorised  | 216              | 5                 | 5                            | 9                        | 1                                  | 5                                  |
|       | Improvised | 568              | 22                | 15                           | 9                        | 2                                  | 3                                  |

## Appendix N – Model comparisons – Study 2

Model comparisons for each fixed effect and IF factor, and associated model fit measures in Tables N1.1-1.4. Associated effect estimates are provided in Tables N2.1-K2.4. NAs were removed from each dataset prior to model comparisons.

Table N1.1

*Linear Mixed Effects Model Comparisons for IOS and IF Factors*

| Dependent variable: IOS; Independent variables: IF Interaction, Condition, Musical Expertise. |               |               |                |                   |                          |               |                   |
|-----------------------------------------------------------------------------------------------|---------------|---------------|----------------|-------------------|--------------------------|---------------|-------------------|
| Model                                                                                         | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |               |                   |
|                                                                                               |               |               |                |                   | df                       | $\chi^2$      | p                 |
| Null model                                                                                    | 268.58        | 276.42        |                |                   |                          |               |                   |
| <b>IOS ~ IF Interaction</b>                                                                   | <b>236.54</b> | <b>247.00</b> | <b>0.275</b>   | <b>0.505</b>      | <b>1</b>                 | <b>34.037</b> | <b>&lt;.001</b>   |
| IOS ~ IF Interaction + Condition                                                              | 237.07        | 252.76        | 0.301          | 0.547             | 2                        | 3.473         | .176              |
| IOS ~ IF Interaction X Condition                                                              | 238.78        | 259.70        | 0.320          | 0.557             | 4                        | 5.764         | .218 <sup>a</sup> |
| IOS ~ IF Interaction + MT                                                                     | 238.37        | 251.44        | 0.277          | 0.504             | 1                        | 0.180         | .672 <sup>a</sup> |
| IOS ~ IF Interaction X MT                                                                     | 239.73        | 255.42        | 0.281          | 0.514             | 2                        | 0.819         | .664 <sup>a</sup> |
| IOS ~ IF Interaction X MT X Condition                                                         | 248.17        | 284.79        | 0.281          | 0.514             | 10                       | 8.371         | .593 <sup>a</sup> |
| Dependent variable: IOS; Independent variables: IF Absorption, Condition, Musical Expertise.  |               |               |                |                   |                          |               |                   |
| Model                                                                                         | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |               |                   |
|                                                                                               |               |               |                |                   | df                       | $\chi^2$      | p                 |
| <b>IOS ~ IF Absorption</b>                                                                    | <b>234.98</b> | <b>245.44</b> | <b>0.318</b>   | <b>0.559</b>      | <b>1</b>                 | <b>35.606</b> | <b>&lt;.001</b>   |
| IOS ~ IF Absorption + Condition                                                               | 237.83        | 253.52        | 0.320          | 0.560             | 2                        | 1.1441        | .564              |
| IOS ~ IF Absorption X Condition                                                               | 239.80        | 260.72        | 0.338          | 0.584             | 4                        | 3.178         | .529 <sup>b</sup> |
| IOS ~ IF Absorption + MT                                                                      | 236.82        | 249.89        | 0.319          | 0.557             | 1                        | 0.160         | .689 <sup>b</sup> |
| IOS ~ IF Absorption X MT                                                                      | 236.78        | 252.47        | 0.332          | 0.581             | 2                        | 2.196         | .334 <sup>b</sup> |
| IOS ~ IF Absorption X MT X Condition                                                          | 247.75        | 284.36        | 0.332          | 0.582             | 10                       | 7.224         | .704 <sup>b</sup> |

Note: Comparisons start with the null model, then made with each prior significant model. <sup>a</sup>Compared with IOS ~ IF Interaction, <sup>b</sup>Comparison with IOS ~ IF Absorption. Random intercepts of participant nested within group (1|participant:group).

Table N1.2

*Linear Mixed Effects Model Comparisons for  $TD_{consensus}$* 

| Dependent variable: Agreement in temporal distortion ( $TD_{consensus}$ ); Independent variables: IF Interaction, Condition, Musical Training (TD) |               |               |                |                   |                          |               |                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|-------------------|--------------------------|---------------|--------------------------|
| Model                                                                                                                                              | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |               |                          |
|                                                                                                                                                    |               |               |                |                   | $df$                     | $\chi^2$      | $p$                      |
| Null model <sup>o</sup>                                                                                                                            | 240.63        | 248.45        |                | 0.426             |                          |               |                          |
| $TD_{agreement} \sim$ IF Interaction                                                                                                               | 242.62        | 253.04        | <0.001         | 0.426             | 1                        | 0.011         | 0.916                    |
| $TD_{agreement} \sim$ IF Interaction + Condition                                                                                                   | 245.84        | 261.47        | 0.005          | 0.428             | 3                        | 0.792         | 0.851 <sup>a</sup>       |
| <b><math>TD_{agreement} \sim</math> IF Interaction X Condition</b>                                                                                 | <b>232.15</b> | <b>252.99</b> | <b>0.109</b>   | <b>0.610</b>      | <b>5</b>                 | <b>18.484</b> | <b>0.002<sup>a</sup></b> |
| $TD_{agreement} \sim$ IF Interaction X Condition + MT                                                                                              | 233.96        | 257.41        | 0.111          | 0.611             | 1                        | 0.188         | 0.665 <sup>b</sup>       |
| $TD_{agreement} \sim$ IF Interaction X Condition + IF Interaction X MT                                                                             | 235.13        | 261.19        | 0.118          | 0.611             | 2                        | 1.012         | 0.603 <sup>b</sup>       |
| $TD_{agreement} \sim$ IF Interaction X Condition X MT                                                                                              | 241.16        | 277.63        | 0.128          | 0.609             | 6                        | 2.984         | 0.811 <sup>b</sup>       |
| Dependent variable: Agreement in temporal distortion ( $TD_{agreement}$ ); Independent variables: IF Absorption, Condition, Musical Training (TD)  |               |               |                |                   |                          |               |                          |
| Model                                                                                                                                              | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |               |                          |
|                                                                                                                                                    |               |               |                |                   | $df$                     | $\chi^2$      | $p$                      |
| $TD_{agreement} \sim$ IF Absorption                                                                                                                | 242.63        | 253.05        | <0.001         | 0.427             | 1                        | 0.005         | 0.946                    |
| $TD_{agreement} \sim$ IF Absorption + Condition                                                                                                    | 245.97        | 261.60        | 0.004          | 0.430             | 3                        | 0.660         | 0.883 <sup>a</sup>       |
| <b><math>TD_{agreement} \sim</math> IF Absorption X Condition</b>                                                                                  | <b>239.71</b> | <b>260.55</b> | <b>0.065</b>   | <b>0.557</b>      | <b>5</b>                 | <b>10.918</b> | <b>0.053<sup>a</sup></b> |
| $TD_{agreement} \sim$ IF Absorption X Condition + MT                                                                                               | 241.61        | 265.06        | 0.066          | 0.558             | 6                        | 11.017        | 0.088 <sup>c</sup>       |
| $TD_{agreement} \sim$ IF Absorption X Condition + IF Absorption X MT                                                                               | 242.36        | 268.41        | 0.078          | 0.551             | 7                        | 12.27         | 0.092 <sup>c</sup>       |
| $TD_{agreement} \sim$ IF Absorption X Condition X MT                                                                                               | 249.54        | 286.01        | 0.084          | 0.553             | 11                       | 13.091        | 0.287 <sup>c</sup>       |

Note: Comparisons start with the null model, then made with each prior significant model. <sup>a</sup>Comparison with null model. <sup>b</sup>Comparison with  $TD_{agreement} \sim$  IF Interaction X Condition. <sup>c</sup>Comparison with  $TD_{agreement} \sim$  IF Absorption X Condition. Random intercepts of participant nested within group (1|participant:group).

Table N1.3

*Model Comparisons for ISC-SC*

| Dependent variable: Inter-subject correlation of skin conductance (ISC-SC); Independent variables: IF Interaction, Condition, Musical Training (TD) |               |               |                |                   |                          |              |                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|-------------------|--------------------------|--------------|-----------------------------|
| Model                                                                                                                                               | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |              |                             |
|                                                                                                                                                     |               |               |                |                   | $df$                     | $\chi^2$     | $p$                         |
| Null model <sup>o</sup>                                                                                                                             | 94.648        | 121.17        |                | 0.503             |                          |              |                             |
| ISC-SC ~ IF Interaction                                                                                                                             | 94.648        | 124.73        | 0.003          | 0.503             | 1                        | 3.458        | .063                        |
| ISC-SC ~ IF Interaction + Condition                                                                                                                 | 87.994        | 128.10        | 0.027          | 0.504             | 3                        | 14.113       | .003 <sup>a</sup>           |
| ISC-SC ~ IF Interaction X Condition                                                                                                                 | 85.476        | 135.61        | 0.033          | 0.516             | 2                        | 6.518        | .038                        |
| ISC-SC ~ IF Interaction X Condition + MT                                                                                                            | 80.202        | 135.34        | 0.055          | 0.503             | 3                        | 7.274        | .007                        |
| ISC-SC ~ IF Interaction X Condition + IF Interaction X MT                                                                                           | 82.195        | 142.35        | 0.055          | 0.502             | 1                        | 0.007        | .932                        |
| <b>ISC-SC ~ IF Interaction X Condition X MT</b>                                                                                                     | <b>58.582</b> | <b>138.79</b> | <b>0.075</b>   | <b>0.506</b>      | <b>5</b>                 | <b>31.62</b> | <b>&lt;.001<sup>b</sup></b> |
| Dependent variable: Inter-subject correlation of skin conductance (ISC-SC); Independent variables: IF Absorption, Condition, Musical Training (TD)  |               |               |                |                   |                          |              |                             |
| Model                                                                                                                                               | AIC           | BIC           | Marginal $R^2$ | Conditional $R^2$ | Improvement in Model Fit |              |                             |
|                                                                                                                                                     |               |               |                |                   | $df$                     | $\chi^2$     | $p$                         |
| ISC-SC ~ IF Absorption                                                                                                                              | 90.413        | 120.49        | 0.008          | 0.501             | 1                        | 7.694        | .006                        |
| ISC-SC ~ IF Absorption + Condition                                                                                                                  | 84.938        | 125.04        | 0.031          | 0.503             | 2                        | 9.475        | .009                        |
| ISC-SC ~ IF Absorption X Condition                                                                                                                  | 86.508        | 136.64        | 0.033          | 0.505             | 2                        | 2.430        | .297                        |
| ISC-SC ~ IF Absorption X Condition + MT                                                                                                             | 79.280        | 134.42        | 0.059          | 0.494             | 3                        | 11.657       | .009 <sup>c</sup>           |
| ISC-SC ~ IF Absorption X Condition + IF Absorption X MT                                                                                             | 80.674        | 140.83        | 0.061          | 0.491             | 1                        | 0.606        | .436                        |
| ISC-SC ~ IF Absorption X Condition X MT                                                                                                             | 65.21         | 145.42        | 0.076          | 0.495             | 5                        | 24.07        | <.001 <sup>d</sup>          |

Note: ISC-SC variable as mean values across all dyads per section, for up to 15 sections. Comparisons start with the null model, then made with each prior significant model. <sup>a</sup>Comparison with null model, <sup>b</sup>Comparison with ISC-SC ~ IF Interaction X Condition + MT. <sup>c</sup>Comparison with ISC-SC ~ IF Absorption + Condition. <sup>d</sup>Comparison with IF Absorption X Condition + MT. Random intercepts of participant nested within group (1|participant:group), section within condition per group (1|section:stim), and group (1|group).



Table N1.4

## Model Comparisons for ISC-HR

| <b>Dependent variable: Inter-subject correlation of heart rate (ISC-HR); Independent variables: IF Interaction, Condition, Musical Training (MT)</b> |            |            |                                  |                                     |                                 |          |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|----------------------------------|-------------------------------------|---------------------------------|----------|-------------------|
| <b>Model</b>                                                                                                                                         | <b>AIC</b> | <b>BIC</b> | <b>Marginal <math>R^2</math></b> | <b>Conditional <math>R^2</math></b> | <b>Improvement in Model Fit</b> |          |                   |
|                                                                                                                                                      |            |            |                                  |                                     | <i>df</i>                       | $\chi^2$ | <i>p</i>          |
| Null model <sup>o</sup>                                                                                                                              | 928.32     | 953.59     |                                  | 0.090                               |                                 |          |                   |
| ISC-HR ~ IF Interaction                                                                                                                              | 930.32     | 960.83     | <.001                            | 0.090                               | 1                               | 0.008    | .929              |
| ISC-HR ~ IF Interaction + Condition                                                                                                                  | 925.61     | 966.03     | 0.011                            | 0.085                               | 3                               | 8.7175   | .033 <sup>a</sup> |
| ISC-HR ~ IF Interaction X Condition                                                                                                                  | 927.88     | 978.40     | 0.012                            | 0.877                               | 2                               | 1.730    | .421              |
| ISC-HR ~ IF Interaction + Condition + MT <sup>o</sup>                                                                                                | 919.67     | 965.14     | 0.020                            | 0.094                               | 1                               | 7.938    | .005 <sup>b</sup> |
| ISC-HR ~ IF Interaction X MT + Condition <sup>o</sup>                                                                                                | 921.48     | 972.00     | 0.020                            | 0.094                               | 1                               | 0.192    | .661              |
| ISC-HR ~ IF Interaction X Condition X MT <sup>o</sup>                                                                                                | 928.73     | 1009.58    | 0.024                            | 0.101                               | 7                               | 4.936    | .668 <sup>c</sup> |
| <b>Dependent variable: Inter-subject correlation of heart rate (ISC-HR); Independent variables: IF Absorption, Condition, Musical Training (MT)</b>  |            |            |                                  |                                     |                                 |          |                   |
| <b>Model</b>                                                                                                                                         | <b>AIC</b> | <b>BIC</b> | <b>Marginal <math>R^2</math></b> | <b>Conditional <math>R^2</math></b> | <b>Improvement in Model Fit</b> |          |                   |
|                                                                                                                                                      |            |            |                                  |                                     | <i>df</i>                       | $\chi^2$ | <i>p</i>          |
| ISC-HR ~ IF Absorption                                                                                                                               | 930.27     | 960.59     | <0.001                           | 0.090                               | 1                               | 0.050    | .824              |
| ISC-HR ~ IF Absorption + Condition                                                                                                                   | 925.66     | 966.08     | 0.011                            | 0.085                               | 3                               | 8.667    | .034 <sup>a</sup> |
| ISC-HR ~ IF Absorption X Condition                                                                                                                   | 927.79     | 978.32     | 0.012                            | 0.089                               | 2                               | 1.869    | .393              |
| ISC-HR ~ IF Absorption + Condition + MT <sup>o</sup>                                                                                                 | 919.42     | 964.42     | 0.020                            | 0.096                               | 1                               | 8.234    | .004 <sup>d</sup> |
| ISC-HR ~ IF Absorption X MT + Condition <sup>o</sup>                                                                                                 | 921.28     | 971.81     | 0.020                            | 0.095                               | 1                               | 0.140    | .708              |
| ISC-HR ~ IF Absorption X Condition X MT <sup>o</sup>                                                                                                 | 928.87     | 1009.7     | 0.024                            | 0.101                               | 7                               | 4.552    | .715 <sup>e</sup> |

Note: ISC-HR variable as mean values across all dyads per section, for up to 15 sections. Comparisons start with the null model, then made with each prior significant model. <sup>a</sup>Comparison with null model, <sup>b</sup>Comparison with ISC-HR ~ IF Interaction + Condition. <sup>c</sup>Comparison with ISC-HR ~ IF Interaction + Condition + MT. <sup>d</sup>Comparison with ISC-HR ~ IF Absorption X Condition. <sup>e</sup>Comparison with ISC-HR ~ IF Absorption + MT + Condition. Random intercepts of participant nested within group (1|participant:group), section within condition per group (1|section:stim), and group (1|group).

Table N2.1.1

Full fixed and random effects for model comparisons for IOS and IF interaction

| Predictors                         | IOS  |                       |      | Est. | IOS          |                       |   | Est.  | IOS          |                       |   |
|------------------------------------|------|-----------------------|------|------|--------------|-----------------------|---|-------|--------------|-----------------------|---|
|                                    | Est. | 95% CI                | p    |      | Est.         | 95% CI                | p |       | Est.         | 95% CI                | p |
| (Intercept)                        | 0.09 | -0.11 – 0.29          | .361 | 0.09 | -0.12 – 0.29 | .396                  |   | 0.09  | -0.12 – 0.29 | .395                  |   |
| IF interact                        |      |                       |      | 0.48 | 0.34 – 0.63  | <.001                 |   | 0.53  | 0.37 – 0.70  | <.001                 |   |
| condition <sub>improvTrad</sub>    |      |                       |      |      |              |                       |   | -0.22 | -0.52 – 0.08 | .146                  |   |
| condition <sub>memoryNotated</sub> |      |                       |      |      |              |                       |   | -0.17 | -0.48 – 0.13 | .266                  |   |
| <b>Random Effects</b>              |      |                       |      |      |              |                       |   |       |              |                       |   |
| $\sigma^2$                         |      | 0.70                  |      |      |              | 0.42                  |   |       |              | 0.39                  |   |
| $\tau_{00}$                        |      | 0.10 case_id:group_id |      |      |              | 0.20 case_id:group_id |   |       |              | 0.21 case_id:group_id |   |
| ICC                                |      | 0.13                  |      |      |              | 0.32                  |   |       |              | 0.35                  |   |
| N                                  |      | 35 case_id            |      |      |              | 35 case_id            |   |       |              | 35 case_id            |   |
|                                    |      | 4 group_id            |      |      |              | 4 group_id            |   |       |              | 4 group_id            |   |
| Observations                       |      | 101                   |      |      |              | 101                   |   |       |              | 101                   |   |
| Marginal $R^2$ / Conditional $R^2$ |      | 0.000 / 0.127         |      |      |              | 0.275 / 0.505         |   |       |              | 0.301 / 0.547         |   |
| AIC                                |      | 271.355               |      |      |              | 242.716               |   |       |              | 247.050               |   |

Table N2.1.1

(Continued)

| Predictors                                            | IOS   |                       |       | Est.  | IOS          |                       |   | Est.  | IOS          |                       |   | Est.  | IOS          |                       |   |
|-------------------------------------------------------|-------|-----------------------|-------|-------|--------------|-----------------------|---|-------|--------------|-----------------------|---|-------|--------------|-----------------------|---|
|                                                       | Est.  | 95% CI                | p     |       | Est.         | 95% CI                | p |       | Est.         | 95% CI                | p |       | Est.         | 95% CI                | p |
| (Intercept)                                           | 0.04  | -0.17 – 0.25          | .732  | 0.09  | -0.11 – 0.29 | .383                  |   | 0.09  | -0.11 – 0.29 | .361                  |   | 0.04  | -0.18 – 0.25 | .729                  |   |
| IF interact                                           | 0.60  | 0.42 – 0.78           | <.001 | 0.48  | 0.34 – 0.63  | <.001                 |   | 0.47  | 0.32 – 0.62  | <.001                 |   | 0.59  | 0.41 – 0.78  | <.001                 |   |
| condition <sub>improvTrad</sub>                       | -0.21 | -0.51 – 0.09          | .161  |       |              |                       |   |       |              |                       |   | -0.17 | -0.48 – 0.13 | .265                  |   |
| condition <sub>memoryNotated</sub>                    | -0.11 | -0.45 – 0.23          | .516  |       |              |                       |   |       |              |                       |   | -0.09 | -0.43 – 0.24 | .586                  |   |
| IF interact × condition <sub>improvTrad</sub>         | 0.24  | -0.08 – 0.56          | .137  |       |              |                       |   |       |              |                       |   | 0.32  | -0.02 – 0.66 | .067                  |   |
| IF interact × condition <sub>memoryNotated</sub>      | -0.10 | -0.54 – 0.35          | .671  |       |              |                       |   |       |              |                       |   | -0.06 | -0.51 – 0.39 | .781                  |   |
| MT                                                    |       |                       |       | -0.04 | -0.26 – 0.17 | .673                  |   | -0.06 | -0.28 – 0.15 | .558                  |   | -0.05 | -0.28 – 0.18 | .655                  |   |
| IF interact × MT                                      |       |                       |       |       |              |                       |   | 0.07  | -0.10 – 0.24 | .423                  |   | 0.09  | -0.11 – 0.29 | .373                  |   |
| condition <sub>improvTrad</sub> × MT                  |       |                       |       |       |              |                       |   |       |              |                       |   | -0.04 | -0.37 – 0.28 | .792                  |   |
| condition <sub>memoryNotated</sub> × MT               |       |                       |       |       |              |                       |   |       |              |                       |   | -0.10 | -0.48 – 0.27 | .580                  |   |
| IF interact × condition <sub>improvTrad</sub> × MT    |       |                       |       |       |              |                       |   |       |              |                       |   | -0.08 | -0.42 – 0.27 | .659                  |   |
| IF interact × condition <sub>memoryNotated</sub> × MT |       |                       |       |       |              |                       |   |       |              |                       |   | 0.24  | -0.19 – 0.66 | .277                  |   |
| <b>Random Effects</b>                                 |       |                       |       |       |              |                       |   |       |              |                       |   |       |              |                       |   |
| $\sigma^2$                                            |       | 0.39                  |       |       |              | 0.42                  |   |       |              | 0.41                  |   |       |              | 0.37                  |   |
| $\tau_{00}$                                           |       | 0.21 case_id:group_id |       |       |              | 0.19 case_id:group_id |   |       |              | 0.20 case_id:group_id |   |       |              | 0.21 case_id:group_id |   |
| ICC                                                   |       | 0.35                  |       |       |              | 0.31                  |   |       |              | 0.32                  |   |       |              | 0.36                  |   |
| N                                                     |       | 35 case_id            |       |       |              | 35 case_id            |   |       |              | 35 case_id            |   |       |              | 35 case_id            |   |
|                                                       |       | 4 group_id            |       |       |              | 4 group_id            |   |       |              | 4 group_id            |   |       |              | 4 group_id            |   |
| Observations                                          |       | 101                   |       |       |              | 101                   |   |       |              | 101                   |   |       |              | 101                   |   |
| Marginal $R^2$ / Conditional $R^2$                    |       | 0.320 / 0.557         |       |       |              | 0.277 / 0.504         |   |       |              | 0.281 / 0.514         |   |       |              | 0.337 / 0.574         |   |
| AIC                                                   |       | 251.735               |       |       |              | 247.191               |   |       |              | 251.547               |   |       |              | 272.844               |   |

Table N2.1.

Full Fixed and Random Effects for Model Comparisons for IOS and IF Absorption

| Predictors                                           | IOS  |                       |       | Est.  | IOS          |                       |   | Est.  | IOS          |                       |   |
|------------------------------------------------------|------|-----------------------|-------|-------|--------------|-----------------------|---|-------|--------------|-----------------------|---|
|                                                      | Est. | 95% CI                | p     |       | Est.         | 95% CI                | p |       | Est.         | 95% CI                | p |
| (Intercept)                                          | 0.08 | -0.13 – 0.28          | .460  | 0.08  | -0.13 – 0.28 | .457                  |   | 0.05  | -0.16 – 0.26 | .619                  |   |
| IF absorb                                            | 0.53 | 0.38 – 0.69           | <.001 | 0.52  | 0.36 – 0.68  | <.001                 |   | 0.56  | 0.40 – 0.72  | <.001                 |   |
| condition <sub>improvTrad</sub>                      |      |                       |       | 0.02  | -0.26 – 0.30 | .889                  |   | 0.02  | -0.26 – 0.29 | .904                  |   |
| condition <sub>memoryNotated</sub>                   |      |                       |       | -0.17 | -0.47 – 0.14 | .289                  |   | -0.11 | -0.43 – 0.20 | .468                  |   |
| IF absorb × condition <sub>improvTrad</sub>          |      |                       |       |       |              |                       |   | 0.18  | -0.10 – 0.47 | .203                  |   |
| IF absorb × condition <sub>memoryNotated</sub>       |      |                       |       |       |              |                       |   | -0.15 | -0.51 – 0.21 | .415                  |   |
| <b>Random Effects</b>                                |      |                       |       |       |              |                       |   |       |              |                       |   |
| σ <sup>2</sup>                                       |      | 0.40                  |       |       |              | 0.40                  |   |       |              | 0.38                  |   |
| τ <sub>00</sub>                                      |      | 0.22 case_id:group_id |       |       |              | 0.22 case_id:group_id |   |       |              | 0.23 case_id:group_id |   |
| ICC                                                  |      | 0.35                  |       |       |              | 0.35                  |   |       |              | 0.37                  |   |
| N                                                    |      | 35 case_id            |       |       |              | 35 case_id            |   |       |              | 35 case_id            |   |
|                                                      |      | 4 group_id            |       |       |              | 4 group_id            |   |       |              | 4 group_id            |   |
| Observations                                         |      | 101                   |       |       |              | 101                   |   |       |              | 101                   |   |
| Marginal R <sup>2</sup> / Conditional R <sup>2</sup> |      | 0.318 / 0.559         |       |       |              | 0.320 / 0.560         |   |       |              | 0.338 / 0.584         |   |
| AIC                                                  |      | 240.989               |       |       |              | 247.821               |   |       |              | 253.424               |   |

Table N2.1.2

(Continued)

| Predictors                                           | IOS   |                       |       | Est.  | IOS          |                       |   | Est.  | IOS          |                       |   |
|------------------------------------------------------|-------|-----------------------|-------|-------|--------------|-----------------------|---|-------|--------------|-----------------------|---|
|                                                      | Est.  | 95% CI                | p     |       | Est.         | 95% CI                | p |       | Est.         | 95% CI                | p |
| (Intercept)                                          | 0.08  | -0.13 – 0.28          | .446  | 0.09  | -0.12 – 0.29 | .413                  |   | 0.05  | -0.16 – 0.26 | .603                  |   |
| IF absorb                                            | 0.53  | 0.38 – 0.68           | <.001 | 0.53  | 0.38 – 0.68  | <.001                 |   | 0.55  | 0.39 – 0.71  | <.001                 |   |
| condition <sub>improvTrad</sub>                      |       |                       |       |       |              |                       |   | 0.05  | -0.23 – 0.32 | .737                  |   |
| condition <sub>memoryNotated</sub>                   |       |                       |       |       |              |                       |   | -0.10 | -0.41 – 0.21 | .512                  |   |
| MT                                                   | -0.04 | -0.26 – 0.17          | .690  | -0.08 | -0.30 – 0.15 | .499                  |   | -0.04 | -0.27 – 0.19 | .718                  |   |
| condition <sub>improvTrad</sub> × MT                 |       |                       |       |       |              |                       |   | -0.01 | -0.32 – 0.31 | .970                  |   |
| condition <sub>memoryNotated</sub> × MT              |       |                       |       |       |              |                       |   | -0.04 | -0.39 – 0.31 | .816                  |   |
| IF absorb × condition <sub>improvTrad</sub>          |       |                       |       |       |              |                       |   | 0.20  | -0.08 – 0.49 | .153                  |   |
| IF absorb × condition <sub>memoryNotated</sub>       |       |                       |       |       |              |                       |   | -0.14 | -0.49 – 0.21 | .436                  |   |
| IF absorb × MT                                       |       |                       |       | 0.11  | -0.04 – 0.26 | .150                  |   | 0.09  | -0.08 – 0.25 | .312                  |   |
| IF absorb × condition <sub>improvTrad</sub> × MT     |       |                       |       |       |              |                       |   | -0.17 | -0.43 – 0.10 | .208                  |   |
| IF absorb × condition <sub>memoryNotated</sub> × MT  |       |                       |       |       |              |                       |   | 0.11  | -0.23 – 0.44 | .534                  |   |
| <b>Random Effects</b>                                |       |                       |       |       |              |                       |   |       |              |                       |   |
| σ <sup>2</sup>                                       |       | 0.40                  |       |       |              | 0.38                  |   |       |              | 0.36                  |   |
| τ <sub>00</sub>                                      |       | 0.22 case_id:group_id |       |       |              | 0.23 case_id:group_id |   |       |              | 0.23 case_id:group_id |   |
| ICC                                                  |       | 0.35                  |       |       |              | 0.37                  |   |       |              | 0.39                  |   |
| N                                                    |       | 35 case_id            |       |       |              | 35 case_id            |   |       |              | 35 case_id            |   |
|                                                      |       | 4 group_id            |       |       |              | 4 group_id            |   |       |              | 4 group_id            |   |
| Observations                                         |       | 101                   |       |       |              | 101                   |   |       |              | 101                   |   |
| Marginal R <sup>2</sup> / Conditional R <sup>2</sup> |       | 0.319 / 0.557         |       |       |              | 0.332 / 0.582         |   |       |              | 0.359 / 0.610         |   |
| AIC                                                  |       | 245.446               |       |       |              | 248.668               |   |       |              | 274.610               |   |

Table N2.2.1

Full Fixed and Random Effects for Model Comparisons for IF Interaction And  $TD_{consensus}$ 

| Predictors                         | $TD_{consensus}$ |                       |       | Est. | $TD_{consensus}$ |                       |   | Est.  | $TD_{consensus}$ |                       |   |
|------------------------------------|------------------|-----------------------|-------|------|------------------|-----------------------|---|-------|------------------|-----------------------|---|
|                                    | Est.             | 95% CI                | p     |      | Est.             | 95% CI                | p |       | Est.             | 95% CI                | p |
| (Intercept)                        | 1.53             | 1.29 – 1.76           | <.001 | 1.53 | 1.29 – 1.76      | <.001                 |   | 1.53  | 1.29 – 1.76      | <.001                 |   |
| IF interact                        |                  |                       |       | 0.01 | -0.14 – 0.15     | 0.916                 |   | 0.03  | -0.14 – 0.20     | .716                  |   |
| condition <sub>improvTrad</sub>    |                  |                       |       |      |                  |                       |   | -0.11 | -0.42 – 0.20     | .497                  |   |
| condition <sub>memoryNotated</sub> |                  |                       |       |      |                  |                       |   | -0.08 | -0.40 – 0.23     | .608                  |   |
| <b>Random Effects</b>              |                  |                       |       |      |                  |                       |   |       |                  |                       |   |
| $\sigma^2$                         |                  | 0.41                  |       |      |                  | 0.41                  |   |       |                  | 0.41                  |   |
| $\tau_{00}$                        |                  | 0.31 case_id:group_id |       |      |                  | 0.31 case_id:group_id |   |       |                  | 0.30 case_id:group_id |   |
| ICC                                |                  | 0.43                  |       |      |                  | 0.43                  |   |       |                  | 0.43                  |   |
| N                                  |                  | 34 case_id            |       |      |                  | 34 case_id            |   |       |                  | 34 case_id            |   |
|                                    |                  | 4 group_id            |       |      |                  | 4 group_id            |   |       |                  | 4 group_id            |   |
| Observations                       |                  | 100                   |       |      |                  | 100                   |   |       |                  | 100                   |   |
| Marginal $R^2$ / Conditional $R^2$ |                  | 0.000 / 0.426         |       |      |                  | 0.000 / 0.426         |   |       |                  | 0.005 / 0.428         |   |
| AIC                                |                  | 243.114               |       |      |                  | 248.461               |   |       |                  | 255.363               |   |

Table N2.2.1

(Continued)

| Predictors                                            | $TD_{consensus}$ |                       |       | Est.  | $TD_{consensus}$ |                       |   | Est.  | $TD_{consensus}$ |                       |   | Est.  | $TD_{consensus}$ |                       |   |
|-------------------------------------------------------|------------------|-----------------------|-------|-------|------------------|-----------------------|---|-------|------------------|-----------------------|---|-------|------------------|-----------------------|---|
|                                                       | Est.             | 95% CI                | p     |       | Est.             | 95% CI                | p |       | Est.             | 95% CI                | p |       | Est.             | 95% CI                | p |
| (Intercept)                                           | 1.61             | 1.36 – 1.86           | <.001 | 1.61  | 1.35 – 1.86      | <.001                 |   | 1.61  | 1.36 – 1.86      | <.001                 |   | 1.62  | 1.38 – 1.87      | <.001                 |   |
| IF interact                                           | -0.05            | -0.22 – 0.12          | .559  | -0.05 | -0.22 – 0.12     | .578                  |   | -0.04 | -0.21 – 0.13     | .650                  |   | -0.01 | -0.19 – 0.17     | .908                  |   |
| condition <sub>improvTrad</sub>                       | -0.04            | -0.31 – 0.23          | .745  | -0.04 | -0.31 – 0.23     | .747                  |   | -0.06 | -0.34 – 0.21     | .644                  |   | -0.11 | -0.39 – 0.17     | .429                  |   |
| condition <sub>memoryNotated</sub>                    | -0.40            | -0.70 – -0.09         | .011  | -0.40 | -0.70 – -0.09    | .011                  |   | -0.40 | -0.70 – -0.10    | .010                  |   | -0.40 | -0.70 – -0.10    | .011                  |   |
| IF interact × condition <sub>improvTrad</sub>         | -0.25            | -0.54 – 0.05          | .102  | -0.24 | -0.54 – 0.05     | .108                  |   | -0.28 | -0.59 – 0.03     | .075                  |   | -0.33 | -0.65 – -0.01    | .043                  |   |
| IF interact × condition <sub>memoryNotated</sub>      | 0.92             | 0.51 – 1.32           | <.001 | 0.92  | 0.52 – 1.33      | <.001                 |   | 0.90  | 0.49 – 1.31      | <.001                 |   | 0.92  | 0.50 – 1.33      | <.001                 |   |
| MT                                                    |                  |                       |       | 0.05  | -0.20 – 0.31     | .667                  |   | 0.08  | -0.18 – 0.33     | .552                  |   | 0.04  | -0.23 – 0.30     | .782                  |   |
| IF interact × MT                                      |                  |                       |       |       |                  |                       |   | -0.08 | -0.25 – 0.09     | .365                  |   | -0.09 | -0.29 – 0.10     | .349                  |   |
| condition <sub>improvTrad</sub> × MT                  |                  |                       |       |       |                  |                       |   |       |                  |                       |   | 0.13  | -0.17 – 0.42     | .401                  |   |
| condition <sub>memoryNotated</sub> × MT               |                  |                       |       |       |                  |                       |   |       |                  |                       |   | 0.03  | -0.30 – 0.37     | .839                  |   |
| IF interact × condition <sub>improvTrad</sub> × MT    |                  |                       |       |       |                  |                       |   |       |                  |                       |   | 0.18  | -0.14 – 0.49     | .267                  |   |
| IF interact × condition <sub>memoryNotated</sub> × MT |                  |                       |       |       |                  |                       |   |       |                  |                       |   | -0.00 | -0.39 – 0.39     | .996                  |   |
| <b>Random Effects</b>                                 |                  |                       |       |       |                  |                       |   |       |                  |                       |   |       |                  |                       |   |
| $\sigma^2$                                            |                  | 0.30                  |       |       |                  | 0.30                  |   |       |                  | 0.30                  |   |       |                  | 0.29                  |   |
| $\tau_{00}$                                           |                  | 0.38 case_id:group_id |       |       |                  | 0.38 case_id:group_id |   |       |                  | 0.38 case_id:group_id |   |       |                  | 0.36 case_id:group_id |   |
| ICC                                                   |                  | 0.56                  |       |       |                  | 0.56                  |   |       |                  | 0.56                  |   |       |                  | 0.55                  |   |
| N                                                     |                  | 34 case_id            |       |       |                  | 34 case_id            |   |       |                  | 34 case_id            |   |       |                  | 34 case_id            |   |
|                                                       |                  | 4 group_id            |       |       |                  | 4 group_id            |   |       |                  | 4 group_id            |   |       |                  | 4 group_id            |   |
| Observations                                          |                  | 100                   |       |       |                  | 100                   |   |       |                  | 100                   |   |       |                  | 100                   |   |
| Marginal $R^2$ / Conditional $R^2$                    |                  | 0.109 / 0.610         |       |       |                  | 0.111 / 0.611         |   |       |                  | 0.118 / 0.611         |   |       |                  | 0.128 / 0.609         |   |
| AIC                                                   |                  | 245.674               |       |       |                  | 249.760               |   |       |                  | 253.968               |   |       |                  | 266.925               |   |

Table N2.2.2

Full Fixed and Random Effects for Model Comparisons for IF Absorption and  $TD_{consensus}$ 

| Predictors                                     | $TD_{consensus}$ |                       |       | Est.  | $TD_{consensus}$ |                       |   | Est.  | $TD_{consensus}$ |                       |   |
|------------------------------------------------|------------------|-----------------------|-------|-------|------------------|-----------------------|---|-------|------------------|-----------------------|---|
|                                                | Est.             | 95% CI                | p     |       | Est.             | 95% CI                | p |       | Est.             | 95% CI                | p |
| (Intercept)                                    | 1.53             | 1.29 – 1.76           | <.001 | 1.53  | 1.29 – 1.76      | <.001                 |   | 1.57  | 1.33 – 1.82      | <.001                 |   |
| IF absorb                                      | -0.01            | -0.17 – 0.15          | .946  | 0.00  | -0.17 – 0.17     | .996                  |   | -0.06 | -0.23 – 0.10     | .437                  |   |
| condition <sub>improvTrad</sub>                |                  |                       |       | -0.08 | -0.36 – 0.20     | .579                  |   | -0.04 | -0.29 – 0.22     | .787                  |   |
| condition <sub>memoryNotated</sub>             |                  |                       |       | -0.09 | -0.41 – 0.23     | .575                  |   | -0.22 | -0.52 – 0.08     | .141                  |   |
| IF absorb × condition <sub>improvTrad</sub>    |                  |                       |       |       |                  |                       |   | -0.21 | -0.49 – 0.06     | .130                  |   |
| IF absorb × condition <sub>memoryNotated</sub> |                  |                       |       |       |                  |                       |   | 0.56  | 0.22 – 0.90      | .002                  |   |
| <b>Random Effects</b>                          |                  |                       |       |       |                  |                       |   |       |                  |                       |   |
| $\sigma^2$                                     |                  | 0.41                  |       |       |                  | 0.41                  |   |       |                  | 0.34                  |   |
| $\tau_{00}$                                    |                  | 0.31 case_id:group_id |       |       |                  | 0.31 case_id:group_id |   |       |                  | 0.37 case_id:group_id |   |
| ICC                                            |                  | 0.43                  |       |       |                  | 0.43                  |   |       |                  | 0.53                  |   |
| N                                              |                  | 34 case_id            |       |       |                  | 34 case_id            |   |       |                  | 34 case_id            |   |
|                                                |                  | 4 group_id            |       |       |                  | 4 group_id            |   |       |                  | 4 group_id            |   |
| Observations                                   |                  | 100                   |       |       |                  | 100                   |   |       |                  | 100                   |   |
| Marginal $R^2$ / Conditional $R^2$             |                  | 0.000 / 0.427         |       |       |                  | 0.004 / 0.430         |   |       |                  | 0.065 / 0.557         |   |
| AIC                                            |                  | 248.296               |       |       |                  | 255.509               |   |       |                  | 253.388               |   |

Table N2.2.2

(Continued)

| Predictors                                          | $TD_{consensus}$ |                       |       | Est.  | $TD_{consensus}$ |                       |   | Est.  | $TD_{consensus}$ |                       |   |
|-----------------------------------------------------|------------------|-----------------------|-------|-------|------------------|-----------------------|---|-------|------------------|-----------------------|---|
|                                                     | Est.             | 95% CI                | p     |       | Est.             | 95% CI                | p |       | Est.             | 95% CI                | p |
| (Intercept)                                         | 1.57             | 1.32 – 1.82           | <.001 | 1.56  | 1.32 – 1.81      | <.001                 |   | 1.56  | 1.32 – 1.81      | <.001                 |   |
| IF absorb                                           | -0.06            | -0.23 – 0.10          | .450  | -0.06 | -0.22 – 0.11     | .500                  |   | -0.05 | -0.22 – 0.12     | .574                  |   |
| condition <sub>improvTrad</sub>                     | -0.03            | -0.29 – 0.22          | .792  | -0.05 | -0.31 – 0.21     | .690                  |   | -0.07 | -0.34 – 0.19     | .579                  |   |
| condition <sub>memoryNotated</sub>                  | -0.22            | -0.52 – 0.08          | .144  | -0.23 | -0.53 – 0.07     | .124                  |   | -0.24 | -0.54 – 0.06     | .114                  |   |
| MT                                                  | 0.04             | -0.21 – 0.29          | .755  | 0.07  | -0.19 – 0.32     | .602                  |   | 0.06  | -0.20 – 0.32     | .629                  |   |
| condition <sub>improvTrad</sub> × MT                |                  |                       |       |       |                  |                       |   | 0.11  | -0.19 – 0.42     | .460                  |   |
| condition <sub>memoryNotated</sub> × MT             |                  |                       |       |       |                  |                       |   | 0.04  | -0.30 – 0.39     | .794                  |   |
| IF absorb × condition <sub>improvTrad</sub>         | -0.21            | -0.49 – 0.07          | .137  | -0.22 | -0.50 – 0.06     | .119                  |   | -0.23 | -0.51 – 0.05     | .109                  |   |
| IF absorb × condition <sub>memoryNotated</sub>      | 0.56             | 0.22 – 0.91           | .002  | 0.54  | 0.20 – 0.89      | .002                  |   | 0.55  | 0.20 – 0.89      | .002                  |   |
| IF absorb × MT                                      |                  |                       |       | -0.09 | -0.24 – 0.07     | .261                  |   | -0.10 | -0.28 – 0.07     | .239                  |   |
| IF absorb × condition <sub>improvTrad</sub> × MT    |                  |                       |       |       |                  |                       |   | 0.02  | -0.24 – 0.28     | .898                  |   |
| IF absorb × condition <sub>memoryNotated</sub> × MT |                  |                       |       |       |                  |                       |   | -0.07 | -0.40 – 0.26     | .679                  |   |
| <b>Random Effects</b>                               |                  |                       |       |       |                  |                       |   |       |                  |                       |   |
| $\sigma^2$                                          |                  | 0.34                  |       |       |                  | 0.34                  |   |       |                  | 0.33                  |   |
| $\tau_{00}$                                         |                  | 0.37 case_id:group_id |       |       |                  | 0.35 case_id:group_id |   |       |                  | 0.35 case_id:group_id |   |
| ICC                                                 |                  | 0.53                  |       |       |                  | 0.51                  |   |       |                  | 0.51                  |   |
| N                                                   |                  | 34 case_id            |       |       |                  | 34 case_id            |   |       |                  | 34 case_id            |   |
|                                                     |                  | 4 group_id            |       |       |                  | 4 group_id            |   |       |                  | 4 group_id            |   |
| Observations                                        |                  | 100                   |       |       |                  | 100                   |   |       |                  | 100                   |   |
| Marginal $R^2$ / Conditional $R^2$                  |                  | 0.066 / 0.558         |       |       |                  | 0.078 / 0.551         |   |       |                  | 0.084 / 0.553         |   |
| AIC                                                 |                  | 257.545               |       |       |                  | 261.553               |   |       |                  | 276.149               |   |

Table N2.3.1

Full Fixed and Random Effects for Model Comparisons for IF Interaction and ISC-SC

| Predictors                         | ISC-SC |                       |      | Est.  | ISC-SC       |                       |       | Est.         | ISC-SC |                       |   |
|------------------------------------|--------|-----------------------|------|-------|--------------|-----------------------|-------|--------------|--------|-----------------------|---|
|                                    | Est.   | 95% CI                | p    |       | Est.         | 95% CI                | p     |              | Est.   | 95% CI                | p |
| (Intercept)                        | 0.20   | 0.08 – 0.32           | .010 | 0.20  | 0.08 – 0.31  | .009                  | 0.20  | 0.07 – 0.32  | .012   |                       |   |
| IF interact                        |        |                       |      | -0.02 | -0.04 – 0.00 | .060                  | -0.02 | -0.04 – 0.00 | .018   |                       |   |
| condition <sub>improvTrad</sub>    |        |                       |      |       |              |                       | 0.12  | 0.05 – 0.19  | .001   |                       |   |
| condition <sub>memoryNotated</sub> |        |                       |      |       |              |                       | -0.00 | -0.08 – 0.08 | .994   |                       |   |
| <b>Random Effects</b>              |        |                       |      |       |              |                       |       |              |        |                       |   |
| $\sigma^2$                         |        | 0.05                  |      |       |              | 0.05                  |       |              |        | 0.05                  |   |
| $\tau_{00}$                        |        | 0.03 section:stim_id  |      |       |              | 0.04 section:stim_id  |       |              |        | 0.03 section:stim_id  |   |
|                                    |        | 0.01 case_id:group_id |      |       |              | 0.01 case_id:group_id |       |              |        | 0.01 case_id:group_id |   |
|                                    |        | 0.00 group_id         |      |       |              | 0.00 group_id         |       |              |        | 0.01 group_id         |   |
| ICC                                |        | 0.50                  |      |       |              | 0.50                  |       |              |        | 0.49                  |   |
| N                                  |        | 30 case_id            |      |       |              | 30 case_id            |       |              |        | 30 case_id            |   |
|                                    |        | 4 group_id            |      |       |              | 4 group_id            |       |              |        | 4 group_id            |   |
|                                    |        | 15 section            |      |       |              | 15 section            |       |              |        | 15 section            |   |
|                                    |        | 12 stim_id            |      |       |              | 12 stim_id            |       |              |        | 12 stim_id            |   |
| Observations                       |        | 1111                  |      |       |              | 1111                  |       |              |        | 1111                  |   |
| Marginal $R^2$ / Conditional $R^2$ |        | 0.000 / 0.503         |      |       |              | 0.003 / 0.503         |       |              |        | 0.027 / 0.504         |   |
| AIC                                |        | 100.611               |      |       |              | 106.804               |       |              |        | 109.459               |   |

Table N2.3.1

(Continued)

|                                                       | ISC-SC |                       |       | ISC-SC |                       |      | ISC-SC |                       |      | ISC-SC |                       |       |
|-------------------------------------------------------|--------|-----------------------|-------|--------|-----------------------|------|--------|-----------------------|------|--------|-----------------------|-------|
| Predictors                                            | Est.   | 95% CI                | p     | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    | Est.   | 95% CI                | p     |
| (Intercept)                                           | 0.20   | 0.07 – 0.33           | .015  | 0.21   | 0.10 – 0.31           | .007 | 0.21   | 0.10 – 0.31           | .007 | 0.20   | 0.11 – 0.29           | .005  |
| IF interact                                           | -0.02  | -0.04 – 0.00          | .120  | -0.02  | -0.04 – 0.00          | .085 | -0.02  | -0.04 – 0.00          | .091 | -0.03  | -0.05 – -0.00         | .038  |
| condition <sub>improvTrad</sub>                       | 0.13   | 0.06 – 0.20           | <.001 | 0.13   | 0.06 – 0.20           | .001 | 0.13   | 0.06 – 0.20           | .001 | 0.15   | 0.08 – 0.22           | <.001 |
| condition <sub>memoryNotated</sub>                    | -0.01  | -0.09 – 0.07          | .832  | -0.01  | -0.09 – 0.07          | .835 | -0.01  | -0.09 – 0.07          | .837 | -0.02  | -0.09 – 0.06          | .686  |
| IF interact × condition <sub>improvTrad</sub>         | 0.01   | -0.03 – 0.05          | .523  | 0.01   | -0.03 – 0.05          | .663 | 0.01   | -0.03 – 0.05          | .660 | 0.01   | -0.03 – 0.06          | .624  |
| IF interact × condition <sub>memoryNotated</sub>      | 0.07   | 0.01 – 0.12           | .021  | 0.06   | 0.00 – 0.11           | .039 | 0.06   | 0.00 – 0.12           | .040 | 0.06   | -0.00 – 0.12          | .070  |
| MT                                                    |        |                       |       | -0.06  | -0.10 – -0.02         | .008 | -0.06  | -0.10 – -0.02         | .009 | -0.06  | -0.10 – -0.02         | .004  |
| IF interact × MT                                      |        |                       |       |        |                       |      | 0.00   | -0.02 – 0.02          | .931 | 0.04   | 0.01 – 0.06           | .010  |
| condition <sub>improvTrad</sub> × MT                  |        |                       |       |        |                       |      |        |                       |      | -0.10  | -0.15 – -0.06         | <.001 |
| condition <sub>memoryNotated</sub> × MT               |        |                       |       |        |                       |      |        |                       |      | 0.04   | -0.01 – 0.09          | .096  |
| IF interact × condition <sub>improvTrad</sub> × MT    |        |                       |       |        |                       |      |        |                       |      | 0.05   | 0.00 – 0.09           | .030  |
| IF interact × condition <sub>memoryNotated</sub> × MT |        |                       |       |        |                       |      |        |                       |      | 0.01   | -0.05 – 0.07          | .673  |
| Random Effects                                        |        |                       |       |        |                       |      |        |                       |      |        |                       |       |
| σ <sup>2</sup>                                        |        | 0.05                  |       |        | 0.05                  |      |        | 0.05                  |      |        | 0.04                  |       |
| τ <sub>00</sub>                                       |        | 0.03 section:stim_id  |       |        | 0.03 section:stim_id  |      |        | 0.03 section:stim_id  |      |        | 0.03 section:stim_id  |       |
|                                                       |        | 0.01 case_id:group_id |       |        | 0.01 case_id:group_id |      |        | 0.01 case_id:group_id |      |        | 0.00 case_id:group_id |       |
|                                                       |        | 0.01 group_id         |       |        | 0.00 group_id         |      |        | 0.00 group_id         |      |        | 0.00 group_id         |       |
| ICC                                                   |        | 0.50                  |       |        | 0.47                  |      |        | 0.47                  |      |        | 0.47                  |       |
| N                                                     |        | 30 case_id            |       |        | 30 case_id            |      |        | 30 case_id            |      |        | 30 case_id            |       |
|                                                       |        | 4 group_id            |       |        | 4 group_id            |      |        | 4 group_id            |      |        | 4 group_id            |       |
|                                                       |        | 15 section            |       |        | 15 section            |      |        | 15 section            |      |        | 15 section            |       |
|                                                       |        | 12 stim_id            |       |        | 12 stim_id            |      |        | 12 stim_id            |      |        | 12 stim_id            |       |
| Observations                                          |        | 1111                  |       |        | 1111                  |      |        | 1111                  |      |        | 1111                  |       |
| Marginal R <sup>2</sup> / Conditional R <sup>2</sup>  |        | 0.033 / 0.516         |       |        | 0.055 / 0.503         |      |        | 0.055 / 0.502         |      |        | 0.075 / 0.506         |       |
| AIC                                                   |        | 118.036               |       |        | 119.368               |      |        | 128.403               |      |        | 128.021               |       |

Table N2.3.2

Full Fixed and Random Effects for Model Comparisons for IF Absorption and ISC-SC

| Predictors                                     | ISC-SC |                       |      | ISC-SC |                       |      | ISC-SC |                       |      |
|------------------------------------------------|--------|-----------------------|------|--------|-----------------------|------|--------|-----------------------|------|
|                                                | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    |
| (Intercept)                                    | 0.20   | 0.09 – 0.31           | .008 | 0.20   | 0.08 – 0.32           | .012 | 0.20   | 0.08 – 0.32           | .012 |
| IF absorb                                      | -0.03  | -0.05 – -0.01         | .005 | -0.03  | -0.05 – -0.01         | .003 | -0.03  | -0.05 – -0.01         | .002 |
| condition <sub>improvTrad</sub>                |        |                       |      | 0.11   | 0.04 – 0.18           | .002 | 0.11   | 0.04 – 0.18           | .001 |
| condition <sub>memoryNotated</sub>             |        |                       |      | -0.00  | -0.08 – 0.08          | .974 | -0.01  | -0.08 – 0.07          | .896 |
| IF absorb × condition <sub>improvTrad</sub>    |        |                       |      |        |                       |      | -0.01  | -0.05 – 0.03          | .575 |
| IF absorb × condition <sub>memoryNotated</sub> |        |                       |      |        |                       |      | 0.04   | -0.01 – 0.08          | .118 |
| <b>Random Effects</b>                          |        |                       |      |        |                       |      |        |                       |      |
| $\sigma^2$                                     |        | 0.05                  |      |        | 0.05                  |      |        | 0.05                  |      |
| $\tau_{00}$                                    |        | 0.04 section:stim_id  |      |        | 0.03 section:stim_id  |      |        | 0.03 section:stim_id  |      |
|                                                |        | 0.01 case_id:group_id |      |        | 0.01 case_id:group_id |      |        | 0.01 case_id:group_id |      |
|                                                |        | 0.00 group_id         |      |        | 0.01 group_id         |      |        | 0.01 group_id         |      |
| ICC                                            |        | 0.50                  |      |        | 0.49                  |      |        | 0.49                  |      |
| N                                              |        | 30 case_id            |      |        | 30 case_id            |      |        | 30 case_id            |      |
|                                                |        | 4 group_id            |      |        | 4 group_id            |      |        | 4 group_id            |      |
|                                                |        | 15 section            |      |        | 15 section            |      |        | 15 section            |      |
|                                                |        | 12 stim_id            |      |        | 12 stim_id            |      |        | 12 stim_id            |      |
| Observations                                   |        | 1111                  |      |        | 1111                  |      |        | 1111                  |      |
| Marginal $R^2$ / Conditional $R^2$             |        | 0.008 / 0.501         |      |        | 0.031 / 0.503         |      |        | 0.033 / 0.505         |      |
| AIC                                            |        | 102.588               |      |        | 106.423               |      |        | 119.931               |      |

Table N2.3.2

(Continued)

| Predictors                                          | ISC-SC |                       |      | ISC-SC |                       |      | ISC-SC |                       |       |
|-----------------------------------------------------|--------|-----------------------|------|--------|-----------------------|------|--------|-----------------------|-------|
|                                                     | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    | Est.   | 95% CI                | p     |
| (Intercept)                                         | 0.21   | 0.11 – 0.30           | .005 | 0.21   | 0.11 – 0.30           | .005 | 0.20   | 0.12 – 0.29           | .003  |
| IF absorb                                           | -0.03  | -0.05 – -0.01         | .001 | -0.04  | -0.06 – -0.02         | .001 | -0.04  | -0.06 – -0.02         | <.001 |
| condition <sub>improvTrad</sub>                     | 0.11   | 0.04 – 0.18           | .002 | 0.11   | 0.04 – 0.18           | .002 | 0.13   | 0.06 – 0.20           | <.001 |
| condition <sub>memoryNotated</sub>                  | -0.01  | -0.08 – 0.07          | .890 | -0.00  | -0.08 – 0.07          | .920 | -0.01  | -0.09 – 0.07          | .830  |
| MT                                                  | -0.06  | -0.10 – -0.02         | .003 | -0.06  | -0.10 – -0.02         | .002 | -0.06  | -0.10 – -0.03         | .001  |
| condition <sub>improvTrad</sub> × MT                |        |                       |      |        |                       |      | -0.09  | -0.13 – -0.05         | <.001 |
| condition <sub>memoryNotated</sub> × MT             |        |                       |      |        |                       |      | 0.03   | -0.02 – 0.08          | .206  |
| IF absorb × condition <sub>improvTrad</sub>         | -0.01  | -0.05 – 0.02          | .531 | -0.01  | -0.05 – 0.02          | .534 | -0.02  | -0.06 – 0.02          | .409  |
| IF absorb × condition <sub>memoryNotated</sub>      | 0.03   | -0.01 – 0.07          | .183 | 0.03   | -0.01 – 0.07          | .168 | 0.03   | -0.02 – 0.08          | .183  |
| IF absorb × MT                                      |        |                       |      | 0.01   | -0.01 – 0.03          | .416 | 0.03   | 0.00 – 0.05           | .036  |
| IF absorb × condition <sub>improvTrad</sub> × MT    |        |                       |      |        |                       |      | 0.04   | -0.00 – 0.08          | .052  |
| IF absorb × condition <sub>memoryNotated</sub> × MT |        |                       |      |        |                       |      | -0.02  | -0.08 – 0.03          | .432  |
| <b>Random Effects</b>                               |        |                       |      |        |                       |      |        |                       |       |
| $\sigma^2$                                          |        | 0.05                  |      |        | 0.05                  |      |        | 0.05                  |       |
| $\tau_{00}$                                         |        | 0.03 section:stim_id  |      |        | 0.03 section:stim_id  |      |        | 0.03 section:stim_id  |       |
|                                                     |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |       |
|                                                     |        | 0.00 group_id         |      |        | 0.00 group_id         |      |        | 0.00 group_id         |       |
| ICC                                                 |        | 0.46                  |      |        | 0.46                  |      |        | 0.45                  |       |
| N                                                   |        | 30 case_id            |      |        | 30 case_id            |      |        | 30 case_id            |       |
|                                                     |        | 4 group_id            |      |        | 4 group_id            |      |        | 4 group_id            |       |
|                                                     |        | 15 section            |      |        | 15 section            |      |        | 15 section            |       |
|                                                     |        | 12 stim_id            |      |        | 12 stim_id            |      |        | 12 stim_id            |       |
| Observations                                        |        | 1111                  |      |        | 1111                  |      |        | 1111                  |       |
| Marginal $R^2$ / Conditional $R^2$                  |        | 0.059 / 0.494         |      |        | 0.061 / 0.491         |      |        | 0.076 / 0.495         |       |
| AIC                                                 |        | 119.505               |      |        | 128.253               |      |        | 136.480               |       |

Table N2.4.1

Full Fixed and Random Effects for Model Comparisons for IF Interaction and ISC-HR

| Predictors                         | ISC-HR |                       |      | Est.  | ISC-HR       |                       |       | Est.  | ISC-HR        |                       |   |
|------------------------------------|--------|-----------------------|------|-------|--------------|-----------------------|-------|-------|---------------|-----------------------|---|
|                                    | Est.   | 95% CI                | p    |       | Est.         | 95% CI                | p     |       | Est.          | 95% CI                | p |
| (Intercept)                        | -0.02  | -0.09 – 0.05          | .416 | -0.02 | -0.09 – 0.05 | .421                  | -0.02 | -0.02 | -0.09 – 0.05  | .414                  |   |
| IF interact                        |        |                       |      | 0.00  | -0.02 – 0.02 | .926                  |       | 0.00  | -0.02 – 0.03  | .798                  |   |
| condition <sub>improvTrad</sub>    |        |                       |      |       |              |                       |       | -0.03 | -0.09 – 0.02  | .239                  |   |
| condition <sub>memoryNotated</sub> |        |                       |      |       |              |                       |       | -0.08 | -0.15 – -0.02 | .007                  |   |
| <b>Random Effects</b>              |        |                       |      |       |              |                       |       |       |               |                       |   |
| $\sigma^2$                         |        | 0.12                  |      |       |              | 0.12                  |       |       |               | 0.12                  |   |
| $\tau_{00}$                        |        | 0.01 section:stim_id  |      |       |              | 0.01 section:stim_id  |       |       |               | 0.01 section:stim_id  |   |
|                                    |        | 0.00 case_id:group_id |      |       |              | 0.00 case_id:group_id |       |       |               | 0.00 case_id:group_id |   |
|                                    |        | 0.00 group_id         |      |       |              | 0.00 group_id         |       |       |               | 0.00 group_id         |   |
| ICC                                |        | 0.09                  |      |       |              | 0.09                  |       |       |               | 0.08                  |   |
| N                                  |        | 34 case_id            |      |       |              | 34 case_id            |       |       |               | 34 case_id            |   |
|                                    |        | 4 group_id            |      |       |              | 4 group_id            |       |       |               | 4 group_id            |   |
|                                    |        | 15 section            |      |       |              | 15 section            |       |       |               | 15 section            |   |
|                                    |        | 12 stim_id            |      |       |              | 12 stim_id            |       |       |               | 12 stim_id            |   |
| Observations                       |        | 1156                  |      |       |              | 1156                  |       |       |               | 1156                  |   |
| Marginal $R^2$ / Conditional $R^2$ |        | 0.000 / 0.090         |      |       |              | 0.000 / 0.090         |       |       |               | 0.011 / 0.085         |   |
| AIC                                |        | 934.005               |      |       |              | 943.074               |       |       |               | 948.878               |   |

Table N2.4.1

(Continued)

| ISC-HR                                                |       |                  |      | ISC-HR |                  |      | ISC-HR |                  |      | ISC-HR |                  |      |
|-------------------------------------------------------|-------|------------------|------|--------|------------------|------|--------|------------------|------|--------|------------------|------|
| Predictors                                            | Est.  | 95% CI           | p    | Est.   | 95% CI           | p    | Est.   | 95% CI           | p    | Est.   | 95% CI           | p    |
| (Intercept)                                           | -0.02 | -0.08 – 0.05     | .457 | -0.02  | -0.10 – 0.06     | .477 | -0.02  | -0.10 – 0.06     | .469 | -0.03  | -0.11 – 0.06     | .429 |
| IF interact                                           | 0.00  | -0.03 – 0.03     | .846 | -0.01  | -0.03 – 0.02     | .508 | -0.01  | -0.03 – 0.02     | .625 | -0.00  | -0.03 – 0.03     | .767 |
| condition <sub>improvTrad</sub>                       | -0.03 | -0.08 – 0.03     | .343 | -0.02  | -0.08 – 0.03     | .414 | -0.02  | -0.08 – 0.03     | .386 | -0.03  | -0.09 – 0.03     | .320 |
| condition <sub>memoryNotated</sub>                    | -0.10 | -0.16 – -0.03    | .004 | -0.09  | -0.15 – -0.03    | .004 | -0.09  | -0.15 – -0.03    | .004 | -0.08  | -0.15 – -0.01    | .019 |
| IF interact × condition <sub>improvTrad</sub>         | 0.00  | -0.05 – 0.05     | .890 |        |                  |      |        |                  |      | 0.00   | -0.05 – 0.05     | .995 |
| IF interact × condition <sub>memoryNotated</sub>      | 0.05  | -0.03 – 0.12     | .198 |        |                  |      |        |                  |      | 0.02   | -0.06 – 0.09     | .687 |
| MT                                                    |       |                  |      | -0.04  | -0.06 – -0.02    | .001 | -0.04  | -0.06 – -0.01    | .004 | -0.02  | -0.05 – 0.01     | .126 |
| IF interact × MT                                      |       |                  |      |        |                  |      | -0.01  | -0.03 – 0.02     | .659 | -0.02  | -0.05 – 0.01     | .253 |
| condition <sub>improvTrad</sub> × MT                  |       |                  |      |        |                  |      |        |                  |      | 0.04   | -0.02 – 0.09     | .195 |
| condition <sub>memoryNotated</sub> × MT               |       |                  |      |        |                  |      |        |                  |      | -0.07  | -0.15 – 0.01     | .089 |
| IF interact × condition <sub>improvTrad</sub> × MT    |       |                  |      |        |                  |      |        |                  |      | -0.01  | -0.07 – 0.04     | .601 |
| IF interact × condition <sub>memoryNotated</sub> × MT |       |                  |      |        |                  |      |        |                  |      | 0.04   | -0.04 – 0.12     | .356 |
| Random Effects                                        |       |                  |      |        |                  |      |        |                  |      |        |                  |      |
| σ <sup>2</sup>                                        |       | 0.12             |      |        | 0.12             |      |        | 0.12             |      |        | 0.12             |      |
| τ <sub>00</sub>                                       | 0.01  | section:stim_id  |      | 0.01   | section:stim_id  |      | 0.01   | section:stim_id  |      | 0.01   | section:stim_id  |      |
|                                                       | 0.00  | case_id:group_id |      | 0.00   | case_id:group_id |      | 0.00   | case_id:group_id |      | 0.00   | case_id:group_id |      |
|                                                       | 0.00  | group_id         |      | 0.00   | group_id         |      | 0.00   | group_id         |      | 0.00   | group_id         |      |
| ICC                                                   |       | 0.08             |      |        |                  |      |        |                  |      |        |                  |      |
| N                                                     | 34    | case_id          |      | 34     | case_id          |      | 34     | case_id          |      | 34     | case_id          |      |
|                                                       | 4     | group_id         |      | 4      | group_id         |      | 4      | group_id         |      | 4      | group_id         |      |
|                                                       | 15    | section          |      | 15     | section          |      | 15     | section          |      | 15     | section          |      |
|                                                       | 12    | stim_id          |      | 12     | stim_id          |      | 12     | stim_id          |      | 12     | stim_id          |      |
| Observations                                          |       | 1156             |      |        | 1156             |      |        | 1156             |      |        | 1156             |      |
| Marginal R <sup>2</sup> / Conditional R <sup>2</sup>  |       | 0.012 / 0.088    |      |        | 0.021 / NA       |      |        | 0.021 / NA       |      |        | 0.026 / NA       |      |
| AIC                                                   |       | 961.407          |      |        | 949.588          |      |        | 958.489          |      |        | 996.574          |      |



Table N2.4.2

Full Fixed and Random Effects for Model Comparisons for IF Absorption and ISC-HR

| Predictors                                     | ISC-HR |                       |      | ISC-HR |                       |      | ISC-HR |                       |      |
|------------------------------------------------|--------|-----------------------|------|--------|-----------------------|------|--------|-----------------------|------|
|                                                | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    |
| (Intercept)                                    | -0.02  | -0.09 – 0.05          | .421 | -0.02  | -0.09 – 0.05          | .412 | -0.02  | -0.09 – 0.05          | .481 |
| IF absorb                                      | 0.00   | -0.02 – 0.03          | .813 | 0.00   | -0.02 – 0.02          | .926 | -0.00  | -0.03 – 0.02          | .799 |
| condition <sub>improvTrad</sub>                |        |                       |      | -0.03  | -0.08 – 0.02          | .247 | -0.03  | -0.08 – 0.03          | .343 |
| condition <sub>memoryNotated</sub>             |        |                       |      | -0.09  | -0.15 – -0.02         | .007 | -0.09  | -0.16 – -0.03         | .004 |
| IF absorb × condition <sub>improvTrad</sub>    |        |                       |      |        |                       |      | -0.01  | -0.05 – 0.04          | .687 |
| IF absorb × condition <sub>memoryNotated</sub> |        |                       |      |        |                       |      | 0.04   | -0.02 – 0.10          | .172 |
| <b>Random Effects</b>                          |        |                       |      |        |                       |      |        |                       |      |
| $\sigma^2$                                     |        | 0.12                  |      |        | 0.12                  |      |        | 0.12                  |      |
| $\tau_{00}$                                    |        | 0.01 section:stim_id  |      |        | 0.01 section:stim_id  |      |        | 0.01 section:stim_id  |      |
|                                                |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |      |
|                                                |        | 0.00 group_id         |      |        | 0.00 group_id         |      |        | 0.00 group_id         |      |
| ICC                                            |        | 0.09                  |      |        | 0.08                  |      |        | 0.08                  |      |
| N                                              |        | 34 case_id            |      |        | 34 case_id            |      |        | 34 case_id            |      |
|                                                |        | 4 group_id            |      |        | 4 group_id            |      |        | 4 group_id            |      |
|                                                |        | 15 section            |      |        | 15 section            |      |        | 15 section            |      |
|                                                |        | 12 stim_id            |      |        | 12 stim_id            |      |        | 12 stim_id            |      |
| Observations                                   |        | 1156                  |      |        | 1156                  |      |        | 1156                  |      |
| Marginal $R^2$ / Conditional $R^2$             |        | 0.000 / 0.090         |      |        | 0.011 / 0.085         |      |        | 0.012 / 0.089         |      |
| AIC                                            |        | 943.054               |      |        | 948.985               |      |        | 961.881               |      |

Table N2.4.2

(Continued)

| Predictors                                          | ISC-HR |                       |      | ISC-HR |                       |      | ISC-HR |                       |      |
|-----------------------------------------------------|--------|-----------------------|------|--------|-----------------------|------|--------|-----------------------|------|
|                                                     | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    | Est.   | 95% CI                | p    |
| (Intercept)                                         | -0.02  | -0.10 – 0.06          | .542 | -0.02  | -0.10 – 0.06          | .538 | -0.02  | -0.11 – 0.06          | .463 |
| IF absorb                                           | -0.01  | -0.04 – 0.01          | .246 | -0.01  | -0.04 – 0.01          | .264 | -0.01  | -0.04 – 0.01          | .370 |
| condition <sub>improvTrad</sub>                     | -0.02  | -0.08 – 0.03          | .423 | -0.02  | -0.08 – 0.03          | .410 | -0.03  | -0.08 – 0.03          | .296 |
| condition <sub>memoryNotated</sub>                  | -0.10  | -0.16 – -0.04         | .002 | -0.10  | -0.16 – -0.04         | .002 | -0.09  | -0.15 – -0.02         | .009 |
| MT                                                  | -0.04  | -0.06 – -0.02         | .001 | -0.04  | -0.06 – -0.01         | .002 | -0.03  | -0.06 – 0.00          | .056 |
| condition <sub>improvTrad</sub> × MT                |        |                       |      |        |                       |      | 0.03   | -0.03 – 0.08          | .325 |
| condition <sub>memoryNotated</sub> × MT             |        |                       |      |        |                       |      | -0.05  | -0.13 – 0.02          | .185 |
| IF absorb × condition <sub>improvTrad</sub>         | -0.01  | -0.05 – 0.03          | .595 | -0.01  | -0.05 – 0.03          | .590 | -0.01  | -0.05 – 0.04          | .713 |
| IF absorb × condition <sub>memoryNotated</sub>      | 0.04   | -0.02 – 0.10          | .198 | 0.04   | -0.02 – 0.10          | .210 | 0.03   | -0.04 – 0.09          | .424 |
| IF absorb × MT                                      |        |                       |      | -0.00  | -0.02 – 0.02          | .799 | -0.01  | -0.04 – 0.02          | .424 |
| IF absorb × condition <sub>improvTrad</sub> × MT    |        |                       |      |        |                       |      | -0.01  | -0.06 – 0.03          | .583 |
| IF absorb × condition <sub>memoryNotated</sub> × MT |        |                       |      |        |                       |      | 0.01   | -0.05 – 0.08          | .683 |
| <b>Random Effects</b>                               |        |                       |      |        |                       |      |        |                       |      |
| $\sigma^2$                                          |        | 0.12                  |      |        | 0.12                  |      |        | 0.12                  |      |
| $\tau_{00}$                                         |        | 0.01 section:stim_id  |      |        | 0.01 section:stim_id  |      |        | 0.01 section:stim_id  |      |
|                                                     |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |      |        | 0.00 case_id:group_id |      |
|                                                     |        | 0.00 group_id         |      |        | 0.00 group_id         |      |        | 0.00 group_id         |      |
| ICC                                                 |        |                       |      |        |                       |      |        |                       |      |
| N                                                   |        | 34 case_id            |      |        | 34 case_id            |      |        | 34 case_id            |      |
|                                                     |        | 4 group_id            |      |        | 4 group_id            |      |        | 4 group_id            |      |
|                                                     |        | 15 section            |      |        | 15 section            |      |        | 15 section            |      |
|                                                     |        | 12 stim_id            |      |        | 12 stim_id            |      |        | 12 stim_id            |      |
| Observations                                        |        | 1156                  |      |        | 1156                  |      |        | 1156                  |      |
| Marginal $R^2$ / Conditional $R^2$                  |        | 0.023 / NA            |      |        | 0.023 / NA            |      |        | 0.026 / NA            |      |
| AIC                                                 |        | 962.661               |      |        | 972.054               |      |        | 998.854               |      |

## Appendix O – Model comparisons – Study 3.2

**Table O1.**

*Model Comparisons First Reducing All Random Effects, While Including All Fixed Effects.*

| Predictors                                       | TD<br>All possible fixed and random |                                                          |             | TD<br>Restrict correlations and intercepts |                                                |             | TD<br>Remove instrument slope |                                              |             |
|--------------------------------------------------|-------------------------------------|----------------------------------------------------------|-------------|--------------------------------------------|------------------------------------------------|-------------|-------------------------------|----------------------------------------------|-------------|
|                                                  | Est.                                | 95% CI                                                   | p           | Est.                                       | 95% CI                                         | p           | Est.                          | 95% CI                                       | p           |
| (Intercept)                                      | 0.08                                | -0.86 – 1.02                                             | .857        | 0.19                                       | -0.80 – 1.19                                   | .696        | 0.13                          | -0.86 – 1.12                                 | .793        |
| IF interact                                      | -0.19                               | -0.38 – 0.00                                             | .054        | -0.18                                      | -0.37 – 0.01                                   | .067        | -0.18                         | -0.38 – 0.01                                 | .064        |
| condition <sub>notateWithout</sub>               | -0.03                               | -0.46 – 0.41                                             | .869        | -0.02                                      | -0.47 – 0.43                                   | .899        | -0.02                         | -0.44 – 0.41                                 | .908        |
| condition <sub>memoryImprov</sub>                | -0.10                               | -0.85 – 0.66                                             | .714        | -0.09                                      | -0.82 – 0.65                                   | .733        | -0.08                         | -0.76 – 0.60                                 | .739        |
| IF absorb                                        | 0.20                                | 0.02 – 0.37                                              | <b>.029</b> | 0.20                                       | 0.02 – 0.38                                    | <b>.027</b> | 0.20                          | 0.02 – 0.38                                  | <b>.026</b> |
| Instrument <sub>structureElab</sub>              | -0.06                               | -0.55 – 0.43                                             | .685        | -0.08                                      | -0.48 – 0.32                                   | .568        | -0.15                         | -0.35 – 0.05                                 | .145        |
| Instrument <sub>balungSolo</sub>                 | 0.01                                | -0.21 – 0.23                                             | .917        | 0.02                                       | -0.18 – 0.22                                   | .809        | 0.03                          | -0.16 – 0.22                                 | .746        |
| pre flow                                         | -0.01                               | -0.14 – 0.11                                             | .819        | -0.03                                      | -0.16 – 0.11                                   | .661        | -0.02                         | -0.16 – 0.11                                 | .740        |
| post flow                                        | -0.00                               | -0.15 – 0.14                                             | .956        | 0.01                                       | -0.14 – 0.16                                   | .928        | -0.01                         | -0.15 – 0.14                                 | .944        |
| music training                                   | -0.10                               | -0.54 – 0.34                                             | .530        | -0.08                                      | -0.51 – 0.34                                   | .569        | -0.08                         | -0.51 – 0.34                                 | .577        |
| IF interact X condition <sub>notateWithout</sub> | 0.06                                | -0.33 – 0.45                                             | .754        | 0.02                                       | -0.37 – 0.41                                   | .925        | 0.00                          | -0.40 – 0.40                                 | .999        |
| IF interact X condition <sub>memoryImprov</sub>  | -0.07                               | -0.54 – 0.40                                             | .765        | -0.07                                      | -0.54 – 0.41                                   | .777        | -0.04                         | -0.52 – 0.44                                 | .862        |
| IF absorb X condition <sub>notateWithout</sub>   | 0.09                                | -0.22 – 0.41                                             | .554        | 0.13                                       | -0.19 – 0.45                                   | .425        | 0.13                          | -0.20 – 0.45                                 | .438        |
| IF absorb X condition <sub>memoryImprov</sub>    | 0.04                                | -0.37 – 0.45                                             | .840        | 0.05                                       | -0.36 – 0.46                                   | .808        | 0.04                          | -0.38 – 0.46                                 | .845        |
| <b>Random Effects</b>                            |                                     |                                                          |             |                                            |                                                |             |                               |                                              |             |
| $\sigma^2$                                       |                                     | 0.08                                                     |             |                                            | 0.08                                           |             |                               | 0.09                                         |             |
| $\tau_{00}$                                      |                                     | 0.02 <small>id_n.group</small>                           |             |                                            | 0.02 <small>id_n.group</small>                 |             |                               | 0.02 <small>id_n.group</small>               |             |
|                                                  |                                     | 0.00 <small>group</small>                                |             |                                            | 0.00 <small>group</small>                      |             |                               | 0.00 <small>group</small>                    |             |
|                                                  |                                     | 0.04 <small>group.1</small>                              |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | 0.01 <small>group.2</small>                              |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | 0.00 <small>group.3</small>                              |             |                                            |                                                |             |                               |                                              |             |
| $\tau_{11}$                                      |                                     | 0.06 <small>group.1.music_training</small>               |             |                                            | 0.05 <small>group.music_training</small>       |             |                               | 0.06 <small>group.music_training</small>     |             |
|                                                  |                                     | 0.02 <small>group.2.instrument struct_vs_elab</small>    |             |                                            | 0.06 <small>group.instrumentStructural</small> |             |                               | 0.19 <small>group.cont_condNotated</small>   |             |
|                                                  |                                     | 0.00 <small>group.2.instrument bal_vs_solo</small>       |             |                                            | 0.01 <small>group.instrumentBalungan</small>   |             |                               | 0.14 <small>group.cont_condMemorised</small> |             |
|                                                  |                                     | 0.06 <small>group.3. cond notasi_vs_without</small>      |             |                                            | 0.02 <small>group.instrumentSolo</small>       |             |                               | 0.03 <small>group.cont_condImprov</small>    |             |
|                                                  |                                     | 0.19 <small>group.3. cond mem_vs_improv</small>          |             |                                            | 0.13 <small>group.cont_condNotated</small>     |             |                               |                                              |             |
|                                                  |                                     |                                                          |             |                                            | 0.11 <small>group.cont_condMemorised</small>   |             |                               |                                              |             |
|                                                  |                                     |                                                          |             |                                            | 0.02 <small>group.cont_condImprov</small>      |             |                               |                                              |             |
| $\rho_{01}$                                      |                                     | -1.00 <small>group.1</small>                             |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | 1.00 <small>group.2.instrumentsstructure_vs_elab</small> |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | -1.00 <small>group.2.instrumentbalungan_vs_solo</small>  |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | -1.00 <small>group.3.cont_condnotasi_vs_without</small>  |             |                                            |                                                |             |                               |                                              |             |
|                                                  |                                     | -1.00 <small>group.3.cont_condmem_vs_improv</small>      |             |                                            |                                                |             |                               |                                              |             |
| <i>N</i>                                         |                                     | 4 <small>group</small>                                   |             |                                            | 4 <small>group</small>                         |             |                               | 4 <small>group</small>                       |             |
|                                                  |                                     | 33 <small>id_n</small>                                   |             |                                            | 33 <small>id_n</small>                         |             |                               | 33 <small>id_n</small>                       |             |
| Observations                                     |                                     | 99                                                       |             |                                            | 99                                             |             |                               | 99                                           |             |
| Marginal $R^2$ / Conditional $R^2$               |                                     | 0.176 / NA                                               |             |                                            | 0.180 / NA                                     |             |                               | 0.173 / NA                                   |             |
| AIC                                              |                                     | 167.367                                                  |             |                                            | 166.513                                        |             |                               | 155.291                                      |             |

Table O1.

(Continued)

| Predictors                                       | TD<br>Remove group intercept |                                          |             | TD<br>Remove musical training slope |                                           |             | TD<br>Remove condition slope |                            |             |
|--------------------------------------------------|------------------------------|------------------------------------------|-------------|-------------------------------------|-------------------------------------------|-------------|------------------------------|----------------------------|-------------|
|                                                  | Est.                         | 95% CI                                   | p           | Est.                                | 95% CI                                    | p           | Est.                         | 95% CI                     | p           |
| (Intercept)                                      | 0.13                         | -0.86 – 1.12                             | .793        | -0.06                               | -1.18 – 1.06                              | .917        | 0.21                         | -1.04 – 1.47               | .733        |
| IF interact                                      | -0.18                        | -0.38 – 0.01                             | .064        | -0.18                               | -0.38 – 0.02                              | .077        | -0.26                        | -0.49 – -0.03              | <b>.027</b> |
| condition <sub>notateWithout</sub>               | -0.02                        | -0.44 – 0.41                             | .908        | -0.03                               | -0.45 – 0.39                              | .859        | -0.07                        | -0.26 – 0.11               | .420        |
| condition <sub>memoryImprov</sub>                | -0.08                        | -0.76 – 0.60                             | .739        | -0.09                               | -0.75 – 0.58                              | .714        | -0.10                        | -0.32 – 0.13               | .395        |
| IF absorb                                        | 0.20                         | 0.02 – 0.38                              | <b>.026</b> | 0.18                                | -0.01 – 0.37                              | .059        | 0.22                         | -0.00 – 0.44               | .053        |
| Instrument <sub>structureElab</sub>              | -0.15                        | -0.35 – 0.05                             | .145        | -0.16                               | -0.38 – 0.05                              | .139        | -0.25                        | -0.48 – -0.01              | <b>.042</b> |
| Instrument <sub>balungSolo</sub>                 | 0.03                         | -0.16 – 0.22                             | .746        | 0.06                                | -0.15 – 0.27                              | .573        | 0.07                         | -0.18 – 0.31               | .593        |
| pre flow                                         | -0.02                        | -0.16 – 0.11                             | .740        | 0.01                                | -0.14 – 0.16                              | .931        | -0.04                        | -0.21 – 0.14               | .684        |
| post flow                                        | -0.01                        | -0.15 – 0.14                             | .944        | -0.08                               | -0.25 – 0.09                              | .375        | -0.11                        | -0.31 – 0.09               | .283        |
| music training                                   | -0.08                        | -0.51 – 0.34                             | .577        | -0.14                               | -0.28 – -0.01                             | <b>.042</b> | -0.21                        | -0.37 – -0.05              | <b>.011</b> |
| IF interact X condition <sub>notateWithout</sub> | 0.00                         | -0.40 – 0.40                             | .999        | 0.03                                | -0.38 – 0.45                              | .871        | 0.33                         | -0.13 – 0.79               | .154        |
| IF interact X condition <sub>memoryImprov</sub>  | -0.04                        | -0.52 – 0.44                             | .862        | -0.08                               | -0.58 – 0.42                              | .745        | -0.29                        | -0.85 – 0.28               | .314        |
| IF absorb X condition <sub>notateWithout</sub>   | 0.13                         | -0.20 – 0.45                             | .438        | 0.11                                | -0.23 – 0.44                              | .529        | -0.06                        | -0.44 – 0.32               | .741        |
| IF absorb X condition <sub>memoryImprov</sub>    | 0.04                         | -0.38 – 0.46                             | .845        | 0.07                                | -0.37 – 0.50                              | .761        | 0.24                         | -0.25 – 0.72               | .338        |
| <b>Random Effects</b>                            |                              |                                          |             |                                     |                                           |             |                              |                            |             |
| $\sigma^2$                                       |                              | 0.09                                     |             |                                     | 0.09                                      |             |                              | 0.12                       |             |
| $\tau_{00}$                                      |                              | 0.02 <sub>id_n:group</sub>               |             |                                     | 0.05 <sub>id_n:group</sub>                |             |                              | 0.08 <sub>id_n:group</sub> |             |
| $\tau_{11}$                                      |                              | 0.06 <sub>group.music_training</sub>     |             |                                     | 0.16 <sub>group1.cont_condNotated</sub>   |             |                              |                            |             |
|                                                  |                              | 0.19 <sub>group.cont_condNotated</sub>   |             |                                     | 0.12 <sub>group2.cont_condMemorised</sub> |             |                              |                            |             |
|                                                  |                              | 0.14 <sub>group.cont_condMemorised</sub> |             |                                     | 0.03 <sub>group3.cont_condImprov</sub>    |             |                              |                            |             |
|                                                  |                              | 0.03 <sub>group.cont_condImprov</sub>    |             |                                     |                                           |             |                              |                            |             |
| $\rho_{01}$                                      |                              |                                          |             |                                     |                                           |             |                              |                            |             |
| $\rho_{01}$                                      |                              |                                          |             |                                     |                                           |             |                              |                            |             |
| ICC                                              |                              |                                          |             |                                     |                                           |             |                              |                            |             |
| N                                                |                              | 4 <sub>group</sub>                       |             |                                     | 0.34                                      |             |                              | 0.41                       |             |
|                                                  |                              | 33 <sub>id_n</sub>                       |             |                                     | 4 <sub>group</sub>                        |             |                              | 33 <sub>id_n</sub>         |             |
| Observations                                     |                              | 99                                       |             |                                     | 33 <sub>id_n</sub>                        |             |                              | 4 <sub>group</sub>         |             |
|                                                  |                              |                                          |             |                                     | 99                                        |             |                              | 99                         |             |
| Marginal $R^2$ / Conditional $R^2$               |                              | 0.173 / NA                               |             |                                     | 0.145 / 0.438                             |             |                              | 0.235 / 0.548              |             |
| AIC                                              |                              | 153.291                                  |             |                                     | 157.481                                   |             |                              | 165.997                    |             |

Table O2.

## Model Comparisons Reducing Fixed Effects by Improvement in AIC Criterion

|                                                  | TD<br>Refit with maximum likelihood estimation |                            |             | TD<br>Remove pre-flow |                            |             | TD<br>Remove interaction with IF interaction |                            |             | TD<br>Remove interaction with IF absorption instead |                            |             |
|--------------------------------------------------|------------------------------------------------|----------------------------|-------------|-----------------------|----------------------------|-------------|----------------------------------------------|----------------------------|-------------|-----------------------------------------------------|----------------------------|-------------|
| Predictors                                       | Est.                                           | 95% CI                     | p           | Est.                  | 95% CI                     | p           | Est.                                         | 95% CI                     | p           | Est.                                                | 95% CI                     | p           |
| (Intercept)                                      | 0.22                                           | -0.93 – 1.36               | .703        | -0.04                 | -0.16 – 0.08               | .527        | -0.03                                        | -0.15 – 0.09               | .610        | -0.03                                               | -0.15 – 0.10               | .671        |
| IF interact                                      | -0.26                                          | -0.48 – -0.05              | <b>.018</b> | -0.27                 | -0.48 – -0.05              | <b>.016</b> | -0.31                                        | -0.49 – -0.12              | <b>.001</b> | -0.32                                               | -0.51 – -0.13              | <b>.001</b> |
| condition <sub>notateWithout</sub>               | -0.07                                          | -0.24 – 0.10               | .394        | -0.08                 | -0.24 – 0.09               | .371        | -0.02                                        | -0.18 – 0.14               | .802        | -0.06                                               | -0.22 – 0.11               | .489        |
| condition <sub>memoryImprov</sub>                | -0.10                                          | -0.30 – 0.11               | .360        | -0.10                 | -0.30 – 0.11               | .359        | -0.15                                        | -0.35 – 0.05               | .138        | -0.11                                               | -0.32 – 0.09               | .272        |
| IF absorb                                        | 0.22                                           | 0.01 – 0.42                | <b>.039</b> | 0.22                  | 0.02 – 0.43                | <b>.029</b> | 0.26                                         | 0.08 – 0.45                | <b>.006</b> | 0.27                                                | 0.09 – 0.45                | <b>.004</b> |
| Instrument <sub>structureElab</sub>              | -0.25                                          | -0.47 – -0.03              | <b>.028</b> | -0.25                 | -0.47 – -0.03              | <b>.027</b> | -0.25                                        | -0.47 – -0.03              | <b>.029</b> | -0.25                                               | -0.47 – -0.03              | <b>.029</b> |
| Instrument <sub>balungSolo</sub>                 | 0.07                                           | -0.16 – 0.29               | .564        | 0.08                  | -0.14 – 0.30               | .471        | 0.06                                         | -0.16 – 0.28               | .590        | 0.08                                                | -0.14 – 0.29               | .479        |
| pre flow                                         | -0.04                                          | -0.19 – 0.12               | .651        |                       |                            |             |                                              |                            |             |                                                     |                            |             |
| post flow                                        | -0.11                                          | -0.29 – 0.08               | .247        | -0.14                 | -0.27 – -0.01              | <b>.041</b> | -0.12                                        | -0.25 – 0.00               | .058        | -0.13                                               | -0.26 – -0.00              | <b>.042</b> |
| music training                                   | -0.21                                          | -0.36 – -0.07              | <b>.005</b> | -0.22                 | -0.36 – -0.08              | <b>.004</b> | -0.22                                        | -0.36 – -0.07              | <b>.004</b> | -0.22                                               | -0.36 – -0.07              | <b>.004</b> |
| IF interact X condition <sub>notateWithout</sub> | 0.33                                           | -0.09 – 0.76               | .125        | 0.33                  | -0.10 – 0.76               | .127        |                                              |                            |             | 0.26                                                | 0.06 – 0.46                | <b>.012</b> |
| IF interact X condition <sub>memoryImprov</sub>  | -0.28                                          | -0.81 – 0.24               | .289        | -0.29                 | -0.82 – 0.23               | .268        |                                              |                            |             | -0.04                                               | -0.28 – 0.19               | .715        |
| IF absorb X condition <sub>notateWithout</sub>   | -0.06                                          | -0.42 – 0.29               | .725        | -0.06                 | -0.41 – 0.29               | .742        | 0.18                                         | 0.02 – 0.35                | <b>.033</b> |                                                     |                            |             |
| IF absorb X condition <sub>memoryImprov</sub>    | 0.23                                           | -0.22 – 0.68               | .308        | 0.24                  | -0.21 – 0.69               | .292        | 0.03                                         | -0.18 – 0.24               | .797        |                                                     |                            |             |
| <b>Random Effects</b>                            |                                                |                            |             |                       |                            |             |                                              |                            |             |                                                     |                            |             |
| $\sigma^2$                                       |                                                | 0.10                       |             |                       | 0.10                       |             |                                              | 0.11                       |             |                                                     | 0.11                       |             |
| $\tau_{00}$                                      |                                                | 0.07 <sub>id_n:group</sub> |             |                       | 0.07 <sub>id_n:group</sub> |             |                                              | 0.07 <sub>id_n:group</sub> |             |                                                     | 0.07 <sub>id_n:group</sub> |             |
| ICC                                              |                                                | 0.39                       |             |                       | 0.40                       |             |                                              | 0.38                       |             |                                                     | 0.38                       |             |
| N                                                |                                                | 33 <sub>id_n</sub>         |             |                       | 33 <sub>id_n</sub>         |             |                                              | 33 <sub>id_n</sub>         |             |                                                     | 33 <sub>id_n</sub>         |             |
|                                                  |                                                | 4 <sub>group</sub>         |             |                       | 4 <sub>group</sub>         |             |                                              | 4 <sub>group</sub>         |             |                                                     | 4 <sub>group</sub>         |             |
| Observations                                     |                                                | 99                         |             |                       | 99                         |             |                                              | 99                         |             |                                                     | 99                         |             |
| Marginal $R^2$ / Conditional $R^2$               |                                                | 0.266 / 0.554              |             |                       | 0.258 / 0.553              |             |                                              | 0.246 / 0.533              |             |                                                     | 0.254 / 0.541              |             |
| AIC                                              |                                                | 166.015                    |             |                       | 161.087                    |             |                                              | 157.395                    |             |                                                     | 155.470                    |             |