'You Hum It, I'll Play It!'
The role of memory in playing the piano by ear

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Submitted in accordance with the requirements for the degree of Doctor of Philosophy

The University of Leeds
School of Music

September 2012

Acknowledgements

This thesis is part of a journey of discovery that I have travelled throughout my life. One that began at a very early age with the discovery of a piano in the front room of my grandparents' house, and continued with the discovery that I could spontaneously play stylistically-harmonised realisations of music that I had never seen notated and had only heard three or four times … that I could play the piano by ear.

Playing the piano by ear has always been, and remains, a very important part of my life and is the key to my musical identity, notwithstanding my formal musical and piano training. But I have always wondered – why am I able to play the piano by ear when other musicians cannot? How is it done? Have I learned to do it or was I born with the ability? Are my mental wiring and physical connections different from other pianists? What makes me tick as a musician? These questions have been with me for over fifty years.

And so I find myself I find myself writing this thesis – an examination of the relationship between musical memory processes and playing-by-ear ability – and I hope that it will take me forward on my journey of discovery and help me answer some of my questions.

Conducting this research project has been a privilege, as well as a rewarding experience, and I would like to take this opportunity to thank those people who have made this part of my journey possible: the 29 highly-talented musicians who willingly volunteered to take part in this research project, without whom this thesis would not have been possible; my supervisors Dr Luke Windsor and Dr Karen Burland for their unwavering support and advice, infinite patience, and the many supervision meetings that were above and beyond the call of duty, without which I could not have coped; Dr Alinka Greasley, who opened my eyes to the wonders of statistics, and Paul Nicholson (University of Leeds, Information Systems Services), who explained SPSS in words of one syllable, without both of whom I could not have completed my analysis; the ever helpful administrative, technical and IT staff at the University of Leeds, School of Music, who facilitated me with rooms, equipment and hard disc space; Drs Steve Muir, Mike Allis, Simon Warner, Allan Greenwood and Ian Sapiro at the University of Leeds, for giving me time to talk to students during their lectures; Dr Stephanie Pitts at the University of Sheffield for her assistance and support; Dave Ireland and Steve Wright, who assisted with verification of the test and other materials used, and Vicki Burrett, who gave up her time to carry out the necessary second marking of test data; and finally, the numerous students and members of academic staff at the University of Leeds, School of Music, and many other musical colleagues and friends, who took the time to complete my playing-by-ear survey.

I would also like to thank the people who have accompanied me on my journey: my parents, for their love and support and for always encouraging me to make music no matter how much it cost; my sons, daughters-in-law and grandchildren, for their unconditional love and their enormous encouragement, support and input; and my sister and brother-in-law, both such talented musicians, who gave up their time to take part in the research.

Finally I dedicate this thesis to the person without whom I could not have written it – my husband, Phil. Thank you for your never-ending love, support, encouragement, advice, proof-reading … and for always telling me I am capable of things that I thought I was not.

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Abstract

The purpose of this thesis is to investigate playing by ear amongst pianists, and determine the cognitive-psychological skills underlying playing-by-ear ability. Whilst earlier studies have focussed on melodic playing-by-ear abilities, mainly amongst children who play wind and string instruments, no studies hitherto have considered two-handed, harmonised playing by ear in adult pianists, or considered the cognitive-psychological factors that facilitate it. Adopting a range of quantitative and qualitative approaches, the thesis contains four individual studies, the first of which is a survey that elicits the views, opinions and beliefs of over 150 trained, adult pianists on playing by ear. Thematic analysis allows a profile of both by-ear and non-by-ear pianists to be drawn, and raises questions regarding the spontaneous nature of playing the piano by ear. The second study is an empirical investigation that uses an author-designed assessment tool to measure the abilities of 29 trained, adult pianists to realise familiar, orchestral music for by-ear piano performance. A more qualitative observation study follows that examines the strategies and practical techniques these pianists employ whilst preparing their by-ear realisations. A number of musical and motor memory skills are identified that have the potential to facilitate playing-by-ear ability, and a theoretical model of the cognitive-psychological process of playing by ear is proposed. During the final study, participants' levels of musical and motor memory are assessed, using a suite of author-designed measures, and the results compared with their playing-by-ear abilities to determine the individual and collective influence of these memory skills on playing by ear. Results suggest that a quantitative difference exists between spontaneous, harmonised by-ear realisations and those that are worked out through trial and error; and that recall memory has a strong influence on two-handed, harmonised playing-by-ear ability. The validity of the proposed cognitive-psychological model is discussed.

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List of Abbreviations

ABRSM	Associated Board of the Royal Schools of Music
ANOVA	Analysis of variance
BE	By-ear
BEAT	By Ear Assessment Tool
BWV	Bach-Werke-Verzeichnis
CD	Compact disc
CM	Compound major
cm	Compound minor
HT	Hands-together
LH	Left-hand
MANOVA	Multivariate analysis of variance
MAPE	Measurement of the Ability to Play by Ear (Delzell, Rohwer & Ballard, 1999)
MIDI	Musical Instrument Digital Interface
NBE	Non-by-ear
RH	Right-hand
SM	Simple major
sm	Simple minor
TAPE	Test of Ability to Play by Ear (McPherson, 1995)

1. Introduction

1.1 Research rationale

There is a perception amongst trained pianists that the ability to play the piano by ear is one that is desired by many but possessed by only a few. Swinburn (1918-1919) characterises the by-ear player as "the natural genius who has never learnt any music, but goes to an opera and plays it beautifully by ear next day" (1918-1919, p. 37). Similarly, Polk (1980) enthuses about by-ear players who "say that they just hear a tune inside their heads that they can translate to the keyboard as easily as others can hum a tune after hearing it" (1980, p. 42). A more neutral description, proffered by McPherson (1995), is that playing by ear is the reproduction of a pre-existing piece of music that has been learned aurally without the aid of notation.

Notwithstanding these descriptions, there remains an element of mystery surrounding playing the piano by ear which raises many questions: what are the cognitive-psychological factors that make playing the piano by ear possible; why are some highly-trained pianists able to spontaneously play a piece that they have heard only once or twice and never seen notated, whilst others are not; are there any specific musical skills that are more highly developed in by-ear pianists than in non-by-ear pianists; could any trained pianist play by ear if they were provided with an opportunity and encouraged to try; is the ability to play the piano by ear a natural ability or one that is learned or developed over time?

Given the wide range of these questions it is surprising that, compared to other areas of musical performance, relatively few studies have investigated playing-by-ear ability. There would seem to be one main reason for this deficiency in the literature. Although playing by ear is a skill which is highly valued within the world of rock, pop, jazz and folk music performance, it seems that these genres have, in the past, been ignored by musicologists and music psychologists in favour of Western art music (Lilliestam, 1996). As a result these genres, and the concept of playing by ear within them, have remained outside the sphere of music research, forming part of a non-literary culture which has sometimes been viewed as not worthy of investigation (ibid). However, although attitudes towards these genres have changed in recent years, only 10% of the 270 research articles discussed by Gabrielsson in his review of literature on musical performance were on the subjects of rock, pop, jazz and folk music (see Gabrielsson, 2003). Furthermore, none of this research was concerned with the by-ear aspects of their respective performance modes. Indeed, the only discussion of playing by ear in Gabrielsson's review is a short overview of McPherson (1995, 1996), who places it in the context of education rather than performance, and whose research forms only 1% of the overall literature reviewed.

Alongside research that discusses playing by ear in a general way (see Musco, 2010), McLucas (2010) presents a perspective on the oral/aural musical tradition amongst musicians in the USA. This discussion strives to make the point that the oral/aural transmission of music (that itself includes the practice of playing by ear) is the norm amongst wider world musics, rather than the exception that those who write about Western musical culture would lead us to believe (McLucas, 2010). However, studies on playing by ear specifically as a musical skill are mainly to be found within the domain of music education. These studies focus on the role of playing by ear in the context of instrumental teaching and learning and the school classroom (see P. Priest, 1985, 1989; Toplis, 1990), and its relationship with other related musical skills (see Luce, 1965; Liggett, 1980; Polk, 1980; McPherson, 1995, 1996; Bernhard, 2004). There are also studies that examine the informal by-ear learning strategies of rock and pop musicians, (see Lilliestam, 1996; Green, 2002; Johansson, 2004).

Some studies include aspects of testing melodic playing-by-ear ability, but focus mainly on the abilities of school children receiving formal woodwind, brass (see Luce, 1965; McPherson, 1995, 1996; Delzell, Rohwer, & Ballard, 1999; Bernhard, 2004) or string (see Luce, 1965) training. However, it is not clear from these studies whether any of the participating children demonstrated playing-by-ear ability prior to the tests. Additionally, Woody and Lehmann (2010) test the melodic playing-by-ear ability of college music students, where the majority were wind players, but a small number were pianists and mallet percussionists. Here, some of the students reported prior playing by ear experience and some did not. Finally, a small number of studies discuss playing by ear amongst 'musical savants' (see for example Sloboda, Hermelin, & O'Connor, 1985; Young & Nettlebeck, 1995; Ockelford & Pring, 2005; Ockelford, 2007, 2011), but these focus on their musical memory skills, rather than on their playing-by-ear ability.

In scrutinising the literature on playing by ear I have found only one published study that attempts to identify and examine the cognitive-psychological factors that underlie playing-by-ear ability in trained musicians (see Woody & Lehmann, 2010). Furthermore, I have found no studies that investigate these factors in the ability of trained pianists to play multi-timbral music by ear in a two-handed, harmonised manner.

1.2 Research context

In an attempt to begin to address this void in the research, and prior to the present research project, I conducted an investigation into the role of musical aural skills (in the sense of those skills tested in Associated Board of the Royal Schools of Music and other practical music examinations) in the playing by ear abilities of trained pianists (see Sapiro, 2007). In that study I described playing by ear in relation to piano performance and considered the two-handed aspects of by-ear playing, such as harmonised realisation. Accordingly, I defined playing the piano by ear as the accurate and fluent, two-handed, harmonised, performance of a piece of music that has been memorised aurally, without reference to musical notation. The study distinguished between "natural by-ear pianists" (Sapiro, 2007, p. 56), and those who practise a "trial and error" (ibid., p. 49) approach. The former were described as those who require little or no preparation time before playing either a familiar or novel piece by ear; the latter were those who require time to 'work out' how the music goes before they are able to play it, whether it is familiar or not.

The 2007 study was an empirical investigation that tested the levels of aural skill of trained pianists and correlated them with their levels of playing-by-ear ability. Unsurprisingly the results demonstrated that participants who demonstrated the highest levels of ability to play by ear also possessed high levels of aural skill. It was also evident that other participants, who had equally high levels of aural skill, had low levels of ability to play by ear. Thus, the study found that having a high level of aural skill did not necessarily enable playing-by-ear ability.

1.3 Research aims

Sapiro (2007) demonstrates that musical aural skill is an important factor in the playing-by-ear ability of trained pianists. However, the findings also imply that there remain other potentially influential cognitive-psychological factors. In endeavouring to continue and develop my investigation through the present research project, the aim of this thesis is to identify these factors and establish their role in the ability of trained pianists to play the piano by ear.

1.4 Research focus

The present thesis focuses on the two-handed, harmonised playing-by-ear abilities of trained, notation-reading adult pianists, who are referred to as 'trained pianists' or 'participants' throughout. To my knowledge, with the exception of my own previous study, the ability of trained pianists to play by ear has not previously been investigated or tested, and the research project uses a combination of quantitative and qualitative techniques to carry this out.

1.5 Participants

The participants in this research project, all of whom are aged 18 or over, were drawn from a wide range of musical backgrounds including undergraduate and postgraduate music students, professional academic musicians, professional performing musicians, piano teachers and amateur pianists. Playing-by-ear ability was not required in order to participate, and volunteers were a mixture of (self-reported) by-ear and non-by-ear pianists, all of whom had received formal piano tuition.

1.6 Reflection and ethical considerations

Taking into consideration that I have been playing the piano by ear for a long time, and that I am also a trained pianist, it is possible that my own experience may have some impact on my interpretation of the data collected from participating pianists. In order to mitigate the effect of this, every effort has been made to corroborate coding and assessment, and also any conclusions drawn from observations. However, at the same time I believe my personal experience of playing the piano by ear is beneficial, as it has allowed me to communicate with participants in a more meaningful way, thereby affording me a greater understanding of the processes involved when playing the piano by ear takes place.

The research project is empirical as opposed to theoretical and has, therefore, required the participation of volunteer pianists. Accordingly, prior to commencement I gained ethical approval from the University of Leeds AREA Faculty Research Ethics Committee, which was granted on 25th March 2009 and has the ethics reference number AREA 08/33. All volunteers taking part in the practical parts of the project completed a consent form prior to commencement.

1.7 Chapter by chapter overview

The thrust of the research project was to identify the cognitive-psychological factors underlying the process of playing by ear amongst trained pianists, and determine their relative importance in that process. It was conducted in three phases and contains four individual studies. The remainder of this section presents the chronology of the research project, introduces each of the four studies, and gives a chapter by chapter overview of the thesis.

In order to create an overall context for the investigation the first phase was a playing-by-ear survey. A structured questionnaire was designed to discover trained pianists' thoughts and feelings about playing by ear in general terms, and the extent to which the opinions of external musical influences impacted on their belief in their own playing-by-ear ability, or lack of it. Following a review of the published literature on playing by ear, the data, which were analysed using a thematic approach (Braun & Clarke, 2006), and the issues arising from them are discussed in the context of appropriate literature in Chapter 2.

The second phase was to examine the practical detail of playing-by-ear ability, and through this address the issues raised by the survey. To achieve this it was necessary to devise an appropriate measure for assessing levels of ability to play the piano by ear. I began by examining established methods of musical assessment, and evaluating the methodological approaches of published research on assessment of playing by ear, with a view to determining its appropriateness for the present research project. I also re-evaluated BEAT, the By-Ear Assessment Tool, a method of empirically measuring playing-by-ear ability in trained pianists, that I designed whilst conducting my earlier study (see Sapiro, 2007). These evaluations, and the ensuing discussion are presented in Chapter 3, along with a detailed description of the BEAT methodology and its theoretical underpinnings.

Having carried out this evaluation, I concluded that BEAT was the most appropriate methodology for use in the present research project. After some modifications, it was used to facilitate the 'BEAT Study' in which the measurement of two-handed, harmonised playing-by-ear ability amongst trained pianists was conducted. The results of the BEAT Study were analysed using appropriate statistical techniques, and discussed in the light of the issues raised by the earlier survey. Chapter 4 includes a detailed description of the modifications applied to the BEAT methodology, and presents an analysis and discussion of the results. Note that all statistical calculations in this thesis have been carried out using IBM SPSS v16 (www.ibm.com) apart from Fisher Exact tests, which were calculated online using http://www.physics.csbsju.edu/stats/ (Kirkman, 1996).

Following the BEAT Study, a more qualitative examination of the playing by ear process was conducted – the 'Strategy Study'. This was designed to ascertain the preparation strategies and practical techniques that trained pianists employ when preparing by-ear realisations for performance, and it was anticipated that identifying these strategies and techniques would enlighten the cognitive-psychological factors underlying playing by ear. The study was conducted by observing video recordings of BEAT Study by-ear preparation sessions, and the data were analysed using a mixture of quantitative and qualitative techniques. The outcomes are discussed in the context of appropriate literature in Chapter 5.

The practical techniques identified by the Strategy Study led to the conjecture that three specific types of memory were active during the playing by ear process: *memory for auditory-musical recall*; *memory for mental representations of musical structures*; and *memory for musical-motor structures*. Following a brief overview of human auditory memory, Chapter 6 presents a discussion of these three memory types in the context of appropriate literature, and a theoretical model of the cognitive-psychological process of playing by ear is proposed.

The final phase in the research project was the determination of the individual and collective effects of the above memory processes on playing by ear, and the validation of the proposed model. To achieve this I designed a series of measures to test these three types of memory and one additional one – *aural-encoding ability*. These formed the 'Memory Study'. The data from each measure were analysed using appropriate statistical techniques and, where appropriate, discussed in the context of the practical techniques identified in Chapter 5. The data were then compared statistically with that collected during the BEAT Study to determine the impact and importance of each memory type on the process of playing the piano by ear. Chapter 7 offers a detailed description of the methodology for each memory test, together with a full discussion of the data, analysis and conclusions.

Chapter 8 contains a full summary of the research project and an evaluation of the assessment methodologies used within it. The discussion then considers a range of issues arising from the research. Finally, the overall conclusions of the research and my personal reflection on it are presented in Chapter 9.

2. Playing by Ear: Opinions, Beliefs and Influences – A Survey

2.1 Rationale

For an investigation into the practical or psychological aspects of any mode of musical performance to be meaningful, it is necessary for that investigation to be set in the context of published literature that focuses on that mode of performance. It is also appropriate for it to reflect the opinions and beliefs of those musicians who practise it (see for example Green, 2002).

The musicians taking part in the present research project are trained pianists and, in order to create a framework within which to conduct the overall investigation, the first phase of the project was to examine the perceptions and beliefs of these musicians with regard to playing the piano by ear. It was anticipated that this would provide an insight into a number of areas of potential interest:

- How individuals perceive playing by ear;
- Individuals' belief in their own playing-by-ear ability or lack of it;
- The influence of teachers, and other musical influences, on that belief;
- Whether those who believe they have playing-by-ear ability see this as an important part of their musical lives.

This chapter continues with a review of published literature on playing by ear, and this is followed by a description of the methodological approach taken to the enquiry. Finally, respondents' views on a wide range of issues relating to their playing-by-ear ability and experiences are presented and discussed.

2.2 Playing by ear – a review of literature

2.2.1 Qualitative and ethnographic studies

Playing by ear forms part of an ancient global tradition where music is passed on through the oral/aural transmission of music from generation to generation (Lilliestam, 1996; Nettl, 2007; McLucas, 2010). In a short interlude presented in the context of a much broader treatise on research in arts education, Nettl (2007) observes that this practice has been, and remains, evident amongst many cultures across the world. In a similar vein, but in a much more detailed account, McLucas (2010) discusses the oral/aural tradition amongst a variety of musicians in the United States, and considers the impact of that tradition on both American popular music and art music. In an attempt to place the discussion in a cognitive-psychological context, she also presents an overview of human memory function, discusses the subject of musical creativity, and examines the concepts of meaning and emotion in music (McLucas, 2010). However, although McLucas advances a wide, cultural perspective on oral/aural learning and transmission of music, her discussion focuses mainly on vocal music rather than instrumental playing by ear.

In a dissertation on talent and genius, Faris (1936) compares the development of playing-by-ear ability to the development of prodigious ability in mathematics and painting. Based on information with respect to a highly intelligent and musically talented male college student, that was gathered via interviews and other written documents, Faris suggests that, like mathematics and painting, playing-by-ear ability is nurtured over a very long period of time, and develops as a result of a number of different factors including isolation from other children, having access to appropriate stimuli, and being in the right environment.

A slightly later paper, presented by Mainwaring (1941), examines the meaning of musicianship, the difficulties encountered in attempting to teach it, and the role of playing by ear within it. He argues that the apparent inability of musicians to play their instruments by ear derives from the manner in which they have initially been taught to play, and describes a process where pupils learn to read notation and then apply that notation to their instrument, resulting in instrumental sounds that are unexpected. Consequently, learners associate notations with physical actions rather than their resultant sounds. To counter this, he advocates that learners should first learn to read, and mentally audiate, the sounds presented by notation, before learning to produce them on their instruments, so that the resulting sounds are associated directly with the notation and are, therefore, expected rather than unexpected. This process, he suggests, would allow learners to "think in terms of music" (Mainwaring, 1941, p. 214) and lead to the capacity to "reproduce on a suitable instrument a given or pre-determined sound: the ability to 'speak the language of music'" (ibid.) or play by ear.

Following in the footsteps of Mainwaring (1941), Priest (1985) investigates the role of playing by ear in instrumental learning and classroom teaching, and proposes the use of by-ear activities that he puts into three distinct categories. The first of these, "getting beyond the notes" (1985, p. 10), describes the need to focus on expressive properties of the sound alongside the accurate interpretation of the notation, and thereby emphasises the importance of listening rather than reading.

The second, “as part of a teaching method” (ibid.), suggests the use of imitation, based on observation, to develop aural sense and musical memory. This, he advocates, would provide opportunities to try techniques that might appear too difficult if notated, therefore dispelling the notion that nothing can be played until it can be read. Finally, Priest’s third category is “busking, improvising and creating” (ibid.), where he suggests taking part in these activities would enhance aural skills. Overall, Priest’s view is that aural experience should be at the heart of music learning and teaching, rather than the development of notation-reading skills, and that playing by ear is central to the development of musicianship (cf. Mainwaring, 1941).

Priest (1989) develops his discussion with a number of observations about playing by ear based on a qualitative study of the by-ear learning experiences of a group of ten British musicians, some of whom had also been taught to play their instruments from notation. In this discussion, Priest infers that music played by ear is learned using a combination of trial and error and experimentation techniques, where established musical devices are in evidence but, amongst those who have not also been formally taught, the terminology required to describe them is sometimes unknown. Furthermore, he indicates that, in contrast to those musicians who have been formally taught, those who develop their skills informally have less difficulty with examination aural tests when encountering them during subsequent formal learning. He also notes that by-ear players play confidently in a number of different keys, and observes that those who are also able to play from notation nevertheless appear to prefer to play by ear. In relation to formal music education, Priest suggests that teachers do not encourage playing by ear, and often disapprove of its practice for two reasons: it is thought to discourage children from learning to read notation; and that playing without notation (where that notation does not exist, as opposed to playing from memory) makes assessment difficult. The consequence of this, he implies, is that the majority of by-ear players view their playing-by-ear experiences as completely separate from their formal learning. Finally, Priest concludes that playing by ear is a skill that could be developed by all musicians, and should be encouraged alongside playing from notation. This notion is based on his belief that “whether the music to be played is heard inwardly, from memory or from notation or heard externally (live or recorded), the playing is by ear” (1989, p. 187).

The potential of playing by ear as a group activity in the music classroom is examined by Toplis (1990). Having made the point that the "strong urge to reproduce music … [is] a universal human experience" (p. 145), she advocates that playing by ear fits naturally into the musical development of children asserting that, as an activity, it feeds into the 'vernacular' and 'idiomatic' stages of the Swanwick and Tillman spiral of musical development (see Swanwick & Tillman, 1986, p. 331). She further suggests that children are naturally motivated to play by ear, although they may not realise that this is what they are doing, and indicates that they "pick out music with which they identify and with whose language they can associate" (Toplis, 1990, p. 146). However, Toplis also observes that this activity is often carried out covertly in the classroom because teachers express disapproval (cf. P. Priest, 1989) and do not encourage it. Furthermore, she notes that much of the music children produce during composing activities resembles, sometimes in its entirety, music that they have inwardly assimilated through listening. As such, their compositions or improvisations are actually representations of playing by ear instead. She also implies that children are frequently disappointed when they realise that their 'compositions' are simply reproductions of music that already exists and suggests that this disappointment could be averted if they were more aware of the value of playing by ear. To this end, Toplis concludes that playing by ear should form a musical activity in the classroom, both in its own right and alongside composing/improvising activities.

Lilliestam (1996) presents a discussion that examines instrumental by-ear playing amongst professional rock musicians. He suggests that playing by ear is a form of tacit knowledge, and bases this notion on three factors: his opinion that playing by ear has gone unrecognised as a musical ability; his observation that this ability is implicitly understood by rock musicians without the need for explanation; and the fact that these musicians have some difficulty in articulating how they play by ear. In examining how rock musicians learned to play their instruments, Lilliestam notes a variety of methods including listening to and playing along with recordings, watching and imitating the fingering patterns of other players, and simply working out what to play through trial and error (cf. P. Priest, 1989). The discussion also demonstrates that many of the musicians interviewed have little knowledge of formal musical terminology, although they have a highly developed musical vocabulary that allows them to communicate their musical requirements to one another (cf. P. Priest, 1989). Lilliestam goes on to discuss the ways in which rock musicians remember music, and suggests that a number of memory processes are involved, including aural, visual, verbal, and what he describes as "tactile-motoric" (Lilliestam, 1996, p. 201). This latter memory type, described by Lilliestam's interviewees as the transfer of the sounds they hear directly to their fingers, suggests a form of ideomotor memory and this type of memory, along with aural memory, is discussed in Chapter 6 of the present thesis. One element that is implicit throughout Lilliestam's discussion is that playing by ear gives rock musicians a sense of musical identity, and there is a suggestion that the composition of new music, which is often collaborative, is shaped by their lives and personal experiences. In conclusion, Lilliestam reflects that there is a need for further research into playing by ear, not only in the context of informal music, but also from more musicological, psychological and pedagogical perspectives.

Building on the work of Lilliestam, Johansson (2004) examines the strategies that professional rock musicians employ to find the necessary chords when playing new and unfamiliar music, by ear, in live or spontaneous performance situations. Six musicians took part in the study – two bassists, two guitarists and two keyboardists, where one of each pair had received formal training and the other had not. These musicians were required to play along with recordings of three original pieces, one in a familiar rock style, one with a more complex harmonic structure, and the third that avoided familiar rock harmonic combinations completely. Johansson observes a range of listening strategies that included paying individual attention to the melody, the bass notes, the harmonic progressions, or the chord voicings; and a number of playing strategies including searching for bass notes, constructing chords from bass notes, or playing the melody when unsure of the chords. He also reports that errors occurring in the harmonic progression when the piece is played for the first time remain when the piece is repeated, and he calls this "instant learning" (p. 98). Additionally, he comments that the musicians who have not received formal training tend to play strictly in the style of the given music, whilst those who have been formally trained are more likely to embellish or change the style of the music whilst playing along. He attributes this to the possibility that formal training requires musicians to playing in a broad range of musical styles, and encourages the musician to place their own stamp on the music. Furthermore, and in keeping with the findings of both Priest (1989) and Lilliestam (1996), Johansson notes a difference in the technical language used to describe musical devices between those who have received formal training and those who have not. Overall, Johansson concludes that rock musicians develop their skill by learning the stylistic traits and harmonic formulae of the genres they wish to play, and suggests that in novel situations they find the required harmony through expectation based on the harmonic rhythm, the melody, the bass line and the general style of the music.

Another study that extends Lilliestam's (1996) research is that conducted by Green (2002), who presents an account of the by-ear learning practices of popular musicians in Britain. In this context, she identifies two distinct types of music education: "traditional music education" (p. 127), and "new musical education" (p. 151). Traditional music education, occupying the period between 1960 and late 1980s, is described as being grounded in formal Western art music and culture, whilst the new musical education period, beginning in the 1990s, sees the introduction of popular and world musics into the music curriculum. Through the words of a group of popular musicians, whose musical experience ranges from those who are just beginning to develop their craft to those who are professional musicians, Green considers what the concept of being musically educated really means. Although it is noted that a small number of musicians in the study had taken some popular-music instrumental lessons, it is evident from the discussion that instrumental learning amongst them is mainly informal and by ear and, for the most part, takes place without teacher intervention. Like Lilliestam (1996), Green suggests that this informal learning occurs by listening to, observing and imitating recordings and live events, and also through peer-group interaction. Furthermore, she notes that, like their formally trained musical peers, those who practise popular music are likely to have families who encourage their musical interests. It is, however, also apparent that whilst those musicians in the study who have received no "classical instrumental lessons" (p. 148) feel that they are musically uneducated, those who have engaged with classical tuition, alongside their more informal instrumental activities, indicate that they benefited little from the experience. Additionally, Green notes that the older musicians, who experienced their musical education during the traditional regime, acknowledge feelings of alienation insofar as their classroom experiences are concerned. They reveal that their teachers often demonstrated a lack of interest in their musical activities outside the classroom and, consequently, had no awareness of their developing levels of musical proficiency (cf.

P. Priest, 1989). Conversely, the comments of the younger musicians, whose musical experiences where shaped by the new music curriculum, indicate that they were more engaged with the classroom music experience, although Green notes that they continued to pursue their informal musical practices away from the classroom. Overall, Green (2002) concludes that there is much that teachers can do to develop the potential of popular music both in the classroom, and in instrumental learning, in particular the use of popular music informal learning practices.

In a later work Green (2008) presents pedagogy that tackles the application of informal learning practices in the classroom. She identifies five fundamental principles that underlie popular music learning practices: pupils learn music that they are familiar with, and choose for themselves; learning takes place through the process of listening to and copying a recording; learning is peer-directed without the direct intervention of teachers; learning is holistic, with no pre-planning or imposed structure; the elements of listening, performing, improvising and composing are integrated, with an emphasis on personal creativity. Green also points out the differences between these approaches and those taken in more formal learning situations, where music is normally chosen by the teacher and is often unfamiliar; aural copying is rarely employed; there is teacher direction throughout; lessons conform to a pre-planned syllabus; and the emphasis is mainly on reproduction rather than creativity (Green, 2008). Having implemented this pedagogy through a project involving a number of British comprehensive schools, Green reports that the teachers who took part responded positively to it, and that pupils found the creative music-making process enjoyable and fulfilling. She also advocates that this method of learning should form part of a broader music curriculum that also includes theoretical instruction with regard to rhythm, melody, harmony, and other music devices including notation skills, making the point that “there is no *necessary* (sic) disjunction between informal music learning and the acquisition of such theoretical knowledge” (Green, 2008, p. 181).

2.2.2 Quantitative and empirical studies

Alongside the research discussed thus far, are studies that take a more empirical approach to investigating playing-by-ear ability, including some that suggest the possibility of a relationship between playing by ear ability and proficiency in other performance musical skills. Luce (1965) investigates the relationship between sight-reading ability, and the ability to play previously unknown melody by ear. He measures these abilities amongst teenage instrumentalists using author-designed tests, and demonstrates a strong statistical correlation between them in this group of musicians. Additionally, although he initially implies that playing by ear is an inherent ability, but one that also requires technical skill, Luce concludes from his investigation that playing by ear ability is, in fact, learned. He bases this conclusion on his observation that playing by ear ability appears to be responsive to training, also noting that the skill of sight-reading does not. Furthermore, he infers that playing by ear may be more beneficial than sight-reading in the development of musicianship amongst pupils who already read and play from notation. A critical analysis of Luce's methodological approach to measuring playing by ear ability, and its results, is presented in Chapter 3, where the discussion focuses on the appropriateness of existing methods of assessing playing-by-ear ability for use in the present research project.

Another study that examines sight-reading ability and the ability to play unfamiliar melody by ear and is that of Bernhard (2004), who investigates the impact of "tonal training (the use of vocalization and solfege syllables to emphasize sensitivity to pitch relationships)" (p. 96) and "traditional training (the identification of discrete notational symbols and their relationships to instrumental fingerings and slide positions)" (ibid.) on their development. In the context of an 'intervention' paradigm, the tonal aptitude, sight-reading and playing-by-ear abilities of an experimental and a control group were measured and compared. Bernhard measured tonal aptitude using Gordon's "Musical Aptitude Profile" (1995; cited in Bernhard, 2004, p. 94); sight-reading using an adaptation of Grutzmacher's "Melodic Sight Reading Achievement Test" (1987; cited in Bernhard, 2004, p. 96); and playing by ear using an adaptation of Delzell, Rohwer and Ballard's "Measurement of the Ability to Play by Ear" (1999; cited in Bernhard, 2004, p. 96). (Note that a critical analysis of Bernhard's methodological approach to testing playing by ear ability, and its results, is presented in Chapter 3.) Bernhard's results suggest that melodic playing by ear ability develops with the application of tonal training, but sight-reading ability does not. Furthermore, like Luce (1965) (and also McPherson (1995, 1996) discussed below) he observed a significant correlation between sight-reading and playing by ear. Overall, Bernhard infers from his findings that the development of playing by ear does not adversely affect the ability to sight-read notation.

The relationship between sight-reading and playing by ear is also alluded to by Liggett (1980). In the context of a paper presenting a brief outline of her approach to developing playing-by-ear ability through ear training, she suggests that playing by ear itself develops directional and spatial relationships which, in turn, aid sight-reading. Additionally, she suggests that playing by ear is strongly linked to musical memorisation, postulating that those students who play by ear are able to memorise written music more quickly and more securely, since they have the "freedom to devote more attention to the sounds" (p. 48). However, Liggett provides no empirical support for the views presented in this paper.

The opinion that learning to play the piano by ear requires the simultaneous development of both visual and aural skills is presented by Polk (1980). She proposes that aural training will "get the ear into the habit of directing the fingers to the proper keys" (p. 42), and the process of visually reading the music will "tell the fingers which keys to play" (ibid.) although, like Liggett, she provides no empirical evidence to support these proposals. However, from them she infers that playing by ear can improve the ability to play from notation, and similarly, that playing from notation can enhance the ability to play by ear. Additionally, Polk warns of the dangers of rote learning through visual observation on the basis that this method of learning may produce results which utilise only visual and motor skills without the application of listening.

The research of McPherson (1995, 1996) builds on the work of Mainwaring (1941), Luce (1965) and Priest (1985, 1989), and reports on an investigation that examines the relationships between five modes of melodic performance: performing rehearsed music, sight reading, playing from memory, playing by ear, and improvisation. Working with teenage clarinet and trumpet players, McPherson assessed their ability to perform rehearsed music through their Australian Music Examinations Board grades, and their sight-reading ability was measured using the 'Watkins-Farnum Performance Scale' (Watkins & Farnum, 1954; cited in McPherson, 1995). To assess the three remaining skills McPherson designed a series of new measures: the "Test of Ability to Play from Memory" (McPherson, 1995, p. 146), the "Test of Ability to Improvise" (p. 149), and the "Test of Ability to Play by Ear" (p. 147). (A critical analysis of McPherson's methodological approach to testing playing by ear ability, and its results, is presented in Chapter 3.) Additionally, a questionnaire was designed to gather data with regard to a series of variables relating to musical background and experience: early exposure to music; starting method; learning other instruments; average amounts of daily practice; and self-reports of improvising, composing, singing and mental rehearsal. The relationship between these variables and the five identified performance modes was also examined. Participating instrumentalists were divided into two groups according to age and ability: group one, who were aged 12 to 15 years and demonstrated grades 3 or 4; and group two, who were aged 15-18, and demonstrated grades 5 or 6.

McPherson reports that group two participants demonstrated higher levels of ability in all performance measures than participants in group one. He also reports statistically significant correlations between all pairs of performance skills across all participants, where the highest was between playing by ear and improvising abilities, followed by those between sight-reading and improvisation, and sight-reading and performing from rehearsed music, which were jointly second. Furthermore, seven of the 10 possible correlations between skills for group one were significant, the highest being between playing by ear and improvising, and all correlations for group two were significant, where the highest was again between playing by ear and improvising. Alongside these observed relationships between the performance modes, McPherson notes that performing rehearsed music was significantly correlated with variables that reflect length of study, and that playing from memory, playing by ear and improvising were each significantly correlated with early exposure to music. He also reports that playing by ear and improvising were both significantly correlated with participants' self-reports of improvising, composing, singing and mental rehearsal which, he suggests, are variables that require the ability to "think in sound" (1995, p. 157; cf. Mainwaring, 1941). Overall, McPherson concludes that the performance skills of teenage instrumentalists develop and consolidate with experience (cf. Luce, 1965), and warns that playing exclusively from notation may hinder the development of aural and audiation skills necessary for playing by ear and improvising. He further suggests that playing by ear and improvisation should be introduced and encouraged in the early stages of musical learning, as they may be effective tools when used as a preamble to learning notation.

The impact of melodic pattern difficulty on playing by ear ability amongst teenage wind players was investigated by Delzell, Rohwer and Ballard (1999), who also examined the effects of both performance experience and instrument played on playing by ear, as well as the relationship between playing-by-ear and tonal aptitude. The study was conducted using participants who were aged either 10/11 years or 15/16 years. Playing by ear was measured using the author-designed "Measurement of the Ability to Play by Ear" (1999, p. 56) and tonal aptitude using the tonal imagery test from Gordon's "Musical Aptitude Profile" (1965; cited in Delzell, et al., 1999, p. 58). (A critical analysis of Delzell et al.'s methodological approach to testing playing by ear ability, and its results, is presented in Chapter 3.) Overall, Delzell et al. reported that the difficulty of melodic patterns influences the ability to accurately reproduce those patterns by ear, and noted a statistically significant relationship between playing-by-ear ability and tonal aptitude. However, in contrast with the findings of Luce (1965) and McPherson (1995, 1996), they conclude that playing-by-ear ability does not develop or improve with experience and maturation and, furthermore, they suggest that the instrument on which playing by ear takes place does not influence the level of by-ear ability demonstrated.

A recent study, by Woody and Lehmann (2010), examined the difference in levels of ability to both sing and play unfamiliar melody by ear between formally trained musicians, and those who had developed their by-ear skills via a more vernacular route. Woody and Lehmann hypothesised that musicians in the latter category would demonstrate higher levels of melodic playing-by-ear ability than their formally trained colleagues. A 'listen-then-play' paradigm was employed to measure the by-ear ability of 24 college music students, who played a range of instruments, and who were grouped according to whether they were "formal" or "vernacular musicians" (p. 104). Once again, a critical analysis of Woody and Lehmann's methodological approach to measuring instrumental playing by ear, and its results, is presented in Chapter 3. In addition to measuring singing and playing by ear, Woody and Lehmann also carried out post-test interviews with their participants, asking them to comment, retrospectively, about their thoughts whilst working with the melodies, and the strategies they used when learning them. These interviews also provided an opportunity for participants to comment on the manner of their instrumental study and their vernacular music-making background. Woody and Lehmann report that their participants described a range of encoding strategies, including melodic pattern identification, mental rehearsal, and the formation of mental representations of the sound. Additionally, based on the interview data, they suggest that formal participants processed melody intervallically, whilst vernacular participants tended to process it in terms of their perception of melody's underlying harmonic structure. Furthermore, Woody and Lehmann note that whilst formal participants make explicit reference to fingering patterns in connection with the manner in which they produce the music on their instruments, vernacular participants do not. Finally, it was noted that vernacular participants had experienced substantially more ear-based musical activities than their formal colleagues. Overall, based on their interview data and the results of their singing and playing-by-ear measures, Woody and Lehmann conclude that vernacular musicians are more skilled at playing by ear than their formally trained colleagues. This conclusion is discussed in more detail in Chapter 7 of this thesis.

Having presented a discussion of existing published research on playing by ear, the remainder of this chapter focuses on the methodological approach taken to the first stage of the present research project, and its findings.

2.3 Methodology and respondents

The enquiry was conducted through a structured survey that contained a mixture of open and closed questions. The first section was completed by all respondents and the remainder of the survey was divided into two sections. Section A was completed by those who believed they could play the piano by ear, and section B by those who believed they could not, or were unsure. The questions in these two sections were mainly similar in terms of their content, but worded slightly differently to reflect respondents' ability to play by ear or not. Respondents to the survey, a copy of which can be found in Appendix 1, were recruited via three methods: the author's attendance at lectures in the School of Music at the University of Leeds (with permission of the appropriate authorities); an email approach to members of staff in the School of Music at the same institution; and the author's personal approach elsewhere.

The survey was completed by 151 respondents, of whom 64 were men and 87 were women, and all of whom had received formal training at the piano. The overall age range was 18–60+, with 85% falling into 18-30 band, and the remaining 15% into the 31-60+ band. Eighty-five per cent were undergraduate or postgraduate music students at the University of Leeds; 6% were School of Music staff; 7% were professional academic or performing musicians or piano teachers; and the remaining

2% were amateur pianists. In total, 56 respondents (37%) reported that they could play the piano by ear and the remaining 95 (63%) reported that they could not, or were unsure.

2.4 Procedure

Respondents were given an overview of the playing-by-ear research project, and told that the survey was designed to discern their thoughts and feelings about playing by ear, and also to give them an opportunity to become involved in the practical part of the project should they wish to. They were advised that the survey would take ten minutes to complete and it was made clear that they were under no obligation to complete it. Additionally, they were asked to leave contact details, in the form of an email address, if they were interested in becoming further involved with the project, or would like more information. Respondents were also informed that all data collected (including any contact details) would be completely confidential, that recruitment was on an unpaid basis, and that leaving their contact details did not entail any kind of commitment to the project.

Completed surveys were allocated an identity code that included the letters 'BE' (by-ear) if the respondent reported that they could play by ear, and 'NBE' (non-by-ear) if they could not, or were unsure. Finally, the analysis of responses was carried out through a combination of thematic and statistical techniques.

2.5 The nature of playing by ear

The overall view conveyed by the respondents is that playing by ear is listening to a piece of music, or hearing it in the head, and then playing it on an instrument. Additionally, a very small number mention that music played by-ear on the piano should be harmonised, and some of them demonstrate differing opinions with regard to the level of musical accuracy required for by-ear performance. There is also a sense that playing by ear is playing from memory, on the basis that it does not utilise musical notation. Some respondents suggest that music to be played by ear has been memorised at some point prior to when it is to be played, whilst others indicate that the music is memorised immediately before playing. Table 2.1 presents a selection of responses that capture the essence of those provided.

Table 2.1 Examples of respondents' views on the nature of playing by ear

Category	Examples of responses
Listen then play back	Being able to play a piece of music by just listening to what you want to play. (73NBE)
	Listening to something, a melody or piece, and playing it back using only aural skills; not seeing a written version or watching someone play; all aurally based. (38BE)
	Playing music without written aids such as manuscript; using your inner ear to recreate a piece of music. (37NBE)
Addition of harmony/accuracy of performance	Being able to hear a piece of music and reproduce it accurately in terms of melody and harmony. (193NBE)
	Listen to the music, working out the harmony and melody and playing them to fit roughly to the music. (148BE)
Playing from memory	Playing from memory, recalling music you've only heard, not reading music from a score. (52NBE)
	Playing from listening to a song and trying to play it back from memory. (62BE)

These views on the nature of playing by ear are consistent with McPherson's (1995) description given in Chapter 1 of this thesis (see page 17) , and respondents' comments on the role of memory in playing by ear are also reflected in the literature. Toplis (1990) infers that playing by ear is only possible because familiar music is sub-consciously memorised by way of exposure to it in everyday life, whilst Priest (1989) presents a more radical view. He proposes that "playing by ear is all music that takes place without notation being used at the time" (1985, p. 174), including playing music memorised aurally, music memorised by rote from an audio-visual physical source, and music memorised from notation. However, Lilliestam (1996) goes further. He speculates that playing by ear utilises a combination of aural, visual and motor memory – aural memory to recall the sound of the music, visual memory to recall the physical shapes formed by the hands and fingers on the instrument, and motor memory to physically play the music.

An aspect of the nature of playing by ear where respondents' opinions are divided is the question of how quickly a piece is played by ear after hearing or recalling it. One view put forward is that playing by ear is spontaneous, where the music is played immediately after hearing or recalling it, implying that no time is needed to work out how the music goes. However, this view receives little support in the literature, with only a passing observation that some by-ear players are able to reproduce music immediately on their instruments after hearing it (Luce, 1965; Polk, 1980). The opposing view is that playing by ear is deductive, where the music is played only after listening to it and spending time working out how it goes using trial and error. This is the main view proposed by Faris (1936), Polk (1980) and Toplis (1990) who, along with Priest (1989), suggest that all musicians are capable of playing music by ear. Respondents' opinions are exemplified in Table 2.2.

Table 2.2 Examples of respondents' views on whether playing by ear is spontaneous or deductive

Category	Examples of responses
Spontaneous	Being able to hear music and play it back straight away, without notation. (101NBE)
	The ability to provide a melody and basic accompaniment spontaneously for any given piece of music without the aid of musical notation. (196NBE)
	Listening to a tune with harmony and then being able to play it straight away. (201BE)
Deductive	Listening to a piece and working out how to play it without written music or chords. (17BE)
	Hearing a tune and working out how to play it through trial and error. (81BE)
	Being able to listen to a song and being able to work out the melodies and chords. (131NBE)

In sum, respondents mainly agree that playing by ear is the ability to play a piece of music from memory that has only been listened to, and not learned from notation, but opinion differs with regard to whether playing by ear is a spontaneous or deductive process.

2.6 Values of, and attitudes towards, playing by ear

Playing by ear is a mode of performance that is frequently associated with those who learn informally (Lilliestam, 1996; Green, 2002), such as rock, pop and folk musicians. However, it is also a skill that is considered to be of value to trained musicians (Polk, 1980; P. Priest, 1989; Musco, 2010). Amongst respondents in the present survey there is a general sense that they consider playing-by-ear ability to be valuable, irrespective of whether they believe they are able to play by ear or not. One reason for this view is that respondents see playing by ear as something that benefits and enhances the development of other musical skills including aural ability, musical memory, sight-reading, improvisation, and general performance skills (cf. Luce, 1965; McPherson, 1995, 1996). As one respondent puts it:

> It provides a good understanding of discovering/learning the instrument. It helps tremendously in sight reading, listening tests and being able to analyse music by ear. It allows you to pick up the rhythm of music easier by hearing it rather than reading it. It can bring a connection and understanding to the music, which translates into the music's interpretation.
>
> (158BE)

Furthermore, there is the suggestion that ability to play by ear removes a musician's dependence on musical notation, meaning that music can be created 'on demand' if required and, finally, some respondents believe that playing by ear is simply enjoyable and fun. Table 2.3 presents a selection of responses that represents their views.

Table 2.3 Examples of respondents' views on the value of playing-by-ear ability

Category	Examples of responses
Enables playing on demand	Don't need sheet music to play piece; it helps the ear develop; helping the musicians to distinguish intervals, chord structure etc. (39BE) You don't need to rely on just the sheet music. (100NBE)
Fun or enjoyment	I find it more enjoyable than having to read from music. (77BE) It is enjoyable and rewarding to know you're right. (129BE)
Develops aural ability	You could develop your understanding of harmony more and improve aural skills. (66NBE) Develop inner ear; stop relying on sheet music; improve expression/creativity. (143NBE)
Develops musical memory	When performing from memory – if you can remember how it sounds you can play it; when improvising. (92NBE) You develop the skill of playing from memory. (65NBE)
Develops composition and improvisation ability	Playing by ear assists with developing improvisation skills and vice versa. (200BE) I can hear melodies, chord progressions in my head, sit down at a piano and play them. Makes composition quicker and easier. (77BE)
Develops sight - reading and performance skills	It would assist my skills in organ performance. (193NBE) Helps with chord voicings, continuo playing; enables smoothing over difficult patches when sight reading and transposition. (197BE)

Conversely, although few in number, it is evident that some respondents do not consider playing-by-ear ability to be of any musical value. The perception is that these participants believe playing by ear is unnecessary on the basis that it is "simply imitating [and] cannot reach a high standard of musicianship" (27BE). However, the majority of respondents have a positive attitude towards playing by ear, with 84% suggesting that it should be encouraged. There is also a sense that some feel it should form part of their musical training alongside learning to read and play from notation:

> It would encourage those who find reading music hard, to play an instrument. Also … it would improve the popularity of playing instruments, as music could be learnt a lot more naturally and not rely on the purchasing of music books or sheets etc. Also teaches the musician to use listening skills better.
>
> (186NBE)

This echoes Mainwaring's (1941) view that musicians should be taught to think in sound and play by ear before being taught to read notation, which would provide them with the skill of forming an aural image of a novel piece of music in the mind's ear before playing it (Mainwaring, 1941). It also reflects the teaching methods that form part of what has become known as the Suzuki method, where children are taught to play from memory using by-ear and rote techniques before they are taught to read notation (Schwarthoff, 2000). (A more detailed account of the Suzuki method is presented in Chapter 8 of this thesis.) Furthermore, other literature presents strong evidence to demonstrate that the development of playing-by-ear ability, alongside formal instrumental tuition, has a positive and beneficial effect on the development of other musical skills, in particular sight-reading, memorisation and improvisation (Luce, 1965; McPherson, 1995, 1996).

The attitudes of teachers towards playing by ear have, in the past, been perceived to be somewhat unenthusiastic, and it is noted that piano teachers in particular are thought to have reservations about the value of playing by ear ability when compared with the development of more formal musical skills (How teachers view playing by ear, 1996). There is a suggestion that playing by ear is often a covert activity that takes place unobserved by teachers (Toplis, 1990), or happens away from the formal musical setting altogether (P. Priest, 1989). Crucially, the literature infers that playing by ear is rarely encouraged by teachers , with many actually discouraging it and sometimes actively expressing disapproval (P. Priest, 1989; Toplis, 1990; Musco, 2010). Although 72% of respondents have received neither encouragement nor discouragement from teachers to play by ear, 22% indicate that they have been encouraged by teachers, and only 7% specify that they have been discouraged or experienced disapproval. Furthermore, 42% of those who have been encouraged report that they are able to play by ear, whilst amongst those who have been neither encouraged nor discouraged the proportion is 34%. This is illustrated in Figure 2.1.

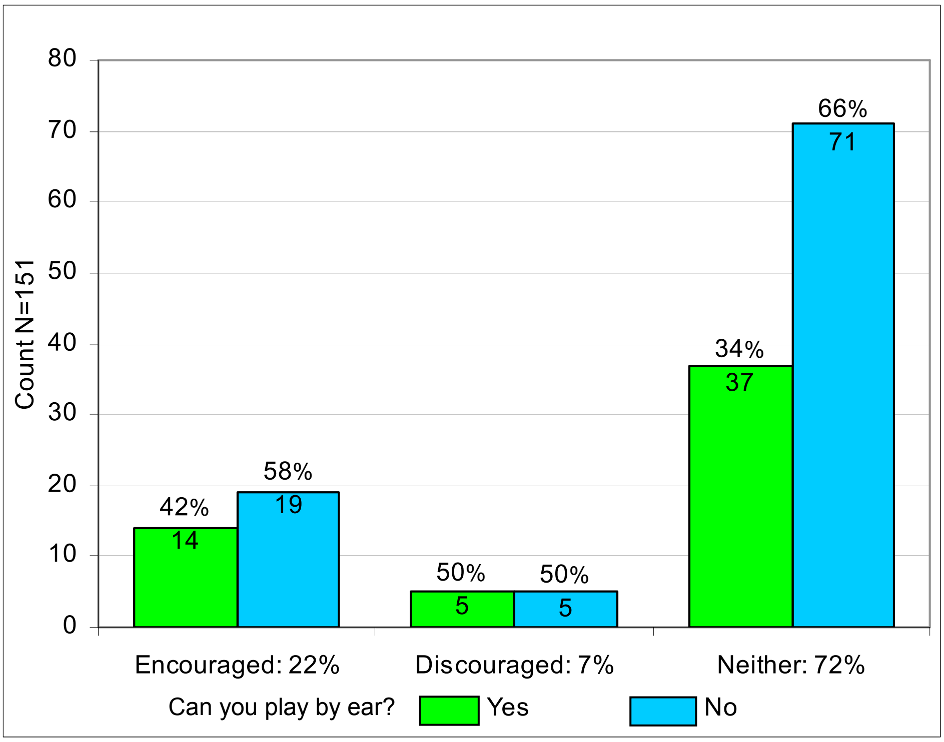

Figure 2.1 Numbers and percentages of respondents who have been encouraged, discouraged, or neither by teachers

However, Pearson's chi-square tests, comparing the reported playing-by-ear ability of respondents who have received encouragement or discouragement with those who have received neither, indicate no statistically significant relationships. This suggests that encouragement or discouragement by teachers makes little difference to whether respondents think they can play by ear or not.

To try to gain a broader picture, the present survey goes beyond the scope of the literature and examines the relationship between playing-by-ear ability and encouragement received from parents, friends and musical colleagues. Some respondents report receiving encouragement from one or more of these sources as well as, and sometimes instead of, their teachers. There are, however, no reports of discouragement from these other sources. Table 2.4 indicates the numbers of respondents receiving encouragement from other sources, and Table 2.5 summarises the overall distribution of encouragement.

Table 2.4 Numbers of respondents receiving encouragement from other sources

	Can you play by ear?	
Encouraged by	Yes (*n*=56)	No (*n*=95)
Parent	14	7
Friend	15	8
Musical colleague	7	5

Table 2.5 Numbers of respondents who have been encouraged only by teachers, by teachers and other sources, or only by other sources

	Can you play by ear?	
Encouraged by	Yes (*n*=56)	No (*n*=95)
Only teachers	1	11
Teachers and other sources	13	8
Only other sources	12	6
Total	26	25

The inclusion of these additional sources of encouragement in the analysis reveals a more complex picture. As Figure 2.2 below demonstrates, the proportion of those who have been encouraged to play by ear, and report ability to do so, has now increased to 51%. This implies that encouragement from other sources, or a combination of other sources and teachers, influences respondents' views on their own playing-by-ear ability, as opposed to that received from teachers alone, which does not. Furthermore, a Pearson's chi-square test, comparing the reported playing-by-ear ability of respondents who have received encouragement from all possible sources with those who have received none at all, demonstrates a significant relationship between encouragement by these sources and respondents' reported ability to play by ear, $X^2 = 6.372$, $df = 1$, $p = .012$, $N = 151$.

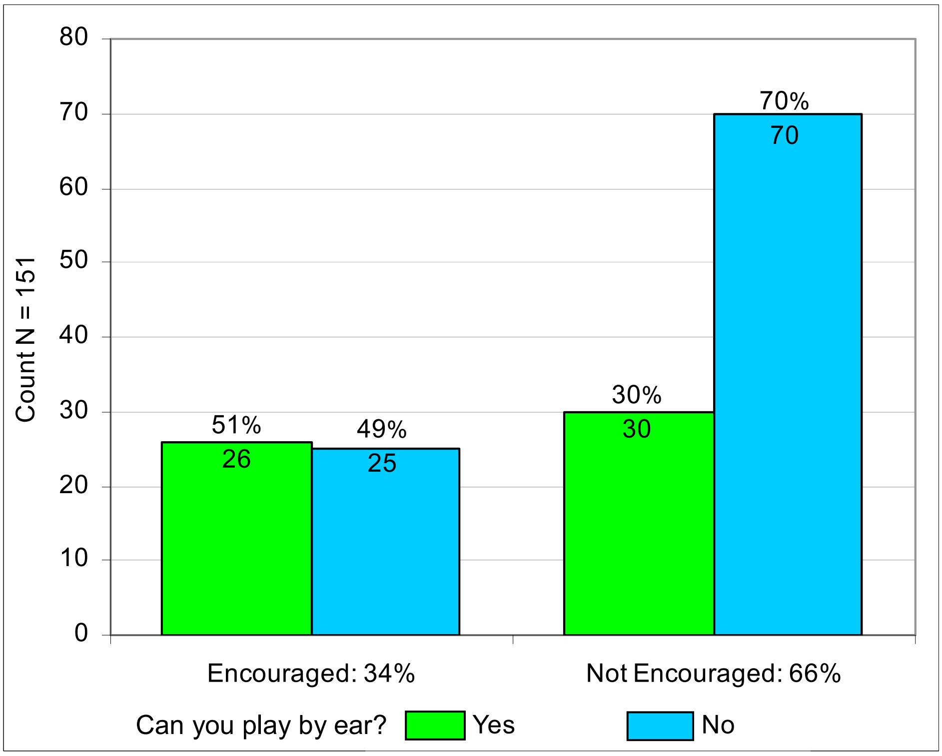

Figure 2.2 Numbers and percentages of respondents who have been encouraged, or not by teachers, parents, friends and musical colleagues overall

The literature on playing by ear suggests that some teachers decline to encourage playing by ear because they believe it is detrimental to the development of notation-reading skills (P. Priest, 1989; Musco, 2010). However, insofar as all respondents in the present survey are trained pianists, 100% of those who report being encouraged to play by ear (irrespective of whether they are able to or not) also report a level of Associated Board of the Royal Schools of Music (hereafter referred to as ABRSM) grade 6 (or equivalent) or higher on their main instruments. Additionally, 35% of these respondents are first-study pianists and, amongst those who are not, an additional 27% also report piano ability at a level of grade 6 or higher. Given the standard of notation reading skill that this level of performance on any instrument demands, receiving encouragement to play by ear does not appear to have had a major impact on the ability of these respondents to learn to read and play from notation. Furthermore, McPherson (1996) presents evidence that significant relationships exist between playing-by-ear ability and sight-reading skill, and between playing-by-ear ability and performing rehearsed music. This suggests that ability to play by ear may have a more positive effect on the development of notation-reading skills than some teachers believe.

Finally, the majority of respondents in the present survey are aged between 18 and 30 years. Given the introduction of popular and world musics into the school music curriculum over the last twenty years or so (Green, 2002), it is possible that many of them may have benefited from this learning experience. It would be reasonable to speculate that for these respondents, the more creative classroom music-making experience facilitated by this curriculum change may have provided opportunities to engage with playing by ear, and thus lead them to believe they were able to play by ear. However, a Pearson's chi-square test comparing these respondents with those in the 31-60+ age band indicates no significant relationship between age band and reported playing-by-ear ability.

To summarise, most respondents view playing by ear as an ability that has musical value; that should be encouraged; and should form part of their training. Some have received encouragement to play by ear by teachers and a small number have been discouraged, although the majority of respondents have received neither. However, whilst this does not seem to influence reported playing-by-ear ability, encouragement from other sources of musical influence does. Furthermore, being encouraged to play by ear does not appear to have a major impact on respondents' abilities in terms of reading and playing from notation. Finally, respondents aged between 18 and 30 are no more or less likely to report playing-by-ear ability than those who are older.

2.7 Origins and awareness of playing-by-ear ability

Respondents who believe they are able to play by ear are almost equally divided in their opinion as to whether it is a natural/inherited ability, or one that is nurtured through musical training over time, and this is illustrated in Figure 2.3.

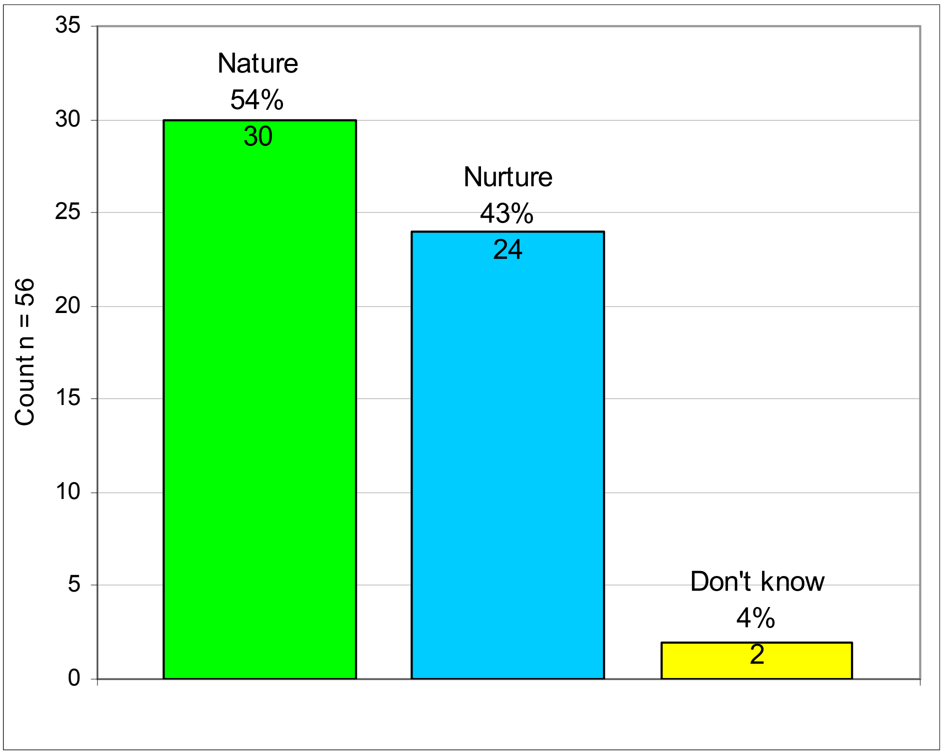

Figure 2.3 Respondents' belief in the origins of their playing-by-ear ability

Amongst those respondents who believe that their playing-by-ear ability is natural or inherited, there are reports that it runs in their family, where they have a parent, grandparent or sibling who also plays the piano by ear. The remaining few suggest that playing-by-ear ability is rooted in their innate ability to discriminate absolute pitch, with one commenting that "perfect pitch helps me to know what to play" (104BE). Conversely, the view is expressed that ability to play by ear is fostered through opportunity and exposure to formal musical training. For these respondents, acquiring aural and theoretical skills, along with the ability to conceptualise scales, intervals and chord progressions, facilitates the development of playing by ear over time. A selection of comments that exemplify respondents' views is presented in Table 2.6.

Table 2.6 Examples of respondents' views on the origins of their by-ear ability

Category	Examples of responses
Nature	Everyone in my family is musical. (192BE)
	Music runs in my family. Mum and dad can play by ear. (14BE)
	Having perfect pitch. (50BE)
Nurture	My musical training in recognising intervals. (17BE)
	Listening well and recognising the characteristics of chords and melodies. (108BE)
	From being able to play the piano, and practice, as well as an understanding of chords. (76BE)

Alongside this, the majority of respondents who are able to play by ear report becoming aware of their ability by experimentation. Some of them describe their deliberate attempts to work music out, whilst others indicate that they simply tried to play music that they had previously heard and remembered. There were also some who reported trying to play along to recorded or broadcast music, while others describe an experience where they discovered their ability by simply "doodling" (89BE) or "by just messing around on the piano" (148BE). Table 2.7 presents a selection of their responses.

Table 2.7 Examples of respondents' methods of becoming aware of playing-by-ear ability

Category	Examples of responses
Working out	Having often just sat at the piano and tried to play things. (2BE)
	Sitting at the piano and figuring out the melody to songs. (39BE)
	Trying and finding that it was possible. (108BE)
Listening and remembering	I heard something on the radio then played it. I listened out for the chords in songs and played them. (25BE)
	By listening to basic pieces and then trying to play them. (76BE)
	Coming back from church and trying to play the hymns using just one hand and thirds. (152BE)
Playing along	Playing along with CDs when I was very small – not necessarily playing what the CD was playing but playing something that fitted well with the music (192BE)
	By playing along to tunes I'd hear. (163BE)
	By playing along to the radio. (81BE)

Other respondents report no real sense of how or when they became aware that they could play by ear, or how the ability developed. They describe "just doing it" (35BE) and having "always been able to do it" (50BE), with some indicating that they only realised that they were playing by ear when it was pointed out to them by others, as one comments:

> My mum played a tune to me on the piano and I played it back to her. She said I could play by ear.
>
> (29BE)

Another respondent comments that "for years I thought everybody could. Other people told me that that was what I was doing" (198BE). Furthermore, he suggests that "most people have this ability [but] it is bred out of us by education". Toplis (1990) makes a similar point when she observes that low levels of practical music making in junior schools can result in playing-by-ear not being given an opportunity to develop.

In summary, opinion amongst respondents is divided as to whether playing by ear is a natural ability or one that is nurtured through musical training. However, the majority of those who report playing-by-ear ability have become aware of their ability by experimenting with playing by ear.

2.8 Engagement with playing by ear

It is unsurprising to find that the majority of respondents who play by ear engage with the process on a regular or occasional basis. Figure 2.4 demonstrates respondents' overall levels of engagement.

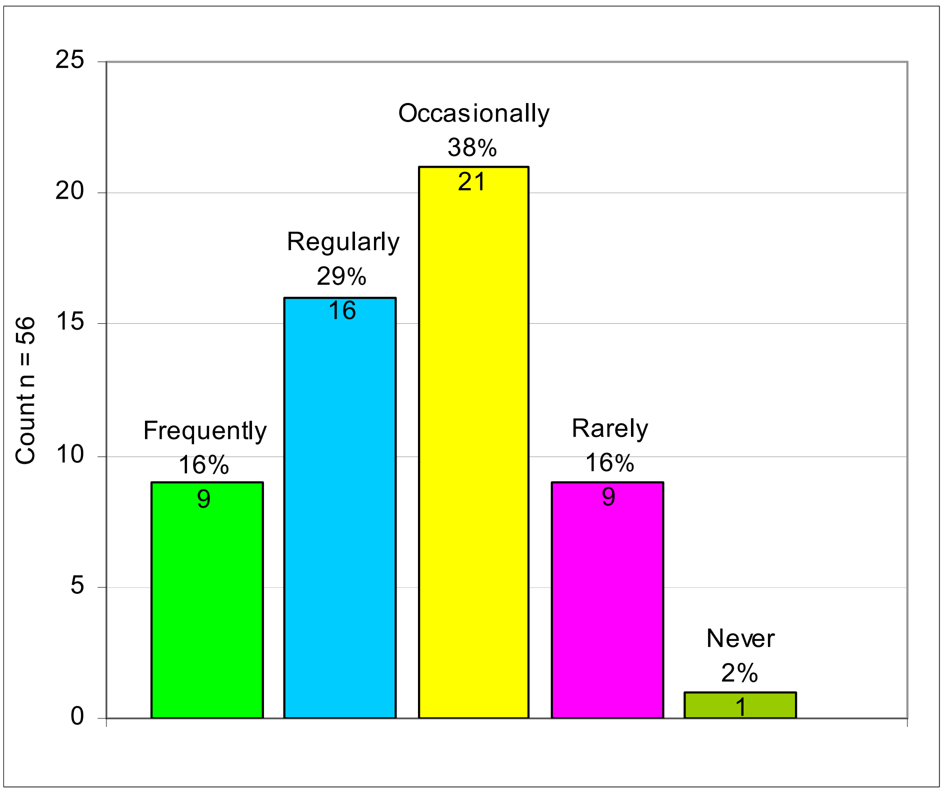

Figure 2.4 Frequency with which by-ear respondents engage with playing by ear

There is an indication that respondents, particularly amongst those who play by ear frequently, see playing by ear as part of their musical identity. They are motivated by the fun and enjoyment they gain from it, coupled with the individuality and musical independence it allows them, and freedom that it gives them to express themselves musically in a way that playing from notation does not. There is also a sense that playing by ear presents a challenge and a feeling of self-satisfaction for some respondents, whilst others suggest that less effort is required to play by ear than to play from notation. Many of the views expressed are consistent with those quoted by Lilliestam (1996) and, to a slightly lesser extent, those presented by Priest (1989). From a more technical perspective, some respondents are motivated by the additional musical benefits that playing-by-ear ability brings them, such as using it as a tool to support composition, transcription and improvisation. Note that the perceived relationship between playing by ear and improvisation is discussed in detail in Chapter 8 of this thesis. Finally there are those for whom playing by ear is driven by necessity, on the basis that they find themselves required to play in situations where no music is available. Table 2.8 presents a representative selection of their responses in this regard.

Table 2.8 Examples of respondents' motivations to play by ear

Category	Examples of responses
Freedom, challenge and self-satisfaction	Freedom to improvise/embellish; a challenge to perform a piece of music. (182BE) It's nice not to be restricted by written music – visual music is very prescriptive. (38BE) It's satisfying and lets you be free to express in your own style. (31BE) That special feeling of knowing I can do something that other pianists can't. (62BE)
Fun and enjoyment	I enjoy it, and find it a good challenge. More exciting than reading sheet music. (50BE) I find it more enjoyable than having to read from music. (77BE) It's fun, no pressure. (64BE)
Easier or necessity	Can sometimes be easier than finding a score. More fulfilling. (89BE) It's just an easier solution than digging out the printed score. (197BE) Necessity – playing with others, or wanting to play something I have no music for. (118BE)
Additional musical benefits	For transcription, simply for learning a song, for composition. (39BE) It's easier, good for ensemble playing and composition. (25BE) When I am composing or arranging music, or improvising. (76BE)

Respondents who report that they rarely or never play by ear imply that they have no interest in it as a mode of performance, commenting that it "never seems relevant" (12BE) in their musical lives, and indicating that it does not form part of their musical identity. As one respondent comments:

> I never have occasion to play by ear because I'm more interested in notated repertoire. The closest I come to playing by ear is accompanying warm-up exercises for choir rehearsals.
>
> (200BE)

They further suggest that it is "easier to play from music" (17BE), or that they "prefer to play accurately and for this [they] need a score" (27BE).   Conversely, the majority of respondents who report that they are unable to play the piano by ear indicate that they would like to be able to although, as Figure 2.5 demonstrates, many of them have never actually tried.

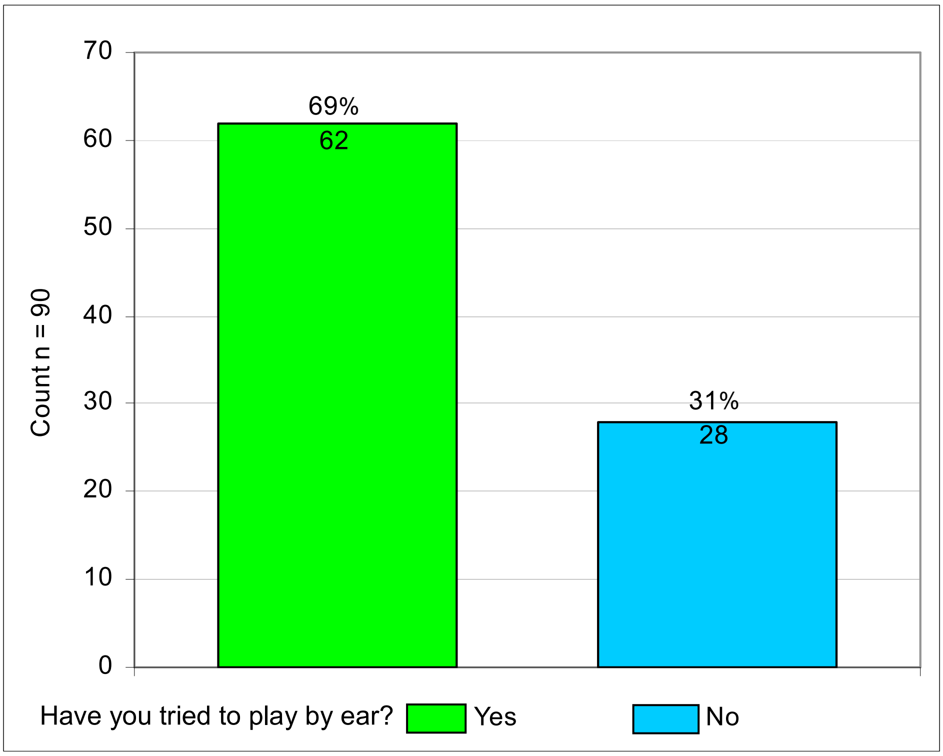

Figure 2.5 Numbers and percentages of non-by-ear respondents who desire by-ear ability, according to whether they have tried to play by ear

Many non-by-ear respondents who have tried to play by ear feel that they fail for a variety of reasons. Some believe they do not possess playing-by-ear ability:

> I tend to think it is a natural facility … I am sure that everyone can improve their ability to work out tunes through trial and error but it will never amount to playing by ear in a truly fluent, spontaneous sense.
>
> (196NBE)
>
> I have always felt that people who play by ear have a talent that I don't possess.
>
> (156NBE)

Others suggest that their efforts are unproductive on the basis that working out the music takes them a long time, and it is quicker to play from notation. Furthermore, alongside the perception that some simply lack confidence, there are respondents who believe they do not have sufficient sense of harmony to play two-handed, or that their technical ability on the piano is insufficient to play without notation. Examples of their responses are presented in Table 2.9.

Table 2.9 Examples of reasons why respondents believe they are unable to play by ear, even though they have tried

Category	Examples of responses
Efforts unproductive	I take a long time to work out the melody line so get flustered and give up. (51NBE)
	Because it takes me so long to figure out that I may as well have written it down. (136NBE)
	My trying was not productive. (47NBE)
	I find it difficult to find the notes. (94NBE)
Insufficient technical or harmonic ability	I find it hard to distinguish middle notes of the chords. (100NBE)
	I couldn't work out all the chords. (4NBE)
	I don't have sufficient technical ability to do so. (37NBE)
Lack of confidence	It doesn't come naturally to me, would have to spend ages finding the correct notes. (186NBE)

Amongst respondents who indicate that they would like to play by ear but have not engaged with it, there is a sense that some have "never really thought of doing it" (15NBE), or simply "never got round to it" (75NBE). Others indicate that they "haven't had the time to dedicate to it" (119NBE) or have "never [been] in a situation that called for it" (157NBE). It is also evident that, for some, teacher attitudes have played a significant part in their lack of engagement, one respondent commenting:

> I was never encouraged to even memorise a piece, let alone try and find it out by myself by ear. … it was not valued by my teacher, the musical world – it was considered messing about.
>
> (194NBE)

In general, respondents who play by ear mainly do so on a regular or occasional basis. Most enjoy playing by ear and present a variety of motivational reasons for this, although there are a small number who choose not to play by ear. Amongst respondents who believe they are unable to play by ear, most would like to be able to, but not all of them have tried.

2.9 Advantages of having playing-by-ear ability

Regardless of whether or not they can play the piano by ear, many respondents observe that there are advantages in having playing-by-ear ability. Some of these are analogous to the values that they place on playing by ear discussed earlier in this chapter including the ability to play music on demand, the freedom from notation, and the support that playing-by-ear ability lends to the development of other musical skills. In addition, the ability to play by ear is seen as an asset in the context of band or ensemble work, particularly where jamming plays a part. Some respondents also highlight the obvious advantage of being able to reproduce music when the printed score is unavailable, such as when being called on to accompany at short notice, or whilst teaching. A flavour of their responses is provided in Table 2.10 below.

Table 2.10 Examples of respondents' comments on the advantages of playing-by-ear ability

Category	Examples of responses
Band work and jamming	When jamming with other musicians in a band, being able to do any tune I know, or picking up an unknown tune very quickly. (31BE)
	If I am playing with people who do not read music. (118BE)
	When you want to play along with other instruments in an ensemble. (9NBE)
	When playing with friends; in a band and making new music. (63NBE)
Accompanying and teaching	When accompanying choirs at short notice, if I know the piece it's easier to make something up by ear. (30BE)
	As an accompanist I am able to bash out a basic accompaniment for a song that the music is not available for. (162BE)
	When I teach my pupils to play pop songs, which I can show them. (201BE)
	It would be good for accompanying people, or just for fun when learning songs. (136NBE)

In the wider context some respondents, who are able to play by ear, mention the additional social advantage in being able to use their ability "to show off to girls" (46BE) or for "impressing friends" (146BE). Similarly, those who are unable to play by ear recognise the social advantages that this ability can provide, and also imply that their lack of ability to play by ear brings about a sense of musical inadequacy in social or other situations:

> In informal situations like parties - spontaneous music-making, when the ability to play music without notation would make me seem more like a pianist and less like a musicologist.
>
> (181NBE)

> You can play anything anytime and [that] to me is much more musical than being able to replicate something from a score, great as that is. I feel inadequate when I can't just sit down and play something in the way someone who can play by ear can.
>
> (194NBE)

Amongst respondents who are able to play by ear, there are those who suggest that there are occasions when this ability can be also be a disadvantage. A very small number of them indicate that playing-by-ear ability makes it "harder to read music" (149BE), or that being able to play by ear can sometimes "deter from actually reading music well [and] sight-reading therefore suffers" (152BE). It is also suggested that there can be difficulties when "trying to play sheet music printed in a different key after [being] learnt and memorised by ear" (114BE). Furthermore, there is perception that playing by ear may encourage musical indifference:

> It can make you lazy. You may play an approximation of what is written in the printed score [rather] than an accurate realisation.
>
> (197BE)

> Because I can get away with it, I've sometimes ended up playing less than interesting accompaniments because I'm too lazy to hunt out the music.
>
> (162BE)

To summarise, whether they are able to play by ear or not, respondents mainly see playing-by-ear ability as an advantage in a musical, and also a social, context. However, some by-ear pianists suggest musical situations when it may be disadvantageous.

2.10 Discussion

The purpose of this survey was to contextualise the wider research project by acquiring an insight into playing by ear through the opinions, perceptions and beliefs of trained pianists, who may or may not be able to play this way. This has been achieved by identifying how these pianists define playing by ear, and determining the value that they, as trained musicians, place on it as a musical ability. The survey has also discovered what motivates these musicians to play by ear and ascertained their levels of engagement with it. Additionally, it has examined the advantages and disadvantages that respondents see in having playing-by-ear ability. Finally, an understanding has been gained of the extent to which their individual views on the nature of playing by ear, and the attitudes of their teachers and other musical influences in their lives towards it, have influenced their belief in their own playing-by-ear ability, or lack of it.

From their descriptions of playing by ear it is clear that the majority of respondents, irrespective of their playing-by-ear ability, broadly agree with the definitions proposed by the literature. However, on a more detailed level very few respondents suggest that playing by ear at the piano includes the need to harmonise the music and play in a two-handed manner, although it is reasonable to expect any piano performance to contain elements of harmony alongside the melody. Given that all respondents are trained pianists, who might be expected to consider the role of two-handedness in the context of playing by ear, this finding is somewhat surprising. Of course it could be argued that, for trained pianists, the concept of two-handed playing and the need for harmonisation are taken as read, and therefore respondents would not necessarily consider the need to mention them specifically in a description of playing the piano by ear.

The comments of some respondents concerning awareness of ability to play by ear reflect opinion to be found within the wider developmental psychology literature as well as within that of music psychology. The suggestion that playing-by-ear ability may be discovered through non-conscious experimentation, as opposed to overt, conscious experimentation, is supported by Toplis's (1990) opinion, discussed earlier in this chapter, that playing by ear forms a natural part of a child's musical development. Additionally, respondents' comments on the origins of their playing-by-ear ability strongly reflect the 'nature/nurture' argument (see Pinker, 2004 for a detailed discussion). The perception that playing-by-ear ability is inherited from parents or grandparents is an expression of the 'nature' theory, where the inference is that musical excellence can only be achieved where there is existing innate/natural musical aptitude (Gagné, 1999). Conversely, the concept of developing playing-by-ear ability through exposure to other musical skills is analogous to the ‘nurture’ theory, which implies that innate musical talent does not exist, but that musical excellence is nurtured through training and practice (Howe, Davidson, & Sloboda, 1998). However, regardless of whether they believe their playing-by-ear ability is natural or nurtured, the majority of respondents who report that they can play by ear also report becoming aware of that ability through experimental methods.

One factor that appears to influence respondents’ reports of ability to play the piano by ear is the attitude of piano teachers and other sources towards it. The perception presented by the literature, that instrumental teachers do not encourage playing by ear (see P. Priest, 1989; Toplis, 1990), is not supported by the present survey, where it is evident that a number of respondents have received teacher encouragement. This implies that attitudes towards playing by ear may be beginning to change, and adds weight to the suggestions in a survey of piano teachers in the United States that this is the case (see How teachers view playing by ear, 1996). Moreover, given the very small number of respondents who report that they have been discouraged from playing by ear by their teachers, the present survey provides little evidence to support the notion, inferred by the literature, that playing by ear is largely discouraged or disapproved of by teachers (see P. Priest, 1989; Toplis, 1990; Musco, 2010). However, it is also evident from the present survey that receiving encouragement from teachers does not result in respondents thinking they can play by ear, and this finding casts some doubt on McPherson’s (1995) speculation that receiving encouragement from teachers may enable playing-by-ear ability to develop.

In fact, the present survey suggests that respondents are more likely to report the ability to play by ear if they have received encouragement from parents, friends and musical colleagues, and this is consistent with evidence demonstrating that the influence of parents and peers on the educational aspirations of students, and their musical ability in particular, is more significant than that of their teachers (Picou & Carter, 1976; Davidson, Howe, Moore, & Sloboda, 1996). This, of course, is not to imply that receiving encouragement from these sources necessarily enables the development of playing-by-ear ability. Rather, it simply infers that those who have been encouraged by parents, friends and musical colleagues in addition to, or instead of, their teachers, are more likely to report that they have playing-by-ear ability than those who have received encouragement only from teachers, or received none at all.

One purely speculative reason for this finding is that, even where they do encourage it, piano teachers nevertheless may not facilitate opportunities for playing by ear as part of the training that they provide, whilst conversely, encouragement received from other sources could lead to informal opportunities to experiment with playing the piano by ear. Moreover, it is thought that parental expectations may play a large part in developing children's musical ability, and also their musical identity, where these attributes are shaped by the interaction between parent and child (Borthwick & Davidson, 2002). It is, therefore, possible that amongst respondents who have received encouragement to play by ear from parents, there may also have been an expectation that this ability would develop, with the result that those respondents may have experimented with playing by ear to try to develop the ability.

There is no doubt that, irrespective of whether they report having playing-by-ear ability or not, most respondents believe it has value as a musical skill, and they largely agree that its practice should be encouraged. Indeed, engagement with playing by ear is mainly enthusiastic amongst respondents who report this ability, and they mainly see it as advantageous within their musical lives. Conversely, a small group of by-ear respondents deliberately choose not to play by ear or do so rarely, regardless of the fact that some of them see advantages in having this ability. These findings appear to reflect the way respondents see playing by ear as part of their musical identity.

Social identity theory suggests that all individuals are members of peer groups, where membership of an "in-group" (Tarrant, North, & Hargreaves, 2002, p. 138) defines them in the terms of the characteristics and behaviours demonstrated by that group. Individuals whose characteristics and behaviours do not conform are excluded from the group, and may be considered to be part of an "out-group" (ibid.). Musicians are generally defined by their ability to play musical instruments (Glover, 1993; cited in Lamont, 2002), and it is evident that music education in Britain has, until recently, been highly dependent on methods that involve the teaching and learning of instrumental and other musical skills via notation (P. Priest, 1989; Green, 2002). However, instrumentalists who have acquired their skills via the informal cultures of rock, pop, jazz, folk and other ethnic and world musics, and therefore play and perform their music by ear, are mainly regarded as being part of a group of vernacular musicians who are distinctly different from those who have been trained to play and perform from notation (P. Priest, 1989; Lilliestam, 1996; Green, 2002;

McLucas, 2010; Woody & Lehmann, 2010). As such, these musicians are regarded as an out-group by the in-group that represents the culture of Western art music. According to social identity theory, members of an in-group are likely to undervalue the activities of an out-group (Tarrant, et al., 2002), and this trait is observed by Lilliestam (1996), who points out that those who take part in Western art music do not always appreciate the contribution that informal musicians make to music in the wider world (see also McLucas, 2010).

It is important to consider that all respondents in the present survey have been trained to play the piano, and 98% of them are either engaged in higher education music studies, or they are/have been employed as professional or academic musicians. Most, if not all of them are, therefore, likely to primarily identify themselves as pianists in the classical rather than the vernacular sense (Green, 2002; Woody & Lehmann, 2010). Furthermore, their training means they are likely to be viewed as such by other classical and also vernacular musicians (Tarrant, et al., 2002). For the small number of by-ear pianists who choose not to play by ear, it is evident that most them received no encouragement from their teachers, or other sources, to play by ear, and thus it is possible that this perceived indifference may have led them to devalue their playing-by-ear ability. But furthermore, their comments indicate that they see playing by ear as characteristic of a vernacular, socio-musical group that they have no desire to associate with. As such, they do not consider playing by ear to be part of their musical identity, and are not motivated to practise it. However, for the majority of respondents who report playing-by-ear ability, their comments demonstrate that they believe having this ability distinguishes them from other ‘classical’ pianists, and allows them to identify with, and participate in, alternative modes of musical performance on an equal footing with those who have developed their skills informally. In a sense, having playing-by-ear ability allows these respondents to be part of two, apparently opposing, socio-musical in-groups. Moreover, it provides them with a sense of musical individuality and distinctiveness within both groups which, in turn, motivates them to play the piano by ear (O'Neill, 2002) as well as from notation.

The majority of respondents in the present survey report that they are unable to play by ear and it is unsurprising that many of these respondents express the desire to be able to do so. Amongst them, many who have tried to play by ear comment that they felt they were unsuccessful in their attempts, and thus they no longer try. This is symptomatic of maladaptive motivational behaviour (Diener & Dweck, 1980; Dweck, 1986), where failure in performance leads to a deterioration and subsequent failure in the next performance and so on, leading to an overall perception of inability in the performer (O'Neill & Sloboda, 1997). As a result, this behaviour reinforces the already self-perceived lack of playing-by-ear ability in this group of respondents, and they do not, therefore, identify themselves as by-ear players. This is consistent with the theory that once a musician adopts a negative discourse towards a particular musical skill, they will not consider it to be part of their musical identity, even if there is evidence to suggest that they have that skill (O'Neill, 2002). It is also apparent that nearly a third of those respondents who desire playing-by-ear ability have not actually tried and, surprisingly, many of them indicate that they simply had not thought of doing it. Significantly, all respondents who have not tried, but would like to be able to play the piano by ear, fall within the 18-30 age band. This suggests that, in addition to not having taken the initiative themselves, these respondents may not have been stimulated to try out playing by ear in the classroom context, in spite of the introduction of popular and world music into the curriculum, discussed earlier. This adds weight to Green's (2006) observation that many classroom music teachers remain ambivalent towards informal learning practices, including the practice of playing by ear, and makes the pedagogical developments she proposes (see Green, 2008) all the more valid.

Finally, it is evident that whether they can play by ear or not, respondents disagree over whether it should be spontaneous or deductive. As discussed earlier, the published research into playing by ear mainly implies that this is a deductive process, where any playing of music that has been learned without the benefit of notation is considered to be playing by ear, regardless of how long it takes to work out. Anecdotally, however, there is a perception amongst trained pianists who do not play by ear, that a by-ear pianist's performance is spontaneous and effortless, where the music appears to flow from the hands in a subconscious manner (Sudnow, 2001). In the present survey, this issue seems to be particularly salient with regard to some respondents' belief in their ability to play the piano by ear. Amongst those reporting playing-by-ear ability it is evident that some explicitly state it should be spontaneous. This implies that these respondents believe in their ability specifically because they are able to spontaneously play music after hearing it. However, others who report ability to play by ear expressly indicate that it is deductive. For these respondents, the time spent working out the music by trial and error does not diminish the fact that the playing is by ear.

Some respondents who report that they are unable to play by ear also consider it to be deductive, and it is possible that these are respondents who deem their own efforts unproductive even after spending time working out the music. However, other respondents who report that they are unable to play by ear believe it should be spontaneous. This suggests that even though they may be able to play a piece after spending time working it out, they do not consider this to be playing by ear and therefore do not believe they have by-ear ability.

2.11 Summary and conclusions

This discussion has identified a number of features that characterise by-ear pianists who have also received formal piano training. In general, these musicians consider playing by ear to be the ability to play music that they have not seen written down but have only listened to, though some consider it to be a spontaneous process while others consider it to be deductive. They see playing-by-ear ability as part of their musical identity and believe that it has wide benefits in developing their other musical skills. They have mainly become aware of their playing-by-ear ability through experimental methods though, whilst some feel the ability has been nurtured through their general musical development, others believe that it is natural/innate or inherited. They have sometimes received encouragement to play by ear and, where this has occurred, it has sustained their belief in their ability. Finally, they engage with playing by ear on a fairly regular basis, and would encourage its practice amongst other musicians.

Similarly, there are a number of traits that symbolise trained pianists who are unable to play by ear. Generally speaking, these musicians also consider playing by ear to be the ability to play music that they have not seen written down, but have only listened to, and whilst some consider it to be a spontaneous process, others believe it is deductive. They acknowledge the musical value of playing-by-ear ability, and the advantages that it brings to musicianship, and would like to be able to play by ear. However, although they have sometimes received encouragement, they nevertheless feel that their efforts to play by ear are unproductive. Finally, the perceived unenthusiastic attitudes of their teachers have nurtured their belief in their lack of ability to play by ear and, for some, this belief is further enhanced by their perception that playing by ear should be spontaneous.

In spite of evidence in the present survey that some piano teachers have become more enthusiastic towards playing by ear (and are encouraging its practice), the finding that the majority of them neither encourage nor discourage it implies that they simply ignore it. One reason for this may be parental or other pressure to 'push' pupils through examinations, leaving little time in lessons for alternative approaches to playing the piano to be investigated. However, it is also possible that teachers simply believe themselves unable to play by ear (How teachers view playing by ear, 1996; P. Priest, 1989; Musco, 2010). Either way, it is feasible that many of their pupils remain unaware of any potential playing-by-ear ability that they may have, because the subject has not been discussed during lessons. This indicates that little has really changed over the last twenty years or so, despite the efforts of researchers to bring the merits of informal learning in general, and playing by ear in particular, to the fore (see P. Priest, 1989, 1993; Lilliestam, 1996; Green, 2002, 2006, 2008; Musco, 2010).

It is possible that many teachers believe themselves to be unable to play by ear specifically because they think it should be spontaneous. If this is the case, the lack of inclusion of playing by ear in their teaching (Musco, 2010) means that this belief is passed on to the next generation of musicians and teachers. Thus, the perception of lack of playing-by-ear ability is perpetual. If this cycle is to be brought to a halt, it is necessary to raise awareness of playing by ear amongst teachers, and encourage them to incorporate it into their teaching. Of course, this idea is far from new and this thesis is not the first to suggest it (see for example P. Priest, 1989; Green, 2002, 2008; Musco, 2010). However, the theoretical suggestions already proposed do not appear to have convinced teachers that they should embrace playing by ear, and attitudes towards it will only begin to change if teachers have a clearer understanding of it. But how can this be achieved, and how can the perceived barrier, between those who believe they are able to play by ear and those who believe they are not, be broken down?

2.12 Moving forward

It has been established that some musicians who responded to the survey consider playing by ear to be playing music spontaneously after hearing it, and it is possible that holding this view has led many of them to believe that they are unable to play the piano by ear. Conversely, it is apparent that other respondents are of the opinion that playing by ear is simply working out the music by listening to it, irrespective of how long it takes, and it is also possible that having this view has led some of these respondents to believe they have playing-by-ear ability.

But is this deductive method really playing by ear? It is likely that those who play by ear deductively would argue that the method of playing by ear is unimportant as long as the music reproduced is fluent, and rhythmically, melodically and harmonically accurate. However, it is probable that many of those who play by ear spontaneously would argue that deductive playing by ear is not really playing by ear at all. It is possible that the answer to this question lies in the circumstances in which the music is required, and in considering this, it is important to bear in mind that this discussion is about the playing by ear abilities of trained pianists. It is highly probable that deductive by-ear players would be able to present a fluent and accurate reproduction of a piece of music more quickly from notation than they could by ear. If the circumstances require music 'on demand', there is no point in trying to play music by ear if it is faster to present the music by playing from notation. On the other hand, if it is music for personal pleasure or performance at a later time, the length of time it takes to achieve is relatively unimportant as long as the product is fluent, accurate and musically satisfying.

More pertinent is the issue of whether spontaneous playing by ear is simply a more efficient execution of deductive playing by ear. If this is the case, it raises the possibility that identifying the cognitive-psychological factors that underlie playing by ear would enable those who play deductively to improve their skills and make their playing by ear more spontaneous. Furthermore, it is necessary to consider whether the products of spontaneous and deductive playing by ear differ substantially in fluency, accuracy and musical quality. The following chapter begins to address these issues.

3. Measuring Playing-by-Ear Ability – An Overview

3.1 Introduction and rationale

Chapter 2 demonstrates an overall consensus of opinion, across the published research literature and respondents in the present survey, that playing by ear is the reproduction of a piece of music that has been listened to but not seen in notated form. However, the discussion in that chapter also suggests that playing by ear is a more complex process than this description implies, particularly with regard to its spontaneous/deductive nature, where the opinions expressed by the literature are as diverse as those presented by respondents. That chapter, therefore, raises a number of questions that require investigation:

- Is spontaneous playing by ear a more efficient execution of deductive playing by ear?
- Does the product of deductive playing by ear differ in accuracy, fluency and musical quality from that produced spontaneously?
- Would identifying the cognitive-psychological factors underlying playing by ear enable deductive by-ear players to improve their skills and play more spontaneously?

If these questions are to be addressed, an attempt must be made to gain a clearer understanding of what playing by ear is, and how it works both in general and, more specifically, in the context of two-handed, harmonised playing by ear on the piano. In order to achieve this, the second phase in this research project examines playing-by-ear ability in a variety of trained pianists, including those who believe they can play the piano by ear and those who believe they cannot.

A small number of published studies have attempted to measure melodic playing-by-ear ability. This chapter continues with an overview of the different types of measures used to assess musical performance in general and an evaluation of the findings of the published studies in the light of their individual methodological approaches to the measurement of playing-by-ear. A discussion of these approaches, with a view to determining their appropriateness for use in the present study, follows.

3.2 Assessing musical performance

The evaluation of musical performance has many facets and takes place in many situations. These range from the informal opinion expressed by a listener or critic after a concert, to the formal and often detailed, critical assessment of an instrumental performance in the context of an examination, competition or audition (Thompson & Williamon, 2003). Two main methods of evaluating musical performance are identified: holistic assessment, where a single mark is awarded from a criterion-referenced scale; and segmented assessment, where marks are awarded for individual attributes of the performance (for example, rhythm, pitch, phrasing) according to a set of defined constructs, with a final mark being derived from a linear combination of these (Mills, 1991). Although there is evidence to suggest that these are both reliable means of measuring musical performance (Thompson & Williamon, 2003), holistic assessment is often seen as more appropriate as it examines the attributes of a performance collectively and in relationship to one another, rather than in isolation (Mills, 1991). Furthermore, this form of assessment has been shown to be no more subjective than segmented assessment (ibid.), and less variability between assessors is evident when holistic assessments take place (Fiske, 1977; Mills, 1991).

The context of an assessment may, however, influence the methodological approach. There is a difference between assessing the musical quality of an individual performance against other performances, such as in a competition, and using a performance to assess the performer's level of instrumental ability, such as in an examination (McPherson & Thompson, 1998). Holistic assessment may be more appropriate for the former, where qualitative judgements can be made. However, a segmented approach may be more appropriate for the latter, where quantitative judgements (often linked to numerical values) can be made of individual elements of the performance. However, regardless of the assessment context, the advantage of the segmented approach is the ability to provide feedback that is sufficiently detailed to identify areas requiring development or improvement.

Where assessment of performance is carried out within the framework of applied research, the resulting data are often required to provide a detailed picture of the differences between performers or performances. In this context, a segmented approach to assessment may be more appropriate on the basis that it can facilitate data that are suitable for statistical analysis, and therefore allow for subtle differences to be observed (Thompson & Williamon, 2003). If levels of playing-by-ear ability are to be measured in a research context, a methodology is required that provides a sufficiently detailed assessment of the individual aspects of playing by ear, as determined by the researcher. It must also be capable of providing appropriate feedback to participants in terms of the musical quality of the reproductions or realisations that form their playing by ear performances. Thus a methodology based on a segmented approach would be the most appropriate for the present research project.

3.3 Studies assessing melodic playing by ear

Existing research studies that have attempted to measure playing-by-ear ability have tended to favour a segmented approach, whereby particular elements of the music being performed are isolated and marked numerically for accuracy, with an overall mark then being calculated from these individual marks. However, not only are these studies few in number, but they are themselves limited in that they examine only melodic playing by ear. Furthermore, with one exception, all the studies examine melodic playing-by-ear ability in children who demonstrate varying levels of instrumental competence and musicianship. Moreover, these studies mainly examine playing by ear in the context of its relationship with other musical abilities, as opposed to investigating its own inherent characteristics. Nevertheless, the studies demonstrate a variety of methodological approaches to segmented assessment, and all produce a measure of playing-by-ear ability. Their various methods are, therefore, discussed here.

3.3.1 Luce (1965)

The earliest published study found by the current author, that attempts to measure playing-by-ear ability, was carried out by Luce (1965). As well as considering the relationship between playing by ear and sight-reading, this study also examined the influence of the amount and type of musical instruction participants had received; their mental ages and intelligence quotient levels; and their personal musical goals. Ninety-eight American high school students, who were aged between 14 and 17 years and were players of woodwind, brass and string instruments, participated in the study. Playing-by-ear ability was examined by presenting participants with six increasingly difficult two-bar melodic sequences to reproduce on their instruments. For each different instrument the whole test was composed in the key most often used for that instrument in an orchestral/band context. Students were shown a notated version of the first note of each new sequence, and instructed that they could hear each sequence a maximum of three times before attempting to reproduce it. Error free reproductions were noted as "success scores" (Luce, 1965, p. 104), and reproductions that contained pitch or rhythmic errors were recorded as "partial success scores" (ibid.). Luce reported 173 success scores and 48 partial success scores amongst the 98 participants, and observed a significant correlation between playing-by-ear and sight-reading ability. He also noted a significant correlation between participants' playing-by-ear scores and their self-reported total amount of training on all instruments they played. However, importantly, he found no correlation between playing by ear scores and the self-reported amounts of training participants had received on the specific instrument for which they were tested for playing-by-ear ability.

On the basis of the significant correlation between participants' total amount of training on all instruments and their playing-by-ear ability on a specific instrument, Luce concluded that playing-by-ear ability may be receptive to training. However, some doubt is cast on this conclusion for two reasons: the lack of correlation between playing by ear and training time on the instrument tested for playing by ear; and the fact that playing by ear was not measured on other instruments that participants played. Furthermore, since Luce presented no detail of how test scores were coded for analysis, it is unclear how these were correlated with participants' amounts of instrumental training time in order to reach this conclusion.

3.3.2 McPherson (1995,1996)

In a later study, McPherson (1995, 1996) developed Luce's research by investigating the relationships between playing by ear, sight-reading, playing from memory, improvisation, and playing rehearsed music, where significant correlations were observed between all skills. In this context, McPherson designed a methodology for assessing playing-by-ear ability that was more sophisticated in its approach. The two-part "Test of Ability to Play by Ear (TAPE)" (McPherson, 1995, p. 147) was used to measure the playing-by-ear ability of 101 Australian high school clarinet and trumpet students, aged between 12 and 18 year, who were working towards grades 3 to 6 of the Australian Music Examinations Board examinations. Participants were split into two groups according to age and ability: 12 to 15 years old, grades 3 and 4; and 15 to 18 years old, grades 5 and 6. In part one, they were asked to give two by-ear reproductions, each in different key, of ‘Happy Birthday to You’ and ‘For He’s a Jolly Good Fellow’. Scoring was carried out on a bar-by-bar basis, where two marks were awarded for each bar that was accurate and fluent in pitch and rhythm, one mark for a bar that was partially accurate in pitch and rhythm, and zero for an incorrect bar. The second part of the test required participants to listen to a short, unknown melody (played in the timbre of their own instrument) four times, before reproducing it twice in the original key and twice transposed into a different key. This process was repeated for three further melodies. Each performance was marked on a scale of nought to five, where nought indicated no attempt, and five indicated an error free performance. Marks for each part of the test were combined to give participants an overall score for playing-by-ear ability. McPherson demonstrated that subjects in the upper age band exhibited higher levels of playing-by-ear ability than their counterparts in the lower age band, and inferred from this that playing-by-ear ability develops with musical training and experience. As mentioned in Chapter 2, in addition to the quantitative assessment of playing by ear, McPherson also presents an analysis of the statistical relationship between playing-by-ear ability and a number of musical background and experience variables. This analysis indicates specific significant correlations between playing by ear and: early exposure to music; starting method; learning other instruments; average amounts of daily practice; and self-reports of improvising, composing, singing and mental rehearsal. From this, McPherson suggests that these factors may assist in the development of the aural skills required to play by ear.

In this study McPherson makes a clear distinction between two approaches to playing by ear: the recall and reproduction of familiar melody; and the memorisation and reproduction of novel melody. In so-doing he has achieved a level of ecological validity that is missing from Luce’s (1965) study. Furthermore, the composite mark arrived at by combining the scores for both parts of the test produces a more informed measure of each individual’s playing-by-ear ability.

3.3.3 Delzell, Rohwer and Ballard (1999)

One aspect of playing by ear that was not considered by Luce or McPherson was the effect of melodic pattern difficulty on participants’ ability to play melody by ear. Delzell, Rohwer and Ballard (1999) set out to measure this effect on the playing-by-ear ability of American, seventh-grade (10/11 years old) and tenth-grade (15/16 years old), woodwind and brass pupils, and they designed the "Measurement of the Ability to Play by Ear (MAPE)" test (p. 56) to measure playing by ear in this context. This test constituted a set of 10 melodic sequences, each consisting of between five and 14 four-beat (one-bar) patterns, with an overall total of 84 patterns in a range of keys. A 'listen-then-play' paradigm was used where a one-bar pattern was heard once and then responded to before the next one-bar pattern was heard. Each sequence of patterns was prefaced with the key chord and starting pitch, which was the same for every pattern in the sequence. Participants were shown a notated version of the starting note and asked to play it on their instrument prior to the commencement of each sequence of patterns. One mark was awarded for each individual correct pattern making a total of 84 marks in all. From their analysis Delzell et al. demonstrated that descending melodic patterns are more difficult to play by ear than ascending melodic patterns, as are patterns in a minor key compared to those in a major key. However, although a wide range of playing-by-ear ability was observed, the authors indicated no statistical difference in levels of by-ear ability between the two age groups, and inferred from this that playing-by-ear ability does not develop with training and experience.

The MAPE methodology allowed participants to hear each sequence only once before they were required to play it by ear. However, in a real-world context, it is unlikely that a musician would be expected to play something by ear that they had only heard once. Thus, it is reasonable to consider whether the results of MAPE would have been different had participants been allowed to listen to the sequences more than once before being asked to respond.

3.3.4 Bernhard (2004)

The impact of training on the playing-by-ear abilities of beginner wind players was investigated by Bernhard (2004). He examined the possibility that their levels of playing-by-ear (and instrumental sight-reading skills) could be increased by developing their sight-singing abilities using fixed vocalisations or solfege. Forty-two American, sixth-grade (11 to 12 year old), wind pupils were randomly assigned to an experimental or a control group. Both groups were then assessed for tonal aptitude using the tonal imagery test from "Musical Aptitude Profile" (Gordon, 1995; cited in Bernhard, 2004, p. 94) and no statistical difference was observed between them. Over the following 10 weeks the experimental group received "tonal training" (Bernhard, 2004, p. 91) whilst the control group did not. At the end of the training period, both groups were tested for melodic playing-by-ear ability using an adaptation of Delzell, et al.'s (1999) MAPE test, that utilised 48 melodic patterns in the keys of B-flat and E-flat major. Bernhard observed that the experimental group achieved higher levels of playing-by-ear ability than the control group, and demonstrated a statistically significant relationship between tonal aptitude and playing-by-ear ability. Additionally, like Luce (1965) and McPherson (1995, 1996), Bernhard noted a significant relationship between playing-by-ear and sight-reading abilities. Overall, he concluded that tonal training may enable the development of melodic playing by ear.

The use of Delzell, et al.'s (1999) MAPE test to assess levels of playing by ear means that Bernhard's results are subject to the same comments as those of Delzell et al. discussed above. However, more importantly, Bernhard does not appear to have designed his intervention experiment in a manner that might have been expected, and this has implications for the results of the study. The lack of post-training measurement of tonal aptitude in both groups makes it impossible to determine whether these levels have improved in the experimental group as a result of the training. Furthermore, the lack of pre-test measurement of playing by ear in both groups makes it impossible to determine whether the level of ability in the experimental group was different to that of the control group prior to the training period. Moreover, and crucially, the lack of pre-test measurement of playing by ear in both groups also makes it impossible to determine whether there has been any improvement in the playing-by-ear ability in the experimental group as a result of the training. These anomalies in Bernhard's method, and their possible impact on the results of the study, demonstrate the importance of establishing baseline measurements if the effects of training are being considered.

3.3.5 Woody and Lehmann (2010)

In a more recent study, Woody and Lehmann (2010) investigated the extent to which the manner of musical training and experience influenced melodic playing-by-ear ability amongst college student musicians at an American university. Two groups of 12 students were recruited, each comprising 10 wind players and two keyboardists (one pianist and one mallet percussionist). The "formal" (Woody & Lehmann, 2010, p. 104) group had developed musical experience exclusively through one-to-one lessons and school ensembles. Conversely, the "vernacular" (ibid.) group had gained theirs more informally, through jazz, pop, folk and church music, although they had received some formal training as well. Participants were asked to reproduce two melodies by ear, one of which they were to sing and the other to play on their instrument. The pieces were characteristic of those found in beginning band method schemes and were, therefore, assumed to present no technical challenges to participants. The melodies, which were presented in the piano timbre, were played to participants twice before their first attempt, and once before each subsequent attempt. For the instrumental reproductions, participants were first informed of the starting pitch. The number of attempts required for an accurate reproduction, in terms of pitch and rhythm, was tracked for each participant, and they were informed by the researcher when an accurate reproduction had been achieved. Additionally, post-test interviews were conducted that determined participants' views on the melodic-memory and motor-memory strategies they used whilst learning to sing and play by ear during the test.

Woody and Lehmann observed that the majority of participants required fewer attempts to sing melody accurately by ear than to play melody accurately by ear. The exceptions to this were the four keyboardists, who required fewer trials to play by ear than to sing by ear. The authors also noted that vernacular musicians required fewer attempts to both sing and play melody accurately by ear than formal musicians. Overall, in light of both the test scores and participants' post-test interview comments regarding memory strategies, Woody and Lehmann concluded that formal musicians may be less skilled at instrumental melodic by-ear reproduction. However, this was not because these musicians lacked the ability to memorise melody, but rather because they lacked the ability to create, from that melody, a motor programme that enabled it to be reproduced on their instruments. Additionally, the authors speculated that keyboardists may be more capable of building a motor programme for playing by ear than other instrumentalists on the basis that they may be able to visualise the physical path of the melody on the keyboard.

Although Woody and Lehmann's results in this study demonstrate that vernacular-musicians achieve instrumental reproductions of melody by ear more quickly than formal-musicians, their overall conclusion is partly based on participants' self-reported memory strategies for playing by ear. This raises the issue of whether the same conclusion would be reached if participants' levels of ability to form a motor programme had been tested, particularly where keyboardists were concerned.

Alongside these studies, a small number of others exist that have observed the playing-by-ear ability of musical savant pianists (see Sloboda, et al., 1985; Young & Nettlebeck, 1995; Ockelford & Pring, 2005; Ockelford, 2007, 2011). However, these studies focus on the measurement of musical memory through playing by ear, rather than the measurement of playing by ear itself. On the basis that their methodological approaches were not judged to be appropriate for use in the present research project they are not considered here. However, their methodologies, findings and conclusions are discussed in Chapter 8.

3.4 The suitability of these methodologies for the present project

In considering the suitability of each of these methodologies for use in the present research project, a number of issues became evident:

- The effectiveness of the marking schemes in providing an accurate assessment of playing-by-ear ability;
- The capability for differentiating between the products of spontaneous and deductive playing by ear;
- The impact of melodic memorisation on the results of the playing by ear tests;
- The ecological validity of the test materials compared with those used in musical performance assessments in the real world.

These issues are addressed in the following discussion.

3.4.1 The effectiveness of marking schemes

When musical performance is assessed it is reasonable to expect that performance to be fluent and accurate, and performance by ear is no exception. McPherson's TAPE (1995, 1996) includes a marking scheme that considers the fluency of the music as well as the accuracy of both rhythmic and pitch elements, and is capable of providing substantial detail about the quality of the playing by ear examined. Conversely, the marking scheme included in Delzell et al.'s MAPE

(Delzell, et al., 1999) (also employed by Bernhard (2004)), is somewhat less effective insofar as it measures the correctness of what are described as “melodic patterns” (Delzell, et al., 1999, p. 55) but does not consider fluency or differentiate between rhythmic and pitch accuracy. Additionally, Luce (1965) presents a marking scheme that is rather vague and it is unclear precisely what is being measured. Furthermore, Woody and Lehmann (2010) measure playing by ear by counting the number of listen-then-play trials required for a perfect reproduction. Consequently their methodology does not include a marking scheme that measures the fluency and accuracy of playing by ear performances on the basis that participants were allowed as many listen-then-play trials as they needed in order for a perfect reproduction to be achieved.

3.4.2 Differentiating spontaneous and deductive playing by ear

By assessing playing by ear in the context of once-only, unrehearsed performances, Luce (1965), Delzell et al. (1999) and Bernhard (2004) have, in effect, measured spontaneous playing by ear. At the same time, McPherson (1995, 1996) and Woody and Lehmann (2010) have examined deductive playing by ear, either by assessing the product of rehearsal (Woody & Lehmann, 2010), or by assessing multiple reproductions of one piece (McPherson, 1995, 1996), which amounts to rehearsal. Because they are restricted to assessing only one or other type of playing by ear, none of these methodologies allows for a comparison to be made between the products of spontaneous and deductive playing by ear. However, as the terms spontaneous and deductive have been applied to playing by ear by the present thesis, the lack of provision for this measurement within these methodologies is neither unreasonable nor unsurprising.

3.4.3 The impact of melodic memorisation

When designing a methodology for assessing playing by ear ability it is important to consider the impact of melodic-memorisation on that ability. This is particularly important if the music used is unfamiliar to participants prior to the test, since this would require it to be committed to memory during the test. In presenting participants with eight-bar unfamiliar melodies, but allowing unlimited memorisation time by way of listen-then-sing or listen-then-play trials, Woody and Lehmann (2010) were able, to some extent, to counter the effect of melodic-memorisation on the playing-by-ear ability of their participants. However, amongst the remaining studies discussed, the second part of McPherson's TAPE (1995, 1996) limits memorisation time by allowing participants to listen to the presented short, unfamiliar melodies only four times before attempting to play them by ear. Similarly, Luce (1965), Delzell et al. (1999) and Bernhard (2004) present participants with unfamiliar one-bar or two-bar melodies, and although Luce allows a maximum of three hearings, Delzell et al. and Bernhard allow only one hearing before playing by ear is attempted. This limit on memorisation time introduces the possibility that the accuracy of the resulting playing by ear may be compromised by participants' levels of ability to accurately memorise or recall the melody, and none of these studies presents any evidence to suggest that this has been considered in the assessment of playing-by-ear ability. Conversely, the first part of McPherson's TAPE (1995, 1996) takes a different approach in that it requires participants to perform well known melodies, with which they are already familiar. These are melodies that have been memorised during the course of everyday life, rather than during the test itself. However, since it is unclear whether or not participants were allowed to refresh their memory for these melodies prior to playing them, the possibility remains that their ability to recall the melodies accurately may have impacted on the accuracy of the resulting playing by ear.

3.4.4 Ecological validity

It could, of course, be argued that presenting participants with melodies as short as one or two bars, as Luce (1965), Delzell et al. (1999) and Bernhard (2004) have done, reduces the impact of melodic memorisation ability, insofar as there are fewer events to memorise and recall before playing. However, on the basis that judgements of ability at the lowest level of music examination are made on performances of music consisting of at least 14 to 16 bars (ABRSM, 1998), the ecological validity of using such short musical sequences to assess playing by ear is open to question. In this respect, although the length of the melodies in McPherson's (1995, 1996) study was unspecified and therefore cannot be commented on, the eight-bar melodies presented by Woody and Lehmann (2010) seem more appropriate and ecologically valid.

3.4.5 Conclusions

Having considered the assessment methodologies of these studies, it was felt that none of them was appropriately designed to examine and assess playing-by-ear ability in the context of the present research project for a number of reasons. In the first place, this project seeks to examine two-handed, harmonised playing by ear as opposed to purely melodic playing by ear, and is concerned with playing by ear in its own right, rather than in the context of its impact on, or its relationship with, other musical skills. Therefore the methodology utilised must include a coding scheme that is sufficiently rigorous to provide a high level of detail in terms of the quality of each individual component of playing the piano by ear. These include not only fluency, and accuracy of rhythm and pitch, but also harmonic accuracy and, given that piano performance is being examined, the overall level of complexity and stylistic awareness of the two-handed realisation. Additionally, if a distinction is to be made between the quality of the products of spontaneous and deductive playing by ear, a method is required that will measure how spontaneous or deductive by-ear realisations are.

The second reason for rejecting the existing methodologies is concerned with the impact of musical memorisation on playing by ear. To measure playing-by-ear ability effectively it is necessary to ensure that the playing is not compromised by participants' ability to encode the music into memory or recall it. With the exception of Woody and Lehmann (2010), none of the methodologies discussed presented a strategy for overcoming this problem.

Finally, if playing by ear is to be regarded as a mode of musical performance alongside other, more conventional modes of performance, the manner in which it is tested must be comparable with those methods of testing applied to other areas of musical performance. Furthermore, if the skill of playing by ear is to be examined in a cognitive-psychological research framework, it is important to ensure that the methodological approach is ecologically valid (Sloboda, 1986). In both these circumstances, it would be more appropriate to use 'real' music in the context of a test of playing-by-ear ability, than it would be to use the types of 'contrived' music that are in evidence in some of the methodologies discussed in this chapter.

Having determined that none of the published research methodologies was appropriate for use in the present research project, it remained to examine Sapiro's (2007) 'By-Ear Assessment Tool' (BEAT). This methodology employed a segmented approach and was devised by Sapiro specifically for the measurement of two-handed, harmonised playing by ear at the piano. It was used in the context of Sapiro's (2007) study (see Chapter 1, page 19), which investigated the role of musical aural skill in the ability to play the piano by ear amongst trained pianists.

3.5 BEAT – the By-Ear Assessment Tool

In order to complete the BEAT assessment, Sapiro's participants were required to prepare the realisation of a piece of orchestral music for by-ear performance on the piano. They were already familiar with the music they were asked to play, but had not played it before either by ear or from notation. Furthermore, it was music that they already knew in their mind's ear, having previously memorised it from an aural source in the context of everyday life. From the performance of this by-ear realisation, an assessment was made of each individual participant's level of proficiency at playing the piano by ear in a two-handed, harmonised manner.

To facilitate this assessment, Sapiro compiled a list of established orchestral television and film themes to use as the playing-by-ear pieces, and ascertained that each participant was familiar with two or more of these themes prior to the assessment. There were three reasons for using established, familiar, orchestral music in this context. Firstly it provided BEAT with a level of ecological validity insofar as the music to be played was real, and that it had been memorised by participants in a real-world context. Secondly, because participants were already familiar with the music, it removed the necessity for them to memorise it during the assessment, thus minimising the effect of musical memorisation on playing by ear. Thirdly, orchestral music was used rather than piano music in order to ensure that participants could not merely try to reproduce exactly what they heard, but would instead attempt to put their own 'stamp' on the music through a piano realisation.

Participants were informed which theme they were required to play immediately prior to the assessment, and they were provided with a recording of it which they were able to use to refresh their memory during a timed preparation period. They were allowed unlimited access to the recording and, as no specific learning paradigm was imposed, they were free to employ any strategy of their choice in order to prepare and realise the piece for a performance at the end of the preparation period. The preparation period was unobserved by Sapiro, but the performance given at the end of the period was conducted in her presence. Furthermore, both the preparation period and the performance were audio and video recorded for the purposes of assessment and analysis.

The marking scheme used to assess and code playing-by-ear ability within BEAT was modelled on that devised by Sloboda and Parker (1985) for assessing melodic recall amongst 19-22 year old British higher education students. In their study, Sloboda and Parker presented subjects with six repetitions of a six-bar melodic sequence in A_1A_2B form that they were required to sing back after each hearing. The authors measured and coded recall using a segmented approach, in terms of six components: melodic-contour, meter, and rhythm according to the accuracy of individual pitches, crotchet beats and time values respectively; phrasing according to whether or not a breath was taken at the end of each phrase; phrase structure according to whether or not the A_1A_2B structure was maintained; and harmonic structure according to whether or not each half bar contained notes that represented the harmonic structure of the original. Sloboda and Parker's coding scheme facilitated data that were appropriate for statistical analysis, whilst providing substantial detail about the musical quality of the individual components of the melodic-recall performances being examined in their study. Furthermore, it was deemed to be more easily adaptable for the purposes of coding two-handed, harmonised by-ear performances on the piano than the coding schemes contained in the methodologies of Luce (1965), McPherson (1995, 1996), Delzell et al. (1999) and Bernhard (2004), which were published at that time.

Within BEAT the final by-ear realisations presented for performance were coded according to a bar-by-bar measurement of five components, in part derived from those used by Sloboda and Parker (1985). These were accuracy of melodic-rhythm, accuracy of melodic-contour, accuracy of harmonic-contour, fluency, and the stylistic-complexity of harmonised accompaniment. Sapiro coded each of the first four components by listening repeatedly to the recorded by-ear realisation and aurally comparing it with its associated original source. This process allowed bar-by-bar accuracy judgments to be made for each component. For each fully-accurate bar in respect of melodic-rhythm, melodic-contour and harmonic-contour, one mark was allocated for each component. One further mark was allocated for fluency in each bar where there was no appreciable hesitation.

Given that the accurate delivery of the harmonic-contour is likely to be more straightforward via a simplistic two-handed harmonisation than a complex one, it was also necessary for the coding to reflect the level of stylistic complexity therein. This was the purpose of Sapiro's fifth marking component – style. To accomplish this a set of seven increasingly sophisticated piano accompaniment style descriptors were devised, and a numerical value assigned to each one that would serve as a multiplier to weight participants' harmonic-contour marks. The descriptors and their multiplier values are presented in Table 3.1. Each participant's realisation was allocated the descriptor that most appropriately represented what was played, and their harmonic-contour marks weighted accordingly. This led to an overall mark that demonstrated the ability to add harmony to the melody in a pianistic manner.

Table 3.1 Style descriptors and their assigned multiplier values (Sapiro, 2007)

Multiplier	Style descriptor
0.0	No harmony
0.5	Bass notes only
1.0	Block chords
1.0	Bass notes & some chords
1.5	Bass notes & broken chords
1.5	Arpeggios
2.0	Stylistically appropriate

To compensate for the fact that not all source materials contained the same number of bars, marks for each component were converted into percentages and a mean calculated. This was used as an overall measure of two-handed, harmonised playing-by-ear ability. This method of coding provided individual and collective data that were sufficiently detailed for the level of statistical analysis demanded by Sapiro's study, and furthermore, it enabled Sapiro to provide participants with comprehensive feedback on all aspects of their respective by-ear realisations.

3.6 Addressing the methodological issues

Sapiro's methodology proved to be successful in measuring two-handed, harmonised playing-by-ear ability, and it goes a long way towards addressing the methodological issues highlighted earlier in this chapter. The use of real music memorised in a real-world context demonstrates ecological validity, and the use of familiar music, together with the provision of a recording, overcomes the effect of musical memorisation on playing by ear. Furthermore, using orchestral music gives participants the opportunity to demonstrate their creativity by requiring them to realise the music in their own style.

The detailed coding criteria facilitate empirical analysis and pedagogical feedback, and allow judgements of musical complexity and stylistic awareness to be made. Finally, the design of BEAT allows the examination of playing by ear in its own right, rather than in the context of comparison with other musical abilities. However, although Sapiro introduced the concepts of spontaneous and deductive playing by ear in the 2007 study, BEAT in its present form did not include the provision to assess them. Neither did it have the capability to compare the quality of their respective products.

Thus, in considering BEAT for use in the present project, it was evident that it would require some methodological developments in order to fully meet the needs of the research. Furthermore, time constraints during the 2007 study did not allow independent verification either of the reliability and validity of BEAT itself, or the assessments carried out by Sapiro at that time. It was, therefore, essential that a re-evaluation of some of the data from the 2007 study be undertaken to establish whether an alternative assessor could award marks that were sufficiently consistent with those originally scored, and thus lead to similar conclusions.

An independent assessor was appointed to use BEAT to verify, through re-marking, the marks awarded to four by-ear realisations drawn from the Sapiro (2007) study. To avoid any form of bias which might affect the reliability of the verification, the assessor appointed was an experienced by-ear pianist, who had also received in excess of 17 years formal piano tuition and achieved an ABRSM grade 8 level of piano performance. She was, therefore, considered to have the appropriate skills to carry out the re-marking. On its completion a paired samples correlation was conducted that demonstrated a significant relationship between the marks for each participant as reported by each assessor, $r = .950$, $p = .025$ (2-tailed), $N = 4$, with a Cronbach's alpha reliability statistic of $\alpha = .969$, $N = 2$. Furthermore, a paired samples t-test indicated no significant difference in the marking level between assessors.

Overall, on the basis that a procedure could be devised for the measurement of, and differentiation between, spontaneous and deductive playing by ear, it was concluded that BEAT would provide a sound methodological basis on which to approach the assessment of playing-by-ear ability amongst trained pianists in the context of the present research project. The manner in which this was carried out is described and evaluated in the following chapter.

4. Playing by Ear in Trained Pianists – The BEAT Study

4.1 Introduction and rationale

Playing by ear is, by necessity, playing from memory and, given the suggestion in Chapter 3 that musical memory may influence playing-by-ear ability, it is reasonable to speculate that it may be an underlying cognitive-psychological factor in the playing-by-ear process. Having identified the By-Ear Assessment Tool (BEAT) (Sapiro, 2007) as an appropriate methodology for measuring playing-by-ear ability, the first stage in the second phase of the research project was to carry out an assessment of two-handed, harmonised playing-by-ear amongst trained pianists. These measurements could then be compared with separate measures of musical memory, amongst the same group of pianists, to determine the impact of musical memory on playing-by-ear ability. This was the purpose of the BEAT Study. However, before this study could commence, it was evident that clarification was required as to exactly what, in a practical sense, playing by ear was considered to be in the context of the overall research project.

Amongst the published studies of melodic playing by ear discussed in Chapter 3, there is an underlying premise that this is the accurate and fluent instrumental reproduction of music that has been presented aurally to the performer. Given that the present project is concerned with harmonised playing-by-ear ability specifically on the piano, and since there is an inherent expectation that piano performance will present melody and harmony in the context of a two-handed execution, the BEAT Study was rooted on the working premise that playing the piano by ear is 'the accurate and fluent, two-handed, harmonised realisation of music that has been presented aurally to the performer'.

This chapter gives an account of the study, beginning with a statement of its objectives and hypotheses, and continuing with a profile of its participants. This is followed by an account of the methodological approach that includes details of the adaptations and additions to Sapiro's (2007) BEAT methodology. An analysis of the data and a discussion of the results then follows.

4.2 Objectives and hypotheses

The BEAT Study has four main objectives:

- To provide an opportunity to observe and examine the range of two-handed, harmonised playing-by-ear ability of trained pianists;
- To determine whether the level of ability of any individual component of two-handed, harmonised playing by ear has a greater impact on overall playing-by-ear ability than any other component;
- To create the opportunity to address the issue of the potential difference in quality between the products of spontaneous and deductive two-handed, harmonised playing by ear at the piano;
- To provide a measure of two-handed, harmonised playing-by-ear ability that can be compared with measures of other cognitive-psychological factors in order to determine the skills underlying playing-by-ear ability in trained pianists.

Based on these objectives, the following hypotheses are proposed:

- A wide range of playing-by-ear ability will be observed amongst participants in the BEAT Study;
- Participants will be differentiated by their ability to realise the harmonic component of the music, and the spontaneity with which they produce their realisations;
- By-ear realisations achieved using a deductive approach will be no less accurate, fluent and musically satisfying than those achieved using a spontaneous approach.

4.3 Participants

The only criterion for qualification to take part in the study was the ability to play the piano from notation. Respondents to the earlier playing-by-ear survey who fulfilled this qualification, and had signalled their interest in becoming further involved in the research project, were contacted. They were sent information about the project and invited to take part in a further study that would provide them with an opportunity to play music by ear, and lead to an assessment of their playing-by-ear ability.

From these respondents, twenty-nine pianists (fifteen men and fourteen women) volunteered to take part, on an unpaid basis. Sixty per cent were undergraduate or postgraduate music students at the University of Leeds and the remaining 40% inhabited a range of musical backgrounds including professional academic musicians, professional performing musicians, piano teachers and amateur pianists. Participants, whose ages ranged from 18 to 60+, fell into seven age bands and the numbers of participants in each band are presented in Table 4.1.

Table 4.1 Numbers of participating pianists in each age band

Age Band	No. of participants
18-21	16
22-25	1
26-30	1
31-35	3
41-45	1
51-60	2
60+	5

All pianists had received, or continued to receive formal piano lessons and seventeen gave piano or organ as their principal instrument. A wide range of piano ability was reported in terms of ABRSM grades or higher qualifications, and this is presented in Table 4.2.

Table 4.2 Participants' self reported levels of piano ability

ABRSM Piano Grade	No. of participants
Grade 8 or higher	18
Grade 7	2
Grade 6	4
Grade 5	3
Grade 3	1
Grade 2	1

Five of the 18 pianists who reported grade 8 piano/organ also reported grade 8 on another instrument, as did four of those who reported lower piano grades. Additionally, seven pianists reported that they believed they possessed perfect pitch and 22 indicated that they did not. Finally, 14 pianists indicated that they could play the piano by-ear; 13 reported that they could not, of whom two had not tried; and two were unsure whether they could play by ear, although both had tried.

4.4 Preparation of materials

In order to prepare musical materials for the study, a short survey was designed and circulated to participants online via FormSite (https://www.formsite .com). The survey listed nineteen television and nine film themes, all of which were orchestral. For each theme participants were asked to indicate whether they had: played the theme by ear; played the theme from printed music; knew the theme but had never played it; or did not know the theme. Their responses to this survey determined a list of appropriate themes for individual participants, based on pieces that they knew but had not played. Each participant was allocated two themes from their list for the test. The selection of themes for each participant was made on the basis of keeping the overall number of different themes required across participants to a minimum. The selected themes were downloaded from http://www.amazon. co.uk, and are presented in Table 4.3.

Table 4.3 TV and film themes used in the BEAT test

Theme	Composer	Year	Key	No. of bars
Casualty	Ken Freeman	1986	F minor	15
Cavatina	Stanley Myers	1970	E major	16
Coronation Street	Eric Spear	1960	A flat major	13
Eastenders	Simon May	1984	E flat major	12
Emmerdale	Tony Hatch	1972	G minor	16
Jurassic Park	John Williams	1993	B flat major	17
Midsomer Murders	Jim Parker	1997	C minor	16

Using Audacity Software v1.2.4 (Bland, Busam, Gunlogson, Mekkes, & Saunders, 2004; available from http://audacity.soundforge.net), each theme was edited to an excerpt lasting no longer than forty-four seconds. They were then burned to CD using Windows Media Player v11 on a Dell Inspiron 2200 laptop running Windows XP Home Edition. Skeleton scores for all excerpts were constructed, by the author, using MuseScore Software (Schreer, 1999-2009; available from http://musescore.org) and these were used for marking purposes. The scores, which provided the melodic line, bass notes, chord symbols and outline structure of each excerpt, were independently verified for accuracy by a musician who is an experienced composer, orchestrator and conductor as well as a trained and by ear pianist. Skeleton scores can be found in Appendix 3.

4.5 Procedure

Before their test sessions commenced, participants were informed that they would be asked to prepare a by-ear realisation of a piece of harmonised music with which they were already familiar, and give a performance of it at the end of the session. They were informed that the session would be audio and video recorded for assessment purposes and would take no more than 20 minutes. It was also made clear that they were free to withdraw themselves and their data from the study at any time, without having to provide a reason for doing so. They were invited to ask questions and in accordance with the University of Leeds ethical requirements, they were asked to complete a consent form. This was worded to cover the entire research project and included not only the BEAT Study but also any subsequent studies they might be invited to take part in. A copy of the consent form can be found in Appendix 2.

The test was conducted in a manner similar to that of Sapiro (2007). Participants were asked to choose which of their allocated themes they would like to prepare for by-ear realisation and performance. They were given access to a piano and a CD recording of their chosen theme to use as a memory aid during the 15 minutes preparation time allowed. They were also informed that the preparation period would be unobserved. No specific learning paradigm was imposed and participants were instructed that they could use the recording in any way they chose that would enable them to prepare the music and play it by ear. It was made clear that there was no explicit expectation about what they might achieve during the session, but that at the end of the preparation time they would be asked to perform their realisation to the best of their ability, in the presence of the author.

Recordings of preparations sessions and by-ear realisations were made using a Sony ICD-UX60 Digital Voice Recorder and a Samsung SMX-F300 camcorder.

4.6 Redesigning and adapting the coding scheme

The assessment of participants' playing-by-ear ability was carried out by the author. This was achieved by comparing each participant's video-recorded performance of their by-ear realisation with the appropriate CD recording and skeleton score. Since none of the pieces used in the test was more than seventeen bars long, the marking unit adopted was the half-bar, rather than the whole bar used by Sapiro (2007), since this afforded a wider range of possible marks. Assessments were recorded using marking grids that were created, by the author, using Microsoft Excel, an example of which is illustrated in Figure 4.1. The columns contained the overall structural format of the piece, including bar numbers, and a row was allocated to each of the five BEAT components. For rhythmic-accuracy, melodic-contour and harmonic-contour (hereafter referred to as rhythm, melody and harmony) a 'y' was inserted for each half bar that was fully accurate. Fluency was similarly marked where there was no appreciable hesitation in the half-bar. Half-bars where inaccuracy or hesitation were evident were coloured red and marked with an 'x'.

		Emmerdale				32 half bars in $^6_8$ time									25 seconds in G Minor																			
Section	A1								A2								A3								B								Correct	
Bar	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		/32	%
Rhythm	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	x	y	y	31	97%
Melody	y	y	y	y	y	y	y	y	x	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	x	y	y	30	94%
Harmony Wtd	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	48	60%
Fluency	y	y	y	y	y	y	y	y	y	y	y	y	x	y	y	y	x	y	y	x	y	y	y	y	x	y	y	y	x	x	y	y	26	81%
Spontaneity	(Time to 1st playthrough = 13 minutes, 87%)																																13	13%
Style	1.5																												Total /276				148	54%

Figure 4.1 Example of a completed BEAT marking grid for 'Emmerdale'

One mark was allocated to each half-bar filled with a 'y' and, based on the working premise that playing the piano by ear includes a harmonic as well as a melodic element, zero marks were awarded for harmony if a one-handed, melodic realisation was presented. Overall marks for each component were entered into the columns on the right-hand side of the grid. To make the process of assessing the stylistic quality and technical complexity of the harmonised accompaniments more straightforward, Sapiro's (2007) style descriptors were revised and their number reduced to five. The multiplier values, which are presented with the style descriptors in Table 4.4, were also recorded on the grid and used to weight participants' harmony marks.

Table 4.4 Revised style descriptors and their associated multiplier values

Multiplier	Style descriptor
0.0	No Accompaniment
1.0	Bass line or bass notes only
1.5	Bass line &/or occasional chords/broken chords
2.0	Bass line &/or one chord/broken chord per bar or half bar
2.5	Pianistic/ improvisatory/ fully harmonised

As already discussed, the BEAT methodology did not include a means of measuring the spontaneous/deductive element of participants' realisations. By way of addressing this, a measure was added to the coding scheme that allowed a judgement to be made of how spontaneously participants were able to realise a familiar piece. A time measurement was taken at the point in the 15 minute preparation session where each participant played the whole piece through accurately for the first time, demonstrating that they had gained an overall grasp of the whole piece. This time measure was then used in the following formula to calculate a mark for spontaneity:

$$\frac{\text{Total preparation time (15 minutes)} - \text{Amount of time taken to first accurate play through}}{\text{Total preparation time (15 minutes)}} = \text{Spontaneity}$$

Where a one-handed, melodic realisation was presented, zero marks were awarded for spontaneity on the basis that a full play through was not achieved at any point during the preparation time.

Finally, marks for individual components were converted to percentages, and the following formula used to calculate a BEAT mark for each participant:

$$\frac{\text{Rhythm} + \text{Melody} + \text{Harmony} + \text{Fluency} + \text{Spontaneity}}{5} = \text{BEAT mark (\%)}$$

Note that in this formula, and hereafter, the expression 'harmony' represents marks for harmonic-contour that have been weighted using style multipliers.

4.7 Results

A random selection of 10% of the data for all assessments conducted during the course of the entire research project were independently verified by the same assessor who had been appointed to verify assessments taken from Sapiro's earlier (2007) study. These data included examples from the BEAT Study as well as examples of data from further cognitive-psychological assessments that will be presented and discussed in Chapter 7. A paired samples correlation demonstrated a significant relationship between the marks for each participant as reported by each assessor, $r = .993$, $p = .000$ (2-tailed), $N = 12$, with a Cronbach's alpha reliability statistic of $\alpha = .996$, $N = 2$. Additionally, a paired samples t-test indicated no significant difference in the assessment level between the two assessors.

The BEAT assessments indicated a wide range of ability to play the piano by ear, $M = 50.86$, $SD = 28.121$, $N = 29$, and it was decided to systematically cluster participants by level of playing-by-ear ability for the main part of the analysis. Although it was anticipated that, as trained pianists, all participants in the study would present two-handed, harmonised by-ear realisations, it appeared that there were some who were unable to play the piano two-handedly in a by-ear context. It was, therefore, deemed appropriate to differentiate between those participants who had fulfilled the working premise set down for the study, by presenting performances of two-handed, harmonised realisations, and those who had not. Twenty participants achieved two-handed, harmonised realisations, and based on their final BEAT marks, these participants fell into three clear groups. A significant *k*-means cluster analysis confirmed this grouping, $F\ (2,17) = 80.893$, $p = .000$, $n = 20$. The remaining nine participants formed a fourth group on the basis that they had presented one-handed, melodic realisations, although it was also evident that these participants also achieved the lowest BEAT marks overall. This supported the original decision to group them together. These four clusters provided the 'group' variable for the following analysis, and descriptive statistics for each group are presented in Table 4.5.

Table 4.5 Descriptive statistics all groups for overall BEAT marks

Group	*n*	Mean	Min	Max	Std. Dev.
1	7	89.57	81	97	5.74
2	7	59.86	52	70	7.62
3	6	41.17	31	48	7.41
4	9	20.22	0	34	12.51

Having grouped participants in this way, a larger standard deviation of the overall BEAT marks was observed for group four. This is accounted for by the wide ranges of marks these participants achieved for rhythm, melody and fluency. An analysis of variance (ANOVA) confirmed an overall significant difference between groups in terms of their BEAT marks, $F\ (3,25) = 80.676$, $p = .000$, $N = 29$. Additional Dunnett T3 post hoc tests (in accordance with Levene's test of equality of variances) further indicated significant differences in means for all pairings of groups. These are presented in Table 4.6.

Table 4.6 Post hoc tests indicating significant differences in group means for overall BEAT marks

Groups	Significance
1 & 2	.000
1 & 3	.000
1 & 4	.000
2 & 3	.006
2 & 4	.000
3 & 4	.008

It is already noted that participants in group four are distinguishable from those in the remaining groups. However, the effect of group on the individual components of BEAT for all groups was examined to determine more specifically which components distinguished the groups from one another overall. Table 4.7 provides descriptive statistics for all groups for all components.

Table 4.7 Descriptive statistics for all groups for BEAT component marks

Component	Group	*n*	Mean	Min	Max	Std. Dev
Rhythm	1	7	99.43	96	100	1.51
	2	7	92.71	82	100	6.89
	3	6	90.50	78	100	7.89
	4	9	61.44	0	97	37.23
Melody	1	7	96.43	88	100	5.02
	2	7	88.57	72	100	10.24
	3	6	87.83	66	100	11.70
	4	9	58.78	0	97	36.08
Harmony	1	7	94.29	85	100	5.31
	2	7	69.71	54	85	13.64
	3	6	32.83	9	58	21.04
	4	9	-	-	-	-
Fluency	1	7	99.43	96	100	1.51
	2	7	86.29	69	100	11.42
	3	6	79.67	54	96	14.37
	4	9	56.78	0	100	34.49
Spontaneity	1	7	77.71	57	94	12.20
	2	7	27.00	8	56	17.05
	3	6	11.17	0	28	11.79
	4	9	-	-	-	-

A multivariate analysis of variance (MANOVA) revealed a significant effect of group on harmony, $F\ (3,25) = 95.994$, $p = .000$, $N = 29$, and on spontaneity, $F\ (3,25) = 65.129$, $p = .000$, $N = 29$, but not on the remaining components. Additional Dunnett T3 post hoc tests confirmed significant differences in group means for harmony and spontaneity. These are presented in Table 4.8.

Table 4.8 Post hoc tests indicating significant differences in group means for harmony and spontaneity

Component	Groups	Significance
Harmony	1 & 2	.012
	1 & 3	.003
	1 & 4	.000
	2 & 3	.030
	2 & 4	.000
Spontaneity	1 & 2	.000
	1 & 3	.000
	1 & 4	.000
	2 & 4	.028

Furthermore, as Figure 4.2 demonstrates, the overall group rank order established for BEAT as a whole holds true for all individual components.

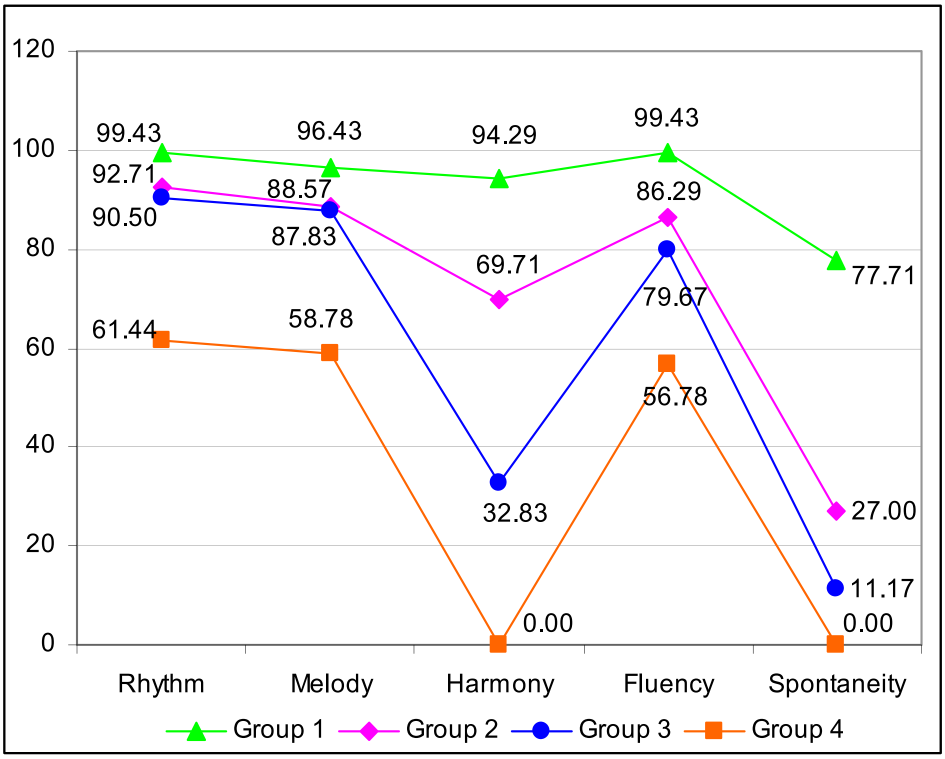

Figure 4.2 Summary of group means for each BEAT component

To ensure that this overall finding was not compromised by the fact that group four received zero marks for harmony and spontaneity, a further MANOVA was carried out that examined the effect of group on the component marks for groups one, two and three only. This indicated a significant effect of group on harmony, $F\ (2,17) = 29.775, p = .000, n = 20$, and spontaneity marks, $F\ (2,17) = 41.114, p = .000, n = 20$. Further Dunnett T3 post hoc tests indicated significant differences in the means for both components between all pairs of groups. These are presented in Table 4.9.

Table 4.9 Post hoc tests indicating significant differences in group means for harmony and spontaneity for groups one, two and three

Component	Groups	Significance
Harmony	1 & 2	.007
	1 & 3	.002
	2 & 3	.016
Spontaneity	1 & 2	.000
	1 & 3	.000

Overall this confirmed that groups are distinguishable from one another on the basis of their level of ability to provide an accurate, harmonised, pianistic accompaniment by ear. Moreover, it confirms that they are further distinguishable from one another based on the level of spontaneity with which participants are able to demonstrate an overall grasp of the music.

One aspect inferred by this analysis is that participants across all groups demonstrate similar levels of ability to reproduce the rhythmic, melodic and fluency components of playing by ear. On the basis that these three components constitute melodic playing by ear, the following formula was used to calculate a melodic playing-by-ear ability mark for each participant:

$$\frac{\text{Rhythm} + \text{Melody} + \text{Fluency}}{3} = \text{Melodic-BEAT mark (\%)}$$

These melodic-BEAT marks demonstrated a wide range of ability to play melody by ear across all participants, $M = 81.39$, $SD = 25.185$, $N = 29$. This is consistent with existing evidence that varying levels of melodic playing by ear can be achieved by musicians with a variety of different backgrounds, experience and training (Delzell, et al., 1999; Luce, 1965; McPherson, 1995, 1996; Woody & Lehmann, 2010). To investigate this further, the melodic-BEAT marks of participants who presented melody in the context of harmonised playing by ear were compared with the melodic-BEAT marks of those who presented melody alone. For the purposes of this part of the analysis, groups one, two and three were combined into one for comparison with group four. As Table 4.10 demonstrates, it is evident that the combined group achieved melodic-BEAT marks that were in a narrower, but mainly higher range than marks achieved by group four.

Table 4.10 Descriptive statistics for combined group and group four for melodic-BEAT marks

Group	*n*	Mean	Min	Max	Std. Dev.
Combined	20	91.47	74	100	7.47
4	9	59.00	0	97	35.62

An independent samples *t*-test indicated a significant difference in means between the combined group and group four for melodic-BEAT, $t = 3.068$, $df = 27$, $p = .000$ (2-tailed), $N = 29$.

To gain a more detailed perspective of the harmonic accuracy and pianistic complexity with which groups one, two and three reproduced the harmonic component of the music, their raw (un-weighted) harmony marks and their style multipliers were examined independently from their overall BEAT marks. Table 4.11 presents descriptive statistics for raw-harmony marks for groups one, two and three, and Table 4.12 provides the distribution of style-multiplier values amongst them.

Table 4.11 Descriptive statistics for groups one, two and three for raw-harmony marks

Group	*n*	Mean	Min	Max	Std. Dev.
1	7	94.29	85	100	5.314
2	7	77.43	54	100	14.606
3	6	41.00	15	69	22.190

Table 4.12 Distribution of style-multiplier values amongst groups one, two and three

Style multiplier	Group 1	Group 2	Group 3
2.5	7	5	1
2.0	0	1	3
1.5	0	1	2
1.0	0	0	0

An ANOVA indicated a significant effect of group on participants' raw-harmony marks, F (2,17) = 20.528, p = .000, n = 20, and a Fisher Exact Test indicated a statistically significant relationship between group and style multipliers, p = .014, n = 20.

To determine any difference in the quality of the outcomes of spontaneous and deductive playing by ear, the BEAT marks of groups one, two and three were recalculated using the following formula that excluded their spontaneity marks:

$$\frac{\text{Rhythm} + \text{Melody} + \text{Harmony} + \text{Fluency}}{4} = \text{BEAT-without-spontaneity mark (\%)}$$

BEAT-without-spontaneity marks revealed the levels of playing-by-ear ability of these participants purely in terms of rhythmic, melodic and harmonic accuracy, fluency, and their ability to produce a stylistically-complex pianistic accompaniment. Group four was excluded from this analysis since their lack of harmonisation meant they were not deemed to have gained a full grasp of the music. Descriptive statistics for BEAT-without-spontaneity marks for groups one, two and three are presented in Table 4.13.

Table 4.13 Descriptive statistics for groups one, two and three for BEAT-without-spontaneity marks

Group	*n*	Mean	Min	Max	Std. Dev.
1	7	96.71	91	99	2.63
2	7	80.43	72	86	5.06
3	6	61.67	55	74	9.20

An ANOVA indicated a significant effect of group on BEAT-without-spontaneity, F (2,17) = 54.541, p = .000, n = 20, and Dunnett T3 post hoc tests further indicated significant differences between groups. These are presented in Table 4.14.

Table 4.14 Post hoc tests indicating significant differences in group means for BEAT-without-spontaneity for groups one, two and three

Component	Groups	Significance
BEAT-without-spontaneity	1 & 2	.000
	1 & 3	.000
	2 & 3	.007

Following this, participants' spontaneity marks were compared with their BEAT-without-spontaneity marks . A graphical representation of this is presented in Figure 4.3 below. A Pearson correlation analysis demonstrated a highly significant relationship between these variables, r = .801, p = .000 (1-tailed), n = 20, indicating that the most accurate, fluent and stylistically-complex realisations were also the most spontaneous.

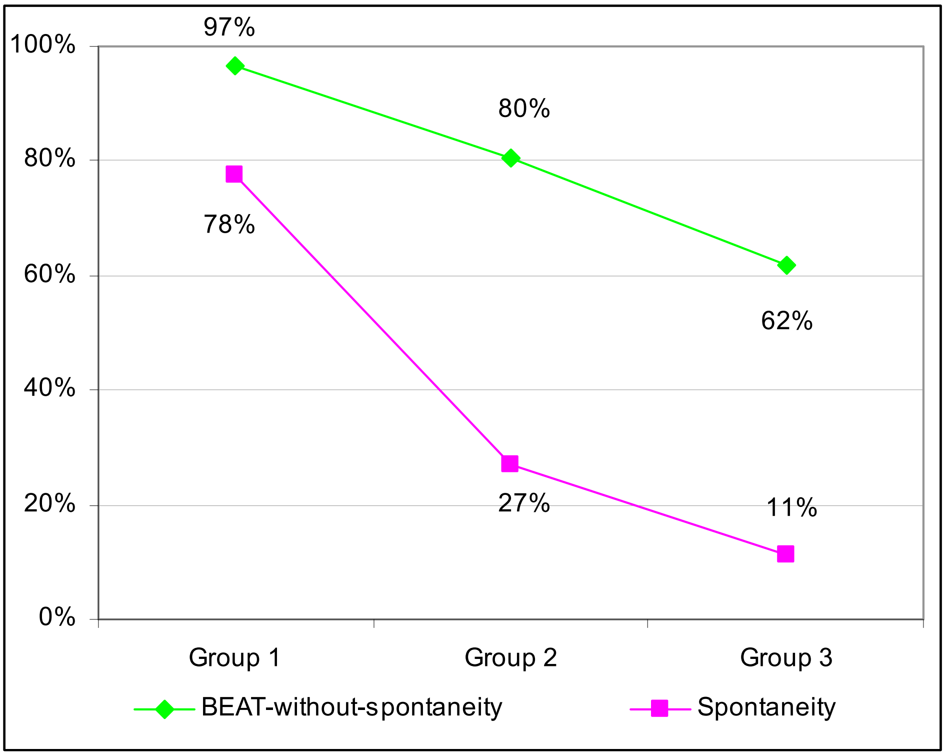

Figure 4.3 Summary of group means for BEAT-without-spontaneity and spontaneity for groups one, two and three

Participants' BEAT marks were then examined in the context of some of their responses to the earlier playing-by-ear survey. Their self-reported piano grades indicated a wide range of piano playing ability (see page 86, Table 4.2) and as Table 4.15 demonstrates, this gives an indication of the level of piano training they have received.

Table 4.15 Distribution of levels of piano-playing ability amongst participants within each group and overall

	Level of piano ability groups			
Group	Grade 8 or higher	Grades 6 & 7	Grade 5	Grades 2 & 3
1	5	2	0	0
2	6	0	1	0
3	2	3	1	0
4	5	1	1	2
Total	18	6	3	2

To determine the effect of piano training on their playing-by-ear ability, participants were grouped according to their level of piano ability. Table 4.16 presents descriptive statistics for this grouping.

Table 4.16 Descriptive statistics for participants' overall BEAT marks grouped by level of piano ability

Group	*n*	Mean	Min	Max	Std. Dev.
Grade 8 or higher	18	56.61	12	93	26.92
Grades 6 & 7	6	50.17	0	97	35.11
Grade 5	3	39.00	31	52	11.35
Grades 2 & 3	2	19.00	6	32	18.38

However, a one-way ANOVA indicated no significant effect of piano ability on participants' BEAT marks.

Participants' self-reported ability to discriminate absolute pitch was examined next. As Table 4.17 demonstrates participants reporting the possession of perfect pitch were represented in all but group three.

Table 4.17 Distribution of participants possessing perfect pitch in each group

Group	Perfect pitch: Yes	Perfect pitch: No
1	5	2
2	1	6
3	0	6
4	1	8

To examine the influence of perfect pitch on playing-by-ear ability, participants were grouped according to their self-reported belief in their possession of perfect pitch. Descriptive statistics are presented in Table 4.18.

Table 4.18 Descriptive statistics for participants' overall BEAT marks, grouped by belief in possession of perfect pitch

Perfect Pitch	*n*	Mean	Min	Max	Std. Dev.
Yes	7	81.00	34	97	22.50
No	22	41.27	0	83	22.60

An independent samples t-test indicated a significant difference between the means of these two groups, $t = 4.055$, $df = 27$, $p = .000$, $N = 29$.

Participants reported ability to play the piano by ear was examined next. Table 4.19 demonstrates the distribution of participants' reported ability according to their group.

Table 4.19 Distribution of participants' reported playing-by-ear ability, by group

		Can you play by ear?		
Group	*n*	Yes	No	Don't know
1	7	7	0	0
2	7	3	4	0
3	6	3	2	1
4	9	1	7	1

To determine the relationship between reported playing-by-ear ability and BEAT marks, participants were grouped according to their reports. Descriptive statistics are presented in Table 4.20. Note that the two participants who indicated that they were unsure whether they could play by ear are excluded from this analysis.

Table 4.20 Descriptive statistics for participants' overall BEAT marks, grouped by reported playing-by-ear ability

Can you play by ear?	*n*	Mean	Min	Max	Std. Dev.
Yes	14	70.86	34	97	21.84
No	13	32.23	0	64	20.64

An independent samples t-test indicated a significant difference between the means of these two groups, $t = 4.713$, $df = 25$, $p = .000$, $n = 27$.

Participants also reported whether or not they had received encouragement to play by ear, and by whom. These data are presented in Table 4.21.

Table 4.21 Numbers of participants in each group who received encouragement to play by ear, and by whom

Group	*n*	Encouragement from:			Total
		Teachers alone	Teachers and others	Others alone	
1	7	0	5	0	5
2	7	0	1	1	2
3	6	0	1	1	2
4	9	1	0	0	1

To determine the overall effect of encouragement on ability to play by ear, participants were grouped according to whether or not they had received any. Descriptive statistics are presented in Table 4.22.

Table 4.22 Descriptive statistics for participants' overall BEAT marks, grouped by encouragement to play by ear

Encouraged to play by ear?	*n*	Mean	Min	Max	Std. Dev.
Yes	10	68.80	6	97	29.70
No	19	41.42	0	83	22.71

A further independent samples t-test indicated a significant difference between the means of these two groups, $t = 2.774$, $df = 27$, $p = .010$, $N = 29$.

Additionally, the relationship between participants' reported playing-by-ear ability and the encouragement they have received to play by ear was examined and is presented in Table 4.23.

Table 4.23 Comparison between participants' reported playing-by-ear ability and whether they have been encouraged to do so, by group

Group	*n*	Encouraged to play by ear?	Can you play by ear?		
			Yes	No	Don't know
1	7	Yes	5	-	-
		No	2	-	-
2	7	Yes	1	1	-
		No	2	3	-
3	6	Yes	1	1	0
		No	2	1	1
4	9	Yes	0	1	0
		No	1	6	1
Total	29	Yes	7	3	0
		No	7	10	2

However, a Pearson's chi-square test indicated no statistically significant relationship between these two variables.

4.8 Discussion

The BEAT Study was based on the working premise that playing the piano by ear is the accurate and fluent, two-handed, harmonised realisation of music that has been presented aurally to the performer. Its objectives were to: observe and examine the range of playing-by-ear ability demonstrated by trained pianists; evaluate the impact of individual component ability on playing-by-ear ability as a whole; and consider the potential difference in musical quality between spontaneous and deductive by-ear realisations.

4.8.1 Melodic playing by ear

It is unsurprising that a wide range of melodic playing by ear has been observed across all participants in the study. Given the likelihood that realising melody without harmony is more straightforward than realising melody with it, the expectation that un-harmonised melody would, at the very least, be as accurate and fluent as harmonised melody is reasonable. However, amongst participants in the

BEAT Study, this is not always the case. Participants in groups one, two and three realised melodies with mainly high levels of accuracy and fluency in the context of varying levels of stylistically-complex harmonisations. Moreover, these melodies are more accurate and fluent than some of the un-harmonised melodies reproduced by participants in group four. Conversely, some participants in group four were able to reproduce melodies with mainly high levels of accuracy and fluency, although they appeared unable to harmonise them. This suggests that the ability to play melody by ear is not necessarily associated with the ability to add harmonisations by ear.

4.8.2 Harmonised playing by ear

Alongside the wide range of melodic playing by ear, a similarly wide range of two-handed, harmonised playing-by-ear ability was evident across participants in groups one, two and three. As well as demonstrating high levels of melodic accuracy in the context of harmonised melody, participants in group one reproduced the harmonic contour with the most accuracy, and their highly stylistically-complex realisations were also the most fluent. Conversely, whilst maintaining relatively high levels of melodic accuracy, participants in groups two and three were successively less accurate in their reproductions of the harmony, although their realisations were reasonably fluent. Furthermore although the stylistic-complexity of realisations presented by participants in group two were mainly commensurate with those of group one, those of participants in group three were less successful. Therefore, in spite of the assumption that delivering the harmony accurately would be more straightforward via a simplistic harmonisation, it is evident that the most accurate harmonisations are also the most fluent and stylistically complex.

4.8.3 Spontaneous and deductive playing by ear

The length of time participants take to demonstrate a grasp of the music (spontaneity) is also a factor that distinguishes the groups. As well as being mainly accurate, fluent and stylistically-complex, the by-ear realisations presented by participants in group one were the most spontaneously achieved. Conversely, participants in groups two and three delivered less accurate, fluent and stylistically-complex realisations that, moreover, required substantial amounts of working out time prior to performance. Thus it is evident that, amongst participants in the BEAT

Study, by-ear realisations that are spontaneous have a higher level of musical quality than those that are deductive. The discussion in Chapter 2 raises the question of whether spontaneous playing by ear is simply a more efficient execution of deductive playing by ear. However, the BEAT Study strongly implies that this is not the case, given that it presented no evidence of deductive by-ear realisations that were highly accurate, fluent and stylistically-complex.

4.8.4 Summary

Participants' by-ear realisations at the highest level are highly accurate, fluent, two-handed, stylistic harmonisations, whilst at the lowest level they are largely inaccurate, halting, one-handed melodies. It is also evident that melody realised in the context of harmony is mainly more accurate than that produced alone, and participants demonstrating the ability to harmonise do so with a range of stylistic complexity. Finally, only participants demonstrating the highest levels of playing by ear produce their realisations spontaneously and, furthermore, deductive realisations are less accurate and fluent than spontaneous ones. Thus, as hypothesised, participants demonstrate a wide range of playing-by-ear ability and are differentiated by their ability to realise the harmonic component of the music, and the spontaneity with which they produce their realisations. However, although it was anticipated that there would be no difference between the products of spontaneous and deductive playing by ear, it is evident that such a difference exists.

The BEAT Study itself provides no explanation for these findings but it is possible that the influence of, as yet unidentified, cognitive-psychological factors may be responsible for the variability in playing-by-ear ability amongst trained pianists. In order to determine this possibility, the findings of the BEAT Study are re-examined in Chapter 7, in the context of further investigations and assessments that are discussed in that chapter. The remainder of this discussion examines the remaining BEAT Study results in the light of speculation arising from literature on playing by ear, and observations arising from the playing-by-ear survey discussed in Chapter 2.

4.8.5 The influence of piano training

Participants in the BEAT study demonstrate a wide range of formal piano training and instrumental ability. It is evident that some of those reporting a high degree of ability also exhibit high levels of ability to play the piano by-ear, whilst others reporting the same high level of ability demonstrate playing by ear at a low level. This finding implies that increasing the level of ability to play the piano from notation does not necessarily lead to increased levels of ability to play the piano by ear, and demonstrates support for similar evidence presented by Delzell et al. (1999) (see Chapter 3). However, it appears to differ from the findings of McPherson (1995, 1996), who suggests that playing-by-ear ability may develop in line with formal instrumental ability. One possible reason for this discrepancy may be attributed to differences in methodological approaches between the two studies. Although the BEAT study and McPherson's study both considered examination grades as a measure of instrumental ability, McPherson's analysis also included a number of other measures of musical development that were not included in the BEAT study (see Chapters 2 and 3 for a discussion of McPherson's research).

4.8.6 The impact of perfect pitch

It is unsurprising to find that some participants demonstrating high levels of playing-by-ear ability also report that they have perfect pitch. However, the analysis also shows that similarly high levels of by-ear ability can be achieved by participants who do not possess perfect pitch, demonstrating that its presence does not guarantee high levels of ability to play by ear. It is important to bear in mind that the ability of participants in the BEAT Study to discriminate absolute pitch has not been tested and, therefore, no statistical relationship between these two abilities can be inferred. Moreover, other studies examining playing by ear have presented no evidence to suggest that such a relationship exists. Accordingly, although it is possible that possession of perfect pitch may assist in the process of playing by ear, it is apparent that playing-by-ear ability does not rely on it.

4.8.7 Belief in ability and the effect of encouragement

Research that examines motivation and self-efficacy infers that belief in ability can influence achievement in that ability (see Pajares & Schunk, 2001 for a review). In keeping with this view participants in group one, who demonstrate the highest levels of ability, evidently also believe they can play by ear. However, by contrast, there are some participants in the remaining groups who believe they can play by ear, but demonstrate lower levels of this ability. Additionally, the discussion in Chapter 2 asserts that pianists who have received encouragement to play by ear are more likely to believe they have the ability than those who have not received encouragement. However, although no statistically significant relationship was observed between these two variables in the BEAT Study, it appears that participants in group one were mainly encouraged to play by ear. It is also suggested in Chapter 2 that encouragement to play by ear received from a combination of teachers and other musical sources is more likely to result in belief in ability than encouragement from teachers alone. Again, participants in group one received more encouragement than participants in the remaining groups, and it was mainly received from a combination of teachers and others. Overall, it has been shown that those who demonstrate high levels of ability also believe they can play by ear, but belief does not guarantee high levels of ability. However, participants' belief in their ability to play by ear is mainly consistent with their demonstrated levels of ability and, furthermore, the amount and type of encouragement they have received also appears to have an impact on that belief.

Overall, participants who demonstrate the highest levels of ability believe they can play by ear, have been encouraged to do so, and have also received a high degree of formal piano training. However, it is apparent that these circumstances do not guarantee playing-by-ear ability.

4.9 The next step

The BEAT Study has been shown that many participants exhibited high levels of melodic accuracy in their by-ear realisations, but only some of them demonstrated equally high levels of harmonic accuracy. Furthermore, those that showed high levels of melodic and harmonic accuracy were capable of high levels of stylistic accompaniments, and moreover, their realisations were the most spontaneous. In revealing these features the BEAT Study has defined playing by ear and it is, therefore, appropriate to revise the working premise set down at the beginning of this chapter into the following definition:

> *Playing the piano by ear is the accurate, fluent and spontaneous, two-handed, stylistically-harmonised realisation of a piece of music that has been memorised aurally, without reference to musical notation.*

To develop a greater understanding of playing by ear, and to attempt to identify the underlying cognitive-psychological factors involved, the manner in which participants prepare their by-ear realisations for performance must be considered in relation to that performance. This is addressed in Chapter 5.

5. Preparing Music for Playing by Ear – The Strategy Study

5.1 Introduction and rationale

The BEAT Study has examined playing-by-ear ability amongst trained pianists. It provides a measure of playing by ear that allows its participants to be grouped according to their level of ability, and has identified a number of attributes demonstrated by those who exhibit playing by ear at the highest levels. Additionally, it has distinguished those who demonstrate ability to play by ear in a two-handed, harmonised manner from those who present playing by ear that is one-handed and purely melodic. However, the main aim of the research project is the identification of the cognitive-psychological factors underlying two-handed, harmonised playing by ear. This requires a broader investigation that gives consideration not only to the level of playing-by-ear ability demonstrated by participants, but also to the strategies they adopt when preparing by-ear realisations for performance, and the practical techniques they demonstrate during that preparation. The purpose of the Strategy Study was to examine these strategies and techniques.

This chapter continues with a statement of the study's objectives and research questions, followed by a brief overview of published studies that examine learning strategies and musical behaviours in the context of: jazz, rock and pop music; piano performance from memory; and melodic playing by ear. The chapter continues with a description of the methodological approach to observation adopted in the Strategy Study and an analysis of those observations follows. Finally, the ensuing discussion comments on the strategies and techniques observed in terms of participants' manner of playing by ear and their levels of playing-by-ear ability, as well as considering their practical techniques in the light of a range of cognitive-psychological factors.

5.2 Objectives and research questions

The Strategy Study has two objectives:

- To identify the preparation strategies adopted and practical techniques demonstrated by trained pianists when preparing music for by-ear realisation and performance;
- To identify, through these strategies and techniques, the cognitive-psychological factors that underlie playing-by-ear ability.

Based on these objectives the following hypotheses are proposed:

- Participants presenting two-handed, harmonised playing by ear will adopt different preparation strategies to those demonstrating one-handed, melodic playing by ear;
- The practical techniques demonstrated by participants will differ according to their levels of playing-by-ear ability.

5.3 Overview of published literature

Learning to play a piece of music on an instrument, whether by ear or not, involves a number of complex cognitive and behavioural strategies (Gruson, 1988; Nielsen, 1999, 2001). The musical behaviours that rock, pop and jazz musicians employ whilst acquiring and developing the skill of learning music for performance from an auditory source are discussed by Lilliestam (1996), Green (2002) and Johansson (2004). However, in the context of these studies participants are not observed in the practice of these strategies and techniques and the discussions focus mainly on participants' verbal self-reports, and anecdotal evidence.

Alongside this, Noice, Jeffrey, Noice and Chaffin (2008) discuss the techniques used by a jazz pianist when using a printed lead sheet to prepare an improvisation on a previously unknown piece. Other studies in a similar vein observe and examine the approaches taken by trained pianists when preparing performances of music memorised from a printed score (see Chaffin & Imreh, 1997, 2001; Williamon & Valentine, 2002; Chaffin, 2007). These studies mainly employ an observational approach, and their ensuing discussions give consideration to the cognitive-psychological factors that underpin performance preparation. However, the practices observed are based on processing music initially learned using notation.

Focussing more on playing by ear, the techniques utilized by trained instrumentalists when learning short, unfamiliar melodies for by-ear reproduction, under test conditions, are examined by Woody and Lehmann (2010), although this discussion is based on participants' verbal reports. Conversely, using video footage recorded specifically for the purpose of observing playing by ear strategies, Sapiro (2007) identifies three overall strategic approaches adopted by trained pianists when preparing familiar music for by-ear performance: listening to the music without playing; listening to and playing along with the music; and playing alone after listening to the music.

Finally, amongst all the studies discussed above, Woody and Lehmann (2010) and Sapiro (2007) are the only ones that attempt to examine cognitive-psychological aspects of playing by ear and furthermore, Sapiro (2007) is the only study that addresses these aspects in the context of two-handed, harmonised playing by ear amongst pianists.

5.4 Methodological approach

In the context of the BEAT Study, participants were video recorded whilst preparing their by-ear realisations specifically for the purpose of observing the preparation strategies they adopted and practical techniques they demonstrated. To conduct the observation a system was required that enabled the progress and content of these preparation periods to be graphically represented. This was facilitated through the use of a set of observation grids, designed by the author, to chart participants' preparation in detail. Using Microsoft Excel, an observation grid was created for each individual TV and film theme used in the BEAT test, an example of which is presented in Figure 5.1. The grids contained the overall structural format of the piece including bar numbers across the top, with a column for time entries down the left hand side. Additionally, cells representing each bar of the music in the main body of the grid were sub-divided so that progress could be tracked by the half-bar.

			Emmerdale		32 half bars in $^6_8$ time				25 seconds in G Minor							
Red = listen alone					Yellow = listen and play along						Blue = play alone					
Format	A1				A2				A3				B			
Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Figure 5.1 Part of the observation grid for 'Emmerdale'

Working down the grid whilst observing a video recording, the participant's data were entered in terms of the three general strategic approaches identified by Sapiro (2007). Colours were used to identify when and where each strategy was employed: red for 'listening alone'; yellow for 'listening and playing along with the recording'; and blue for 'playing alone'. Time markers, which were entered each time the participant stopped and re-started playing or listening, represented the amount of elapsed time from the commencement of the session. Notes were added to the grid, indicating where the playing was right-hand (RH) or left-hand (LH) only, or hands-together (HT). More detailed observational notes were recorded separately. An example of a partially-completed grid for 'Emmerdale' is presented in Figure 5.2.

Emmerdale **32 half bars in $^6_8$ time** **25 seconds in G Minor**

Red = listen alone Yellow = listen and play along Blue = play alone

Format	A1				A2				A3				B			
Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.06																
0.50	RH								RH only melody correct from this point							
1.17	RH correct				RH not sure about this bit				RH correct from here							
1.41	RH only correct here				Trial and error here											
1:56	RH only mainly correct															
2.24	HT mainly correct, arpeggiated harmony on LH															
2:30	HT mainly correct, arpeggiated harmony on LH															
2:34	HT mainly correct, arpeggiated harmony on LH															
2:37	HT mainly correct, arpeggiated harmony on LH															
2:48					HT mainly correct, arpeggiated harmony on LH											
2:56								HT mainly correct, arpeggiated harmony on LH								
3.01	HT mainly correct, arpeggiated harmony on LH															
3.25	Some HT and some RH only here															
3.47	HT mainly correct, arpeggiated harmony on LH															
4.12			RH here		RH here											
4:28									RH here							
4.32									RH here							

Figure 5.2 Partially completed observation grid for 'Emmerdale'

Following observation and charting, analysis of participants' observation grids (and any additional notes) was conducted to identify the strategies participants adopted for learning and preparing familiar music for playing by ear, and the practical techniques they demonstrated within these strategies.

5.5 Results

Participants demonstrated two types of preparation strategies whilst preparing familiar music for by-ear realisation: commencement strategies, that describe the manner in which participants began their preparation; and practice strategies, that detail how they continued to work during the 15 minutes preparation time they were allowed in the BEAT test.

Participants' commencement strategies are presented in Table 5.1.

Table 5.1 Commencement strategies observed amongst participants according to their manner of playing by ear

Commencement strategy	Two-handed, harmonised (n = 20)	One-handed, melodic (n = 9)
C1 Listening to whole piece before starting to play	7	1
C2 Listening to and playing along with recording	11	5
C3 Listening only to part of piece before starting to play	1	2
C4 Starting to play without first listening to the piece	1	1

Although it is evident that almost all participants began their preparation by listening to the music in one way or another, it is also clear that the majority attempted to play along with the recording whilst listening to the music for the first time.

Moving forward from their commencement strategies, participants demonstrated a number of practice strategies that illustrate how they continued to work during the preparation period. These are presented in Table 5.2.

Table 5.2 Practice strategies observed amongst participants according to their manner of playing by ear

Practice strategy	Two-handed, harmonised (n = 20)	One-handed, melodic (n = 9)
P1 Listen & play along only	1	0
P2 Play only	1	0
P3 Listen only AND Listen & play along	1	0
P4 Listen & play along AND Play only	10	5
P5 Listen only AND Play only	2	0
P6 Listen only, Listen & play along AND Play only	5	4

The majority of participants adopted practice strategies that included the listen and play along (P1) technique. Furthermore, as Figure 5.3 exemplifies, the majority of those who began the preparation process by listening to and playing along with recording (C2) continued to include this technique in their ongoing practice strategy.

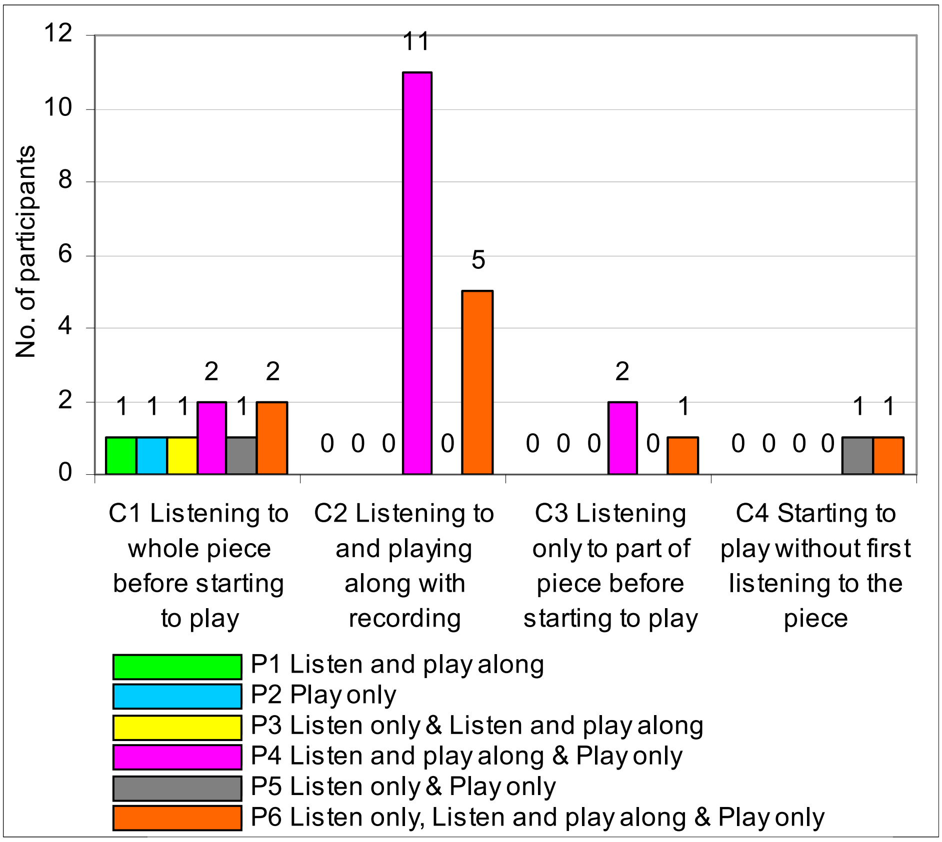

Figure 5.3 Cross-tabulation of commencement and practice strategies for all participants

When participants' preparation strategies were compared according to the manner of their playing by ear, a Fisher Exact test indicated no significant difference between the commencement and practice strategies demonstrated by participants presenting two-handed, harmonised playing by ear and those demonstrated by participants who presented one-handed, melodic playing by ear. Note that all Fisher Exact test results in this analysis are two-tailed. Preparation strategies were then compared with participants' group categories to determine whether there was any relationship between the strategies they adopted and their demonstrated levels of playing-by-ear ability, as measured by the BEAT test. Again, Fisher Exact tests indicated no statistically significant differences between all possible pairings of groups. Finally, participants' preparation strategies were compared with their self-reported belief in their ability to play by ear to determine whether there was any relationship between the strategies they adopted and that belief. Note that the two participants who reported they were unsure of their ability are excluded from this analysis. Once again, Fisher Exact tests indicated no statistically significant differences in the use of commencement and practice strategies between these two groups of participants.

Within the context of their overall preparation strategies participants demonstrated a range of practical techniques in three specific areas: learning techniques, handing techniques (playing hands-together or hands-separately) and accompanying techniques. The learning techniques describe the manner in which participants divided the music into manageable segments for learning. Five learning techniques were identified and are presented in Table 5.3.

Table 5.3 Learning techniques observed amongst participants according to their manner of playing by ear

Learning technique	Two-handed, harmonised (n = 20)	One-handed, melodic (n = 9)
L1 Work on whole piece all the time	8	0
L2 Work on large segments, 4 bars to 8 bars	3	1
L3 Work on combination of small (1 bar to 4 bars) & large (4 bars to 8 bars) segments	6	2
L4 Work on combination of whole piece and segments of piece	3	2
L5 Work on small segments, 1 bar to 4 bars	0	4

Table 5.3 shows that the majority of participants prefer to work either exclusively on the whole piece (L1) or on a combination of small and large segments of the piece (L2 to L5). However, as Figure 5.4 below demonstrates, participants who worked exclusively on the whole piece (L1) were mainly those in group one, whilst those in groups two and three demonstrated techniques L2 to L4. Furthermore, although no participants in group four demonstrated technique L1, it was apparent that some of

them worked on small segments (L5), a learning technique not observed amongst those participants who presented two-handed, harmonised playing by ear.

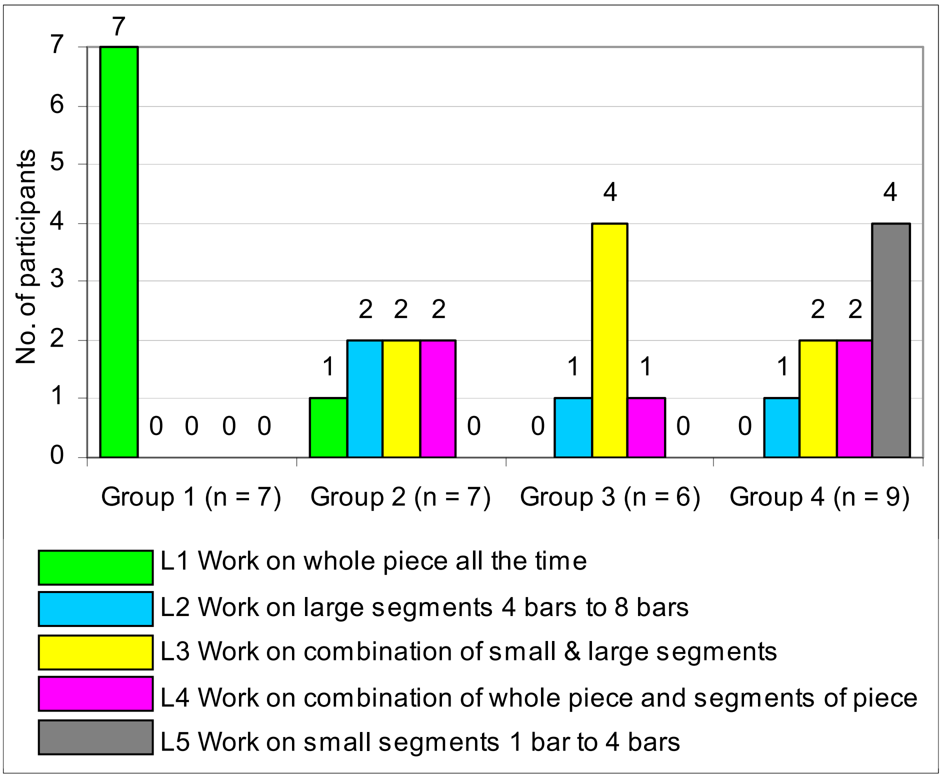

Figure 5.4 Distribution of learning techniques amongst participants, by group

Table 5.4 presents Fisher Exact tests indicating statistically significant differences in the learning techniques between groups.

Table 5.4 Fisher Exact tests comparing learning techniques between groups

Fisher Exact Test	*p*
Group 1 vs. Group 2	= .005
Group 1 vs. Group 3	< .001
Group 1 vs. Group 4	< .001
Group 1 vs. Groups 2 & 3	< .001

Finally a further Fisher Exact test indicated a statistically significant difference in learning techniques between participants presenting two-handed, harmonised playing by ear and those presenting one-handed, melodic playing by ear, $p = .007$, $N = 29$. This distribution is illustrated in Figure 5.5.

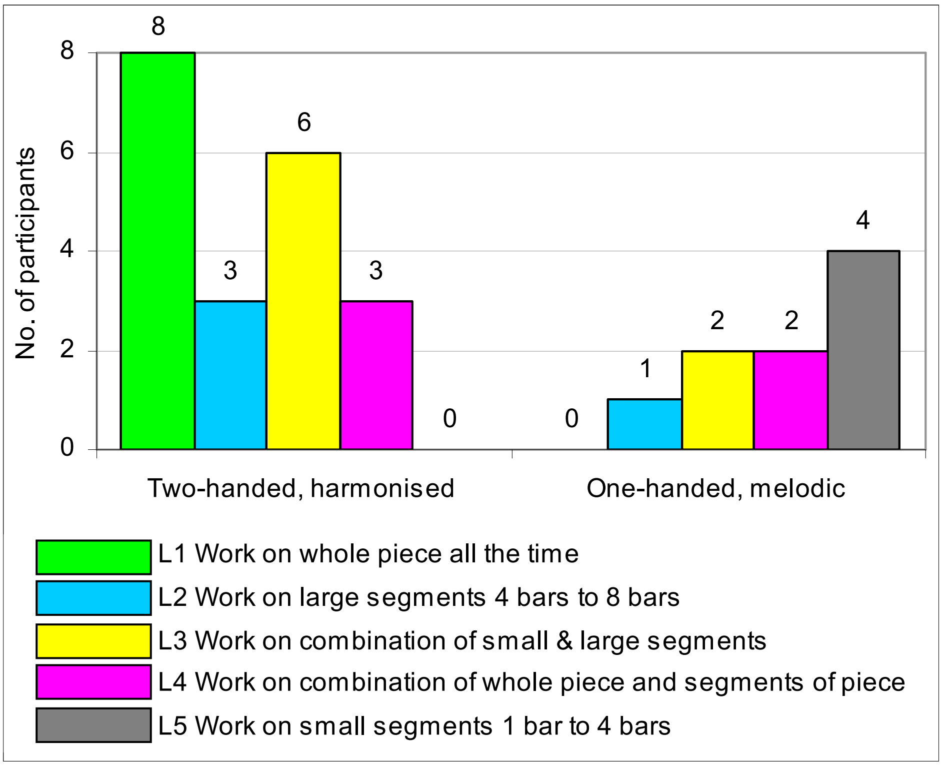

Figure 5.5 Distribution of learning techniques amongst participants, by manner of playing-by-ear ability

The handing techniques of participants presenting two-handed, harmonised playing by ear were examined next. These describe the manner in which they used hands-together and hands-separate methods to develop the fingering structures and hand positions they required to achieve a two-handed performance. Four handing techniques were identified and are presented in Table 5.5.

Table 5.5 Handing techniques observed amongst participants presenting two-handed, harmonised playing by ear

Handing technique	No. of participants ($n = 20$)
H1 Hands-together from start	4
H2 Right-hand then hands-together	10
H3 Left-hand then hands-together	2
H4 Mix of hands-separate & hands-together	4

It appears that many participants demonstrated the right-hand then hands-together technique (H2). However, as Figure 5.6 below illustrates, although technique H2 was observed across all groups, four participants in group one demonstrated the hands-together from start technique (H1) that was not evident amongst groups two and three. Fisher Exact tests indicated a significant difference in the handing techniques between groups one and three, $p = .050$, $n = 13$, and between group one and groups two and three combined, $p = .008$, $n = 20$.

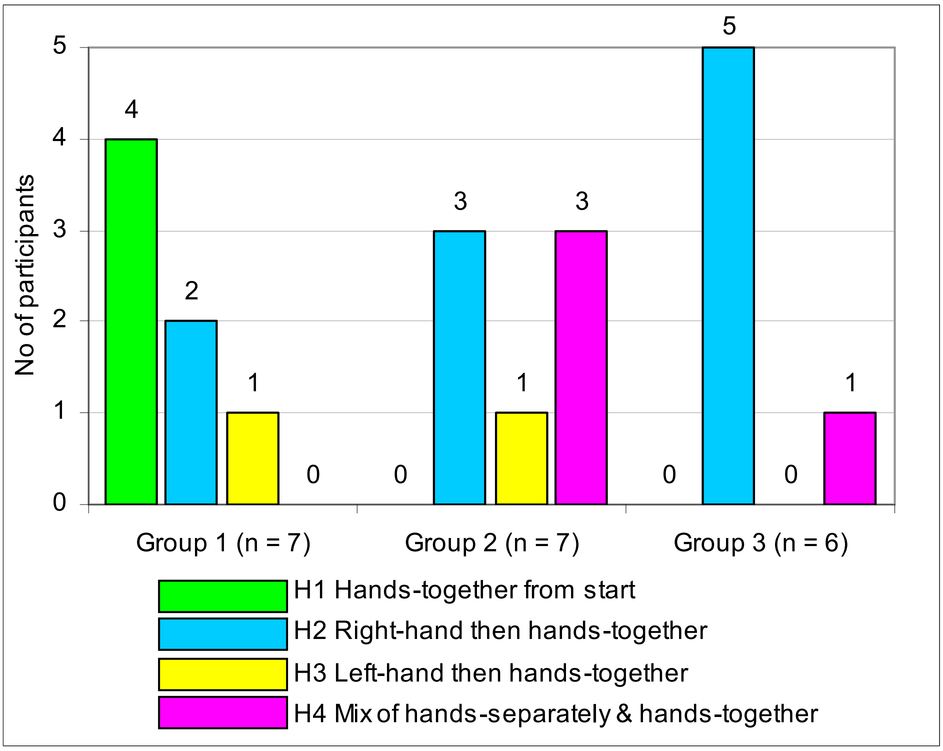

Figure 5.6 Distribution of handing techniques amongst participants presenting two-handed, harmonised playing by ear, by group

The concept of playing the piano by ear carries an expectation that an element of harmonic accompaniment will be provided alongside the melody, and five accompanying techniques were observed. These describe the way in which participants presenting two-handed, harmonised playing by ear combined the melodic and harmonic aspects of the music, and are presented in Table 5.6.

Table 5.6 Accompanying techniques observed amongst participants presenting two-handed, harmonised playing by ear

Accompanying technique	No. of participants (*n = 20)*
A1 Stylistically harmonised from start	4
A2 Melody, then bass notes, then stylistically harmonised	5
A3 Melody, then chords added	6
A4 Melody, then bass notes, then chords	3
A5 Bass notes or chords, then melody with stylistic harmony	2

It was evident that the majority of participants demonstrated an approach that allowed them to reproduce the melody before the harmony (A2, A3 and A4). However, as Figure 5.7 below demonstrates, the only participants who applied stylistic harmony to the melody from the start of the preparation period (A1) were amongst those in group one. Fisher Exact tests indicated a significant difference in accompanying techniques between groups one and three, $p = .002$, $n = 13$, and between group one and groups two and three combined, $p = .005$, $n = 20$.

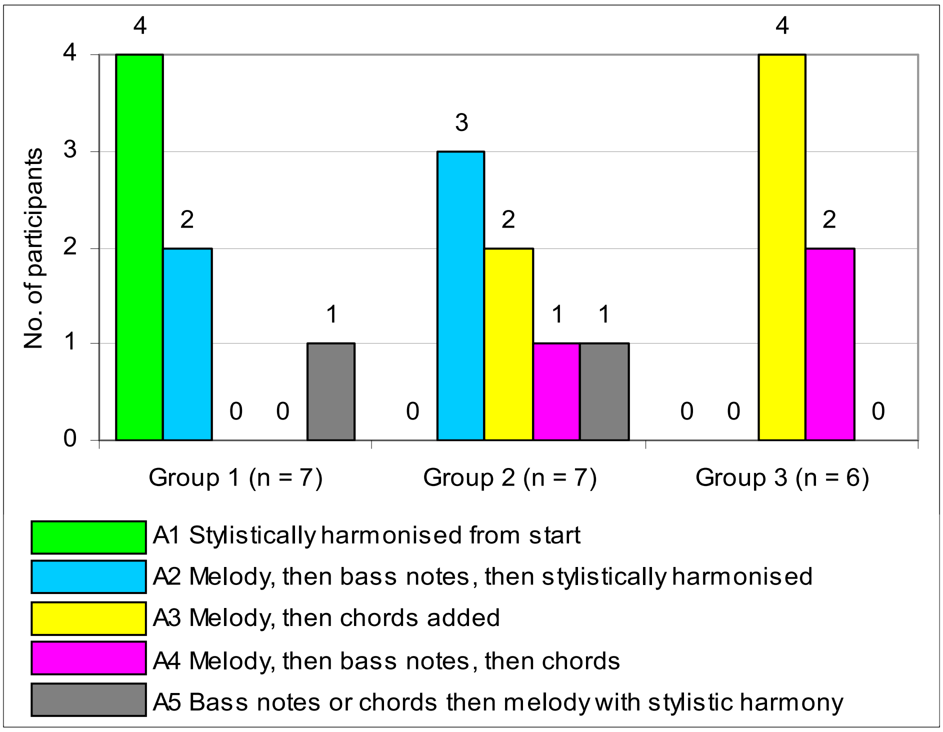

Figure 5.7 Distribution of accompanying techniques amongst participants presenting two-handed, harmonised playing by ear, by group

The practical techniques demonstrated by participants presenting two-handed, harmonised playing by ear were then compared according to their belief in their ability to play by ear. However, Fisher Exact tests indicated no statistically significant difference in learning techniques, handing techniques, or accompanying techniques between participants who believe they are able to play by ear and those who do not.

Participants in group four, all of whom presented one-handed, melodic playing by ear, used their right hand to play the melody. Additionally, three participants made very occasional attempts to use their left hand to facilitate some accompanying during the preparation period, although these attempts were unsuccessful. However, these three participants nevertheless presented one-handed, melodic by-ear realisations during the BEAT test and were, therefore, assigned to group four.

5.6 Discussion

This examination set out first to identify the preparation strategies adopted and practical techniques demonstrated by participants when preparing familiar music for playing by ear, and then to consider each of these in the context of participants' manner of playing by ear, and their level of playing-by-ear ability. It also sought to begin to identify the cognitive-psychological factors underlying playing-by-ear ability.

5.6.1 Preparation strategies

On the basis that playing by ear does not benefit from notation for information, it seems likely that the process of preparing a piece of music for by-ear realisation, whether familiar or not, would begin with listening. In an interview study of the learning practices of popular musicians, Green (2002) asserts that these musicians begin learning music by ear by first listening to it through without playing along with a recording. Additionally Green, along with Campbell (1995) and Johansson (2004), shows that popular musicians continue their learning by listening and playing along, although none of these studies presents observational evidence to support these assertions. Participants in the present study mainly began their preparation time by listening to the music, but contrary to Green (2002), the majority also attempted to play along with the recording during that first listen through, although this may have been because they were already familiar with the music. However, participants demonstrated consistency with the findings of Campbell (1995), Green (2002),and Johansson (2004) in using ‘listening and playing along with the recording’ as an ongoing practice strategy.

In the context of these preparation strategies, it would be reasonable to expect to find differences in approach amongst pianists according to: their belief in their ability to play by ear; the manner of their playing by ear; and their demonstrated level of by-ear ability. However, this not the case amongst participants in the BEAT Study, suggesting first of all that that prior belief in the ability to play by ear does not influence the way in which pianists approach preparing music for by-ear realisation. In addition, the approaches adopted impact neither on the musical standard of the culminating realisation, nor on whether it is two-handed and harmonised, or otherwise. Whilst there is no apparent effect of participants’ preparation strategies on playing by ear, it is evident that the practical techniques they demonstrate in the context of those preparation strategies do impact on the playing by ear process.

5.6.2 Learning techniques

Participants were asked to prepare and perform familiar pieces of music by ear, and the learning techniques they demonstrated during the preparation period represented the ways in which they did or did not divide the music into segments for learning. Amongst participants presenting two-handed, harmonised playing by ear, all of those in group one worked on the whole piece, without dividing it into smaller segments. Additionally, a small number of participants in groups two and three also demonstrated this technique, either exclusively or in combination with other techniques, although they demonstrated lower levels playing-by-ear ability than those in group one. It is evident, therefore, that this technique does not guarantee a high level of by-ear performance. The remaining participants in groups two and three, and those in group four, divided the music into variably sized segments for learning. However, this technique did not enable these participants to present by-ear realisations that were commensurate with those of group one. Furthermore, participants in group four seemed unable to include the harmonic aspects of the music in their realisations.

In a study that examines the learning techniques of trained pianists, Rubin-Rabson (1940b) observes that the quality of performances of short pieces (eight bars) memorised from notation remains the same whether the phrases are learned as whole structures, or divided into smaller learning segments. From this she infers that the division of longer pieces of music into segments for memorisation or learning does not violate the performance outcome. The pieces used in the BEAT Study were relatively short (with no piece exceeding a duration of 17 bars) but it is evident from the Strategy Study observations that higher levels of by-ear performance are likely to be achieved by working on the whole piece, whilst dividing the piece into learning segments leads to a less successful performance. This finding contradicts Rubin-Rabson's assertion but reflects the observations of Gruson (1988), whose examination of the rehearsal skills of trained pianists indicates that more experienced pianists are more likely to repeat sections of the music, whilst those who are less experienced tend to repeat individual notes. It is, of course, impossible to speculate whether participants demonstrating the highest levels of playing-by-ear ability would have achieved these levels if they had demonstrated the latter technique instead.

It is important to bear in mind that Rubin-Rabson's study was concerned with the memorisation of unfamiliar music from notation, and the learning techniques examined therein were facilitated by visual as well as aural stimuli. Similarly, Gruson's subjects were asked to learn from notation, through practice, an unfamiliar piece, although this did not require memorisation. Participants in the BEAT Study were asked to play familiar music that had been aurally encoded into long-term memory at some time prior to the study, without the benefit of notation and, consequently, the need to encode the music during the preparation period was avoided. Nevertheless, it was necessary for participants to recall that music during the preparation period, albeit directly from long-term memory, or by listening to the recording provided, and the learning techniques demonstrated by individuals appear to reflect their ability to accurately recall the rhythmic, melodic and harmonic aspects of the music. This implies that participants who worked on the whole piece may have the capacity to recall long segments of music, although those in group one appear to be capable of recalling them with more accuracy and detail than other participants who demonstrated this technique. It also suggests that participants in the remaining groups, who worked on smaller segments of the music, may not have the capacity to recall longer segments. Moreover, their ability to recall smaller segments with sufficient accuracy and detail appears to be demonstrably lower than the ability of participants in group one to recall longer segments. Finally, it is conceivable that participants in group four may have lower levels of recall, particularly in terms of the harmonic aspects of the music. This raises the question of how music is recalled from long-term memory.

It is thought that incoming sensory data are encoded through the grouping of individual events into chunks. The number of events in a chunk is thought to be seven (plus or minus two), representing the number of events that can be simultaneously held in short-term/working memory (Miller, 1956; Simon, 1974). In memory for music, individual events, such as rhythm, pitch, tempo and dynamics, group together to form chunks that represent meaningful musical structures (Snyder, 2000). Furthermore, chunks that are associated with one another cluster hierarchically (with chunks containing chunks) to form higher level chunks representing, for example, musical phrases. This process increases the number of events that can be simultaneously processed in short-term/working memory (ibid.). Finally, chunks are stored in long-term memory as mental representations of longer musical structures, and retrieved serially to short-term/working memory during recall, where one chunk cues the next as the detailed musical structure is recalled (ibid.).

If, as Snyder suggests, a musical phrase constitutes a chunk in memory, it is necessary to bear two points in mind:

- The number of events in a chunk could be as few as five, but may be as many as nine;
- The theoretical number of events within a hierarchically-clustered chunk increases exponentially based on the number of events contained in the lowest-level chunks.

It is, therefore, possible that the ability to work on the whole piece, demonstrated by some participants in the BEAT Study, was the result of their ability to retrieve and process chunks that are longer and more hierarchically-complex, and contain a greater number of events, than those processed by their colleagues, who broke the music down. This suggests that there may be a relationship between musical recall memory, in the sense of recalling the cognitive elements of the music, and playing-by-ear ability, and this possibility is examined more fully in Chapters 6 and 7.

5.6.3 Handing techniques

Playing the piano, whether from notation or by ear, requires the delivery of hand and fingering movements that may be complex in nature, and pianists must spend time practising to develop proficiency and fluency in the use of these motor structures (Ericsson, Krampe, & Tesch-Romer, 1993). The handing techniques demonstrated by participants during the BEAT preparation period illustrate the manner in which they carried out this practice. The majority of those in group one played hands-together throughout their practice period. However, this is not to suggest that high standards of by-ear performance are only possible by practising hands-together, since the remaining participants in group one presented performances of a similarly high standard having practised hands-separately followed by hands-together. Conversely, the majority of participants in groups two and three also practised hands-separately followed by hands-together, but these participants were not able to achieve the same standard of by-ear performance as participants in group one. It is, therefore, evident that this latter technique does not necessarily guarantee a high standard of by-ear performance. Additionally, the remaining participants in groups two and three were observed interpolating periods of hands-separate practice between periods of hands-together practice but, similarly, this technique did not lead to a high standard of by-ear performance. Finally, the right-hand only technique demonstrated by the majority of participants in group four mainly resulted in a low level of melodic by-ear performance.

The literature on handing techniques in piano learning and practice suggests that a high standard of performance, from memory or otherwise, can be achieved: by practising hands-together exclusively (Brown, 1933); by first working on the hands-separately and gradually progressing to hands-together (Rubin-Rabson, 1939); or by a combination of the two (Rubin-Rabson, 1940a, 1940b). Furthermore, it is thought that hand movements in keyboarding are organised into a motor programme prior to movement execution (Shaffer, 1978). Trained pianists are thought to be capable of building up a library of motor structures in long-term memory, from the notated music they have played previously, and retrieve and transfer them to address the physical demands of the notation in other playing situations, such as sight-reading (Parncutt, Sloboda, & Clarke, 1999; Palmer & Meyer, 2000; Meyer & Palmer, 2003). Extrapolating from this, it is possible that the handing techniques demonstrated by participants in the BEAT Study may reflect their ability to retrieve and transfer previously-memorised motor structures and form them into an appropriate motor programme for realisation. Some participants are able to achieve this for both hands simultaneously and others are not. This would be consistent with Keele's (1968) theory that motor structures are stored in long-term memory and compiled into appropriate motor programmes prior to movement initiation. This aspect of motor memory is discussed in more detail in Chapter 6.

The majority of participants in the BEAT Study demonstrated hands-separate followed by hands-together techniques, or a combination of these, but achieved varying standards of by-ear performance as a result. This suggests that participants who achieved a higher standard of by-ear performance using these techniques may be more able to retrieve and transfer learned motor structures for use in novel situations than those demonstrating lower levels of by-ear performance. Additionally, for those demonstrating the hands-together technique, it is possible that they also have levels of retrieval and transfer technique that allow them to process two parts simultaneously. However, for those participants demonstrating right-hand only technique, although they may have varying levels of ability to retrieve right-hand structures, it is possible that they may not be sufficiently capable of retrieving left-hand structures to be able to include them without notation for guidance.

Bearing in mind that playing by ear does not benefit from notation, participants' actions in the playing-by-ear task were not facilitated or guided by a visual representation of the music. Furthermore, although participants in the BEAT Study were asked to play music with which they were already familiar, they had neither attempted to play it by ear previously, nor seen a notated version of it. Given that the music was orchestral, rather than played on the piano, this meant they had no prior knowledge of the pianistic motor structures that might be required in order to play their pieces. However, it is possible that these motor structures may, in fact, be multi-dimensionally integrated into the cognitive recall memory chunks discussed in the previous section (Gruson, 1988; Ockelford, 2007), and overall, just as with musical recall, this discussion infers a potential relationship between memory for motor structures and playing-by-ear ability. This is examined in more detail in Chapters 6 and 7.

5.6.4 Accompanying techniques

Harmonic accompaniment is a crucial component in playing the piano by ear and the ability to provide it is a distinguishing feature amongst participants in the BEAT Study. The accompanying techniques demonstrated by participants during their preparation period represent the manner in which they constructed a harmonised realisation of the music they were given. Amongst participants in group one the majority appeared able to construct a stylistically-harmonised version of the music from the start. This is not to suggest that this is the only accompanying technique that facilitates a high standard of by-ear performance, since the remaining participants in group one demonstrated similarly high standards of by-ear performance after having constructed the melody alone before adding harmony. However, the ability to include a harmonised accompaniment at the outset promotes the likelihood of a more spontaneous performance, on the basis that less time is required to construct the piece. Furthermore, the results of the BEAT Study indicate that those participants demonstrating the highest levels of playing-by-ear ability are also capable of the most spontaneous performances. The question is, how can some participants construct a fully harmonised piece whilst others appear to require a more step-by-step approach?

The immediately obvious answers to this question lie in the earlier parts of this discussion. Achieving a fully-harmonised realisation of music requires the ability to recall its melodic and harmonic configuration simultaneously, and retrieve and transfer suitable motor structures in order to form a motor programme, and it has been established that the reliance of these processes on memory capacity requires further investigation. Nevertheless, before a motor programme can be compiled, the musical configuration must be converted into a structure that represents both its form and its stylistic attributes, such as that represented by a musical score. However, the absence of notation means that the ability to formulate this representation is required. Moreover, in the context of the BEAT Study, the music to be played was based on an aural source that was orchestral, rather than pianistic in nature, meaning that decisions with regard to the pianistic nature of the stylistic structure was, literally, in the hands of the participant.

Sloboda (1976, 1985) suggests that trained pianists memorise stylistic structures whilst playing from notation, and that these mental representations are transferable from familiar music to novel music where stylistic attributes are similar, thereby making situations such as sight-reading more manageable. In view of this, it appears that participants in group one who created stylistically-harmonised realisations from the start of preparation may be more capable of retrieving those structures and applying them in situations where there is no visual stimulus.

The remaining participants in group one, and many of those in group two, demonstrated stylistic harmonisation only after first working on the melody and harmonic bass notes or chords. It is possible that these participants needed to recall the harmonic outline of the music before being able to retrieve the necessary stylistic structures. Amongst remaining participants, it may be that those in groups two and three, whose stylistic harmonisations are less complex, are less capable of retrieving stylistic structures. Finally, there is the possibility that participants in group four may be prevented from retrieving stylistic structures by their apparent inability to recall the harmonic aspects of the music, discussed above. Thus, this discussion implies the likelihood of a relationship between memory for mental representations of stylistic musical structures and playing-by-ear ability, and this too will be examined in Chapters 6 and 7.

5.7 Summary

The Strategy Study has examined the ways in which participants spent time preparing by-ear realisations for performance during the BEAT test. It was hypothesised that the preparation strategies adopted by participants presenting two-handed, harmonised realisations would differ from those adopted by participants whose realisations are one-handed melodies. However, the discussion demonstrates that the adopted strategies do not differ according to the manner of playing by ear. It was also theorised that the practical techniques exhibited by participants would differ according to their level of ability to play by ear, and this has been shown to be the case.

It is evident from the BEAT Study that participants exhibiting the highest levels of by-ear ability present realisations that are spontaneous, accurate and fluent. The Strategy Study has shown that to achieve this these participants have begun immediately to play along with a recording of a whole (short) piece; and employed a hands-together technique to create a fully harmonised and stylistically-complex realisation as they play. Conversely, participants who present the lowest levels of playing by ear take varying amounts of time to present performances that are inaccurate and lacking in fluency. Accordingly, these participants mainly require time playing along to segments of a piece, using one hand alone to create the melody before using hands-together to create a simple chordal accompaniment. Finally, participants who require substantial amounts of time to realise un-harmonised melodies that lack accuracy and fluency have been shown to use only their right hand to play along with small segments of that melody.

This discussion speculates that ability to present successful by-ear performances of familiar music may be reliant on a variety of recall, retrieval and transfer abilities, inferring the possibility that the underlying nature of the practical techniques demonstrated by participants may be rooted in abstract, or higher-order cognitive memory functions. It has already been established that playing by ear is playing from memory, and it seems that multiple memory processes may be in action when playing by ear takes place. Given that the performance of any music from memory requires a number of complex, sequential musical-memory skills (Palmer, 2005), it is reasonable to hypothesise that a combination of memory skills may be required in order for playing by ear to take place.

5.8 Moving forward

The main aim of the present thesis is to identify cognitive-psychological factors underlying the process of playing by ear, and establish the nature of their role in the playing-by-ear ability of trained pianists. Thus far it has: presented a definition of playing the piano by ear; demonstrated that a wide range of playing-by-ear ability exists amongst trained pianists; and identified the attributes and skills demonstrated by those who present two-handed, harmonised playing by ear at the highest level. The discussion in this chapter suggests that levels of skill in a number of memory processes may influence playing-by-ear ability. This leads to the hypothesis that memory may be a major cognitive-psychological factor in the playing by ear process. The following chapters consider this hypothesis and put it to the test.

6. Musical Memory – An Overview

6.1 Introduction

The discussion in the previous chapter suggests that the learning, handing and accompanying techniques demonstrated by participants, whilst preparing music for by-ear realisation, are rooted in a number of individual memory processes. The present chapter, therefore, serves to contextualise the hypothesis that memory may have a salient role in the playing by ear process. It begins with an overview of existing theories of human memory, and continues with theories of auditory-musical memory, memory for mental representations of musical structures, and memory for motor learning. The discussion then turns to the process of memorising music for performance in the context of music learned and memorised from notation. Finally, the memorisation of music for playing by ear is considered in the light of these memory processes, and a theoretical model representing the cognitive-psychological process underlying playing the piano by ear is proposed.

6.2 Human memory

Theories of human memory suggest it is a developmental process that contains three elements: sensory memory, short-term/working memory, and long-term memory. Sensory memory is thought to contain two distinct areas: iconic memory where incoming visual data are processed; and echoic memory where incoming sonic events are processed (Neisser, 1967). Incoming data may be transformed into categorical perceptual events that are distinguishable from one another, such as musical pitches (Snyder, 2000). When explicit/conscious memorisation takes place, these events are passed consciously to short-term/working memory where they are retained for output through rehearsal. Alternatively, incoming data may be immediately replaced with new incoming events and forgotten (Baddeley, 1990, 1997, 2004).

Control procedures and conscious events are processed in short-term/working memory (Atkinson & Shiffrin, 1968; Snyder, 2000). Control procedures include: the processing of data for immediate response; the rehearsal/encoding of data for long-term memory storage; and the formation of strategies for retrieving data from long-term memory storage (Atkinson & Shiffrin, 1968). Short-term/working memory is thought to contain a "central executive" (Baddeley, 1997, p. 52), which serves as a control system for sensory information, and within this there are three slave storage systems. The “visuo-spatial sketchpad” (ibid.) is where visual and spatial information are processed, and the “phonological loop” (ibid.) processes auditory information and acts as a store for sequential sound data. The third slave system, the “episodic buffer” (Baddeley, 2000, p. 417), acts as a temporary storage area where information from the other slave systems is integrated multi-dimensionally (Baddeley, 2000, 2004). It also facilitates the transfer of information to and from long-term memory and is thought to be an area of conscious awareness (Baddeley, 2003). Events passed consciously from sensory memory to short-term/working memory are chunked into groups of events (Miller, 1956; Simon, 1974). These chunks are then either passed to long-term memory, where they form schemata or mental representations of longer events (Snyder, 2000), or else they are forgotten (Atkinson & Shiffrin, 1968; Snyder, 2000). (See Chapter 5, page 123 for a fuller description of chunking in short-term/working memory.)

Conversely, when implicit/subconscious memorisation takes place, events that have been processed in sensory memory pass directly and subconsciously to long-term memory for storage (Snyder, 2000). This type of memorisation represents the acquisition of knowledge without intention, such as language, and the kinds of over-learned sequences of actions that are carried out automatically, but may be difficult to articulate verbally (Cleeremans, Destrebecqz, & Boyer, 1998; Robertson & Pascual-Leone, 2003) .

Long-term memory is where new memories are formed, on the basis of previous experience, and stored for recall to short-term/working memory for output, even after long periods of time (Baddeley, 1990, 1997, 2004). It comprises two memory stores, the first being implicit/procedural memory, where knowledge of how to carry out tasks is stored (Cleeremans, et al., 1998). The second is explicit/declarative memory, which is itself divided into two areas: episodic memory, where knowledge of personal experiences and past events are stored; and semantic/conceptual memory, where knowledge of factual events that are stored (Tulving, 1993).

Figure 6.1 presents a schematic diagram that summarises the theoretical structure of human memory discussed here, and indicates the flow of data between the three areas of memory.

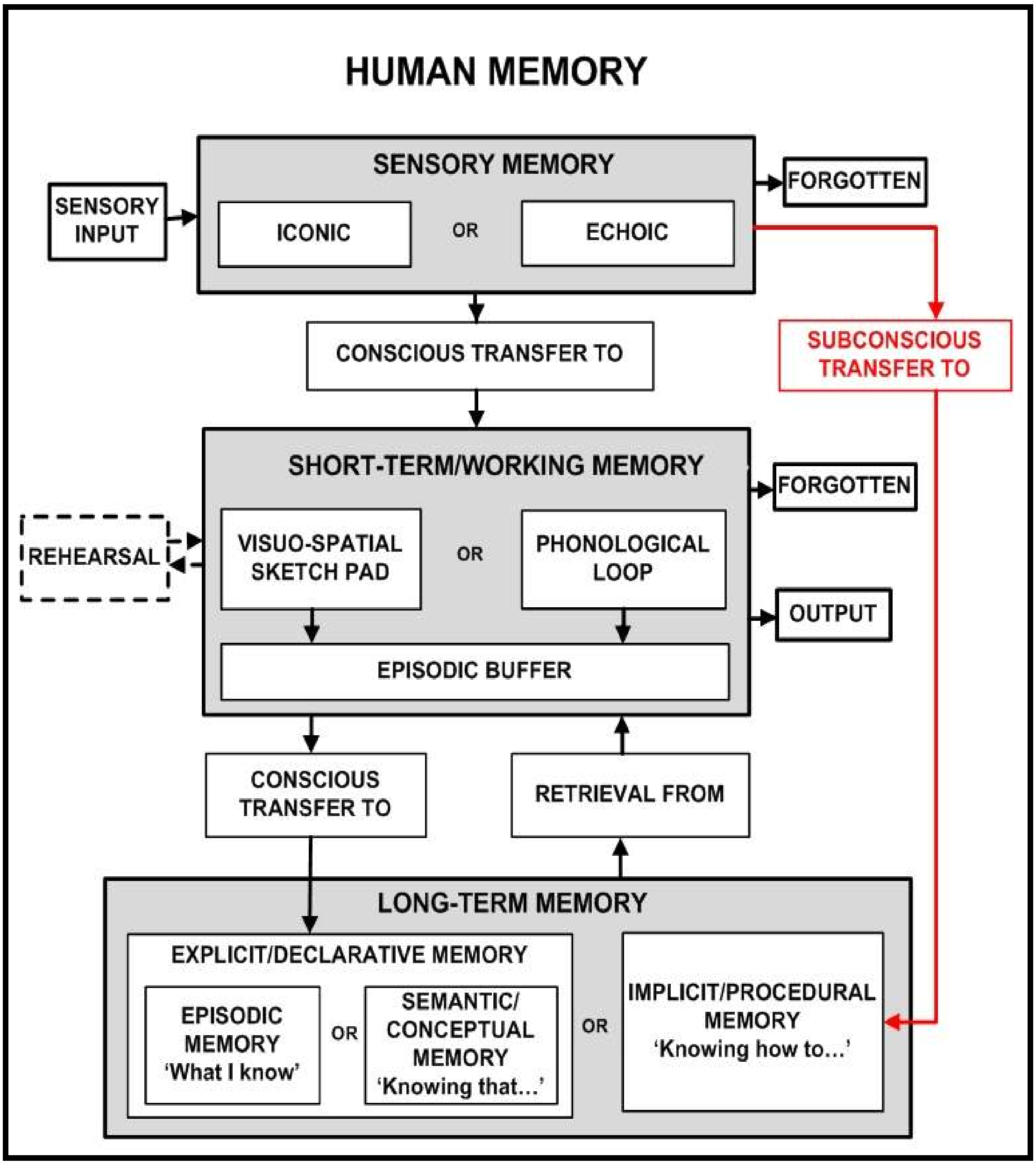

Figure 6.1 Schematic diagram of the theoretical structure of human memory

6.3 Auditory-musical memory

There are a number of differing theories of auditory-musical memory that are in some way based on the theories of human memory discussed in section 6.2 above.

6.3.1 Snyder (2000)

Snyder's (2000) theoretical model infers that, alongside the functional processes of sensory memory, short-term/working memory, and long-term memory, there are three corresponding levels of temporal musical organisation: "event fusion level" (Snyder, 2000, p. 27); melodic and rhythmic level; and formal level respectively. At event fusion level, highly rapid acoustic vibration events within one musical element (for example pitch) are consolidated into single, recognisable events. These events are then stored at the melodic and rhythmic level through the formation of musical phrases via chunking. The length and structure of these phrases is limited by the capacity of short-term/working memory to hold them in the present. Finally, it is at the formal level where musical structures such as movements, sections and whole works are encoded. These are structures that have too great a time scale to be preserved in conscious awareness in their entirety. Semantic schemata, or mental representations, of these musical structures are compiled via rehearsal through short-term/working memory. Incoming data are compared with existing schemata held in long-term memory that have been formed from previous experiences (Schulkind, 2002; Dalla Bella, Peretz, & Anonoff, 2003). This facilitates the recognition of whole musical structures, and the individual elements contained therein. Where the incoming data are novel, assimilation with existing schemata allows the formation of new ones that are then stored in long-term memory. The flexible transfer of individual elements between existing schemata allows them to be matched for use in different musical situations. Chunking allows the recall of these large scale structures for the purpose of memorised musical performance, where they are hierarchically recalled to short-term/working memory for conscious processing (Snyder, 2000).

6.3.2 Deutsch (1999)

Alongside Snyder's model are theories that consider how music is processed in short-term/working memory. Based on her own empirical research into memory impairment (see Deutsch, 1999 for a review), Deutsch advocates that short-term memory for music is a multi-faceted, specialised system (Deutsch & Feroe, 1975; Deutsch, 1972, 1999) within which sub-systems exist that contain values for musical elements such as pitch, duration, interval size and loudness. Each of these sub-systems is itself sub-divided: the pitch sub-system comprises memory for absolute pitch and memory for pitch relationships; the duration subsystem contains memory for absolute duration and memory for durational/temporal relationships; the sub-system for interval recognition consists of memory for melodic/sequential intervals and their attributes, and memory for harmonic/simultaneous intervals and their attributes; and so on. Incoming musical data are stored in parallel in these sub-systems and their respective sub-divisions, and re-combined during the retrieval process. However, the quality of the information retrieved depends on the amount of elapsed time between input and retrieval (Deutsch, 1999).

6.3.3 Berz (1995)

An alternative theory of short-term/working memory for music is presented by Berz (1995). This theory suggests that although music is auditory data, it cannot be processed via Baddeley's (Baddeley, 1990, 1997) phonological loop. Instead Berz proposes the existence of a "music memory loop" (Berz, 1995, p. 362) that sits alongside the other slave storage systems within Baddeley's central executive. Sequential musical data are processed within the music memory loop prior to being encoded into long-term memory. The data are then integrated with other musical data already stored therein to compile schemata/mental representations based on previous experience (Berz, 1995). This hypothesis is rooted on the assumption that music is memorised in a manner that differs from speech, and Berz provides evidence to support both this assumption, and his hypothesis, via a review of relevant literature (see Berz, 1995).

6.3.4 Ockelford (2007)

A more recent theory that seeks to extend those of Baddeley and Berz, suggests the presence of a dedicated music module that spans short-term/working and long-term memory. Ockelford's (2007) hypothesis, which is based on evidence provided by his investigation into the musical memory skills of a musical savant (see Ockelford, 2007), proposes a "musical executive" (p. 28) which takes the form of a hierarchical, domain-specific controller that exercises control over two stores of data: the "short term memory music bundle" (p. 27) and the "long term memory music bundle" (p. 30). The musical executive has two forms of input. The first is the novel incoming auditory data that take the form of "fragments and attributes from various locations in the original piece, of varying lengths, types and degrees of abstraction" (p. 26). These data are stored in the short-term memory music bundle. The second form of input is existing schematic data that have been previously stored in the long-term memory music bundle. The role of the musical executive is to select multidimensional stylistic elements from existing schemata, modify them appropriately, and synthesise them with the novel data to form mental representations that make musical sense. Additionally, information from existing schemata may be used to fill in the gaps caused by the limits of short term memory. Finally, there are two forms of output: the mental representation itself, and the motor programme required to execute it (Ockelford, 2007).

6.3.5 Summary

This discussion exemplifies four theoretical models of auditory-musical memory: Berz (1995), Deutsch (1999), Snyder (2000) and Ockelford (2007). Figure 6.2 below summarises these models in a composite schematic diagram that superimposes them on to the model of human memory presented on page 131 (Figure 6.1). The diagram indicates the directional flow of data between the different areas of auditory-musical memory, and illustrates where the models of Deutsch, Berz and Ockelford sit in terms of Snyder's overall theoretical structure.

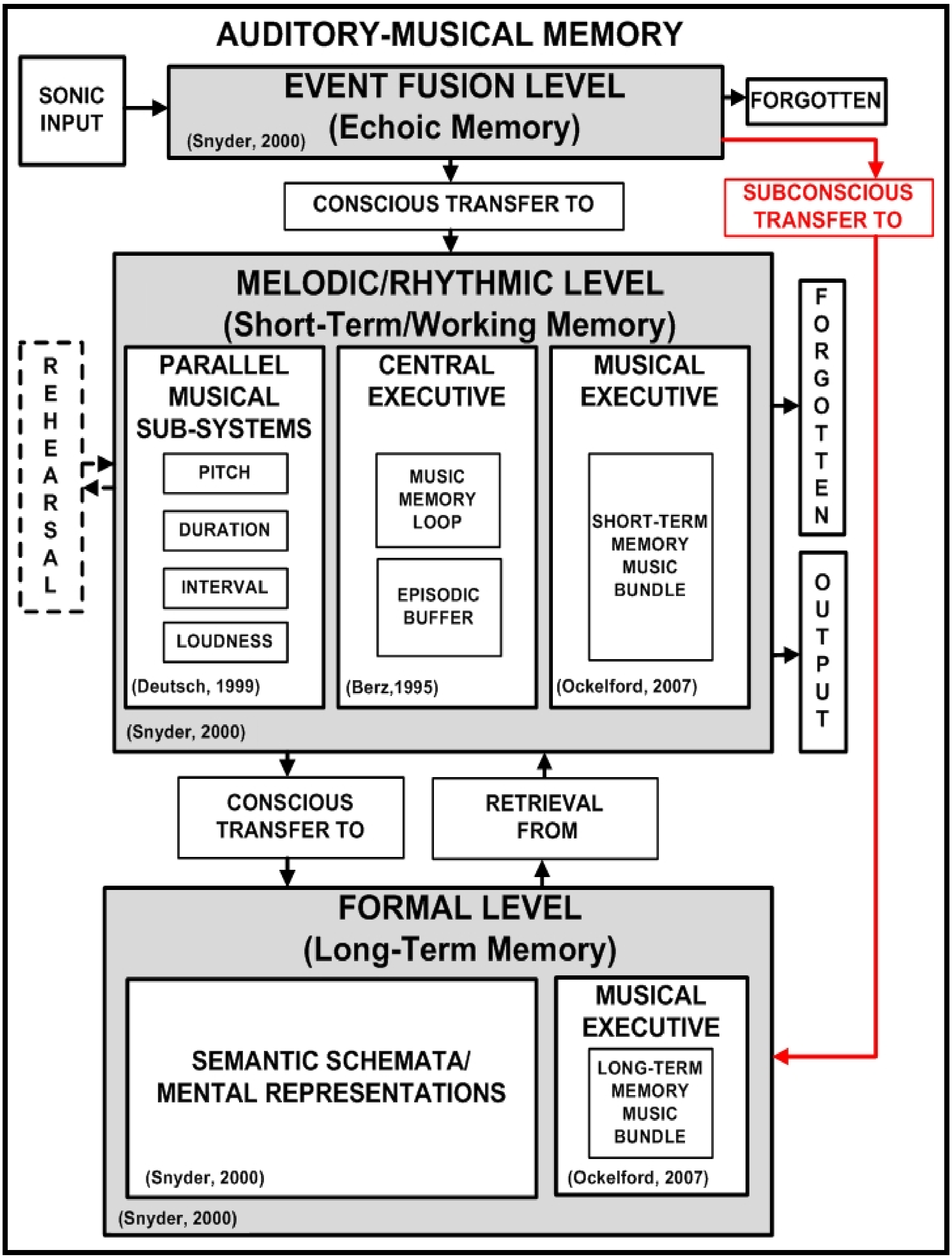

Figure 6.2 Composite schematic diagram of the alternative theoretical models of musical memory

Overall, this section has examined the structure and function of auditory-musical memory in the context of human memory and gives an insight into the manner of musical encoding, recognition and recall. It is evident from the discussion that the formation of mental representations of the overall structure of music is an important element within the theoretical models presented. The following two sections examine theories that consider the manner in which mental representations of the types of stylistic musical structures found in notated music, and their associated motor structures may be encoded into long-term memory.

6.4 Memory for mental representations of musical structures

It is theorised that trained musicians develop a library of mental representations of musical structures in long-term memory (Sloboda, 1976, 1985). This is formed through the sub-conscious memorisation of musical structures, such as an alberti bass or scalic passage, from notation, during practice (see also Hallam, 1997). These structures are thought to be encoded as 'music', that is in the context of rhythmic, melodic and harmonic rules, rather than simply as visual patterns (Sloboda, 1985; see also Halpern & Bower, 1982). According to this theory, encoded structures are linearly retrieved from long-term memory in response to visual cues provided by novel notation in situations such as sight-reading. This leads to the formation of what Sloboda calls a "structurally based representation of the music" (1985, p. 89) in the mind to which expressive variation is then applied. A motor programme for realisation is then constructed from the mental structural representation (Sloboda, 1985).

Clarke (1988) considers memory for mental representations of musical structures in the context of memorising music for performance. He presents a theory that reflects Snyder's (2000) theoretical model of musical memory (see this chapter, page 131) and also Schmidt's (1975) schema-theory of motor learning (see this chapter, page 138), and demonstrates how these combine when musical performance from memory takes place. Clarke suggests that musical structures encoded from notation form hierarchical mental representations or "generative structures" (Clarke, 1988, p. 4) of entire pieces that also include elements of expressive variation. These generative structures then drive the motor programmes necessary for realisation. However, given the considerable length of some pieces of music, it is thought unlikely that a fully-formed generative structure could be active in memory in its entirety throughout a memorised performance. Instead activation takes place as the music progresses, where low levels of the structure are active within individual phrases, but higher levels become active when phrase or section boundaries are approaching. At this point, knowledge of the relationships between previous and following phrases is required along with their relationship to the structure as a whole (Clarke, 1988).

The theories of Sloboda and Clarke suggest that mental representations of musical structures are necessary for musical performance to take place. However, it is evident that the physical realisation of music on an instrument also has a motor requirement. The next section, therefore, considers theories of motor memory and motor learning.

6.5 Motor memory and motor learning

There would seem to be no specific theories indicating the overall process and structure of motor memory. There is, however, evidence to suggest that kinaesthetic data may be processed independently from other sensory data in short-term/working memory (Posner & Konick, 1966; Posner, 1967), and that motor control data require physical reinforcement in order to stabilise (Adams & Dijkstra, 1966). Conversely, ideomotor theory (Koch, Keller, & Prinz, 2004; Drost, Rieger, Brass, Gunter, & Prinz, 2005; Shin, Proctor, & Capaldi, 2010; Herwig & Waszak, 2012), suggests that "actors select and initiate voluntary actions by activating an anticipatory 'image' of the movement's intended effects, which then triggers execution of the associated movement itself" (Koch, et al., 2004, p. 363). This theory implies that the perception of an action in the mind directly stimulates the previously memorised motor responses required to execute it.

Rosenbaum (1991) anecdotally infers that long-term memory for motor control is "especially resistant to forgetting" (p. 103), and it is thought that self-selected positioning movements are encoded more effectively than those that have been manipulated by external forces (Kelso & Stelmach, 1976, cited in Rosenbaum, 1991). Furthermore, it is thought likely that movements are encoded in terms of the location of a limb at the termination of a movement, rather than in terms of the distance travelled by the limb to that location (Laabs, 1973). Finally, and from a more psychological perspective, it is thought that mental representations of musical-motor structures, in the form of fingering and handing patterns, may be encoded and stored in long-term memory independently from other sequential musical information (Parncutt, et al., 1999; Palmer & Meyer, 2000; Meyer & Palmer, 2003).

There are also number of theories of motor learning that feature the concept of a motor programme. One theory postulates the closed-loop learning system

(Adams, 1971 cited in Adams, 1987), where movement is initiated by a brief motor programme, or “memory trace” (Adams, 1987, p. 59), that selects an appropriate response to a motor command. Perceptual feedback from that response then compiles a “perceptual trace” (ibid., p. 58) in memory that represents the correct movement, based on prior experience (Newall, 1991). However, it is also suggested that rapid motoric activity, such as playing the piano, is unlikely to be achieved through response to sensory feedback for each individual keystroke (Rosenbaum, 1991) .

An alternative theory asserts an open-loop motor learning system (Keele, 1968), where sensory input is converted into motor commands that are remembered even where the movement is uninitiated. These commands are compiled into motor programmes, prior to movement initiation, where individual motor programmes facilitate the progression of entire movement sequences without the need for peripheral feedback (Keele, 1968). This type of motor programme is thought to include not only the serial order of the motor commands, but also the prosodic or dynamic qualities such as stresses or accents (Shaffer, 1978).

By way of developing these theories, Schmidt (1975) proposes a schema theory of motor learning. Here, generalised motor programmes (schemata) for different classes of movement, based on previous experience, are stored in long-term memory. Specific movement parameters are then applied to these, according to individual movement requirements, to provide a more detailed and specific motor programme, prior to movement initiation. Overall, Rosenbaum (1991) defines a motor programme as “a functional state that allows particular movements, or classes of movements, to occur” (p. 109).

Finally, the theories of Rosenbaum and colleagues go some way towards combining theories of motor memory and motor control discussed here. Rosenbaum, Kenny and Derr (1983) propose that sequential finger presses on a keyboard, such as during piano playing, are controlled by a motor programme that is both hierarchically structured and hierarchically executed via a “tree-traversal process” (p. 87). Here, low-level movement elements are processed in a limited capacity “motor output buffer” (Rosenbaum, 1991, p. 110) in short-term/working memory. These movements are then facilitated by higher-level control elements retrieved from long-term memory storage (Rosenbaum, 1991).

The sections in this chapter thus far have discussed human memory and three different types of memory processes within it. The following section considers how these three memory processes come together when music is memorised for performance.

6.6 Memorising music for performance

Conventional Western musical notation is a visuo-spatial representation of the sound of the music that contains precise pitch, temporal and structural data and, in some cases, motor data in the form of handings and fingerings. When novel music is sight-read, and then learned via practice using notation, the playing is facilitated by the detailed visuo-spatial data provided therein, and the aural feedback data that physical realisation provides. Furthermore, as long as the notation is available, there is no requirement to explicitly retain the visuo-spatial and aural data in long-term memory. However, musicians are thought to be able to memorise music implicitly, where visuo-spatial and aural data are encoded sub-consciously via repeated practice during the learning process (Hallam, 1997).

Explicitly memorising music from notation requires the use of auditory, visuo-spatial, motor (Hughes, 1915; Hallam, 1997) and structural (Clarke, 1988) memory. At the highest level many musicians demonstrate a form of expert memory (Ericsson & Kintsch, 1995) that is believed to be developed through experience and practice (Chaffin, 2007; Chaffin & Imreh, 1997, 2002; see also Chase & Simon, 1973), and is analogous to that observed in other domains such as chess (see, for example, Knecht, 2003). Ericsson and Kintsch (1995) propose a model of expert memory that contains three stages:

- The encoding of novel material in a meaningful way, based on existing knowledge;
- The identification of a formal structure and the formation of an efficient retrieval structure based on it;
- The rapid retrieval of information from long-term memory.

When music is memorised from notation, the visuo-spatial and aural data contained therein facilitate all three stages of this process:

- The formation of a mental representation of the aural and visuo-spatial elements of the music, encoded in the light of existing knowledge of musical structures (Snyder, 2000);

- The development of that mental representation into a hierarchical, or generative, structural representation (Clarke, 1988) from which a system of hierarchical retrieval cues is created, that expedites recall of the music during performance (Chaffin, 2007; Chaffin & Imreh, 2002, 1997; Noice, et al., 2008);
- The formation of a motor programme for physical realisation of the music based on those retrieval cues (Chaffin, 2007).

Overall, it is unlikely that explicit memorisation of a piece of music would take place unless the music had already been learned, and could be played to a reasonable standard whilst using notation. It is, therefore, apparent that memorisation forms the final element in the process of learning and preparing music from notation for performance from memory.

Having scrutinised how musical notation is encoded prior to performance from memory, the process of encoding music from an auditory source for by-ear realisation is now considered.

6.7 Towards a model of playing by ear

The absence of notation from the playing-by-ear process means that memorisation of music to be played must be the first element in the preparation of music for playing by ear. Furthermore, memorisation relies entirely on aural data received from an external source and does not benefit from the aural feedback that physical realisation from notation provides. Encoding of the music may be active, via music being specifically attended to; or passive, via music encountered in everyday life (Saffran, Johnson, Aslin, & Newport, 1999). It is, however, thought that most people are capable of actively or passively memorising music they have heard (Halpern, 1984). Furthermore, with regard to the ability to recognise music previously memorised, there is evidence to suggest that aural encoding of music occurs with a high degree of accuracy, even amongst those who have not had the benefit of musical training (see Madsen & Staum, 1983; Madsen & Madsen, 2002).

Of course, playing by ear cannot take place unless the memorised music can be recalled. Once again, it has been shown that most people have the capacity to recall music they have memorised (Halpern, 1984), although the level of overall accuracy of that recall may depend on the musical expertise of the listener (Sloboda & Parker, 1985). Furthermore, those with musical training are thought to be able to process the harmonic aspects of the music more effectively than those who are untrained (Bigand, Madurell, Tillmann, & Pineau, 1999).

Extrapolating from this, it seems likely that trained pianists would be able to accurately memorise music from an aural source and recall it with varying degrees of accuracy. However, despite the fact that aural encoding does not provide visuo-spatial detail of musical and motor structures, a by-ear pianist must nevertheless be able to form a motor programme for physical realisation of the music. At first glance, the concept of ideomotor theory, discussed earlier in this chapter, appears to provide some explanation for this process. Indeed, there is some evidence to suggest that, amongst expert pianists, hearing a piano chord automatically stimulates the previously memorised motor response (fingering pattern) required to execute it (Drost, et al., 2005). However, whilst this theory may hold for the reproduction of simple piano sounds on a piano, where there is a direct relationship between the sounds heard and the motor actions required to play them, it does not explain how by-ear pianists are able reproduce other instrumental sounds, where there is no such direct relationship. This is particularly salient when the music to be played by ear on the piano is orchestral, as is required in the present project.

It seems, therefore, that where playing the piano by ear is concerned, the aural image of the music represented in the mind after recall requires the additional representation of the musical devices therein so that appropriate fingering choices can be made during the formation of the motor programme. Indeed, the theories of expert memory for music discussed in this chapter indicate the requirement to form a generative, structural representation of the music in the mind to facilitate the formation of a motor programme for its delivery as the realisation progresses. As such, this imposes an interim step into the process whereby a cognitive representation of the music's theoretical structure is created between the cognitive formation of the sound for action, and the action itself (cf. Schmidt, 1975; Sloboda, 1985; Clarke, 1988).

Given this discussion, it is reasonable to assume that the ability to give a two-handed, harmonised by-ear piano performance requires a pianist to be capable of: aurally recalling harmonised, multi-timbral music encoded from an auditory source; synthesizing that aural recall with both musical and motor structures already stored in long-term memory; and creating both the mental and motor representations necessary to physically realise the music on the piano in a two-handed manner. The assumption of underlying relationships between playing by ear and memory for auditory-musical recall, memory for mental representations of musical structures, and memory for musical-motor structures would seem to have a sound theoretical basis. Therefore, a theoretical model of the cognitive-psychological process of playing the piano by ear is proposed where these musical-memory skills combine sequentially to allow a by-ear realisation.

This model, which is presented schematically in Figure 6.3 below, has five sequential stages:

- Novel music is aurally encoded into long-term memory where an *aural representation* is formed in the light of previous experience and existing musical schemata. This encoding may be active or passive, occurring prior to playing by ear; or active, occurring concurrently with playing by ear;
- The aural representation is retrieved from long-term memory, using memory for auditory-musical recall, allowing an *aural image* of its sound to be formed in the conscious mind;
- Musical structures, retrieved from those previously encoded and stored in long-term memory using memory for mental representations of musical structures, are mentally synthesised with the aural image to form an *aural-structural representation* of the rhythmic, melodic, harmonic and temporal properties of the music;
- Motor structures, retrieved from those previously encoded and stored in long-term memory using memory for musical-motor structures, are mentally synthesised with the aural-structural representation to form a *motor programme*;
- The motor programme is used to facilitate a by-ear *realisation* on the piano.

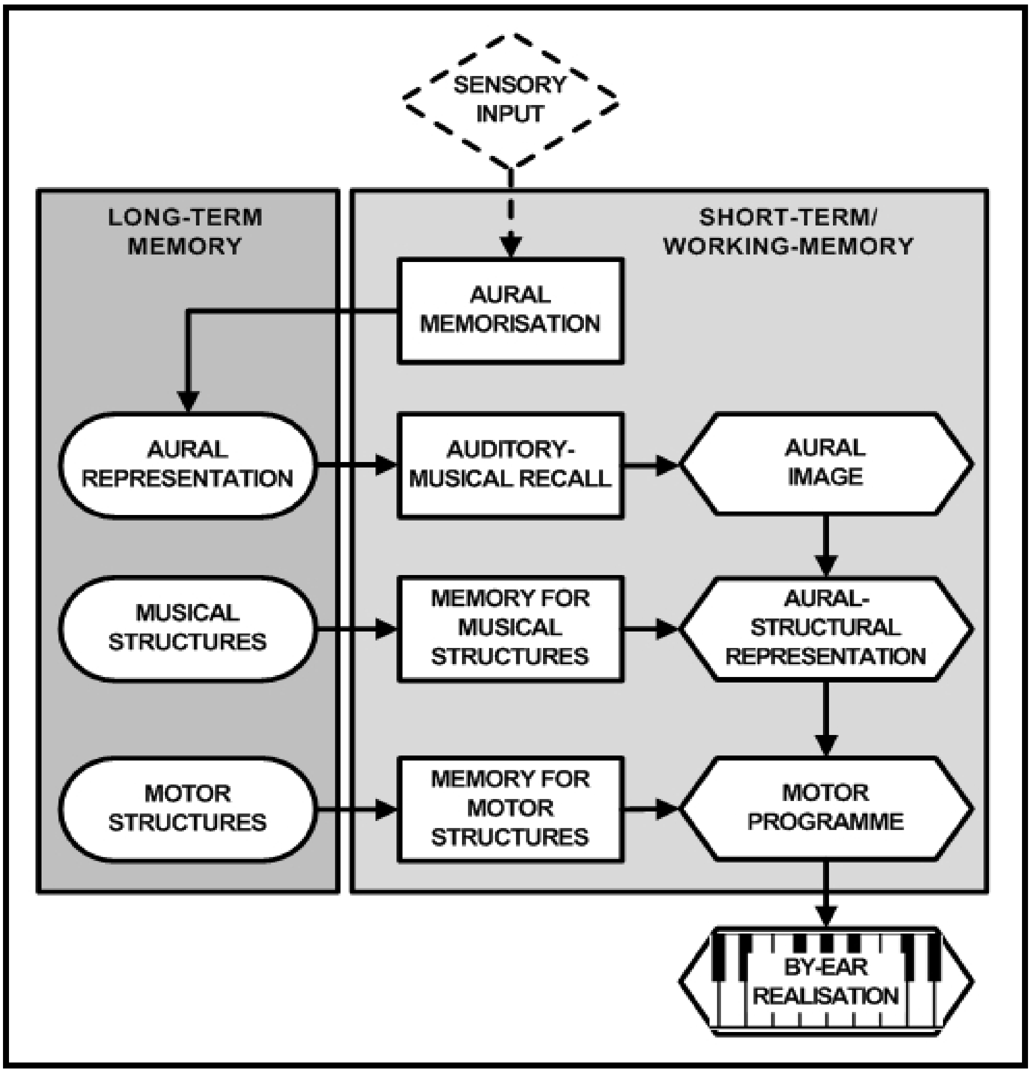

Figure 6.3 Schematic diagram of proposed model of the cognitive-psychological process of playing the piano by ear

Having theorised this model of playing by ear, the next stage in this research project was to establish its validity and, at the same time, evaluate the extent to which the aforementioned memory skills enable two-handed, harmonised by-ear realisations that are spontaneous and fluent. This is undertaken in Chapter 7.

7. The Role of Memory in Playing by Ear – The Memory Study

7.1 Introduction and rationale

Chapter 6 has presented a model of the cognitive-psychological process of playing the piano by ear (see page 143, Figure 6.3) that employs three sequential musical memory retrieval procedures: the retrieval of aural music from long-term memory using memory for auditory-musical recall (hereafter referred to as recall memory); the retrieval of musical structures from long-term memory using memory for mental representations of musical structures (structures memory); and the retrieval of motor structures from long-term memory using memory for musical-motor structures (motor memory). The model itself is derived from evidence presented in Chapter 5, where it is suggested that these memory processes may underlie the practical techniques demonstrated by participants when preparing by-ear realisations for performance during the BEAT test.

To examine the nature of the relationship between these three memory skills and playing by ear, it was necessary to design a suite of tests to measure their levels amongst the trained pianists who took part in the BEAT Study. The individual and collective influences of the memory skills could then be determined by comparing the results of each memory test with participants' levels of playing-by-ear ability as determined by the BEAT test. This would also allow the validity of the proposed cognitive-psychological model of playing by ear to be determined.

It is, however, evident that these three memory procedures form the second, third and fourth stages of the proposed model, the first stage being the encoding of novel musical sounds into long-term memory. As discussed in Chapter 3, participants in the BEAT Study were asked to realise familiar music for by-ear performance, that they had aurally encoded into long-term memory, either actively or passively, at some point in the past. Consequently, any strategies used to memorise that music were not observed in the context of the BEAT Study and, therefore, not discussed in Chapter 5. Nevertheless, to properly validate the proposed model an additional test for measuring the accuracy of participants' aural encoding was designed. This 'aural memorisation' test formed the initial element in the Memory Study.

This chapter continues with a statement of the study's objectives and hypotheses, and this is followed by four sections containing detailed descriptions of the methodological approaches to testing aural memorisation, recall memory, structures memory and motor memory respectively. These sections also include the results of the tests and, for recall memory, structures memory, and motor memory, a short discussion of those results in the context of the practical techniques discussed in Chapter 5. The following main analysis then compares the results of the memory tests with those of the BEAT test. Finally, the ensuing discussion focuses on the influence of these four memory skills on ability to play the piano by ear, and examines the playing-by-ear process in the light of the proposed cognitive-psychological model.

Note that the suitability, appropriateness and level of difficulty of all test materials used in the Memory Study were independently verified by two highly qualified pianists and piano teachers, neither of whom had been involved in the BEAT Study. The measures were then pre-tested by five volunteer pianists, none of whom took part in either the BEAT or Memory studies, but who fulfilled the criteria set out for taking part in the BEAT study (see Chapter 4). The measures were administered to these volunteers individually under identical conditions to those described in the sections below, and descriptive statistics for each pre-test are also presented in those sections. During both pre-testing and actual tests, participants' responses were recorded for assessment purposes using either a Sony ICD-UX60 Digital Voice Recorder, or a Samsung SMX-F300 camcorder, or both. Finally, marks for all assessments were converted to percentages so that they could be easily compared with one another, and with BEAT Study marks.

7.2 Objectives and hypotheses

The Memory Study has two main objectives:

- To determine the individual and collective influences of aural memorisation, recall memory, structures memory, and motor memory on the ability to play the piano by ear;
- To determine the validity of the proposed model of the cognitive-psychological process of playing by ear.

Based on these objectives, the following hypotheses are proposed:

- High levels of accurate aural memorisation will be observed across all participants;

- Two-handed, harmonised playing-by-ear ability will depend on levels of skill in recall memory, structures memory, and motor memory;
- Deficiency in any one of these three memory skills will either: inhibit spontaneity, leading to deductive two-handed, harmonised playing by ear; or else inhibit two-handed, harmonised playing by ear altogether.

7.3 Participants

To carry out the Memory Study the trained pianists who took part in the BEAT Study were approached and invited to take part in further tests. All 29 agreed to do so and a full participant profile can be found on page 85.

7.4 The aural memorisation test

Before music can be played without notation it must be memorised and, according to the proposed model, the process of playing by ear begins with the aural encoding of music into long-term memory. The discussion of auditory-musical memory in Chapter 6 describes a process where auditory input is compared with musical schemata therein (Schulkind, 2002; Dalla Bella, et al., 2003), and new schemata are created where data do not match those already existing (Snyder, 2000). Extrapolating from this, it is reasonable to surmise that if an existing schema has been encoded accurately, incoming data with the same blueprint would bring about an exact match meaning that recognition would occur and a new schema would not be formed.

In an attempt to measure how accurately participants in the BEAT Study were able to encode music aurally, a test was designed that required them to recognise and identify melodies they had already heard when those melodies were repeated in the context of other, similarly structured melodies. Recognising the repeated melody would demonstrate that their original encoding of the melody was accurate.

The test was modelled on a process developed by Madsen and Staum (1983) to measure the effects of interference caused by similarity in a musical recognition task. In their study, the authors required non-musician, adult participants to recognise melodies when similarly structured melodies were interpolated between the test melody and its repetition. They found that non-musicians demonstrated a high level of ability to recognise melody they had heard before, regardless of the amount of interference. In a similar study using the same methodology and materials, Madsen and Madsen (2002) observed a similarly high level of recognition ability amongst adult trained musicians, and children (aged 12 to 16 years) receiving musical tuition.

7.4.1 Preparation of materials

For the aural-memorisation test, four similarly structured melodies, with a simple-duple temporal structure, were composed in G major by the author. To create four similar sets of pieces, temporal, modal and temporal/modal variations were then derived from each melody, making a total of 16 pieces. The modal and temporal structure and format of each of the four pieces in each set are presented in Table 7.1, and scores for all 16 pieces can be found in Appendix 4.

Table 7.1 Summary of structure and format of composed melody and variations

Melody	Name	Key	Time	Format
Theme	Simple Major (SM1, 2 ,3 & 4)	G major	$\frac{2}{4}$	Four bars long; treble clef; range one octave.
Variation One	Compound Major (CM1, 2, 3 & 4)	G major	$\frac{6}{8}$	Identical melodic contour to 'SM'; rhythmic structure modified to reflect compound duple time.
Variation Two	Simple Minor (sm1, 2, 3 & 4)	G minor	$\frac{2}{4}$	Identical rhythmic structure to 'SM'; melodic contour modified to reflect minor key.
Variation Three	Compound Minor (cm1, 2, 3 & 4)	G minor	$\frac{6}{8}$	Identical rhythmic structure to 'CM'; identical melodic contour to 'sm'.

The pieces were compiled into ten listening trials for presentation to participants: eight test trials and two practice trials. Each trial comprised a sequence of five pieces: a test piece followed by four other pieces, one of which was a repetition of the test piece. Table 7.2 illustrates the serial positions of the test pieces amongst the interpolated pieces within the eight test trials and two practice trials. Each serial position was used twice for the repetition of the test piece across the eight test trials. The remaining pieces in each trial were arbitrarily selected from amongst all four sets of pieces and randomly interpolated into the remaining serial positions, with the condition that the test piece was the only piece to be repeated in any trial.

Table 7.2 Serial positions of test pieces amongst interpolated pieces for test and practice trials (bold items are the same as test pieces)

	Test Piece	Interpolated Pieces – Serial Positions			
Test Trials	**SM1**	**SM1**	sm2	CM3	cm4
	sm1	CM2	**sm1**	SM4	cm3
	CM1	sm4	cm2	**CM1**	SM3
	cm1	sm3	CM4	SM2	**cm1**
	SM2	sm1	cm3	CM4	**SM2**
	sm2	CM1	SM3	**sm2**	cm4
	CM2	sm3	**CM2**	SM4	**cm1**
	cm2	**cm2**	sm4	CM3	SM1
Practice Trials	**SM3**	cm1	CM2	**SM3**	sm2
	cm4	SM2	**cm4**	sm3	CM1

Trials were then randomly ordered for presentation to participants (see Table 7.3).

Table 7.3 Order of trial presentations (bold items are the same as test pieces)

Trial	Test Piece	Interpolated Pieces – Serial Positions			
Practice 1	**cm4**	SM2	**cm4**	sm3	CM1
Practice 2	**SM3**	cm1	CM2	**SM3**	sm2
1	**sm1**	CM2	**sm1**	SM4	cm3
2	**SM2**	sm1	cm3	CM4	**SM2**
3	**CM1**	sm4	cm2	**CM1**	SM3
4	**cm2**	**cm2**	sm4	CM3	SM1
5	**sm2**	CM1	SM3	**sm2**	cm4
6	**CM2**	sm3	**CM2**	SM4	cm1
7	**SM1**	**SM1**	sm2	CM3	cm4
8	**cm1**	sm3	CM4	SM2	**cm1**

To determine the appropriateness of the trials, the appointed independent verifiers compared them with those used by Madsen and Staum (1983) and Madsen and Madsen (2002), and found them to be of a similar standard. Recordings were then created for presentation to participants.

The pieces in each trial were played one after the other on a Roland XP10 multi-timbral synthesizer, with three seconds of silence interpolated between them. They were initially recorded via MIDI (Musical Instrument Digital Interface) using Cubase Essential 5 (available from www.steinberg.net) on a Dell Inspiron 2200 laptop. Simple-duple pieces were played at a speed of ♩ = 80 and compound duple pieces at a speed of ♩. = 80. Each compiled trial was then played back through the Dell laptop and recorded in mp3 digital audio encoding format using Audacity v1.2.4 (Bland, et al., 2004). Trial number announcements were also recorded in mp3 format using a Sony ICD-UX60 Digital Voice Recorder. Using Audacity, these were introduced to the beginning of each trial, and 10 seconds of silence was appended to the end of each trial. The trials were then compiled into a Windows Media Player 11 playlist, according to Table 7.3 above, and burnt to CD. Finally, an answer sheet was designed that would facilitate the recording of participants' responses to the test, a copy of which can be found following the scores in Appendix 4.

7.4.2 Procedure

Participants undertook the aural-memorisation test individually but in the presence of the author. They were informed that they were to be tested on their ability to recognise music they had heard previously. The listening trials were presented to participants via CD. For each trial they were required to listen to the test melody and then identify whether the following four melodies were 'identical to' or 'different from' the test melody. Reponses were recorded on the answer sheet provided by placing a ✓ for 'identical to' and a × for 'different from' in the appropriate boxes. Before the test began, participants were given full instructions and informed that it would last no longer than 10 minutes. It was made clear that they were free to withdraw themselves and their data at any time should they wish to do so, without giving a reason. Additionally, they were reminded that the consent form that they had completed during the BEAT Study was also valid for all four tests conducted during the Memory Study. They were then given the two practice trials to ensure that they were clear about what was required, and the eight test trials followed.

7.4.3 Coding and marking scheme

Participants' responses were marked and coded by the author. One mark was awarded for each correct identification in each trial yielding a maximum of four marks for each trial, and a maximum overall test mark of 32. Participants' marks were converted to percentages.

7.4.4 Pre-test results

The following pre-testing of the trials indicated that a range of marks was possible for aural memorisation, and although these were observed to be high, they were consistent with the findings of Madsen and Staum (1983) and Madsen and Madsen (2002) and were, therefore anticipated. Descriptive statistics for pre-test marks are presented in Table 7.4.

Table 7.4 Descriptive statistics for aural memorisation pre-test marks

Aural memorisation	*N*	Mean	Min	Max	Std. Dev.
Pre-test marks	5	78	63	100	16.07

7.4.5 Results and discussion

As anticipated in the light of pre-testing, the results of the memorisation test indicate that all participants are capable of high levels of melodic recognition (in terms of the similarity or difference between a test melody and other similarly structured melodies) and a ceiling effect was evident in the results. Descriptive statistics are presented in Table 7.5.

Table 7.5 Descriptive statistics for aural memorisation marks

	N	Mean	Min	Max	Std. Dev.
Aural memorisation marks	29	97.31	88	100	3.52

Nevertheless, and ceiling effect notwithstanding, these data demonstrate that all participants are capable of highly accurate encoding of aural-musical materials into long-term memory, and are consistent with the findings of Madsen and Staum (1983) and Madsen and Madsen (2002). A more detailed examination of the data, and the observed ceiling effect, is presented in section 7.8.

7.5 The recall memory test

The discussion in Chapter 5 observes that participants achieving the highest levels of playing by ear worked exclusively on the whole piece without breaking it down into learning segments. However, although other participants also demonstrated this technique, their by-ear realisations were less successful, as were those of participants who broke the music down into segments. These observations led to the assumption that the learning techniques demonstrated by participants represent the manner in which they recall the music when preparing their by-ear realisations, and the possibility of a relationship between playing-by-ear ability and recall memory was suggested.

In light of this, the second stage of the proposed model of playing by ear specifies that the encoded aural representation is recalled from long-term memory to form an aural image of the music in the 'mind's ear'. The next step in the Memory Study was, therefore, to measure participants' levels of recall memory.

If recall memory is to be demonstrated and measured, it is necessary to find a way to reproduce what is being recalled (Sloboda & Parker, 1985). From a musical perspective, one way of demonstrating this is to sing aloud the music that has been recalled. Indeed the 'listen-and-sing-back' paradigm has been, and remains, a significant element of the aural test section of the graded music examinations administered by the ABRSM. In this context, candidates are required to listen to musical phrases that have been played on the piano and use recall memory to facilitate singing them back. At the lowest level, candidates sing back two-bar phrases, progressing to short melodies as the grades advance. Higher grades then require candidates to sing back the upper or lower parts of a two-part texture and finally, at the highest level, they are required to sing back the lowest part of a three-part texture (see ABRSM, 2011).

Given this established use of the listen-and-sing-back paradigm, it was considered to be an appropriate method for measuring participants' levels of recall memory. However, it was observed that the ABRSM approach is predisposed to place all recall materials in the context of the piano timbre, regardless of the fact that music in the real world is not performed exclusively on the piano. Therefore in designing measures for use in the Memory Study, ecological validity was established by placing recall materials in the context of a variety of instrumental timbres that included the piano. Furthermore, the expectation that by-ear realisation on the piano will include a harmonised accompaniment imposed the necessity to measure harmonic as well as melodic recall. As a result, the design of recall-memory measures included opportunities to demonstrate recall of both upper and lower parts of two-part and four-part musical textures, as well as single line melodies.

7.5.1 Preparation of materials

Two sets of five, four-bar recall trials were created by the author using materials adapted from the four-part chorales of J.S. Bach (Riemenschneider, 1941). Details of time signature, key, timbre and number of textural parts for each trial piece are presented in Table 7.6. Where trial pieces contained more than one textural part, the same timbre was used for all parts. Scores for both sets of trials can be found in Appendix 5.

Table 7.6 Time signature, key, timbre and number of textural parts in each trial piece, in each set

Set	Trial	Time Sig	Key	BWV No.	Timbre	No. of parts
	One	$\frac{3}{4}$	G minor	187.7	Marimba	One
	Two	$\frac{4}{4}$	A minor	153.1	Flute	Two
One	Three	$\frac{4}{4}$	B♭ major	308	Mandolin	Two
	Four	$\frac{4}{4}$	G major	267	Violin	Four
	Five	$\frac{4}{4}$	F major	281	Piano	Four
	One	$\frac{4}{4}$	D major	302	Trumpet	One
	Two	$\frac{4}{4}$	C major	377	Alto Sax	Two
Two	Three	$\frac{4}{4}$	F major	20.7	Clarinet	Two
	Four	$\frac{4}{4}$	G minor	277	Guitar	Four
	Five	$\frac{3}{4}$	C major	65.2	Cello	Four

The level of difficulty of the parts to be recalled was similar across all trials, but trials became successively more demanding by virtue of where in the texture the part to be recalled was placed. Independent verification of test materials confirmed that the trials were appropriate for the task and pre-testing followed.

Materials were then prepared for presentation to participants. Each trial piece was played at a tempo of ♩ = 110 on a Roland XP10 multi-timbral synthesizer set to the allocated timbre, and recorded via MIDI on a Dell Inspiron 2200 laptop using Cubase Essential 5. Where pieces contained more than one part, each part was recorded separately and they were then sequenced together. Using Cubase, the tonic chord (in the appropriate timbre) and two bars worth of crotchet pulse (in a snare drum timbre) were introduced immediately before the first note of each piece. At the end of each piece, one full bar of silence was inserted, and then the piece was repeated. Thus, in each trial the tonic chord and pulse of the piece were heard immediately before the piece, which was repeated before a response was expected.

Once compiled, each trial was played back through the Dell laptop and recorded in mp3 format using Audacity v1.2.4 (Bland, et al., 2004), where one full minute of silence was appended to each mp3 to create time for a response. Verbal instructions for the sing-back requirements for each individual trial were recorded in mp3 format using a Sony ICD-UX60 Digital Voice Recorder. These were inserted at the beginning of their respective trials files using Audacity and are presented in Table 7.7.

Table 7.7 Sing-back requirements for each trial

Trial	Sing-back requirement
One	Single line melody
Two	Upper part of two-part piece
Three	Lower part of two-part piece
Four	Uppermost part of four-part piece
Five	Lowermost part of four-part piece

Finally, Windows Media Player 11 was used to create two playlists from the mp3 files of the recorded trials – Recall-Memory Trials Set One and Recall-Memory Trials Set Two, and these were then burnt to CD for presentation to participants.

7.5.2 Procedure

The test, which immediately followed the aural-memorisation test, was undertaken by participants individually, but in the presence of the author. Participants were told that the purpose of the test was to measure their ability to recall music they had just heard, and this would be done by listening to music and singing it back. They were informed that each trial was in a different instrumental timbre, and that they would hear the sing-back instructions for each trial before it began. They were then instructed that, in each trial, the tonic chord would be sounded and following this they would hear two bars of crotchet pulse played on a snare drum. This would then be followed by two performances of the music, after which they were required to sing back the requested part of the texture.

It was made clear to participants that the quality of their singing was unimportant and they were told that their responses could be vocalised to any sound, or hummed, and could be in a different key to the recorded example if they preferred. Finally they were informed that the 10 minute test would be audio recorded, and reminded that they were free to withdraw themselves and their data at any time should they wish to do so, without giving a reason.

7.5.3 Coding and marking scheme

Participants' responses, which were assessed and coded by the author using the audio recordings, were documented using marking grids that were created in Microsoft Excel, an example of which is illustrated in Figure 7.1. Responses to all tests were assessed for accuracy of rhythm (hereafter referred to as recall-rhythm) and pitch (recall-melody) on a bar-by-bar basis, where a 'y' was entered into the grid for each fully correct bar for each attribute. Additionally, for tests three and five, where lower parts were recalled, a 'y' was also entered for bars where the implied harmony (recall-harmony) was fully correct, regardless of whether the pitch contour of the required part was precisely accurate. Finally, for all three attributes, bars containing errors were coloured red and marked with an 'x'.

Test	Rhythm					Melody					Harmony				
Bar	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
1.1	y	x	y	y	3	y	x	y	y	3					
1.2	y	x	y	y	3	y	x	x	x	1					
1.3	x	x	x	y	1	x	x	x	y	1	x	x	x	y	1
1.4	y	y	y	x	3	y	y	y	x	3					
1.5	y	y	y	x	3	y	y	n	n	2	y	y	y	y	4
2.1	x	y	y	y	3	x	y	y	y	3					
2.2	y	y	x	y	3	y	y	x	y	3					
2.3	y	y	y	y	4	y	x	x	y	2	y	y	x	y	3
2.4	y	x	y	x	2	y	x	y	x	2					
2.5	y	y	x	y	3	y	y	x	y	3	y	y	x	y	3
Total					28					23					11
													Scaled		28
Percentage					70%					58%					69%
Overall mark															65%

Figure 7.1 Example of a completed marking grid for the recall memory test

A maximum mark of 40 was possible for recall-rhythm and for recall-melody, and the maximum mark of 16 for recall-harmony was scaled to 40, making a total maximum mark of 120 for the whole test. The range of marks available in all aspects of this test meant that the marking unit of a whole bar was sufficient. Final marks for each participant were converted to percentages.

7.5.4 Pre-test results

Pre-testing of the trials indicated a range of wide marks for recall memory, and descriptive statistics for pre-test marks are presented in Table 7.8.

Table 7.8 Descriptive statistics for recall memory pre-test marks

Recall memory	*N*	Mean	Min	Max	Std. Dev.
Pre-test marks	5	60.20	25	95	27.26

7.5.5 Results and discussion

As expected from the pre-testing, a wide range of marks was evident for recall memory across all participants, $M = 58.79$, $SD = 19.85$, $N = 29$. To examine their recall memory in conjunction with their by-ear learning techniques, participants' marks for recall memory were clustered according to their BEAT Study groups. These groups represent participants' levels of playing by ear ability in terms of their overall BEAT marks, where group one demonstrated the highest levels of two-handed, harmonised playing by ear; groups two and three demonstrated successively lower levels of two-handed, harmonised playing by ear; and group four presented one-handed, melodic playing by ear, as well as the lowest overall levels of playing by ear ability (see Chapter 4, page 91 for a detailed description of grouping criteria and relevant statistics). Descriptive statistics for recall memory are presented in Table 7.9, and the learning techniques demonstrated by each group can be found in on page 116 (Figure 5.4).

Table 7.9 Descriptive statistics for recall memory marks, by group

Group	*N*	Mean	Min	Max	Std. Dev
1	7	84.14	76	97	7.67
2	7	61.00	42	74	12.21
3	6	51.33	41	65	8.26
4	9	42.33	24	68	16.33

It is evident from these results that participants in group one, who demonstrated the learning technique of working exclusively on the whole piece, exhibit the highest levels of recall memory. This supports the assumption, proposed in Chapter 5, that they were able to employ this learning technique because they have ability to process long and hierarchically-complex chunks of musical data with high levels of accuracy. Furthermore, the fact that participants in remaining groups demonstrate successively lower levels of recall memory may provide an explanation as to why their learning techniques resulted in less successful realisations than those of participants in group one, even amongst those who worked on the whole piece. Overall, these results support the suggestion that a relationship exists between playing-by-ear ability and recall memory, and this relationship is examined and discussed in detail in sections 7.8 and 7.9.

7.6 The structures memory test

Chapter 5 demonstrates that some participants who demonstrate high levels of harmonised playing by ear are able to realise the music with stylistic complexity from the very start of their preparation, although other participants are not. The discussion in that chapter suggests that the accompanying techniques employed by participants may be representative of their ability to retrieve and transfer mental representations of musical structures, and indicates a relationship between playing-by-ear ability and structures memory.

Bearing this in mind, the model of playing by ear proposed in Chapter 6 indicates that, following the formation of the aural image, an aural-structural representation of the music is formed in the mind. This is achieved by synthesising the aural image of the music with musical structures drawn from those already encoded in long-term memory using structures memory. Sloboda's (1976, 1985) theory of memory for mental representations of musical structures (see Chapter 6, page 136) infers that these representations are encoded via notated music, and subsequently retrieved and applied to novel music where stylistic attributes are similar (Sloboda, 1976). To measure participants' level of structures memory a test was devised that required them to use it to retrieve musical structures from long-term memory.

The test was modelled on Sloboda's (1976) study of musical proof-readers' error. In that study, Sloboda measured the ability of trained pianists to retrieve and transfer mental representations of musical structures via a sight-reading exercise. Subjects were required to sight-read pieces composed in a familiar and well-established musical style into which deliberate pitch errors had been introduced that conflicted with that style. They were, however, unaware that the scores they were sight-reading from had been altered. Sloboda found that his subjects mainly overlooked such misprint errors in favour of playing what was expected stylistically. From this he asserted that their sub-conscious substitution of the 'correct' structures when sight-reading demonstrated their ability to retrieve and transfer previously memorised mental representations of musical structures (Sloboda, 1976, 1985).

As with Sloboda's study, the test of structures memory devised for the Memory Study utilised a sight-reading exercise where pieces in a familiar style contained stylistically-conflicting pitch errors. Measuring the number of automatic 'corrections' participants made to deliberately altered notes in the score would indicate their level of ability to use structures memory to retrieve appropriate mental representations of musical structures from long-term memory.

7.6.1 Preparation of materials

In keeping with the Sloboda (1976) study, stylistic familiarity was accomplished by developing materials that were adapted from the piano sonatas of the Czech composer Jan Ladislav Dussek (1760-1812), a lesser known contemporary of Mozart. Scores were downloaded from http://www.free-scores.com and were adapted using MuseScore Software (Schreer, 1999-2009). Materials were prepared at three levels of difficulty to accommodate different levels of pianistic skill amongst participants. At the highest level (level three) a 16-bar excerpt was adapted from the 1st movement of the Sonata in C major Opus 46 No. 1 (Craw 17). Some rhythmic aspects were simplified in order to avoid the use of semiquavers, and six pitch alterations were introduced, three on the treble stave and three on the bass stave. The Sonata in B flat major Opus 46 No. 3 (Craw 19), 1st movement, was adapted for level two. The 16-bar excerpt was transposed into G major and rhythmic aspects were simplified to avoid the use of quavers. Again, six pitch alterations were introduced, three on the treble stave and three on the bass stave. The excerpt for level one was adapted from the Sonata in F major Opus 46 No. 2 (Craw 18), 2nd movement. This 16-bar adaptation contained a reduced amount of hands-together playing. As a result, it consisted of fewer pitches and it was necessary to reduce the number of pitch alterations to four – two on the treble stave and two on the bass stave. Alterations at all levels consisted of the pitch of a note being shifted up or down by one letter-name, although any additional accidentals remained unchanged and the resulting score appeared unaltered. This manner of alteration was consistent with Sloboda (1976). Altered scores were then printed on A4 paper for presentation to participants. Altered and unaltered versions of scores for each level can be found in Appendix 6.

Finally, independently appointed verifiers compared the scores with those used by Sloboda (1976) to ensure that they were suitable, and pre-testing indicated that the levels of difficulty were appropriate.

7.6.2 Procedure

Participants undertook the structures memory test individually, but in the presence of the author, immediately after the recall-memory test. Twenty-six participants who reported ABRSM grade 5 or higher carried out the test at level three, and of the remaining three, one received level two and two received level one. In order to avoid the possibility of compromising the test, participants were not informed of its purpose beforehand, but were simply told that they would be carrying out a test of sight-reading. Each participants was given the sight-reading piece that was appropriate for their level of ability, and asked to begin to play within five seconds of receiving it. Two attempts were allowed, and the speed of each attempt was at the participant's discretion. Participants were told that the test would take five minutes, and informed that it would be audio and video recorded. They were also reminded that they were free to withdraw themselves and their data at any time.

7.6.3 Coding and marking scheme

Participants' responses to the test were coded and assessed by the author using the video recording. Assessments were documented using marking grids that were created in Microsoft Excel, an example of which is illustrated in Figure 7.2 below. The grids contained a set of rows for each hand. Prior to the test, the bar by bar sequence of pitches, as notated in the original, unaltered score, was entered into the cells in the first row of each set (labelled 'actual') in black type. Cells representing bars that had been altered in the participant's score were coloured yellow. The sequence of pitches for the altered bars was entered into the appropriate cells on the second row (labelled 'altered') using blue type for the altered pitch and black for those remaining. These cells were also coloured yellow.

Pitches played by participants during the test were subsequently entered into the cells in the third row of each set (labelled 'played'). For all bars, any pitches played that were not as notated in the participant's score were entered in red. Additionally, *altered* pitches that were substituted with *actual* pitches were also entered in red, but in a larger font size. Finally, *altered* pitches that were played as notated in the participant's score were entered in blue. The total number of pitches played according to the notation in each bar (across both hands) was entered in the row labelled 'notations', and the number of substitutions in each bar was entered in the row below. Finally, where *altered* pitches had been substituted for *actual* pitches, these were indicated for each hand in the two remaining rows, labelled 'RH misprints corrected' and 'LH misprints corrected'.

Adapted from Dussek Op 46 No 1							
		Bar 1	Bar 2	Bar 3	Bar 4	Bar 5	Bar 6
RH	Actual	G ECCDE	D DEC	C^1 GEEFG	F FGEG	A F AC^{1}BC^1	G E GC^{1}BC^1
	Altered						G D GC^{1}BC^1
	Played	E ECCDE	D DEC	C^1 GEEFG	F FGEG	A F AC^{1}BC^1	G D GC^{1}BC^1
		Bar 1	Bar 2	Bar 3	Bar 4	Bar 5	Bar 6
LH	Actual	CGEGCGEG	BGDGCGEG	CGEGCGEG	BGDGCGEG	FFFFFFFF CCCCCCCC	EEEEEEEE CCCCCCCC
	Altered			CGEGCGFG			
	Played	CGEGCGEG	BGDGCGEG	CGEGCGEG	BGDGCGEG	FFFFFFFF CCCCCCCC	EEEEEEEE CCCCCCCC
HT	Notations	13	12	13	13	22	22
	Substitutions	1	0	1	0	0	0
RH misprints corrected							0
LH misprints corrected				1			

Figure 7.2 Example of part of a marking grid for structures memory test level three

Retrieval of mental representation of musical structures was coded by allocating one mark for each 'correction' to a deliberately altered note in each sight-reading attempt. Rhythmic errors were disregarded and, where a number of alternative notes were played at a 'correction' point, the first note played was subject to marking. A maximum of 12 marks were available for levels two and three, and eight for level one. Final marks for each participant were converted to percentages.

7.6.4 Pre-test results

Pre-testing of the trials indicated that a range of wide marks was possible for structures memory, and descriptive statistics for pre-test marks are presented in Table 7.10

Table 7.10 Descriptive statistics for structures memory pre-test marks

Structures memory	*N*	Mean	Min	Max	Std. Dev.
Pre-test marks	5	41.60	8	75	26.40

7.6.5 Results and discussion

Participants demonstrated an unexpectedly low and narrow range of structures memory ability, $M = 21.00$, $SD = 18.54$, $N = 29$, evidencing a floor effect. To examine participants' levels of structures memory ability in conjunction with their accompanying techniques, their marks were clustered according to their BEAT Study groups (see Chapter 4, page 91 for a detailed description of grouping criteria and relevant statistics). Descriptive statistics for structures memory are presented in Table 7.11, and the accompanying techniques exhibited by groups one, two and three are illustrated on page 119 (Figure 5.7). Note that in presenting one-handed playing by ear, participants in group four did not demonstrate accompanying techniques.

Table 7.11 Descriptive statistics for structures memory marks, by group

Group	*N*	Mean	Min	Max	Std. Dev
1	7	20.29	0	42	15.87
2	7	23.86	8	42	11.26
3	6	18.67	0	33	13.75
4	9	20.89	0	50	18.54

The discussion in Chapter 5 suggests that participants who are able to immediately harmonise their realisations with stylistic complexity are more likely to be able to retrieve and transfer mental representations of musical structures than remaining participants. However, these data imply otherwise. Indeed, the data suggest that all participants, including those in group four who did not present harmonised by-ear realisations, have equally low levels of structures memory. This does not, therefore, explain why some participants were able to produce stylistically-complex harmonisations brings into question relationship between structures memory and playing by ear ability, inferred in Chapter 5. A detailed analysis and discussion of this relationship, and a consideration of the observed floor effect in the results, are presented in sections 7.8 and 7.9.

Furthermore, it was evident that participants mainly played the test pieces according to the notation they were given during the structures-memory test, and did not ‘correct’ deliberate pitch errors in that notation. This observation is in direct contrast with Sloboda’s (1976) findings, and the implications of this are also considered and discussed in sections 7.8 and 7.9.

7.7 The motor memory test

It is observed in Chapter 5 that participants presenting harmonised playing by ear at the highest level began to realise the music either using a hands-together technique, or else with hands-separate followed by hands together. However, although other participants also demonstrated these techniques, and also a combination of alternating hands-separately and hands-together, their by-ear realisations were less successful. Furthermore, some participants demonstrated only a one-handed technique. Given these observations, the discussion in Chapter 5 inferred that these handing techniques may represent the way in which participants retrieve and transfer motor structures, and suggested a relationship between playing-by-ear ability and motor memory.

Giving consideration to this, the model of playing by ear proposed in Chapter 6 includes the formation of a motor programme to facilitate realisation as its penultimate stage. This is accomplished by using motor memory to retrieve motor structures (Schmidt, 1975) and synthesising them with the aural-structural representation of the music.

Palmer and Meyer’s (2000; Meyer & Palmer, 2003) theory of sequence memory in music suggests that motor information is stored in memory independently of other sequential musical data, such as rhythm and melody (see Chapter 6, page 137 for a brief discussion). This theory is based on evidence that skilled pianists are able to transfer learned motor structures for use in novel musical situations. In order to measure participants’ levels of motor memory it was necessary to design a test that necessitated them to retrieve learned motor structures from long-term memory.

The test was adapted from the method used by Palmer and Meyer in their (2000) study of motor independence. In their study, the authors used a transfer-of-learning paradigm to assess the speed with which pianists were able to apply learned, one-handed motor structures in novel situations. Pianists were given a ‘training’ melody with prescribed fingering which was practised, and then performed in a speed trial containing 10 repetitions. They were then presented with a ‘transfer’ melody, containing either: familiar melody and fingering; familiar melody and novel fingering; novel melody and familiar fingering; or novel melody and fingering. This was played four times at speed without prior practice. The duration of the final training trial was then compared with the average speed of the four transfer trials. Amongst other findings, Palmer and Meyer inferred from their results that motor information is independently stored and processed in long-term memory, and that learned motor structures are retrieved and transferred for use in novel situations (Palmer & Meyer, 2000).

The motor memory test designed for the present study also employed a ‘transfer of learning’ paradigm. It required participants to learn, through practice, a four-bar piece of two-handed, harmonised piano music containing marked fingering, and then attempt to transfer the learned fingering patterns to a similarly structured novel piece. Measuring the consistency with which they transferred these patterns would indicate their ability to retrieve them from long-term memory.

7.7.1 Preparation of materials

In order to accommodate participants’ differing levels of pianistic ability, and to mitigate inevitable sight-reading issues, materials were prepared at four levels of difficulty, where level four was the highest level. Four-bar training pieces in C Major, with a metrical structure of $^4_4$, were composed by the author for each level. At the lowest level (level one) pieces were for individual hands alone, and pieces for the remaining levels were hands-together. The range of pitches and the rhythmic complexity increased with each level, thereby increasing the demand on motor (fingering) skill. Levels one, two and three utilised a pitch range of a perfect 5^{th} for each hand, meaning that no change of hand position would be necessary, whilst the highest level (level four) extended that range to an octave. Levels one and two contained a mixture of crotchets and minims, level three included quavers, crotchets and minims, and level four utilised quavers, crotchets, dotted crotchets and minims. No chords were present at any level. A transfer piece for each level was then derived by transposing the original pieces into A minor. Although this necessitated changes in pitch, the fingering structures remained the same. Finally, scores were prepared using MuseScore (Schreer, 1999-2009) and printed on A5 paper for presentation to participants. These can be found in Appendix 7 Independent verifiers then confirmed that the tests were set at appropriate levels when compared with those of Palmer and Meyer (2000), and pre-testing followed.

7.7.2 Procedure

Following the structures-memory test, participants undertook the motor memory test individually, but in the presence of the author. Twenty-six participants who reported ABRSM grade 5 or higher carried out the test at level four, and of the remaining three, one received the test at level three, one at level two and one at level one. During the test, each participant was presented with the four-bar piano piece appropriate to their level of ability and given a maximum of three minutes to learn to play it fluently. They were asked to try and adhere to the marked fingering, and told that memorisation of the piece was not required. Following this they completed a training trial by playing and repeating the piece 10 times in succession, without stopping. This was carried out using the score and they were asked to play at a speed that did not compromise the fluency of the playing. They were then given the transfer piece and asked to play it through three times as fluently as possible, using the score but with no preparation. Participants were made aware that the test would take six minutes, and told that it would be audio and video recorded. They were also reminded that they were free to withdraw themselves and their data at any time. On completion of the motor memory test, which signalled the end of the Memory Study, participants were thanked for their continuing interest and involvement with the research project.

7.7.3 Coding and marking scheme

Participants' responses were coded and assessed by the author. Using the video footage, each participant's final training trial was selected and its right and left hand fingering patterns compared with those observed in each of that participant's transfer trials. Assessments were recorded on marking grids that were prepared using Microsoft Excel, an example of which is illustrated in Figure 7.3 below. Participants' training and transfer trial fingering patterns for each bar, for each hand, were entered into the appropriate cells. Any individual fingers used in the transfer trials that differed from those used in the training trial were typed in red. For each hand, where the fingering for a whole bar in a transfer trial was consistent with that used in the training trial, the cells representing those bars in the transfer trial were coloured blue.

	Training Trial		Transfer Trial 1		Transfer Trial 2		Transfer Trial 3	
	RH	LH	RH	LH	RH	LH	RH	LH
Bar 1 fingering	21432	531	21432	531	21432	531	21432	531
Bar 2 fingering	31432	531	32432	421	32432	421	32543	421
Bar 3 fingering	125434	5315	125434	4215	125434	5315	125434	4215
Bar 4 fingering	5	3	5	3	5	2	5	2
No. of consistent bars			3	2	3	2	3	1
Total overall consistent bars								14
								58%

Figure 7.3 Example of marking grid for motor memory test level four

Consistency of motor transfer was coded by allocating marks on a bar by bar basis for each hand. In each transfer trial, one mark was allocated for every bar where the fingering was consistent with the training trial. A total of eight marks was available for each transfer trial, making a possible maximum of twenty-four marks at all levels. Final marks for each participant were converted to percentages.

7.7.4 Pre-test results

Pre-testing of the measures indicated that a range of wide marks was possible for motor memory, and descriptive statistics for pre-test marks are presented in

Table 7.12 Descriptive statistics for motor memory pre-test marks

Motor memory	*N*	Mean	Min	Max	Std. Dev.
Pre-test marks	5	67.60	46	96	18.98

7.7.5 Results and discussion

A relatively high range of ability to transfer motor structures was observed amongst participants, demonstrating some consistency with the findings of Palmer and Meyer (2000) and Meyer and Palmer (2003), $M = 80.21$, $SD = 17.44$, $N = 29$. To consider participants' handing techniques in the context of their levels of motor memory, their marks have, once again, been clustered according to their BEAT Study groups (see Chapter 4, page 91 for a detailed description of grouping criteria and relevant statistics). Descriptive statistics for motor memory are presented in

Table 7.13, and handing techniques for groups one, two and three can be found on page 118 (Figure 5.6). Note that participants in group four used a right-hand only technique.

Table 7.13 Descriptive statistics for motor memory marks, by group

Group	*N*	Mean	Min	Max	Std. Dev
1	7	95.43	88	100	5.38
2	7	77.86	54	100	18.95
3	6	71.67	58	88	14.10
4	9	75.89	54	100	19.13

These results suggest that participants in group one, who either played hands-together from the start, or progressed from hands-separately to hands together, demonstrate the highest levels of motor memory. This supports the notion, put forward in Chapter 5, that they are able to retrieve appropriate motor structures to form a motor programme. However, it is evident that some participants in groups two and three employed the same handing techniques as some of those in group one, but exhibit lower levels of motor memory. Furthermore, participants in group four, who presented melodic realisations using only used their right hand, demonstrate levels of motor memory that are in a similar range to those in groups two and three. This suggests that they are similarly capable of retrieving hands-together structures but were nevertheless unable to produce two-handed realisations by ear. Overall, these results support the suggestion that a relationship exists between playing by ear and motor memory and, once again, this is examined and discussed in detail in sections 7.8 and 7.9.

7.8 Overall results and main analysis

As reported in Chapter 4, a random selection of 10% of the data for all assessments conducted during the BEAT and Memory Studies was independently verified. A paired samples correlation demonstrated a significant relationship between the marks for each participant as reported by each assessor, $r = .993$, $p = .000$ (2-tailed), $N = 12$, with a Cronbach's alpha reliability statistic of $\alpha = .996$, $N =$

2. Additionally, a paired samples t-test indicated no significant difference in the assessment level between the two assessors.

To determine the possible relationships between the different memory types tested and playing-by-ear ability, participants' overall BEAT marks were compared with their overall marks in the aural memorisation, recall memory, structures memory and motor memory tests (referred to throughout this analysis as memorisation, recall, structures and motor respectively). Significant correlations were observed between BEAT and recall, $r = .852$, $p = .000$, $N = 29$; and BEAT and motor, $r = .418$, $p = .013$, $N = 29$. Note that these and all further correlations in this analysis are one-tailed. However, no correlations were observed between BEAT and memorisation, or BEAT and structures although, given the respective ceiling and floor effects observed for memorisation and structures, this was unsurprising.

It was also reported in Chapter 4 that participants were clustered into four groups according to their BEAT test results (see page 91 for a detailed description of grouping criteria and relevant statistics). Participants in groups one, two and three demonstrated a wide range of harmonised playing-by-ear ability, where those in group one presented the highest levels overall. Conversely, participants in group four presented only melodic realisations and also demonstrated the lowest levels of playing-by-ear ability overall. Descriptive statistics for participants' recall, structures and motor tests have been reported according to these groups in earlier sections of this chapter but, for ease of reference, they are presented again in Table 7.14 along with those for aural memorisation. It was anticipated that clustering the data in this way for the main analysis would enable a more detailed picture of the influence of the four memory types on playing by ear to be gained.

Table 7.14 Descriptive statistics for memorisation, recall, structures and motor, by group

Memory test	Group	*n*	Mean	Min	Max	Std. Dev
Memorisation	1	7	96.14	88	100	4.14
	2	7	98.29	94	100	2.93
	3	6	98.50	94	100	2.51
	4	9	96.67	88	100	4.09
Recall	1	7	84.14	76	97	7.67
	2	7	61.00	42	74	12.21
	3	6	51.33	41	65	8.26
	4	9	42.33	24	68	16.33
Structures	1	7	20.29	0	42	15.87
	2	7	23.86	8	42	11.26
	3	6	18.67	0	33	13.75
	4	9	20.89	0	50	18.54
Motor	1	7	95.43	88	100	5.38
	2	7	77.86	54	100	18.95
	3	6	71.67	58	88	14.10
	4	9	75.89	54	100	19.13

An independent measures MANOVA was conducted to determine the effect of group on the marks for each memory type. A highly significant effect of group on recall was observed, F (3,25) = 16.354, p = .000, N = 29, as well as a smaller, but significant effect of group on motor, F (3,25) = 3.022, p = .048, N = 29. However, no significant effect of group on the two remaining memory types was found. Post hoc tests (in accordance with Levene's test of equality of variances) indicated some significant differences between group means for recall and motor and these are presented in Table 7.15.

Table 7.15 Post hoc tests indicating significant differences in group means for recall and motor

Memory test	Type	Groups	Significance
Recall	Tukey HSD	1 & 2	.008
		1 & 3	.000
		1 & 4	.000
		2 & 4	.027
Motor	Dunnett T3	1 & 3	.036

As memorisation and recall are both components of auditory-musical memory these two variables were examined to determine any possible relationship between them. Although no significant correlation was evident, Figure 7.4 illustrates that groups two, three and four demonstrate lower levels of recall than group one, even though their levels of memorisation are similarly high. Furthermore it illustrates that high levels of playing-by-ear ability are only evident where high levels of recall are also present, regardless of high levels of accuracy in memorisation.

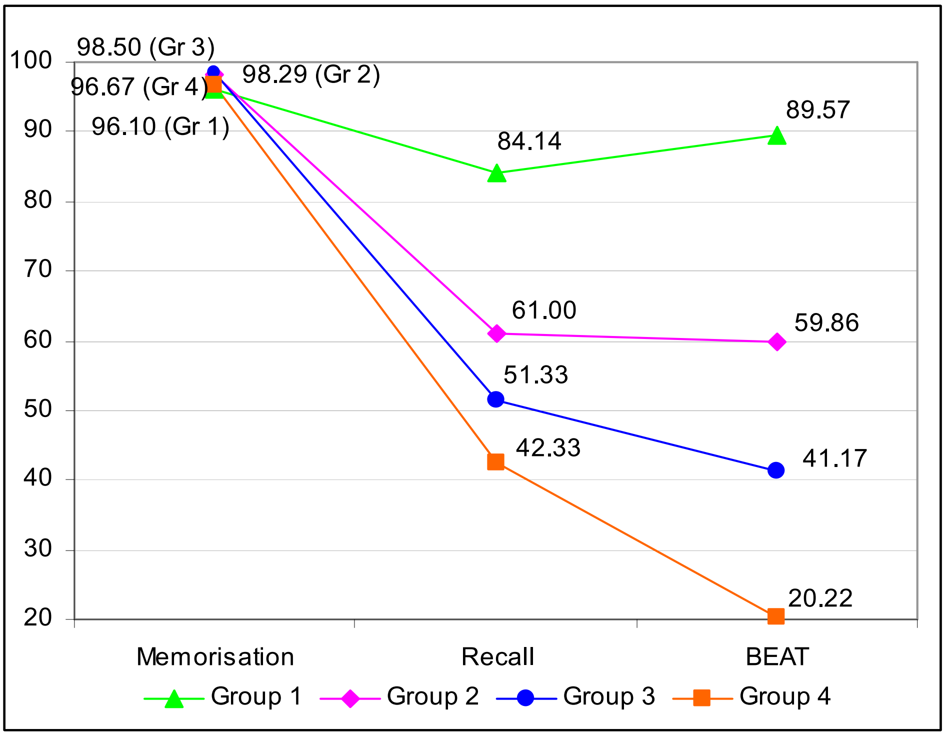

Figure 7.4 Summary of group means for memorisation, recall and BEAT

Following this, the individual and collective influences of all four memory types on BEAT marks were examined. It is evident that alongside the already established narrow but high range of marks for memorisation and wide range of marks for recall, participants also demonstrate a relatively wide range of marks for motor, and a narrow but low range of marks for structures. Individual linear regressions indicated a significant effect of recall on BEAT marks, $R^2 = .725$, $F(1,27) = 71.250$, $p = .000$, $N = 29$; and a smaller but nevertheless significant effect of motor, $R^2 = .169$, $F(1,27) = 5.501$, $p = .027$, $N = 29$; but no effect of the two remaining memory types.

Bearing in mind participants' already established high levels of memorisation, Figure 7.5 illustrates that despite low levels of structures, and even where levels of motor are high, the highest levels of playing-by-ear ability are evident only where high levels of recall are also present.

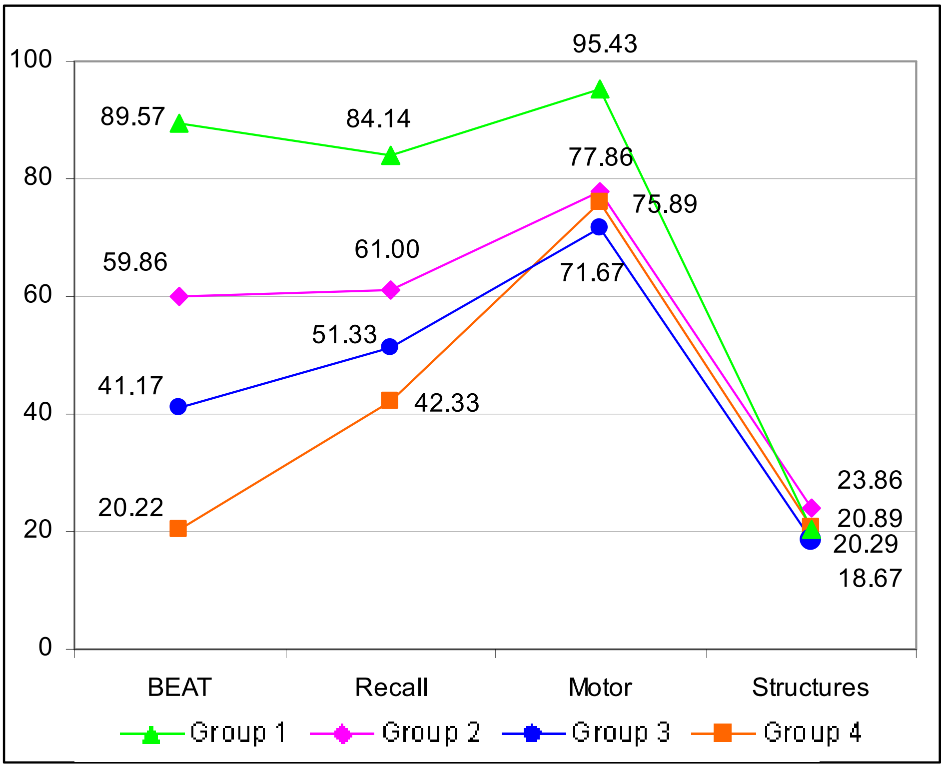

Figure 7.5 Summary of group means for BEAT, recall, structures and motor

After ensuring that no significant collinearity existed between variables, a stepwise multiple linear regression was conducted to determine the main effect. A strong significant main effect of recall was evident on BEAT marks, $R^2 = .725$, F

(1,27) = 71.250, p = .000, N = 29, and the regression model excluded memorisation, structures and motor. At this point it is necessary to consider that this research project is concerned with the ability of trained pianists to play by ear in a two-handed, harmonised manner. To ensure that the observed effect of recall on BEAT marks was not compromised by the inclusion of data for group four, an additional stepwise multiple linear regression was conducted that excluded their data. This similarly revealed a strong significant main effect of recall on BEAT marks, R^2 = .666, F (1,18) = 35.880, p = .000, n = 20, and excluded the three remaining memory types. Note that it is impossible to comment on whether having a high level of recall without a sufficiently high level of motor would preclude high levels of playing-by-ear ability, as no participants in the BEAT Study demonstrated this combination of memory skills.

To obtain a more detailed picture of the effect of recall on playing by ear, marks for recall-rhythm, recall-melody and recall-harmony for all participants were compared respectively with their BEAT test marks for rhythm, melody and harmony. This would determine whether any one component was more influential than another. Descriptive statistics for each recall component for each group are presented in Table 7.16, and those for BEAT components can be found on page 93 (Table 4.7).

Table 7.16 Descriptive statistics for recall-rhythm, recall-melody and recall-harmony, by group

Recall Component	Group	*n*	Mean	Min	Max	Std. Dev
Recall-rhythm	1	7	87.43	83	95	4.28
	2	7	74.14	58	88	10.22
	3	6	58.83	48	70	7.22
	4	9	59.33	33	93	17.81
Recall-melody	1	7	77.57	65	95	10.55
	2	7	54.00	38	78	14.21
	3	6	38.67	20	58	13.31
	4	9	29.67	13	55	15.29
Recall-harmony	1	7	87.57	75	100	9.61
	2	7	55.29	25	88	22.24
	3	6	57.00	31	88	20.43
	4	9	38.22	13	69	19.77

Significant correlations were observed between all three pairs of components for all participants and are presented in Table 7.17.

Table 7.17 Correlations between recall components and BEAT components for all participants

BEAT and Recall Component	Correlation
Rhythm and recall-rhythm	$r = .517, p = .002$
Melody and recall-melody	$r = .607, p = .000$
Harmony and recall-harmony	$r = .671, p = .000$

Furthermore, an independent measures MANOVA indicated a significant effect of group on recall-rhythm, $F\,(3, 25) = 9.461$, $p = .000$, $N = 29$; recall-melody, $F\,(3,25) = 17.778$, $p = .000$, $N = 29$; and recall-harmony, $F\,(3,25) = 9.255$, $p = .000$, $N = 29$. Additional Tukey HSD post hoc tests revealed significant differences in means for a number of group pairings and are presented in Table 7.18.

Table 7.18 Post hoc tests indicating significant differences in group means for recall-rhythm, recall-melody and recall-harmony

Recall Component	Groups	Significance
Recall-rhythm	1 & 3	.001
	1 & 4	.000
Recall-melody	1 & 2	.017
	1 & 3	.000
	1 & 4	.000
	2 & 4	.008
Recall-harmony	1 & 2	.017
	1 & 4	.000

Finally, the effect of each recall component on its equivalent BEAT component was examined for groups one, two and three only. A significant correlation was observed between recall-harmony and (BEAT) harmony, $r = .556$, $p = .005$, $n = 20$, but not between remaining components. Linear regressions demonstrated a significant effect of recall-harmony on (BEAT) harmony, $R^2 = .309$, $F(1,18) = 8.047$, $p = .011$, $n = 20$, but no effect between other components. The effects of recall-rhythm on (BEAT) rhythm, and recall-melody on (BEAT) melody were then independently calculated for group four. A significant correlation was observed between recall-melody and (BEAT) melody, $r = .696$, $p = .019$, $n = 9$. Linear regression revealed a significant effect of recall-melody on (BEAT) melody, $R^2 = .484$, $F(1,7) = 6.569$, $p = .037$, $n = 9$, but no effect of recall-rhythm on (BEAT) rhythm.

In order to ensure that this part of the analysis was not compromised by the effect of the style weighting applied to the harmony marks in the BEAT test (see page 90, Table 4.4), the effect of recall-harmony on the raw-harmony marks of groups one, two and three was also examined. Descriptive statistics for raw-harmony marks by group can be found on page 97 (Table 4.11). However, a linear regression revealed a similar significant effect of recall-harmony on raw-harmony marks, $R^2 = .228$, $F(1,18) = 5.316$, $p = .033$, $n = 20$.

Following this, overall recall marks were compared with fluency and spontaneity marks for groups one, two and three. This would examine whether recall influenced the fluency and spontaneity of playing by ear that was specifically two-handed and harmonised. A significant correlation was observed between recall and fluency, $r = .511$, $p = .011$, $n = 20$; and linear regression demonstrated a significant effect of recall on fluency, $R^2 = .262$, $F\ (1, 18) = 6.337$, $p = .021$, $n = 20$. Furthermore, a significant correlation was observed between recall and spontaneity, $r = .784$, $p = .000$, $n = 20$; and linear regression revealed a significant effect of recall on spontaneity, $R^2 = .615$, $F\ (1, 18) = 28.780$, $p = .000$, $n = 20$.

With respect to the one-handed, melodic playing by ear, a significant correlation was noted between recall memory and fluency for group four, $r = .790$, $p = .011$, $n = 9$; and linear regression demonstrated a significant effect of recall memory on fluency, $R^2 = .571$, $F\ (1,7) = 11.639$, $p = .011$, $n = 9$.

In view of the observed small effect of motor on overall BEAT marks, motor marks for all groups were compared with their individual BEAT component marks, with the exception of spontaneity where the marks of group four were excluded. A significant correlation was observed between motor and fluency, $r = .338$, $p = .037$, $N = 29$; and linear regression indicated a small, although not statistically significant, effect of motor on fluency ($R^2 = .114$, $F\ (1,27) = 3.475$, $p = .073$, $N = 29$). Additionally, a significant correlation was noted between motor and spontaneity for groups one, two and three, $r = .497$, $p = .013$, $n = 20$; and linear regression demonstrated a significant effect of motor on spontaneity, $R^2 = .247$, $F\ (1,18) = 5.911$, $p = .026$, $n = 20$. However, as Figure 7.6 illustrates, regardless of levels of motor, the highest levels of fluency and spontaneity are only present where levels of recall are also high.

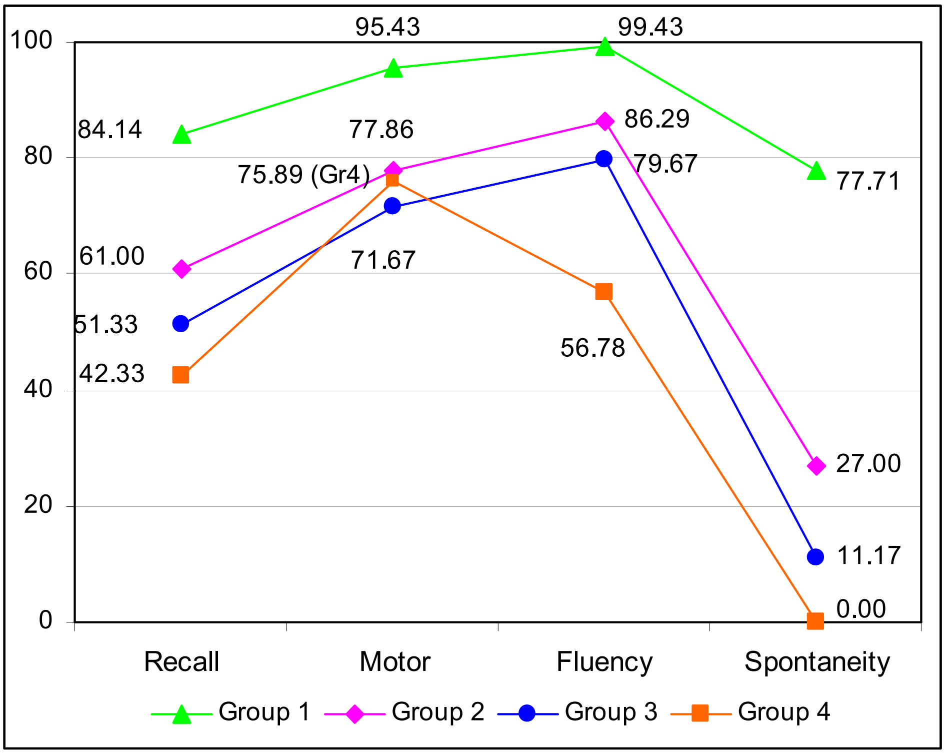

Figure 7.6 Summary of group means for recall, motor, fluency and spontaneity

Although no effect of structures was observed on playing-by-ear ability overall, or its individual components, the test data were re-examined in an attempt to determine whether any other relevant findings were evident. Given existing evidence of a correlation between playing-by-ear ability and sight-reading skill (see Luce, 1965; McPherson, 1995, 1996; Bernhard, 2004), the data were first scrutinised to determine whether such a relationship existed for participants in the Memory Study. To achieve this, participants' sight-reading skill was measured and coded according to the percentage of pitches they played as notated, during the first sight-reading attempt. The second sight-reading attempt was excluded on the basis that it was, technically, rehearsed rather than sight-read. Descriptive statistics for participants' sight-reading marks are presented in Table 7.19.

Table 7.19 Descriptive statistics for sight-reading, by group

Group	*n*	Mean	Min	Max	Std. Dev.
1	7	96.86	94	100	2.19
2	7	95.29	88	98	3.35
3	6	92.00	90	94	1.55
4	9	85.56	70	98	10.27

A significant correlation was observed between BEAT marks and sight-reading marks, $r = .552$, $p = .000$, $N = 29$.

Following this, the difference between the percentage of performance errors on both un-altered notes and deliberately altered notes between the two sight-reading attempts was examined. For the purpose of this analysis, played 'corrections' to the deliberately altered pitch notations were considered to be performance errors. As Figure 7.7 illustrates, the mean percentage for performance errors on un-altered notes is reduced on the second sight-reading attempt. This is consistent with the findings of Sloboda (1976), on whose study the structures memory test was modelled. Furthermore, the mean percentage for performance errors on deliberately altered notes is also reduced on the second attempt. This finding is, however, in direct contrast with Sloboda, who found that performance errors on deliberately altered notes increased on the second sight-reading attempt.

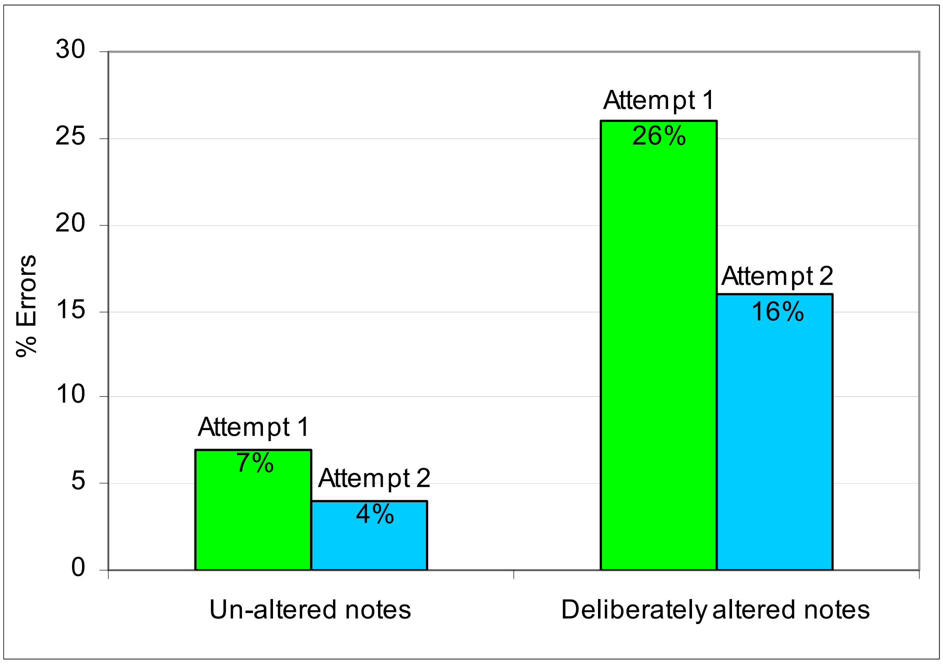

Figure 7.7 Percentage of errors on un-altered notes and deliberately altered notes for sight-reading attempts one and two

Wilcoxon Signed Ranks tests indicated that the reduction in the percentage of errors on the second attempt was statistically significant for both un-altered notes, $Z = -2.279$, $p = .023$ (2-tailed), $N = 29$, and altered notes, $Z = -2.621$, $p = .009$ 2-tailed), $N = 29$. A Spearman bivariate correlation was then conducted to ascertain the systematic relationship between the number of errors on altered and un-altered notes for the first attempt only, again on the basis that the second attempt was technically rehearsed. However, no significant relationship was found.

7.9 Discussion: Comparing playing-by-ear ability with memory skills

The Memory Study has ascertained that participants demonstrate high levels of aural memorisation; a wide range of memory for auditory-musical recall (recall memory); a low, narrow range of memory for mental representations of musical structures (structures memory); and a relatively high range of memory for musical-motor structures (motor memory). More specifically, the analysis demonstrates that participants in group one, who exhibited the highest levels of two-handed, harmonised playing-by-ear ability in the BEAT test, possess the highest levels of recall memory. They also demonstrate levels of structures memory that are analogous to those demonstrated by remaining participants. Furthermore, they are amongst participants exhibiting the highest levels of motor memory. Conversely, participants in groups two and three, who exhibited successively lower levels of two-handed, harmonised playing-by-ear ability, demonstrate lower levels of recall memory than group one. However, some of them exhibit levels of structures memory and motor memory that are commensurate with group one. Finally, participants in group four, who exhibited the lowest levels of playing-by-ear ability, and presented one-handed, melodic realisations in the BEAT test, demonstrate the lowest levels of recall memory. However, some of them demonstrate levels of structures memory and motor memory that are commensurate with participants in other groups. As well as establishing levels of ability, the analysis also indicates that recall memory has a major impact on two-handed, harmonised playing-by-ear ability, motor memory has a less important role, and structures memory has a minor role in the process.

7.9.1 Aural-memorisation

It is obvious that playing by ear cannot take place unless an aural representation of the music is first encoded and then recalled from long-term memory. The very high levels of aural memorisation demonstrated by all participants are unsurprising given that the ability to encode music aurally is not the exclusive domain of trained musicians, and most people, whether musically trained or not, are thought to demonstrate this ability (Madsen & Staum, 1983; Halpern, 1984; Madsen & Madsen, 2002). Conversely, it is surprising that participants demonstrate such a wide range of recall memory alongside their high levels of aural memorisation, considering that a listener's level of musical expertise is thought to influence their musical recall ability (Sloboda & Parker, 1985) and the fact that all participants are trained pianists. This suggests that accurate aural encoding of musical material does not necessarily guarantee accurate aural recall of that material. However, bearing in mind that aural memorisation was measured in the context of participants' ability to recognise previously encoded data, this finding is consistent with evidence demonstrating that high levels of recognition do not always facilitate accurate recall (Du Plessis, 1994; Baddeley, 1997). This is not to suggest that playing by ear would not be possible in the presence of low levels of aural memorisation but, even if recall memory skills were high, inaccurate encoding would result in inaccurate recall and lead to musically unsatisfactory by-ear realisations.

7.9.2 The aural image and recall memory

It is reasonable to expect a performance of memorised music to contain a high level of rhythmic, melodic and harmonic accuracy and, according to the proposed model of the cognitive-psychological process of playing by ear presented in Chapter 6 (see page 143), the role of recall memory is to facilitate the creation of an aural image of the music that is as accurate as possible. Alongside the most accurate playing by ear, participants in group one achieved the highest levels of recall memory overall, as well as in each of its individual components. However, participants in the remaining groups demonstrated lower levels of recall memory and it is unsurprising to find that these are reflected in the accuracy of their by-ear realisations. Additionally, it appears that individual elements of recall memory impact more on the accuracy of by-ear realisations of some participants than they do on others.

The analysis shows that participants who exhibit the lowest overall levels of playing-by-ear ability, and presented only melodic playing by ear, also demonstrate the lowest levels of ability to recall melody. It is apparent from the video recordings of their BEAT preparation sessions, observed during the Strategy Study, that some of the melodic errors made by these participants at the beginning of their preparation were consistently repeated throughout the session and, furthermore, the level of errors increased as that preparation progressed, leading to inaccurate melodic realisations.

The overall perception of a melody is thought to depend on the predictability of its pitch contour (Krumhansl, 1979, 1987), and where that contour does not conform to expectation, such as when pitch errors occur, the melody may not make musical sense to the listener. To compound this situation, melodic recall can be impaired if pitches are erroneously replaced by other diatonic pitches when that melody is repeated. This similarity effect (Cuddy, Cohen, & Miller, 1979) is particularly problematic when concurrent alteration to the rhythmic aspects of the melody occur (Boltz & Jones, 1986; Deutsch, 1980; Jones, Summerell, & Marshburn, 1987; Monahan, Kendall, & Carterette, 1987).

Extrapolating from this, it is possible that the low levels of melodic-recall demonstrated by some participants in group four have prevented them from accurately recalling the melodic contour of the music, leading to the initial formation of an inaccurate aural image of the melody in the mind's ear. As a result, these participants have introduced pitch errors into their first attempts to play the melody, compromising its predictability and impairing its perception. Furthermore, it appears that the invoked similarity effect has impaired their ongoing melodic recall and perception, making the melodic contour even less predictable and increasing pitch errors. This downward spiral of inaccuracy has, therefore, further impaired the aural image of the melody being formed by these participants as preparation continues, and has ultimately led to an inaccurate by-ear realisation. This would explain why these participants presented inaccurate melody by ear, in spite of the learning techniques they used.

Conversely, it appears that the progressively higher levels of melodic-recall memory demonstrated by groups one, two and three, and also those remaining in group four, have enabled them to recall the melodic contour of the music with more accuracy, and form a more accurate aural image of the melodic elements of the music to begin with. These participants have, therefore, made fewer errors in their initial attempts to realise those melodic elements, thereby reducing impairment caused by melodic similarity, and preserving the predictability of the melodic contour. This, in turn, has allowed them to maintain the accuracy of the aural image of the melodic elements as preparation progresses, and has led to realisations that are more melodically accurate.

It is also evident that ability to recall the harmonic contour of the music has an impact on the harmonised by-ear ability of participants in groups one, two and three. Group one demonstrated the highest levels of harmonic recall and presented accurate and stylistically-complex harmonisations to their already accurate melodies. Conversely, groups two and three delivered harmonisations that were of similar stylistic complexity to those of group one, but were successively less harmonically accurate, and this is surprising given that musical training is thought to enhance ability to recall the harmonic aspects of the music (Bigand, et al., 1999) Once again it was evident, from the video recordings, that some of the harmonic errors made by participants in groups two and three were repeated consistently throughout their preparation, with additional errors occurring as their sessions progressed.

As with melody, the perception of harmonic sequences is thought to be based upon the diatonic relationships between the chords within a tonal hierarchy, as well as a sense of expectation about what might come next within a chord sequence (Krumhansl & Kessler, 1982). Consequently, memory for the recall of harmonic sequences may be impaired by similarity effect if a component chord in a repeated harmonic sequence is substituted by different diatonic chord (Bharucha & Krumhansl, 1983).

Once again, extrapolating from this, it is possible that the successively lower levels of harmonic recall demonstrated by groups two and three have resulted in the inaccurate recall of the harmonic structure and progression of the music, leading to the formation of an aural image containing an impaired harmonic element. As a result these participants have insinuated ‘incorrect’ chords into the harmony when playing, compromising its predictability and causing impairment to its perception. The arising similarity effect has impaired their ongoing recall and perception, further compromising the predictability of the harmonic progression. As before, the downward spiral of inaccuracy has resulted in the introduction of additional ‘incorrect’ chords, and further impaired the harmonic element of the aural image as preparation continues. This goes some way to explaining why participants in groups two and three presented harmonisations that were stylistically-complex, but lacking in accuracy, even where the melodic contour was correct, and regardless of their learning techniques.

Conversely, the high levels harmonic recall demonstrated by group one have enabled them to recall the harmonic progression with greater accuracy, allowing them to form a more accurate aural image of the harmonic element of the music at the start of preparation. Accordingly their initial attempts to reproduce the harmony have contained fewer errors, thereby reducing the impact of harmonic similarity and preserving the predictability of the harmonic progression. Overall their ongoing accurate recall of the melodic and harmonic elements of the music have allowed their initially formed accurate aural image to be maintained through to realisation.

7.9.3 Harmonisation

The discussion in Chapter 4 has shown that melody produced in the context of harmony is mainly highly accurate, and is not compromised by the level of accuracy of the harmony that accompanies it. The fact that participants in groups one, two and three demonstrate high levels of rhythmic and melodic recall alongside varying levels of harmonic recall provides some explanation for this finding. Furthermore, the fact that these components of recall memory appear to function at different levels simultaneously implies that they may be processed independently in short-term/working memory. This would be consistent with Deutsch's (Deutsch & Feroe, 1975; Deutsch, 1972, 1999) theory that short-term memory is a multi-faceted, specialised system for musical processing (see Chapter 6, page 132). The BEAT Study also demonstrates that although some participants in group four presented highly accurate melodies by ear, they appeared unable to harmonise them. However, these participants mainly demonstrated low levels of harmonic recall and it is possible that this may have prevented them from recalling sufficient information to attempt harmonisation. Furthermore, it seems likely that those participants in group four who presented the very lowest levels of melodic playing by ear may have found harmonisation too great a challenge, given that they demonstrated insufficiency in both melodic- and harmonic-recall memory.

Overall, it is evident that deficiency in recall memory inhibits accuracy in two-handed, harmonised playing by ear amongst trained pianists. More specifically, insufficient levels of harmonic recall appear to inhibit the ability to play the piano by ear in a harmonised manner, even where levels of rhythmic and melodic recall are high.

7.9.4 The appropriateness of the structures memory test

It is surprising to find that structures memory appears to have little influence on two-handed, harmonised playing-by-ear ability, particularly as, unlike memorisation, the ability to form mental representations of musical structures is less likely to be encountered outside the domain of trained musicians. Furthermore, as discussed earlier in this chapter, the floor effect observed in the data suggests that all participants demonstrate low levels of structures memory, indicating that they lack the ability to retrieve musical structures and use them to form an aural-structural representation of the music (see page 161). However, the BEAT Study demonstrated that some participants are nevertheless capable of creating harmonisations that are highly stylistically-complex in nature (regardless of their levels of harmonic accuracy), and it is difficult to envisage how this is possible given that the stylistic blueprint of a by-ear realisation is contained in the aural-structural representation of the music. This leads to speculation either that the pre-test results presented a false impression of the suitability of the test materials, or that the methodological approach taken in the structures test as a whole may have been inappropriate. Given that the pre-test results did not indicate an issue with the materials, the appropriateness of the structures memory test must be examined.

The methodology, as described earlier in this chapter, was chosen on the basis of Sloboda's (1976) evidence that good sight-readers demonstrate high levels of retrieval and transfer of mental representations of musical structures. This evidence was itself based on a measure of pianists' sight-reading ability in terms of the number of times they 'corrected' misprinted pitches in a notated piano sight-reading test. These corrections were counted as errors on altered notes, and they were compared with errors on un-altered notes. According to Sloboda's hypothesis, the fewer errors a pianist makes on un-altered notes, the more they are likely to make on altered notes, indicating good retrieval and transfer of musical structures when sight-reading (Sloboda, 1976). However, no such negative relationship is evident amongst participants in the Memory Study, implying that they did not transfer structures that would allow them to correct misprinted pitches where necessary. Furthermore, it is evident that participants in the Memory Study reduced the number of errors they made on the deliberately altered notes during the second sight-reading attempt, in direct contrast with Sloboda's subjects.

Of course, it could be argued that participants in the present study are, in fact, better sight-readers than Sloboda's subjects on the basis that they played a faithful representation of the printed notation, rather than their own interpretation based on what they perceived the notation should say. Moreover, rather than implying that their ability to transfer musical structures is insufficient, this suggests that they were actually transferring structures that were appropriate for the pitches that were notated. It is, therefore, possible that the structures memory of participants in the BEAT Study may have been incorrectly measured, and that a wider, and possibly higher, range of skill actually exists amongst them. This would explain how some participants were apparently able to achieve the sufficiently rich aural-structural representations they required to create the stylistically-complex harmonisations evident in their by-ear realisations. Moreover, it would explain how some participants in group one were able to include stylistic accompaniments from the start of their preparation sessions.

Either way, and original intentions notwithstanding, it seems that the structures test, and indeed Sloboda's test, may have indicated more about participants' sight-reading abilities than about their ability to retrieve and transfer musical structures. This suggests that a sight-reading test was not appropriate for this measurement and, together with the fact that Sloboda's study was limited to only seven subjects, means that the results of his test as well as those of the structures test in the Memory study should be treated with caution. However, in providing a measure of sight-reading ability, the structures test has facilitated an examination of the relationship between the sight-reading skills and harmonised playing-by-ear abilities of participants in the present study. The observed strong relationship between these two skills strengthens and enhances the findings of earlier research, particularly as that earlier research has focussed only on the relationship between sight-reading skill and melodic playing by ear (see Luce, 1965; McPherson, 1995, 1996; Bernhard, 2004).

7.9.5 Fluency in playing by ear

There is an inherent expectation that a musical performance will contain a high degree of fluency, even where rhythmic or pitch inaccuracies may occur from time to time. Therefore, it seems reasonable to assume that motor memory has a salient role in the playing-by-ear process, given that any physical movement requires an array of commands, in the form of a motor programme, to control the serial order of movements (Keele, 1968; Shaffer, 1978; Rosenbaum, 1991). However, the analysis indicates that motor memory has only a marginal impact on participants' ability to play fluently by ear, and demonstrates that levels of recall memory have a greater impact.

The high levels of recall memory and motor memory demonstrated by group one appear to allow them to create motor programmes that facilitate the highly-fluent delivery of accurate and stylistically-complex, two-handed realisations. Conversely, groups two and three demonstrate levels of motor memory that are only slightly lower than those of group one. However, although their fluency levels are reasonably high, they are less acceptable from a performance point of view than those of group one. It appears, therefore, that the lower levels of recall memory demonstrated by groups two and three hamper their ability to form the motor programme necessary for a higher degree of fluency, regardless of their motor memory skills. As for group four, the lack of fluency in their one-handed realisations is somewhat surprising, given that these could be construed as being more straight-forward to deliver than the two-handed realisations presented by groups one, two and three. However, in a similar manner to groups two and three, it appears that the efforts of group four to play fluently by ear were hampered by their mainly low levels of recall memory. This raises the question of how recall memory influences the fluency of by-ear realisation.

The discussion in Chapter 5 demonstrates that when they were preparing their music for by-ear realisation, participants in group one worked exclusively on the whole piece (see page 121). It was inferred from this that these participants were likely to be capable of forming, recalling and processing long, complex and highly musically accurate, hierarchical chunks of data. Furthermore, the discussion in the present chapter indicates that these participants also demonstrate high levels of sight-reading ability and, of course, recall memory. It is thought that fluent sight-readers can read several pitches ahead of where they are playing and, moreover, retain those pitches in memory after the visual stimulus has been removed (Sloboda, 1974). This is by virtue of being able to create and process complex chunks of information (Wristen, 2005), and Sloboda calls this distance the “eye-hand span” (1974, p. 5). Furthermore, in a study that considers the abilities of trained pianists to anticipate and plan the execution of musical sequences when sight-reading and learning new music from notation, Drake and Palmer (2000) demonstrate that pianists with higher skill levels require have a greater capacity to both efficiently plan ahead and accurately anticipate the actions required in terms of both pitch and timing.

Extrapolating from these observations, it is possible that a combination of high levels of recall memory and sight-reading skill, together with the capacity to chunk efficiently, may allow participants in group one to *recall* ahead of where they are playing whilst forming the aural image of the music in the mind’s ear. This ‘ear-hand span’ would then advance the formation of both the aural-structural representation and the motor programme constructed on it, allowing playing by ear to progress fluently. However, although the sight-reading skills of participants in groups two, three and four are also high, it is evident from Chapter 5 that their ability to chunk data is less effective than that of participants in group one. This, together with their lower levels of recall memory, may prevent them from recalling ahead to the same extent as participants in group one, resulting in less fluent by-ear realisations, even where those realisations are one-handed and melodic.

Overall, it seems that even where levels of motor memory are sufficient to form the motor programme, insufficient levels of recall memory nevertheless inhibit the fluency with which music can be performed by ear.

7.9.6 Spontaneity in playing by ear

One of the requirements set out in the definition of playing by ear in Chapter 4 is that is should be spontaneous (see page 107) and it is apparent from responses to the playing-by-ear survey, discussed in Chapter 2, that this requirement is the most contentious. The discussion in Chapter 2 also raised the question of whether spontaneous playing by ear is simply a faster and more efficient execution of deductive playing by ear, and one expectation of the BEAT Study was that deductive realisations would be no less accurate and fluent than those that were spontaneous. However, that study demonstrated that participants who required working-out time produced by-ear realisations that were less accurate, fluent and stylistically-complex than those produced spontaneously (see Chapter 4, page 104).

If a by-ear realisation is to be spontaneous, it follows that the player must be able to progress rapidly through the by-ear process thereby gaining a full grasp of the music in the shortest possible time. But crucially, the resulting realisation must, above all, be accurate and fluent, regardless of its level of stylistic complexity. It is, therefore, necessary for the memory skills underlying playing by ear to be sufficient to allow not only accuracy, but also rapid processing.

Participants in group one are able to recall the aural representation of the music with high levels of accuracy and it seems likely that this allows them to rapidly form a rich and detailed aural image. This provides for an accurate and detailed aural-structural representation, and following motor programme, that facilitate their accurate, fluent and stylistically-complex realisations spontaneously. However, for remaining participants, insufficient recall memory means that the aural image is not only inaccurate and diminished in melodic and/or harmonic detail, but also takes time to work out. This funnelling down of musical data, from the richly detailed aural representation to an aural image that is reduced in detail, leads to the formation of an aural-structural representation and a motor-programme that are also diminished. Finally, this leads to a by-ear realisation that is impoverished in terms of accuracy, musical detail, fluency and stylistic complexity that, moreover, has taken time to achieve and therefore lacks spontaneity. This is regardless of participants' levels of structures memory and motor memory. A graphical representation of this funnel effect is presented in Figure 7.8, but note that it does not portray an actual timescale, nor a specific reduction in musical detail.

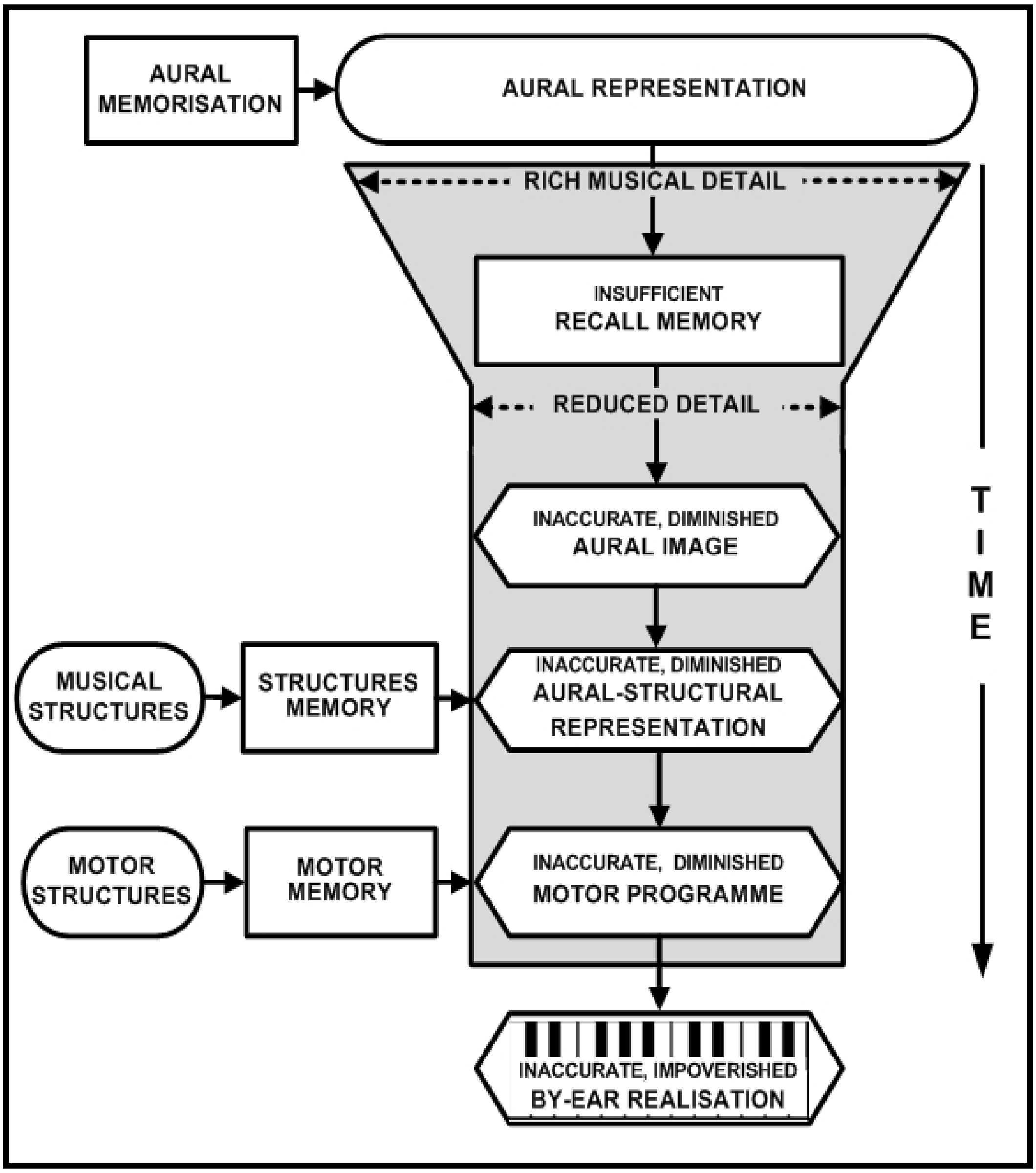

Figure 7.8 Graphical representation of the funnel effect brought about by insufficient recall memory

Furthermore, it is reasonable to speculate that should levels of structures and/or motor memory also be insufficient, the steepness of the funnel effect would increase. This would result in additional impairment to the aural-structural representation and/or motor programme, leading to the further inaccuracy and impoverishment of the final by-ear realisation. Moreover, it would also further decrease the level of spontaneity with which that realisation would be produced.

This section of the chapter has discussed participants' ability to play the piano by ear in the light of their musical memory skills. The following section now considers the validity of the proposed theoretical model of the cognitive-psychological process of playing by ear.

7.10 Validating the proposed cognitive-psychological model of playing by ear

The theoretical model of the cognitive-psychological process of playing by ear, proposed in Chapter 6, has five sequential stages: the formation of an aural representation of music via aural memorisation; the retrieval of the aural representation, using memory for auditory-musical recall (recall memory), to form an aural image of the music in the mind's ear; the synthesis of the aural image with musical structures, retrieved using memory for mental representations for musical structures (structures memory), to form an aural-structural representation in the mind; the synthesis of the aural-structural representation with motor structures, retrieved using memory for musical-motor structures (motor memory), to form a motor programme; and the by-ear realisation of the music on the piano (see page 143, Figure 6.3).

The analysis in the current chapter has shown that participants can satisfactorily encode music aurally into long-term memory, meaning that the first stage in the process is conceivable. Furthermore, the observed statistical effect of recall memory on overall playing-by-ear ability indicates the feasibility of the second stage. Moreover, the high levels of motor memory demonstrated by participants, and the small but nevertheless statistically significant effect of motor memory on playing-by-ear ability, indicates that the fourth stage is viable. And, of course, the majority of participants were able to present some level of by-ear realisation. Nevertheless, it is evident that the third stage in the model – the formation of an aural-structural representation – may be problematic.

The rationale for the inclusion of an aural-structural representation in the model was Ericsson and Kintsch's (1995) assertion that the process of expert memory includes the creation of a formal structure of material, in this case music, in the mind. From the point of view of playing by ear, this structure represents the development of the aural image of the music in terms of the pianistic structures that are necessary to then construct a motor programme for realisation. As this discussion has pointed out, it is possible that the methodology for measuring structures memory was inappropriate and, although the results suggest otherwise, participants demonstrating the highest levels of by-ear ability were actually transferring the required mental representations of musical structures, and fulfilling that stage of the model. However if the test was accurate, suggesting that an aural-structural representation does not form part of the model, there remains the question of how participants proceeded from the formation of an aural image of the music to the construction of a motor programme, and whether an alternative mechanism, not requiring the use of structures memory, is facilitating this part of the process.

It is thought that the visuo-spatial properties of keyboard instruments may allow a pianist to form a *mental-motor map* of the physical course of a piece of music on the instrument (Shaffer, 1981). In the context of their study of the impact of musical training and experience on melodic playing by ear, Woody and Lehmann (2010) comment that the pianists (and mallet percussionists) amongst their subjects may have used this process to facilitate the construction of a motor programme for playing melody by ear (see page 73 of this thesis for details of Woody and Lehmann's study). This observation is based on the speed with which participants in the study produced their by-ear instrumental melodic responses, and also their post-test interview data, although the authors acknowledge that the observation is preliminary and, therefore, unverified. Nevertheless, it suggests the possibility that participants in the BEAT Study may similarly have synthesised the aural image with both the visuo-spatial properties of the piano keyboard and previously encoded motor structures to form a mental-motor map of their music. This would replace the need to use structures memory to form an aural-structural representation and, in some ways, leans instead towards a form of ideomotor memory, although it includes a visual element in the formation of the motor response that does not form part of ideomotor theory (see Chapter 6 for a discussion both of ideomotor theory, and of its appropriateness as a theory of memory for playing the piano by ear). Of course, it is likely that the quality and accuracy of the resulting by-ear realisation would be the same either way, given that both an aural-structural representation and a mental-motor map would depend on the accuracy of the aural image of the music, which is itself dependent on accurate recall. Nevertheless, Woody and Lehmann's theory gives rise to an alternative model of the cognitive-psychological process of playing the piano by ear, and this is illustrated in Figure 7.9.

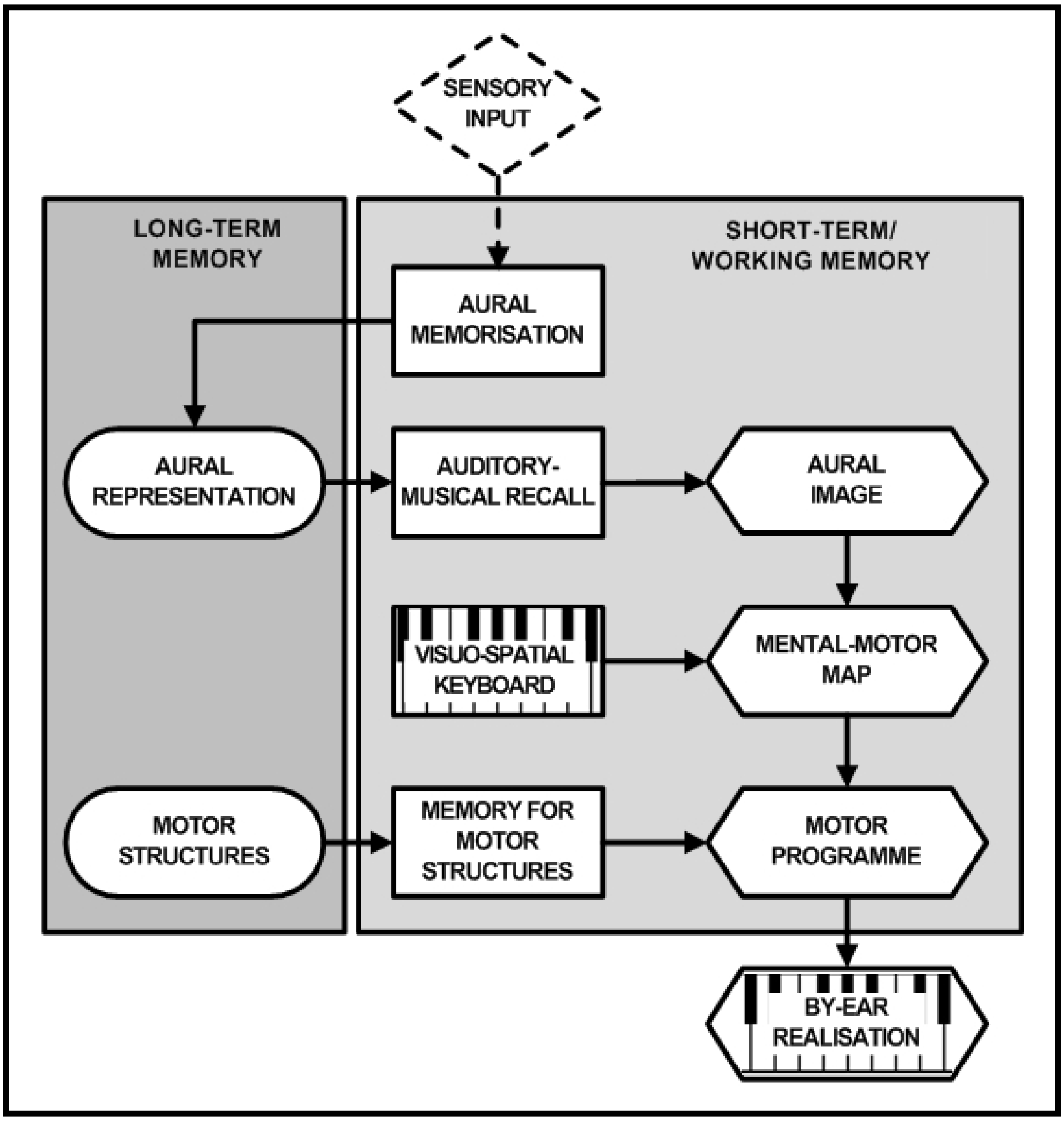

Figure 7.9 Schematic diagram of an alternative model of the cognitive-psychological process underlying playing the piano by ear

It is important, however, to bear in mind that these two representations of the musical structure are very different. An aural-structural representation, as its name implies, provides aural information about the overall contour of the music, and the pianistic structures and stylistic devices therein. Conversely, in representing the physical course of those structures on the keyboard, a mental-motor map presents the information in a more visual way, rather like watching an old-fashioned player-piano or pianola. This introduces the possibility of a visual element in playing by ear that has not been considered by this thesis. Furthermore, whilst the concept of a mental-motor map appears straightforward in terms of playing melody on the piano by ear, its formation in the context of harmonised piano music is not. Charting the course of multiple pitches played simultaneously, as they are in harmonised music, is likely to be substantially more complex, especially if the music being realised is orchestral where the musical structures do not relate directly to the piano keyboard.

In raising these points, this discussion does not imply that the notion of the mental-motor map as an alternative to the aural-structural representation is unreasonable, particularly where melodic playing by ear is concerned. Indeed, it is possible that participants in the BEAT Study were achieving their by-ear realisations via this alternative process. Furthermore, and regardless of the motor complexity of harmonised music, the mental-motor map model presents a more feasible alternative to the original than the ideomotor model, where the motor response would be formed directly from the aural image (see Chapter 6 for a discussion of this point). Nevertheless, this author would argue that, where playing by ear is harmonised, it is more plausible that an aural-structural representation forms part of the process than a mental-motor map. This implies that the cognitive-psychological process underlying harmonised playing by ear may differ from that underlying melodic playing by ear. Further research is, therefore, necessary before a definitive model of the cognitive-psychological process of playing by ear can be confirmed.

7.11 Summary and conclusions

This thesis has identified four memory processes that have the potential to underlie the ability to play the piano by ear in a two-handed, harmonised manner: aural memorisation, recall memory, structures memory and motor memory. The Memory Study has shown that participants are highly capable of memorising music aurally, although their demonstrated range of ability to accurately recall it aurally is very broad, particularly where harmonic recall is concerned. Additionally, the study has shown that participants have mainly high levels of motor memory, although their levels of structures memory are lower. Overall, it has been shown that recall memory is the most salient influence on the ability to play the piano by ear, where insufficient ability to recall the harmonic elements of the music inhibits harmonised playing by ear ability altogether.

To be more specific, only participants demonstrating the highest levels of recall memory are capable of spontaneous, accurate and fluent, two-handed, harmonised realisations by ear. For those remaining, the inability to form an accurate aural image of the music using recall memory results in successively less accurate, and progressively more deductive by ear realisations. This finding contrasts with evidence, presented by Woody and Lehmann (2010), demonstrating that the melodic playing by ear abilities of trained musicians (including pianists) are inhibited by inability to form a motor programme, rather than inability to recall the music. Furthermore, whilst they do not imply that trained musicians are unable to play by ear, Woody and Lehmann have shown that the musicians in their study who had received formal training demonstrated lower levels of melodic playing by ear than their colleagues who developed their musical skills more informally through participation in jazz, pop, rock and church ensembles. Conversely, the BEAT Study has shown that trained pianists are capable of demonstrating very high levels of melodic playing by ear, and moreover, many of them exhibit very high levels of two-handed, harmonised playing by ear. However, it is acknowledged that the melodic and harmonised by-ear abilities of participants in the BEAT Study have not been compared with those of pianists who have gained their musical skills informally, as those in Woody and Lehmann's study have. It is also noted that the methodological approach taken by Woody and Lehmann to measuring playing-by-ear ability was distinctly different to that employed in the BEAT Study (see Chapter 3, page 73).

In addition to the identification of the aforementioned memory processes, this thesis has proposed a theoretical model of the cognitive-psychological process of playing the piano by ear (see Chapter 6, page 143). However, given that the evidence presented in the Memory study cannot confirm the existence of an aural-structural representation in the proposed model, an alternative model is also presented (see this chapter page 190). Nevertheless, it is argued that the model originally proposed is more likely to represent the process of harmonised playing by ear.

Finally, it is acknowledged that the investigation in this research project has been limited to examining the ability of trained pianists to play familiar music by ear. Other areas of further research that would broaden the findings of this thesis would be an investigation into the ability to realise familiar music amongst by-ear pianists who have developed their musical skills through the more informal jazz, pop and rock music route; and the abilities of these pianists and those who have been received formal training to realise novel or unfamiliar music by ear. Furthermore, an observation of the preparation strategies and practical techniques adopted by by-ear pianists who have developed their musical skills informally might provide additional insight into the proposed and alternative models of the cognitive-psychological process of playing by ear contained in this thesis.

This discussion has examined the findings of the final study in this research project. Chapter 8 summarises the research project as a whole and presents a discussion on a number of issues arising from it.

8. General Discussion

8.1 Introduction

This thesis has reported on a research project containing a progressive series of investigative and empirical studies that were conducted with the aim of determining the cognitive-psychological factors that underlie the ability to play the piano by ear. In an attempt to develop both existing research that examines melodic playing by ear, and the author's own earlier study that examines the influence of aural skill on playing by ear amongst trained pianists (see Sapiro, 2007), the present project has focussed on harmonised playing-by-ear ability specifically in adult pianists who have received formal musical and piano training.

This chapter begins with a detailed summary of the whole project and its overall findings. It continues with an evaluation of the methodological approaches employed in each study, and this is followed by a comparison between the rehearsal and performance skills observed in playing by ear and those evident in skilled piano performance from notation. The discussion then reconsiders the nature of playing by ear, and compares the memory skills and playing by ear abilities of the participants in this project with those of musical-savant pianists. An examination of the pedagogical impact of the research is then presented, and the chapter closes with a consideration of areas where additional investigation would broaden the findings of this thesis, and extend existing research on playing by ear.

8.2 Summarising the research project

The pianists taking part in this research project inhabited a wide variety of musical backgrounds, ranging from undergraduate music students and amateur pianists to professional performing and academic musicians, with some believing they were able to play the piano by ear and others believing they could not. The broad spectrum of piano ability and musical experience amongst participants provided the opportunity to gather rich and detailed quantitative and qualitative data, particularly from those who participated in the practical studies. The results of these studies have identified a number of factors relating to playing-by-ear ability and its cognitive-psychological underpinnings, as well a giving a broad insight into how trained musicians view playing by ear as a musical ability, and the practices they employ to carry it out. The results have also facilitated the development of a theoretical model of the cognitive-psychological process of playing by ear. The overall structure of the phases of the project, and the studies within them, are summarised in Table 8.1.

Table 8.1 Overall structure of the research project

Phase	Stage	Chapter	Description
One	Playing-by-ear survey	2	A qualitative survey of opinion on playing by ear amongst 151 trained, adult pianists.
Two	The BEAT Study	4	An assessment of two-handed, harmonised playing-by-ear ability of 29 trained, adult pianists.
	The Strategy Study	5	An evaluation of the strategies and techniques employed by participants in the BEAT Study when preparing to realise familiar, orchestral music for by-ear piano performance.
	The model	6	Formulation of a model of the cognitive-psychological process of playing by ear
Three	The Memory Study	7	An assessment of aural memorisation, recall memory, structures memory and motor memory skills of participants in the BEAT Study.
			A comparison between the playing-by-ear abilities and memory skills of participants in the BEAT Study.
			Validation of the model of the cognitive-psychological process of playing by ear.

8.2.1 Phase one

The playing-by-ear survey elicited the opinions and beliefs of trained pianists with regard to playing the piano by ear, and investigated the factors that influenced those opinions and beliefs. It also compared the views expressed by respondents with opinion presented in the published literature on playing by ear. One-third of respondents to the survey report the ability to play by ear, and their responses indicated that these pianists generally see it as important to both their musical development and their musical identity. They play by ear regularly, and whilst not all have been encouraged themselves, they would nevertheless encourage others to engage with it. Some of these pianists believe that their ability is innate, whilst others believe it is nurtured, and they are divided in their opinion over whether playing by ear is a spontaneous act or one that is deductive.

The survey also shows that respondents who report inability to play by ear (or are unsure) would like to be able to do so, and they acknowledge its musical value. However they have mainly found their efforts to play by ear unproductive, even when encouraged to try, and imply that teacher attitudes, alongside their own belief that playing by ear should be spontaneous, have influenced their perceived lack of ability.

In presenting these profiles the survey served to contextualise the overall project and raised the question of whether spontaneous playing by ear is simply deductive playing by ear that is achieved more efficiently. This was addressed during phase two.

8.2.2 Phase two

The second phase contained two studies: the empirical BEAT Study and the more qualitative Strategy Study. The BEAT Study was based on the working premise that playing the piano by ear is the accurate and fluent, two-handed, harmonised realisation of music that has been presented aurally to the performer (see page 84). Its main purpose was to measure the ability of trained pianists to play familiar music by ear. Following a discussion of assessment methods in music, and an evaluation of a number of methodologies that attempted to measure melodic playing-by-ear ability, Sapiro's (2007) By Ear Assessment Tool (BEAT) was adopted for the study on the basis of its capability to measure two-handed, harmonised playing by ear on the piano (see Chapter 3, page 79). The BEAT test allowed participants 15 minutes to prepare a by-ear realisation of a short piece of familiar, orchestral music that they had not played before. The test results demonstrated that the majority of the 29 participants were capable of a high level of melodic playing by ear. However, two-handed, harmonised by-ear ability varied considerably, ranging from spontaneous, accurate, highly fluent and stylistically-complex realisations, through to inaccurate, unsophisticated realisations that required time to work out. Moreover, not all participants in the study were capable of presenting realisations were that were two-handed and harmonised. The study also presented evidence that spontaneous by-ear realisations are more accurate, fluent and stylistically complex than realisations that are worked out, demonstrating that spontaneous playing by ear is not simply deductive playing by ear that is implemented with greater efficiency. Finally, based on the findings of the BEAT Study, the original working premise was revised to form a definition of playing the piano by ear stating that it is 'the accurate, fluent and spontaneous, two-handed, stylistically-harmonised realisation of a piece of music that has been memorised aurally, without reference to notation'.

The remaining study in phase two of the project, the Strategy Study, examined the overall preparation strategies adopted by participants in the BEAT Study when they were preparing their by-ear realisations, and the practical techniques they exhibited within those strategies. The examination observed two types of preparation strategies: commencement strategies, that indicated how participants began their preparation; and practice strategies, that specified how they worked through the remainder of their preparation time. The discussion observed that the preparation strategies adopted by participants did not differ according to whether their playing by ear was two-handed and harmonised, or one-handed and melodic.

Within these strategies, three practical techniques were identified: learning techniques, that demonstrated the manner in which participants broke the music down into learning segments; handing techniques, that exhibited their use of hands-together and hands-separately; and accompanying techniques that illustrated how they combined the melodic and harmonic elements of the music. It was evident that the techniques participants demonstrated differed according to their level of playing-by-ear ability.

Additionally, it was shown that these techniques are rooted in three different memory skills: memory for auditory-musical recall, memory for musical-motor structures, and memory for mental representations of musical structures. Overall this indicated the likelihood that memory is a salient factor in playing-by-ear ability amongst trained pianists. In light of this, and after an examination of a range of memory theories, a theoretical model of the cognitive-psychological process of playing by ear was proposed (see page 143, Figure 6.3).

8.2.3 Phase three

The final phase of the project was an investigation into the influence of these memory skills on playing-by-ear ability, and the determination of the validity of the proposed model. The Memory Study assessed the memory skills of the 29 trained pianists who took part in the BEAT Study through a suite of tests that were designed by the author specifically for this purpose. Four areas of memory were measured: aural memorisation, recall memory, structures memory and motor memory. Participants demonstrated very high levels of aural memorisation, a wide range of recall memory, high levels of motor memory and low levels of structures memory. These memory skill measures were first discussed in the context of the practical techniques that gave rise to them. They were then compared with participants' levels of ability to play by ear (as measured by the BEAT test) to determine their individual and collective influence on by-ear ability. The comparison showed that the ability of trained pianists to present spontaneous, accurate, fluent and stylistically-complex, two-handed, harmonised realisations by ear depends on levels of ability to recall the music accurately. Furthermore, insufficient harmonic recall inhibits by-ear spontaneity and, moreover, sometimes inhibits two-handed, harmonised playing by ear altogether. The remaining memory skills were found to have less influence on playing-by-ear ability. Given participants' low levels of structures memory, an evaluation of the suitability of the structures-memory test was conducted. Although the test had a strong theoretical and methodological basis, the evaluation implied that the sight-reading exercise it employed may have been an inappropriate method of measuring memory for mental representations of musical structures. Nevertheless, the structures-memory test indicated a strong relationship between two-handed, harmonised playing-by-ear ability and piano sight-reading skill, which supported the findings of other research on playing by ear.

Finally, with respect to the proposed theoretical cognitive-psychological model of playing by ear, the Memory Study presented evidence to support the roles of aural memorisation, recall memory and motor memory in facilitating the respective concepts of an aural representation, an aural image, and a motor programme as stages in that process. However, insufficient evidence of the role of structures memory brought into question the presence of an aural-structural representation. Although speculative evidence from other research (see Woody & Lehmann, 2010) presented the possibility that a mental-motor map might take the place of an aural-structural representation in the model, it was asserted that this was unlikely in the process of realising harmonised piano music by ear.

Having summarised the project, it is appropriate to evaluate the effectiveness of the methodological approaches adopted to carry it out. These are discussed in the following section.

8.3 Evaluating the methodological approaches

8.3.1 The BEAT Study

The By Ear Assessment Tool was the first of a series of author-designed measures to be used in this project. Its purpose was to measure participants' levels of ability to play the piano by ear via assessment of the accuracy, fluency, spontaneity and stylistic complexity of their by-ear realisations. BEAT had been shown to be an effective method of measuring playing-by-ear ability in the context of the author's earlier study (see Sapiro, 2007), and has been similarly effective in the present project, where the results are consistent with those of Sapiro's earlier study.

Based on the findings of the earlier (2007) study, the 15 minute time limit for preparing by-ear realisations during the BEAT Study was considered to be appropriate. Nevertheless, given the overall finding that spontaneous playing by ear is more accurate and fluent than deductive playing by ear, some consideration must be given to whether this relatively short amount of preparation time might have had some impact on the BEAT test outcomes. For participants who demonstrated spontaneous playing by ear this was clearly not an issue. As discussed in Chapter 7, these participants achieved their accurate and fluent realisations quickly, and were observed spending the remainder of their preparation time simply replaying them, or repeating sections that they could already play accurately and fluently, or refining the stylistic detail of their harmonisations. However, for participants who needed to work out what to play, particularly where harmony was concerned, consideration was given as to whether a longer amount of preparation time might have allowed some of them to achieve a level of accuracy and fluency that was similar to that demonstrated by spontaneous by-ear players. This is not to suggest that an unlimited amount of time should have been allowed, although it could be argued that, with the exception of sight-reading, the assessment of a musical performance would normally take place only after a significant period of learning and practice. Of course, it could also be argued that if playing by ear is the spontaneous reproduction of music from an aural source, in the same way that sight-reading is a spontaneous attempt to play a piece from a visual source, a test of ability should not allow large amounts of preparation time.

Ultimately, in light of the results of the subsequent Memory Study tests, it became evident that the amount of time allowed for preparation was not a salient factor in the BEAT test. On the basis that ability to play by ear depends on the accuracy of musical recall, and given that interference caused by inaccurate realisations of the music further impairs recall, it is likely that a longer period of preparation time would have made little difference to participants who demonstrated deductive playing by ear. In fact, as the discussion in Chapter 7 highlights, it was evident from the video recordings that some of the initial errors made by these participants were repeated consistently, with additional errors being observed as the preparation progressed. Furthermore, amongst those demonstrating the very lowest levels of playing by ear, it quickly became apparent that they would not be able to reproduce the music to any great extent, no matter how long they were given. Thus, it appears that limiting preparation to 15 minutes did not impact on the quality of the realisations of deductive by-ear players, given that their recall memory skills were insufficient.

From a procedural perspective, the assessment of participants' by-ear realisations was a time consuming and labour intensive process, although the richness of the data it yielded allowed detailed judgements to be made about individual aspects of each participant's ability to play the piano by ear. The importance of this cannot be over-estimated, particularly where there is a desire to provide participants with appropriate feedback on their ability. It is, therefore, possible that some benefit may have been gained by capturing participants' preparation, and subsequent by-ear performances, electronically using MIDI software, since this would have provided a notated version of events to complement the audio and video recordings. Unfortunately a Yamaha Disklavier equipped piano, which would directly facilitate this type of data capture, was not available at the time of the present project, although its use would be recommended if a similar study were to be conducted.

8.3.2 The Memory Study

The Memory Study contained a total of four memory tests: aural memorisation, recall memory, structures memory and motor memory. A recognition paradigm was employed for the aural-memorisation test on the basis of theories of memory suggesting that where existing schemata have been encoded accurately, incoming data with the same schema will match exactly and recognition will occur. This approach was found to be successful in the context of the Memory Study, and yielded results that were consistent with the results of the studies on which the test was modelled.

The recall-memory test utilised a listen-and-sing-back paradigm on the basis of its established use in other music examination contexts. Indeed, the manner of the test was such that all participants in the study were familiar with its style and procedure. However, one obvious concern with a test of this type is the ability of the respondent to vocally articulate what they can actually hear in their head. Indeed, it was evident that some participants were disquieted about having to sing their responses until they were reassured that the quality of their singing was not important. One possible way round this perceived problem might have been to ask participants to demonstrate their recall by playing the melodies on their instruments. However this would, in effect, turn a test of recall memory into a test of playing by ear, with the possibility that the recall might have been compromised by structures and motor memory factors, the effects of which were unknown at that point in the project.

It was evident from the results of the recall-memory test that many participants found more difficulty with the lower parts of the two and four part textures than they did with melody alone or melody in the context of a polyphonic texture. Having deliberately placed each test in a different musical timbre it is difficult to ascertain whether this would have been the case if all tests had been in the piano timbre, which respondents would undoubtedly have been more used to. Nevertheless, given that the BEAT test required the playing of orchestral music by ear, it was appropriate that the recall test should be similarly multi-timbral.

With respect to the practicalities of coding participants' responses, capturing them using MIDI as well as audio recording might have been of some assistance. As it is, the method of coding by listening and re-listening to recordings of participants' responses is likely to have been more effective than that often applied during the aural test section of practical instrumental examinations, where responses are assessed for accuracy as they are performed, leaving no opportunity to double check.

An extensive evaluation of the structures-memory test has already been presented in Chapter 7 (see page 182). It is, therefore, not discussed again here except to comment that, as with the BEAT test above, capturing participants' sight-reading attempts using MIDI might have assisted with the marking and coding process.

Finally, the motor memory test, with its transfer-of-learning paradigm, demonstrated results that were consistent with those of Palmer and Mayer (2000) on whose study it was modelled. From a practical perspective, this test was simple to administer and participants had no difficulty in carrying it out. However, the coding and assessment was, once again, time consuming since each participant's final training trial and three transfer trials required individual observation, via the video recordings, to assess accuracy of fingering transfer.

Overall, the methodological approaches adopted in this research project have been mainly successful. They have yielded rich and varied data that has enabled conclusions to be drawn about the role of memory in playing-by-ear ability and, with the exception of the structures-memory test, each would stand alone as an independent measurement tool for the memory skills under scrutiny. Having presented a summary of the project and its findings, and evaluated its methodological approaches, this discussion compares the practical and performance skills evident in playing the piano by ear with those observed in during practice and performance from notation

8.4 Playing by ear and playing from notation: comparing rehearsal behaviours and performance skills

As well as identifying the cognitive-psychological processes involved in playing by ear, this research project has shown that trained pianists exhibit a number practical techniques and performance skills when respectively preparing and performing music by ear. Furthermore, it is evident that these techniques and skills vary according to pianists' levels of playing-by-ear ability. In the same vein, research in piano performance has shown that the range of practice techniques (Gruson, 1988) and performance skills (Drake & Palmer, 2000) demonstrated by trained pianists when rehearsing and playing notated music varies according to their level of experience in playing from notation. But do these rehearsal behaviours and performance skills vary according to the mode of performance?

8.4.1 Rehearsal behaviours

The rehearsal behaviours demonstrated by participants exhibiting the highest levels of two-handed, harmonised, by-ear ability in the BEAT study, and observed during the Strategy study, signify a schema-driven, or top down, approach to preparing music for by-ear performance. These pianists were observed working on the piece as a whole, rather than dividing it into smaller sections, and processing the melody and harmony concurrently to facilitate the immediate development of stylistically-harmonised accompaniments. Additionally, although some used a hands-separate followed by hands-together approach, participants mainly played hands-together from the commencement of preparation. Furthermore, they corrected errors in the context of repetitions of the whole piece rather than by repeating isolated sections, and they achieved accurate play-throughs more quickly than participants who demonstrate lower levels of by-ear ability.

Conversely, the rehearsal behaviours of participants exhibiting lower levels of two-handed, harmonised, playing-by-ear ability imply a more data-driven, or bottom-up, approach to preparation. These pianists tended to work on segments of the piece, gradually constructing the whole piece as preparation progressed. Additionally, they mainly worked hands-separately before moving on to hands-together, and processed the melody and bass notes independently before attempting to create stylistic harmonisations. Errors, which were greater in number than those observed amongst their more-able colleagues, were corrected in the context of repeated segments, and accurate play-throughs took significantly longer to achieve.

Some of these rehearsal behaviours reflect those observed by Gruson (1988), who notes that practice techniques amongst trained, notation-reading pianists vary according to their levels of piano skill and competence. Gruson indicates that, amongst her participants, those pianists with higher levels of skill adopted a top-down approach to practice, breaking the piece down into hierarchically meaningful sections, and practising these using a hands-separate technique in the early stages of learning. She also notes that these pianists made fewer errors than their less-skilled colleagues, and corrected any errors that did occur through repetition of sections or the whole piece, rather than by repeating individual notes or bars. Conversely, Gruson observes that the less-skilled pianists amongst her participants tended to learn using a bottom-up approach that focused on building up the piece by practising small sections. They mainly worked note by note or bar by bar, and corrected errors through the repetition of individual notes or single bars (Gruson, 1988).

This comparison suggests that pianists who demonstrate high levels of ability to play by ear employ the same or similar rehearsal behaviours when preparing music for by-ear realisation as skilled notation-reading pianists use when practising from notation. Similarly, those with lower levels of ability in each mode of playing seem to share the same or similar rehearsal behaviours as each other. However, amongst participants in the BEAT study are those who report high levels of competence in playing the piano from notation, but at the same time demonstrate low levels of ability to play the piano by ear. It would be an interesting area for further research to investigate whether such pianists adopt different rehearsal behaviours for each mode of playing, as would be implied by the observations in Gruson's (1988) study and the present research project.

8.4.2 Performance skills

When performing their by-ear realisations it is evident, from the results of the BEAT study, that participants with high levels of by-ear ability achieved a high degree of rhythmic, melodic and harmonic accuracy, and made significantly fewer harmonic errors, and progressively fewer melodic errors, than their less-able colleagues. They demonstrated ability to maintain temporal control, playing in time with the underlying beat, and presented their realisations at appropriate tempi, with fluency and spontaneity. Furthermore, these participants appeared to be able to forward plan the execution of the motor programme necessary for delivery of the realisation by virtue of recalling ahead the aural image of the music in the mind's ear, a skill not observed amongst those who demonstrated lower levels of playing-by-ear ability (see Chapter 7 for a discussion of the 'ear-hand span' theory). Conversely, participants with low levels of playing-by-ear ability presented realisations that were mainly melodically accurate, at appropriate tempi, and relatively fluent, but were lacking in harmonic accuracy.

Drake and Palmer (2000) conducted a study of the performance skills of notation-reading pianists whose abilities ranged from novice to expert, and some of their findings demonstrate similarities with those observed during the BEAT study. They noted that the highly-experienced pianists in their study presented performances at tempi appropriate for the pieces, and made fewer errors than those pianists with lower levels of experience, whose performances were not only less accurate but also slower and less fluent. Drake and Palmer also noted that, like participants demonstrating high levels of playing-by-ear ability in the BEAT study, highly experienced pianists were able to maintain temporal control. Furthermore, they indicated that these pianists demonstrated the ability to plan movement sequences in advance of execution, although this was measured in terms of the number of anticipatory errors made whilst reading notation ahead. Finally, Drake and Palmer observed that highly-experienced pianists tended to preserve performance fluency, or “relative timing” (2000, p. 3) (defined as the accurate placement of duration events relative to surrounding events), at the expense of occasional pitch inaccuracies, whilst less-experienced pianists focussed more on playing accurate pitches, resulting in performances that sometimes lacked fluency (Drake & Palmer, 2000).

As with rehearsal behaviours, this comparison suggests that pianists who exhibit high levels of ability to play by ear mainly demonstrate the same or similar performance skills as experienced notation-reading pianists. Similarly, those with lower levels of ability in each mode of playing seem to share the same or similar performance skills as each other, although there appears to be one exception. Drake and Palmer (2000) indicate that inexperienced notation-reading pianists tend to sacrifice fluency in performance in order to play the notated pitches correctly. They attribute this to the fact that less-skilled pianists focus primarily on pitch, rather than duration or metrical structure, when learning music, and consequently sometimes temporally disrupt the music in order to ensure that the pitches they play are correct (Drake & Palmer, 2000). Conversely, pianists demonstrating low levels of playing-by-ear ability in the BEAT study played their realisations fluently but these contained inaccurate chord sequences. This seems to suggest that by-ear players sacrifice harmonic accuracy in order to produce a fluent realisation. But is this really the case? The Memory study presents evidence that participants with low levels of by-ear ability have low levels of harmonic-recall memory. As a result, the harmonic sequences in their realisations are the product of the inaccurate recall of the harmonic structure of the music. At the same time, these participants have relatively high levels of motor memory that allows them to form the necessary motor programmes for realisation based on their inaccurate recall of harmonic events. They do not, therefore, sacrifice harmonic accuracy for in order to play fluently, but simply fluently play what they can recall, regardless of how accurate it is. Overall, just as with rehearsal behaviours, it would be interesting to investigate whether performance skills differ for each mode of playing amongst participants in the BEAT study who report high levels of competence in playing the piano from notation but exhibit low levels of ability to play the piano by ear.

Having compared rehearsal behaviours and performance skills between playing by ear and playing from notation, this chapter continues by speculating on whether playing by ear is improvisation or imitation.

8.5 Playing by ear: improvisation or imitation?

This thesis has presented evidence to demonstrate that playing by ear can be spontaneous or deductive. However, in addition to this there is some suggestion, both by respondents to the playing-by-ear survey (discussed in Chapter 2), and the published literature on playing by ear, that this ability is akin to the ability to improvise (P. Priest, 1989). Furthermore, McPherson (1995, 1996) presents evidence of a strong correlation between these two abilities amongst student wind players. Conversely, other respondents to the playing-by-ear survey express the opinion that playing by ear is simply imitation. When considering these views, it is essential to make the distinction between the *act* of playing by ear and the *product* of that action – the by-ear realisation itself. That the act of playing by ear can be either spontaneous or deductive in nature is not in dispute, but there remains the question of whether the resulting by-ear realisation can be considered to be an improvisation, whether it is an improvisatory version of the original, or whether it is simply an imitation.

There are a number of different types of improvisation, and The New Harvard Dictionary of Music and Grove Online, respectively, present the following definitions:

> Improvisation, extemporisation: the creation of music in the course of performance.
>
> (Nettl, 1986)

> Improvisation: the creation of a musical work, or the final form of a musical work, as it is being performed. It may involve the work's immediate composition by its performers, or the elaboration or adjustment of an existing framework, or anything in between.
>
> (Nettl, et al., 2007-2012)

In the context of Western music, these definitions imply that the term 'improvisation' covers a range of musical skills. These include the spontaneous creation of new music without reference to that which already exists; the spontaneous creation of jazz solos based on existing, pre-determined pieces of music (Pressing, 1998; Johnson-Laird, 2002; Biasutti & Frezza, 2009); and the "idiomatic improvised embellishment" (Levin, 1992, p. 222) of pre-existing music, by the performer, in the style of the composer (Levin, 1992, 2002).

Literature on improvisation in jazz (see Ashley, 2009 for a review) describes a theoretical process that includes memorisation, recall, a mental representation of the musical structure, and motor control (Pressing, 1998; Johnson-Laird, 2002; Biasutti & Frezza, 2009). Additionally, it is evident that for this type of improvisation, the improviser requires particular musical skills and knowledge of certain musical devices. These include a referent, that may be a piece of music, a chord sequence, or musical genre on which the improvisation is to be based; a cognitive libraries of previously memorised musical structures and generalised motor programmes; an ability to predict the contour of the music in order to anticipate what other ensemble players might do (Pressing, 1998; Biasutti & Frezza, 2009); and levels of memory skill sufficient to allow the production of an improvisation in real time (Pressing, 1998). Thus, it appears that the sequential, cognitive-psychological memorisation and recall/retrieval processes thought to underlie jazz improvisation, and indeed idiomatic improvisation, are analogous to those set out in the sequential model of the playing by ear process proposed in the present thesis (see page 143, Figure 6.3). This implies that playing by ear and improvisation are essentially the same, but is this really the case?

In the context of the BEAT Study, participants were required to prepare and perform by-ear realisations of harmonised, orchestral music (the referent) that they had memorised, either implicitly or explicitly, at some point prior to the task. It was necessary for them to aurally recall that music in terms of its rhythmic, melodic, harmonic, structural and motor elements in order to create realisations that remained melodically and harmonically faithful to the original referent. A further expectation was that realisations would include stylistically-complex, harmonised accompaniments based on the harmonic contour of the music. Given that the musical structures and devices in orchestral music do not relate directly to the piano, the creation of piano realisations of orchestral pieces requires elements of cognitive and motoric creativity and abstraction that may be similar to those required during jazz or idiomatic improvisation. It must, of course, be borne in mind that the explicit intention in both jazz and idiomatic improvisation is to augment the referent through the addition of new music. This is achieved by systematically developing the existing musical material to create new material, either in the improviser's style (as in jazz) or in the style of the original composer (as in idiomatic improvisation). Playing by ear, however, has no such intention and is constrained by the referent. It will, therefore, retain its identity and remain recognisable, although it may include some stylistic manipulation of the referent's melodic and harmonic elements. Indeed, the BEAT study presented examples of this. Thus, the difference in the intended outcome of the performance may be seen as the differentiating factor between playing by ear and improvisation.

There is, however, a more subtle distinction between playing by ear (as defined by this thesis) and improvisation that becomes evident when improvisation is considered in its broadest definition – music created spontaneously during performance, without the requirement of a referent. On the basis that this form of improvisation does not require the memorisation and recall of pre-existing music, it follows that the underlying cognitive-psychological process is different to that occurring when playing by ear takes place. Indeed, playing by ear, whether it be spontaneous or deductive, cannot take place at all without the memorisation and recall of a referent. Given this dissimilarity, and the fact that there is a distinctive difference in the products of playing by ear and referent-based improvisations, this author argues that a by-ear realisation of a piece of orchestral music in a pianistic style is improvisatory in nature, but is not an improvisation.

In suggesting that playing by ear is not improvisation, the author does not imply that it must, therefore, be imitation. It is possible that had participants in the BEAT Study been asked to reproduce piano music by ear instead of orchestral music, some of them would nevertheless have presented improvisatory realisations in their own piano style. But this does not mean that playing by ear is *never* imitation, as there are bound to be instances where by-ear pianists will deliberately try to recreate piano music eidetically, and it is possible that the circumstances demanding the playing by ear will dictate its nature.

The discussion in Chapter 3 briefly mentions the existence of musical savants, whose playing by ear is thought to be highly imitative, if not eidetic. A small number of studies have examined the recall-memory skills of these musicians through playing by ear and, to determine how, or whether, their recall-memory skills and playing by ear abilities differ from those demonstrated by participants in the present project, those studies and their findings are discussed in the following section.

8.6 Playing-by-ear ability in musical savants

The present thesis has focussed on playing by ear and musical memory amongst trained pianists who represent the educational ‘mainstream’, and it has shown that high levels of playing by ear are accompanied by high levels of recall memory amongst these musicians. Alongside them, however, musical savants evidently exhibit high levels of ability to play the piano by ear and high levels of memorisation and recall memory, despite displaying severely impaired cognitive and behavioural function (Treffert, 2009).

In their study of NP, a male savant pianist in his early twenties, Sloboda, et al. (1985) presented him with two pieces of music to learn and play by ear: one tonal (Grieg, Opus 47, No. 3) and the other atonal (Bartók, ‘Whole Tone Scale’ from *Mikrokosmos*, Book 5). These pieces were selected on the grounds that they were within NP’s pianistic capabilities. The authors reported that he gave an almost perfect performance of the Grieg piece, having heard each section of the piece only four times, and playing hands-together from the start. Errors were mainly melodic rather than harmonic, and the tonal and structural integrity of the original was maintained throughout the piece. From this the authors inferred that NP processed the melodic and harmonic elements of the music simultaneously. Furthermore, NP is reported to have given a further almost perfect performance of the Grieg piece after a period of 24 hours, during which he had played many other pieces. Based on this, the authors further suggested that NP’s recall of the music did not suffer from the effects of melodic or harmonic interference. However, it is also reported that NP had more difficulty with the Bartók piece, which was thought by the authors to be because he was unfamiliar with the atonal structures therein.

A similar study was conducted by Young and Nettlebeck (1995) who compared the skills of their subject, TR, with those demonstrated by Sloboda et al.'s NP. TR, a 12 year old male savant, was presented with the same pieces as NP and similarly asked to learn and perform them by ear. Although TR was younger than NP, these pieces were considered by Young and Nettlebeck to be appropriate to his level of piano expertise. The authors reported that TR's first reproduction of the Grieg piece was almost perfect with only one melodic error, that was nevertheless harmonically consistent; and one incidence of the inversion of a chord, that retained harmonic integrity. On the basis of the accuracy of TR's performance of a phrase repeated several times in the piece, Young and Nettlebeck inferred that, like NP, TR's recall of the music was not affected by melodic or harmonic interference. When presented with the atonal Bartok piece the authors reported that, although he found it more difficult that the Grieg, TR was more successful in his reproduction of it than NP had been. They attributed this to the fact that TR was already familiar with the 'whole-tone' structure used in the Bartók piece.

More recently a series of articles has reported on the musical-memory skill of another male savant pianist in his twenties, Derek Paravacini (DP), who is severely visually impaired and has extreme learning difficulties (Ockelford & Pring, 2005; Ockelford, 2007, 2011). DP's ability to learn and recall tonal music for playing by ear (see Ockelford & Pring, 2005; Ockelford, 2007), was explored through a piece that was composed by Ockelford specifically for the purpose using a style with which DP was familiar – "Chromatic Blues" (see Ockelford, 2007, p. 14 for a score). The authors reported that after one hearing DP produced a version that was not perfect, but nevertheless maintained stylistic, rhythmic, melodic and harmonic integrity through the introduction of stylistically-appropriate materials from other similar pieces in his repertoire. They assumed from this that DP's inability to maintain the whole piece in working memory led him, in a non-conscious manner, to intuitively "plug the gaps" (Ockelford & Pring, 2005, p. 905) so that the piece would make musical sense. Furthermore, on the basis of further performances mentioned but not specifically reported on, and in contrast with NP and TR, the authors asserted that DP's subsequent recall of the piece, after weeks and months, was influenced by the interference effect of his own earlier imperfect reproductions.

In testing DP's ability to memorise and play an atonal piece by ear (see Ockelford, 2011), two pieces were presented: the opening 11 bars of 'Magical Kaleidoscope' from Schoenberg's *Klavierstüke* Opus 11, No. 1 which was completely atonal; and a piece, composed by Ockelford, that specifically imitated the overall structure and style of the Schoenberg piece but was more tonal in its approach – "Kooky Minuet" (see Ockelford, 2011, p. 258 for a score). Ockelford reported that DP struggled to reproduce the Schoenberg piece immediately after hearing it, and that subsequent recall further deteriorated over the following weeks and months. Conversely, the more tonal Kooky Minuet was played more accurately immediately after hearing it, although Ockelford comments that DP's subsequent "recollection of the global structure [was] eccentric" (p. 279). The study concluded that DP's ability to recall music for playing by ear was impaired either when he was unable to recognise the tonal structure of the piece, and thus its predictability was destroyed; or where a tonal structure did not exist.

There is a perception, albeit anecdotal, that musical savants reproduce music by ear that is not only spontaneous but also eidetic, and the reports of the almost perfect reproductions presented by NP and TR support this view. Conversely, like some participants in BEAT Study, DP evidently suffers from recall impairment brought about by his own initial inaccurate reproductions. However, unlike participants in the BEAT Study, whose recall impairment simply resulted in incorrect realisations, DP apparently introduced suitable musical materials, that he had heard elsewhere, at points where he experienced a memory lapse and, based on this observation, Ockelford (2007) suggests that DP's reproductions are improvisations. However, considering the discussion in the previous section of this chapter, the author of the present thesis takes issue with this suggestion, particularly as Ockelford reports that DP does this non-consciously and therefore with no deliberate intention to create a new piece.

Furthermore, in 2006 this author (Sapiro) attended a lecture where she was given an opportunity to discuss DP's capabilities with Professor Adam Ockelford (DP's teacher and mentor), and during which she volunteered to take part in a video-recorded playing-by-ear session with DP (see Derek Paravicini: The Musical Genius, 2006). Sapiro played, on the piano in her own by-ear style, a piece with which DP was unfamiliar and, although his immediate reproduction of it was not eidetic, it was melodically and harmonically similar, highly imitative of Sapiro's piano style, and made musical sense. Accordingly, since DP evidently does not have the ability to decide to create a new piece from the musical material he hears and, moreover, this was certainly not his intention on this occasion, this author would argue that his reproduction was not an improvisation *on* what she played, but rather it was an improvisatory and intuitive imitation of it.

To compare the abilities demonstrated by musical savants with those of participants in the BEAT Study it appears that, like those participants, the ability of the musical savants to play the piano by ear is facilitated by the skill of rapidly memorising and then recalling musical material, where tonality and predictability of musical contour have an salient role, and memory interference effect can be a factor. Furthermore, like participants in BEAT Study group one, the savants present their by-ear reproductions spontaneously and fluently. Additionally, similarities are evident between these two groups of musicians in the area of practical techniques. Participants in group one demonstrated that they were capable of working on the whole piece, processing melody and harmony simultaneously, and using a hands-together approach from the start. Similarly, amongst the savants, all three evidently played the melody and harmony hands-together, with TR and DP playing the whole (tonal) piece immediately after hearing it, and NP taking a slightly more segmented approach. Overall, it appears that the ways in which these two groups of musicians use memorisation and recall memory processes to facilitate playing by ear are analogous. Furthermore, although the musical-savant studies have not presented actual measures of memorisation and recall memory, based on the reported quality of their playing by ear reproductions, it appears that the levels of these memory skills demonstrated by NP, TR and DP are, broadly speaking, similar to those of the participants in BEAT Study group one who exhibited the highest levels of playing-by-ear ability. It must, of course, be borne in mind that participants in the BEAT Study were required to realise orchestral music by ear and could not, therefore, attempt to present eidetic reproductions of their music. Consequently, the playing by ear skills demonstrated by these pianists are not directly comparable with those presented by the musical savants. Furthermore, by examining only the memorisation and recall skills of musical savants, the studies discussed do not provide an insight into how savants are actually able to turn that recall into a by-ear reproduction using the motor system. This raises the question of whether remaining stages in the playing by ear process of musical savants are the same as those in the cognitive-psychological model proposed in this thesis. Given the intellectual as well as the sometimes physical differences between these two groups of musicians, a direct comparison of their abilities to play both tonal and atonal, piano and multi-timbral music would be a fascinating area for further research.

Having discussed the playing by ear abilities of musical savants, this discussion now examines impact of this thesis on mainstream pedagogical practice.

8.7 Pedagogical impact of the research

8.7.1 Improving ability to play the piano by ear – the need for better aural-skill training

Judging by the responses to the playing-by-ear survey discussed in Chapter 2, it is evident that many trained pianists would like to be able to play by ear, and indeed many of them indicate that they have tried to do so, but nevertheless believe they are unsuccessful. This thesis has shown that recall-memory skill is a key factor in playing-by-ear ability amongst trained pianists, and it is apparent that recall forms one element of what is generally referred to as musical 'aural skill' (see Chapter 7, page 152). The ABRSM suggests that "the purpose of aural [training] is to establish the link between listening to music and playing music" (Taylor, 1998, p. 16) and the testing of aural skill forms part of their practical instrumental examinations. On the basis that the majority of the pianists who participated in the BEAT and Memory Studies reported an overall instrumental level of grade 8 or higher (see Chapter 4, page 86), it would be reasonable to assume that their recall memory skills would be at a level appropriate for their standard of instrumental ability. However, as previously discussed, a wide range of recall-memory skills was observed, and only those participants with the highest levels of recall were able to achieve a high standard of playing by ear. So, can some explanation be found as to why the levels of recall-memory skill of remaining participants are lower than their standard of instrumental ability would suggest, and can these skills be developed?

Pratt (1998) observes that many students appear to experience difficulties with aural tests and presents a variety of reasons for this: the teaching of aural skills in isolation from other musical skills; the heavy dependence on the use of the piano timbre in training and tests; the reliance on contrived rather than real music in the training materials and tests; the competitiveness of the assessment and the stress that this brings; and the lack of motivation amongst students to embrace these skills (Pratt, 1998). The ABRSM has addressed some of these issues insofar as its aural training and test materials now contain excerpts of real music, but these nevertheless remain in the piano timbre. However, Pratt further advocates that the narrow training programmes undertaken by students preparing for the aural components of instrumental (and other) music examinations may be detrimental to developing their aural awareness (Pratt, 1998) and, by default, their ability to recall music. Covington and Lord (1994) go further, implying that many highly trained professional musicians and instrumental teachers also encounter difficulties with aural skills. As far as teachers are concerned, it is inevitable that this will influence the way in which they address these skills when teaching, where some may not attempt to teach them until immediately before the examination, and others may avoid teaching them altogether (P. Priest, 1993).

This discussion provides some explanation as to why some participants in the BEAT Study demonstrated low levels of recall memory. However, given that the ABRSM syllabus for aural tests (ABRSM, 2011) presents a progressively more demanding range of recall measures as the grades progress, it seems likely that some level of development in recall-memory skill may be achievable. Furthermore, as long as aural tests continue to form part of practical music examinations, instrumental teachers have a duty to try to develop these skills in their pupils and students. This means that they must endeavour to maintain or, if possible, develop their own skills so they are confident in their own ability. To this end, the ABRSM offers professional development courses in aural training (ABRSM, 2012a) to encourage teachers to embrace this aspect of their teaching practice, although they are not obliged to attend. Furthermore, pupils and students need to engage with aural skills in a positive way, and the ABRSM has recently launched the 'Aural Trainer' application for mobile devices in an attempt to persuade pupils and students to take more responsibility for their own learning.

It is possible that these developments might bring about an increase in the standard of aural training amongst piano teachers, with the result that the levels of recall memory demonstrated by their pupils may improve. This, in turn, might lead to more successful outcomes if pupils experiment with playing by ear. However, bearing in mind the observation in Chapter 2 that piano teachers are ambivalent about playing by ear, there is no guarantee that pupils will be given playing by ear opportunities during piano lessons, even if improved aural training results in the development of their recall-memory skills. So how can piano teachers be persuaded to include playing by ear in their teaching and learning schemes, even if they believe they are unable to play by ear themselves?

8.7.2 Developing ability to play the piano by ear – possibilities for teaching and learning

There is some evidence to suggest that many piano teachers consider playing by ear to be an informal practice that does not have a place in formal instrumental learning (How teachers view playing by ear, 1996). However, there is no pedagogical reason why playing by ear cannot form the initial stage of an instrumental teaching and learning scheme that goes on to include playing from notation, sight-reading, playing from memory and, for that matter, improvisation. McPherson's (1995, 1996) research, some aspects of which have already been discussed in this thesis, presents evidence of the positive influence that these musical skills have on one another, and the present project has demonstrated a strong relationship between two-handed piano sight-reading and playing the piano by ear. Moreover, it is inconceivable that piano teachers would exclude playing from notation and sight-reading from their teaching and learning strategies, and highly likely that playing from memory would be included at a more advanced level; and yet it is evident that the skills of playing by ear and improvisation are often ignored (P. Priest, 1989; T. L. Priest, 1994).

Priest (1989) proposes a "pedagogical model of instrumental learning" (p. 189), illustrated in Figure 8.1, where playing by ear (which he labels 'imitation') and improvisation (which he labels 'invention') are systematically incorporated into instrumental learning. In this model, improvisation complements the more formal skills of playing from notation (which would almost certainly include sight-reading) and playing from memory, whilst playing by ear is seen as their foundation.

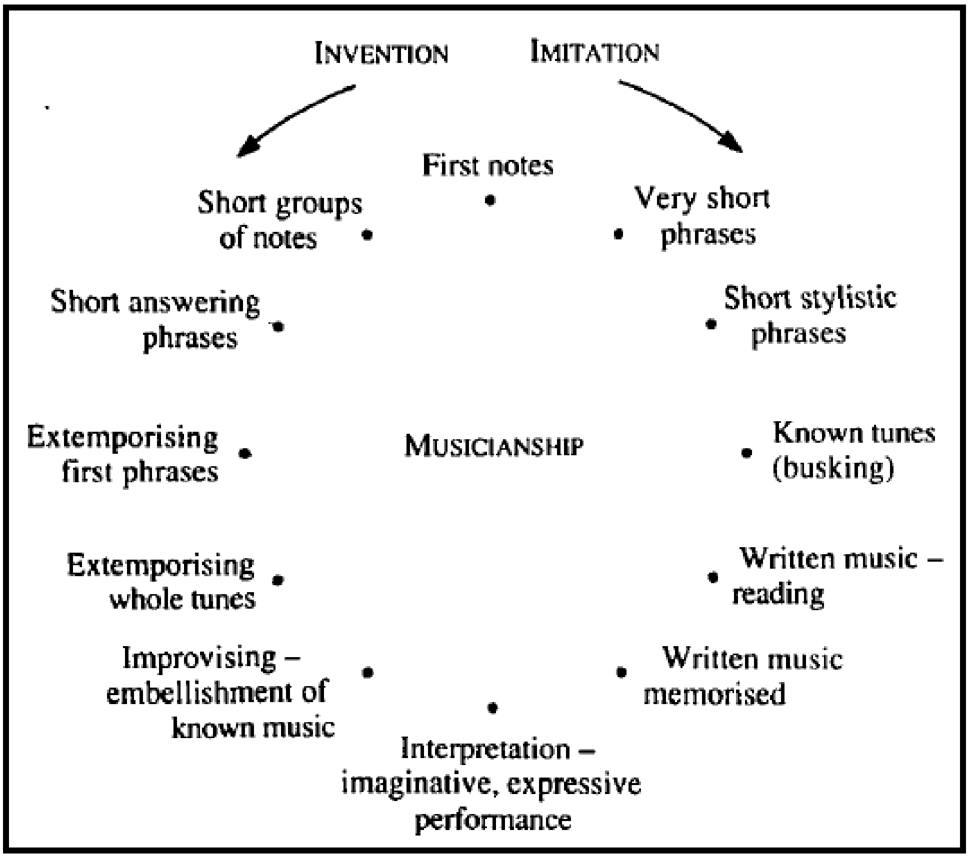

Figure 8.1 Pedagogical model of instrumental learning (P. Priest, 1989, p. 189)

Priest's model reinforces the point that the progression from novice to accomplished musician requires not only the ability to play and memorise from notation, but also the musicianship that is gained from the musical freedom of playing by ear and the musical inventiveness of improvisation. It also adds weight to Mainwaring's (1941) view, discussed in Chapter 2, that musicians should learn to play their instruments by ear before being taught to play them using notation, in much the same way that children learn to speak before they are taught to read.

Whether pianists can actually be *taught* to play by ear in a two-handed, harmonised manner is unclear, and this author has found no studies that present evidence to suggest that they can. Apart from the obvious need for a measure of technical piano capability, there are no 'rules' for the pianist to be taught, and no specific or prescriptive code, such as notation, to dictate what to play or how to play it. It seems, therefore, more reasonable to speculate that playing by ear develops through the application of the underlying skills that facilitate it. Nevertheless, there are some published books (see, for example, Liddell, 1980; Schott, 2002) and several internet sites (see, for example, www.pianoencyclopedia.com;

www.pianomagic.com; www.playpianotoday.com) claiming that they can teach piano-by-ear, although these frequently require quite an advanced knowledge of music theory, or else they teach through the copying of fingering patterns and other rote techniques.

One teaching method that is thought to engender piano learning through playing by ear is that of Shinichi Suzuki, who believed that children should be taught to play musical instruments in the same manner as they learned their mother tongue (Bigler & Lloyd-Watts, 1979). According to this method, beginning instrumentalists are required to listen to music repeatedly, thoroughly encoding it into memory, before attempting to play it by ear using a trial and error approach (Comeau, date unknown). However, it appears that Suzuki's writings offer no specific pedagogical methodology for the delivery of instrumental learning by ear (Krigbaum, 2005, cited in Comeau, date unknown), and Comeau suggests that Suzuki students play actually imitatively, having been taught passively by way of verbal instruction and formulaic rote-learning, rather than actively by ear. Indeed, studies examining the practices of Suzuki string teachers suggest that a larger percentage of lesson time is spent on a combination of teacher instruction and teacher modelling, than on student performance (Duke, 1999; Colprit, 2000). Furthermore, Comeau suggests that the Suzuki method of learning does not enable students to cognitively conceptualise musical patterns and devices, and that this lack of comprehension of musical organisation results in the inability to form an aural representation of the music from a score when notation reading is introduced (Comeau, date unknown).

There is some evidence to suggest that playing-by-ear ability develops as instrumental training progresses (McPherson, 1995, 1996), although there are participants in the present project whose low levels of by-ear ability belie their high levels of piano training. Nevertheless, it is possible that two-handed, harmonised piano-by-ear ability might develop alongside more formal practices if piano teachers include it as part of their teaching and learning schemes.

Given Priest's (1989) model of instrumental learning, and the above discussion on improving aural skills, it is reasonable to suggest that if playing by ear is to be the foundation of instrumental learning, teachers should commence development of its underlying cognitive-psychological skills as early as possible. This thesis has found musical recall memory to be the most important skill in playing by ear, although it must be borne in mind that this finding is the result of an investigation into the abilities of trained adult pianists. Novices, whether they are adults or children, would obviously need to develop aural-memorisation skills, knowledge of musical structures, and motor skills at the same time.

8.7.3 Teaching and learning strategies for playing by ear

Teaching and learning strategies that would facilitate the cognitive-psychological skills necessary for the development of playing by ear could include aural activities such as: listening to and talking about music; clapping games to create a sense of rhythmic structures; singing games and echo or call-and-response songs so that pupils begin to find their own musical voice and develop their memorisation and recall memory. Other, more practical, skills require exploration and experimentation on the piano: trying out different piano sounds – high, low, loud, soft, legato, staccato, and so on; playing single notes and note clusters to develop an awareness of musical and motor structures and a sense of the difference between consonance and dissonance; rote playing and call and response games on the piano to gain a sense of the relationship between the sounds and the physical layout of the keyboard. Above all, teachers must be willing to sing and play the piano both *with* their pupils, and *to* their pupils, preferably from memory if unable to play by ear, so that pupils do not develop a perception that music can only be played if a page of dots and lines is placed before them.

Alongside these musical strategies, there are conditions that require a more psychological strategic approach. Many young beginners will be aware of the kinds of activities their peers undertake during piano lessons, and will often expect to be presented with a 'music book' without which they may feel unable to touch or play the piano, or will believe they are not allowed to. It is, therefore, important to introduce and encourage a physical relationship with the instrument from the very first moments of the first lesson. Some youngsters feel awkward and find it difficult to make this first physical contact with the piano keyboard. Indeed, teachers who work in their own homes or studios need to be aware that youngsters can be intimidated by the size and physicality of a piano, especially a grand, particularly if they have a keyboard or electronic piano at home. They often have to be reassured that the piano will not 'break' before they will make any attempt even to touch it. These preconceptions and anxieties are a barrier to creativity and must be broken down at all costs if children are to relax and feel comfortable with playing by ear and, indeed, playing the piano at all.

Parental attitude can sometimes be an obstruction to developing playing-by-ear ability. Parents will often expect to see notation at the very first lesson, and it needs to made clear that allowing the beginner to experiment and find their own 'piano voice' is a more natural way to learn, and that notation will come later. Furthermore, many parents see 'piano practice' as a form of homework that requires a set amount of time and has a rigid structure. It is, therefore, important that they understand that in the early stages of learning at least, their children will simply be asked and encouraged to experiment with piano sounds in their own way, and also spend time simply listening to music. Crucially, parents must realise that their children need the freedom to explore the instrument, and that this will sometimes result in sounds that they may consider to be less than musical. Above all, they must refrain from discouraging their children from making these 'noises' on the piano. Moreover, parents should join their children in their piano explorations, becoming active partners in their journey of musical discovery.

These are just a few of the musical and psychological strategies that the present author has developed as a result of her own efforts to introduce and develop playing-by-ear ability in novice piano pupils, both children and adults. Other teachers who work in this way will have their own and, in addition, McPherson (2005) identifies a range of playing-by-ear learning strategies, which he asserts would allow children to develop melodic playing by ear ability more effectively if they were taught to use them. These include visualising the contour of a melody; singing the melody; relating the sounds to instrumental fingering; and playing along with a recording (McPherson, 2005), although clearly not all of these could be undertaken by absolute beginners.

In order to encourage teachers who feel they do not have playing by ear ability to include it in their teaching, the ABRSM has recently introduced a professional development course in playing by ear for teachers of all instruments, although it focuses on playing the piano by ear. The course information web page describes beginning by "focusing on … listening skills, learning what to listen for in a tune and how to remember it" (ABRSM, 2012b). It goes on to suggest that participants will "build on these skills by working out simple accompaniments to melodies by ear and analysing chord progressions from well-known songs" (ibid.).

In providing this workshop the ABRSM has acknowledged the importance of playing by ear, and in so doing provides support for the view that it has a place in formal musical teaching and learning.

This section has discussed the possibility of improving and/or developing playing by ear ability, and suggested a number of teaching and learning strategies that may facilitate this, and the discussion now considers other areas for further research and investigation.

8.8 Broadening the research

In addition to the suggestions for additional research already proposed in this thesis, this section proposes a number of future studies that would broaden the findings of this research project.

8.8.1 Playing by ear: thoughts, opinions and beliefs of piano teachers

It is apparent from the responses to the playing-by-ear survey, discussed in Chapter 2, that some piano teachers are embracing playing by ear. However, the overwhelming perception from the survey is that they mainly ignore it. Of course, this assumption is based on data collected from the point of view of piano learning, and a more reliable way of determining the current situation would be to conduct a playing-by-ear survey that gathered data from a piano teaching perspective. This would elicit piano teachers' views on: their belief in their own playing-by-ear ability; how they see playing by ear as part of formal piano tuition; and how they would incorporate it into their piano-teaching schemes. Such a survey would present a discussion that would sit alongside Green's work on the development of informal learning in the school environment (see Green, 2002, 2006, 2008, 2012).

8.8.2 The experience of playing by ear

The Strategy Study provided an insight into the preparation strategies and practical techniques that its participants demonstrated when preparing music for playing by ear. However, this study was purely observational and did not provide an opportunity for participants to talk about what they were doing. Research into theories of action suggest that individuals' descriptions of their actions on a task are not necessarily the same as their actual behaviour (Argyris, 1982). With this in mind, it would be interesting to determine whether pianists' accounts of how they prepare music for by-ear realisations are the same as the strategies and techniques they actually demonstrate during that process. A study that incorporated a video-recorded practical by-ear task into a one-to-one interview would be one way of achieving this. Participants would first talk about how they prepare familiar music for playing by ear, then carry out the process, and finally talk about it again whilst observing themselves. Interviews could also be structured so that participants were encouraged to describe what they were thinking about and how they were feeling whilst they were playing by ear. Overall, this type of study would allow an insight to be gained into it how pianists experience playing by ear both practically and psychologically.

8.8.3 Developing musical recall memory and improving playing-by-ear ability

The possibility that musical recall memory may develop with training has been proposed by the discussion in the current chapter. The discussion further suggests that recall development may lead to improvement in playing-by-ear ability amongst trained adult pianists by making it more spontaneous. One way of investigating this is through an intervention study that would allow deductive by-ear pianists to undergo a course of recall-memory training, where pre-training and post-training assessments of both recall memory and ability to play familiar music by ear would determine these possibilities.

8.8.4 Playing-by-ear ability amongst children and adult learners

The current chapter has suggested that playing by ear should be an element of piano tuition from a pupil's very first lesson, and that it should develop alongside other, more formal, musical skills. An assessment of the harmonised, piano by-ear abilities exhibited by children and adult learners at various stages in their musical development would develop existing research that examines melodic playing by ear amongst children in general, and the work of McPherson and colleagues in particular.

8.9 Summary

This chapter has summarised the research project and presented a discussion on a number of topics inspired by it. It has also indicated several areas for further research and study that would broaden the findings of this thesis. The following final chapter summarises the main findings of this thesis, re-examines the proposed definition of playing the piano by ear, and presents the author's reflection on the research project as a whole.

9. Conclusion

9.1 Introduction

Over the last four years I have conducted a research project that has examined playing-by-ear ability amongst trained adult pianists, and attempted to determine the cognitive-psychological factors underlying that ability. This thesis has reported four main research findings that result from my investigation:

- Spontaneous, harmonised by-ear realisations are the most accurate, fluent and stylistically-complex;
- There is a strong indication that spontaneous, harmonised playing by ear is not simply a more efficient execution of deductive playing by ear;
- Recall memory is the cognitive-psychological factor that has the most influence on playing-by-ear ability in trained, adult pianists;
- Harmonised playing by ear in trained, adult pianists is inhibited by insufficient harmonic-recall memory.

In light of these findings, I begin this final chapter by re-addressing the questions I raised informally at the very beginning of Chapter 1 (see page 17), and continue with a reconsideration of the definition of playing by ear that I proposed in Chapter 4 (see page 107). Finally, I close this thesis with my personal reflection on both the research project and playing the piano by ear.

9.2 The mystery of playing by ear

In presenting the rationale for my research in Chapter 1, I raised a number of informal questions in the light of my observation that an element of mystery surrounds playing the piano by ear: what are the cognitive-psychological factors that make playing the piano by ear possible; why are some highly-trained pianists able to spontaneously play a piece that they have heard only once or twice and never seen notated, whilst others are not; are there any specific musical skills that are more highly developed in by-ear pianists than in non-by-ear pianists; could any trained pianist play by ear if they were provided with an opportunity and encouraged to try; is playing the piano by ear a natural ability or one that can be learned or developed over time?

During the course of my investigation I believe I have, through the research objectives of the various studies, answered four of the five questions posed. The project has demonstrated that recall memory is the main cognitive-psychological influence on playing by ear, and has also shown that some pianists are able to play spontaneously by ear because they possess high levels of recall-memory skill. Additionally, it has shown that pianists who achieve harmonised by-ear realisations have more highly developed harmonic-recall that those who can only reproduce melodies by ear and, having been presented with an opportunity, a number of pianists have achieved playing by ear, albeit with varying degrees of success. As to whether playing by ear is a natural ability, or one that is learned or developed, this thesis does not have a definitive answer. Having readdressed these questions, it remains to reconsider the definition of playing by ear in the light of the overall findings of this thesis.

9.3 Reconsidering the definition of playing the piano by ear

The definition proposed at the end of Chapter 4 states that playing by ear is the accurate, fluent and spontaneous, two-handed, stylistically-harmonised realisation of a piece of music that has been memorised aurally, without reference to musical notation. Amongst those taking part in this research project, the seven pianists in group one demonstrated a level of playing by ear ability during the BEAT Study that was commensurate with this definition. However, amongst the remaining 22 pianists, the nine in group four were unable to present realisations that were harmonised. Therefore on the basis of the above definition, and the expectation that piano performance would normally be harmonised, it is reasonable to argue that these pianists cannot play the piano by ear. But what of the 13 pianists in groups two and three, who required a deductive approach to playing by ear? Given that spontaneous, stylistically-harmonised, by-ear realisations have been shown to be more successful than those produced deductively, these participants could also be judged to be unable to play the piano by ear. But this suggests that the only pianists who can play by ear are those who demonstrate the very highest levels of ability, and is this judgment really fair?

It is certainly the case that participants in groups two and three played the piano *by ear* on the basis that they did not use notation, despite the fact that their realisations had to be worked out first, and were less accurate and fluent than those of group one. However, there is an obvious expectation amongst listeners and audiences that musical performances will be fluent and accurate, with anything less normally being considered unacceptable. Therefore it is reasonable to expect the same of a performance by ear, in as much as the manner of learning and preparation should not influence the quality of outcome, regardless of whether the realisation has been worked out or is spontaneous. But just as an inexperienced or amateur pianist will often give a less than perfect performance of music using notation, there is no reason why a higher standard should be expected of a by-ear pianist just because notation is absent. Indeed, it could be argued that by-ear pianists demonstrate a far higher level of creativity and musicianship by realising harmonised music they have never seen written down, even though that realisation may be imperfect. Of course, ultimately this will depend on the perceived level of imperfection – audiences would not want to listen to a musical performance by ear or from notation where the number of errors was so great as to make the music unrecognisable. But consider circumstances where the pianist is simply playing for personal fulfilment. In this situation there are no (other) listeners to consider, and the level of spontaneity, accuracy and fluency are of concern only to the pianist him or herself. So, is playing by ear *only* that which takes place in accordance with the definition proposed in this thesis? Or is *all* playing that occurs after aural memorisation, and in the absence of notation, playing by ear? This debate will rage as long as playing by ear continues to be regarded as something that not all pianists can do.

The discussion in this thesis demonstrates that there are sound pedagogical reasons for including playing by ear as part of musical learning for all pianists from the commencement of their training. However, just as with playing the piano from notation, or indeed any other learning process musical or not, a wide range of by-ear ability would no doubt emerge amongst piano pupils. Moreover, it is likely that only a small number of pianists will develop the skills necessary to achieve the very highest levels of playing-by-ear ability. Nevertheless, for those remaining, developing playing by ear ability would allow them to become more skilled musicians, enjoy a greater sense of musical fulfilment, and be secure in the knowledge that they are completely in tune with their instruments. Based on this discussion, perhaps an alternative definition of playing by ear would be:

Playing the piano by ear is the stylistically-harmonised realisation of music that has been memorised aurally, without reference to notation.

9.4 Reflection

In conducting this research project, I hoped to inspire an interest in playing by ear amongst trained pianists, and stimulate a debate with regard to its place in the context of musical performance. Having been delighted to receive 151 responses to the playing-by-ear survey, which formed the first phase of this project, I was extremely gratified to find that almost 20% of those respondents were motivated to volunteer for the BEAT and subsequent Memory Studies. Amongst volunteer pianists, half of them reported an inability to play by ear prior to the BEAT Study and, by providing these participants with an opportunity to engage with this practice, I believe I have encouraged them to take a more active interest in this approach to music-making. Indeed, many of them commented that they had enjoyed the experience and, in light of their achievement during the BEAT test, they would continue to experiment with playing by ear. I hope, therefore, that through the future publication of this research, I will continue to raise awareness of playing by ear as a mode of performance amongst other more conventional methods, and stimulate a re-evaluation of the aspects of musicianship that the practice of playing by ear brings to musicians and musicianship.

In the acknowledgements section at the very beginning of this document, I observed that this thesis was, for me, part of my continuing journey of musical discovery. As well having the privilege of being able to encourage pianists to try playing by ear through this project, I have also been privileged to meet other trained pianists who, like myself, demonstrate spontaneous playing-by-ear ability. In talking to these pianists about their skills (albeit briefly and informally) and, more importantly, having had the opportunity to observe them closely whilst realising and performing music by ear, I now have a much greater insight into, and appreciation of, my own playing by ear ability. From a purely personal perspective, conducting this research project and writing this thesis have taken me forward on my ongoing musical journey, and given me a more finely tuned sense of what makes me tick as a musician and pianist.

9.5 And finally …

There is no doubt that there will always be the “natural genius who …goes to an opera and plays it beautifully by ear next day” (Swinburn, 1918-1919). However, although the majority of pianists are unlikely to be capable of these ‘dizzy heights’, this thesis has shown that playing the piano by ear is more accessible than many pianists might think.

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Appendix 1

"You Hum It, I'll Play It!"

Thank you for taking the time to complete this survey, which will form part of my investigation into playing the piano by ear.

1. Please indicate your age band:

   18-21 ☐ **22-25** ☐ **26-30** ☐ **31-35** ☐ **36-40** ☐

   41-45 ☐ **46-50** ☐ **51-55** ☐ **56-60** ☐ **60+** ☐

2. Please indicate whether you are: **Male** ☐ **Female** ☐
3. If you are associated with the School of Music, please tick your programme of study:

BMus	☐	MMus Composition	☐	MPhil	☐
BA Music	☐	MMus Musicology	☐	PhD	☐
BA Popular & World Musics	☐	MMus Performance	☐	Staff	☐
Graduate Diploma in Music	☐	MMus Music Technology & Computer Music	☐	Other (please specify) ……………………	☐
Joint Honours: Music & ………..	☐				

4. If you are associated with another department, please state your department and your programme of study.

   ……………………………………………………………………………………………………

5. Which musical instrument(s) can you play? (Please list main instrument first, and ABRSM/Trinity-Guildhall or other grade if applicable)

   (i) …………………… Grade: ……… (ii) ………………… Grade: ………

   (iii) …………………… Grade: ……… (iv) ………………… Grade: ………

6. Have you ever had piano lessons? **Yes** ☐ **No** ☐

   If **Yes**, for how long? …………………………... …

7. If **Yes**, do you still have piano lessons? **Yes** ☐ **No** ☐

   If **No**, when did you stop? ………………………………

8. How would you define '**playing by ear**'? ………………………………………………

   ……………………………………………………………………………………………………

9. Can you play the piano by ear?

   Yes ☐ **No** ☐ **Don't know** ☐ **I don't play the piano** ☐

   If **Yes**, please go to section **A** on page **2**.

   If **No**, please go to section **B** on page **4**.

Page 2

Section A – to be completed if you can play the piano by ear.

A.1 How many years have you been able to play the piano by ear?

1-5 ☐ **6-10** ☐ **11-15** ☐ **16-20** ☐

20-25 ☐ **25-30** ☐ **30+** ☐ **Don't know** ☐

A.2 How did you discover that you could play the piano by ear?..................................

....

....

A.3 Where do you think your ability to play the piano by ear comes from? ....

....

....

A.4 Would you consider yourself to be highly motivated to play the piano by ear?

Yes ☐ **No** ☐

A.5 How often do you play the piano by ear?

Frequently ☐ **Regularly** ☐ **Occasionally** ☐

Rarely ☐ **Never** ☐

A.6 If you have answered **Frequently**, **Regularly** or **Occasionally** to **A.5**, what motivates you to play the piano by ear?..

....

....

A.7 If you have answered **Rarely** or **Never** to **A.5**, explain why you choose not to play the piano by ear..

....

A.8 Do you think playing the piano by ear should be:

Encouraged ☐ **Discouraged** ☐ **Neither** ☐

Why?...

....

....

A.9 Has anyone ever **encouraged** you to play the piano by ear? **Yes** ☐ **No** ☐

If **YES**, please indicate those who have encouraged you (tick all that apply):

Teacher ☐ **Parent** ☐ **Friend** ☐

Musical colleague ☐ **Other** (please specify)..

PLEASE CONTINUE ON PAGE 3

Page 3

Section A continued.

A.10 Has anyone ever **discouraged** you from playing the piano by ear?

Yes ☐ **No** ☐

If **YES**, please indicate those who have discouraged you (tick all that apply):

Teacher ☐ **Parent** ☐ **Friend** ☐

Musical colleague ☐ **Other** (please specify) ....

A.11 If you have been discouraged, has this ever deterred you from playing the piano by ear?

Yes ☐ **No** ☐ **Don't Know** ☐ **Not Applicable** ☐

A.12 Can you play the piano from printed music? **Yes** ☐ **No** ☐

A.13 Which mode(s) of performance do you prefer?

Playing by ear ☐ **Playing from printed music** ☐ **Improvising** ☐

Playing from memory (memorised from printed music) ☐ **No preference** ☐

A.14 When, if ever, have you found the ability to play the piano by ear an **advantage**?

....

....

A.15 When, if ever, have you found the ability to play the piano by ear a **disadvantage**?

....

....

A.16 Can you play any other instrument(s) by ear? **Yes** ☐ **No** ☐

If **YES**, please state which instrument(s):..

....

A.17 I am currently looking for volunteer pianists, who DO and DO NOT play by ear, to get involved in the practical stage of this investigation, which would take about an hour of your time. If you are interested in taking part, or would like more information, please provide me with your name and an email address so that I can contact you. Your details will be kept confidential.

Name:.. Email:...

THIS IS THE END OF THE SURVEY. THANK YOU AGAIN FOR TAKING PART.

<u>Page 4</u>

<u>Section B</u> – to be completed if you can play the piano from printed music but can play other instruments by ear.

B.1 Would you like to be able to play the piano by ear?

Yes ☐ **No** ☐

B.2 Do you think it would be an advantage to be able to play the piano by ear?

Yes ☐ **No** ☐ **Don't know** ☐

B.3 If you answered **Yes** to **B.2**, when do you think it would be advantageous to be able to play the piano by ear?...

....

....

B.4 Have you ever tried to play the piano by ear?

Yes ☐ **No** ☐

B.5 If you have answered **Yes** to **B.4**, please explain why you believe that you **cannot** play by ear, or **don't know** whether you can play by ear............................

....

....

B.6 If you have answered **NO** to **B.4**, explain why you have not tried to play the piano by ear...

....

B.7 Do you think playing the piano by ear should be:

Encouraged ☐ **Discouraged** ☐ **Neither** ☐

Why?..

....

....

B.8 Has anyone ever **encouraged** you to try playing the piano by ear?

Yes ☐ **No** ☐

If **YES**, please indicate those who have encouraged you (tick all that apply):

Teacher ☐ **Parent** ☐ **Friend** ☐

Musical colleague ☐ **Other** (please specify) ....

B.9 If you have not tried to play the piano by ear, do you think some encouragement would have led you to try?

Yes ☐ **No** ☐ **Don't Know** ☐ **Not Applicable** ☐

PLEASE CONTINUE ON PAGE 5

Page 5

Section B continued.

B.10 Has anyone ever **discouraged** you from playing the piano by ear?

Yes ☐ **No** ☐

If **YES**, please indicate those who have discouraged you (tick all that apply):

Teacher ☐ **Parent** ☐ **Friend** ☐

Musical colleague ☐ **Other** (please specify)..

B.11 If you have been discouraged, has this ever deterred you from trying?

Yes ☐ **No** ☐ **Don't Know** ☐ **Not Applicable** ☐

B.12 I am currently looking for volunteer pianists, who DO and DO NOT play by ear, to get involved in the practical stage of this investigation, which would take about an hour of your time. If you are interested in taking part, or would like more information, please provide me with your name and an email address so that I can contact you. Your details will be kept confidential.

Name:.. Email:...

THIS IS THE END OF THE SURVEY. THANK YOU AGAIN FOR TAKING PART

Appendix 2

Participant Consent Form

Title of Study: "You Hum It, I'll Play It!" The role of memory in playing by piano by ear

The participant should complete the whole of this sheet himself/herself

	Please confirm the statements by putting your initials in the boxes below.
I have read and understood the participant information sheet.	
I have had the opportunity to ask questions and discuss this study.	
I have received satisfactory answers to all of my questions	
I have received enough information about the study	
I understand that I am free to withdraw from the study: 1. At any time 2. Without having to give a reason for withdrawing	
I understand that any information I provide, including personal details, will be confidential, stored securely and only accessed by those carrying out the study.	
(When relevant) I understand that any information I give may be included in published documents but my identity will be protected by the use of pseudonyms.	
I agree to take part in this study.	
Participant Signature …………………………………..……. Date	
Name of Participant:	
Researcher Signature ……………………………………... Date	
Name of Researcher: Diane Sapiro	

Thank you for agreeing to take part in this study.

Appendix 3

Skeleton Scores used for BEAT marking

Theme from ‘Casualty’

Ken Freeman

Theme from 'Cavatina'

Stanley Myers

Theme from ‘Coronation Street’

Eric Spear

Theme from 'Eastenders'

Simon May

Theme from 'Emmerdale'

Tony Hatch

Theme from 'Jurassic Park'

John Williams

Theme from 'Midsomer Murders'

Jim Parker

Appendix 4

Recognition-Memory Test Scores

Recognition Pieces Set One

Simple Major (SM1)

Compound Major (CM1)

Simple Minor (sm1)

Compound Minor (cm1)

Recognition Pieces Set Two

Simple Major (SM2)

Compound Major (CM2)

Simple Minor (sm2)

Compound Minor (cm2)

Recognition Pieces Set Three

Simple Major (SM3)

Compound Major (CM3)

Simple Minor (sm3)

Compound Minor (cm3)

Recognition Pieces Set Four

Simple Major (SM4)

Compound Major (CM4)

Simple Minor (sm4)

Compound Minor (cm4)

Musial Memory – Recognition

Answer Sheet

Participant ID: **Date:**

Instructions

1. This experiment contains two practice trials, which do not count, followed by eight trials which will be marked.
2. In each trial you will hear a test piece which is immediately followed by four more pieces.
3. You are asked to identify whether each of the four following pieces is *identical* to the test piece or *different* from it.
4. All pieces are four bars long and in $^4_4$ time.
5. Please place your answers in the grid below by placing a ✓ in the appropriate box for pieces you think are *identical* to the test piece and a ✗ in the box for pieces you think are *different* from the test piece in each trial.

Trial Test Piece	Piece 1	Piece 2	Piece 3	Piece 4
Practice 1				
Practice 2				
1				
2				
3				
4				
5				
6				
7				
8				

Appendix 5

Recall-Memory Trial Scores - Set One

Trial One: Single Line Melody - Marimba

♩= 110

Adapted from Bach BWV 187.7

Trial Two: Upper Part of Two Part Piece - Flute

♩= 110

Adapted from Bach BWV153.1

Trial Three: Lower Part of Two Part Piece - Mandolin

♩= 110

Adapted from Bach BWV 308

Trial Four: Uppermost Part of Four Part Piece - Violin

♩= 110

Adapted from Bach BWV 267

Trial Five: Lowermost Part of Four Part Piece - Piano

♩= 110

Adapted from Bach BWV 281

Recall-Memory Trial Scores - Set Two

Trial One: Single Line Melody - Trumpet

Trail Two: Upper Part of Two Part Piece - Clarinet

Trial Three: Lower Part of Two Part Piece – Alto sax

Trial Four: Uppermost Part of Four Part Piece - Guitar

Trial Five: Lowermost Part of Four Part Piece - Cello

Appendix 6

Structures-Memory Test Scores

Level three, unaltered score (highlighted notes represent those altered in scores presented to participants)

Level three, altered score (as presented to participants)

Level two, unaltered score (highlighted notes represent those altered in scores presented to participants)

Sonata

adapted from Dussek (1760-1812) Op46 No 3

Level two, altered score (as presented to participants)

Sonata

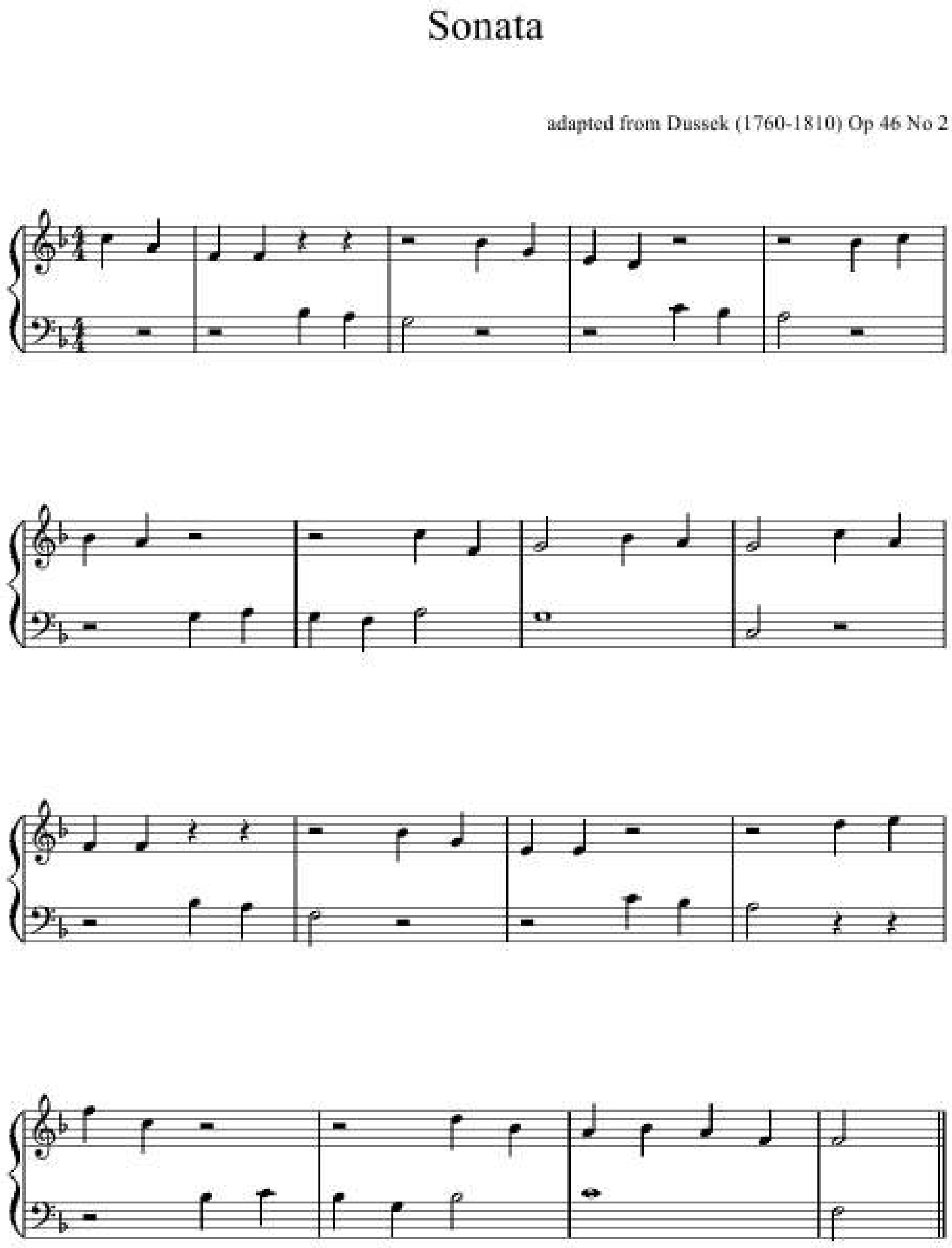
adapted from Dussek (1760-1812) Op46 No 3

Level one, unaltered score (highlighted notes represent those altered in scores presented to participants)

Sonata

adapted from Dussek (1760-1810) Op 46 No 2

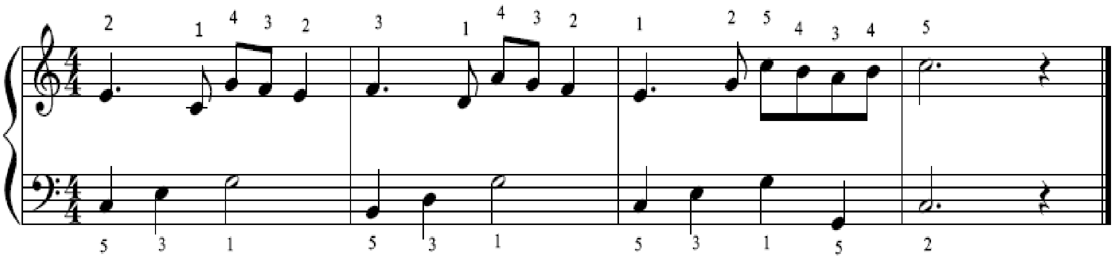
Level one, altered score (as presented to participants)



Appendix 7

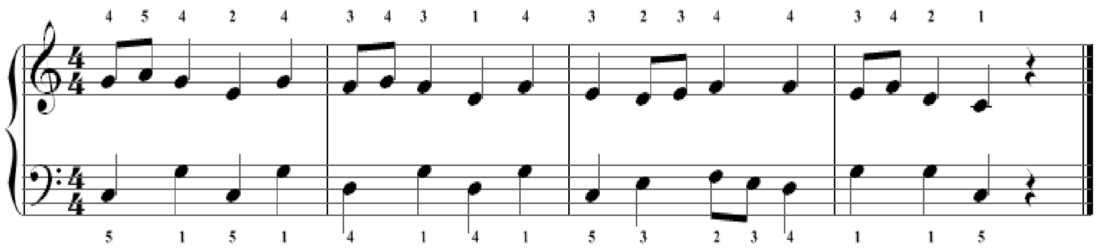
Motor-Memory Test Scores

Level 4 Training Piece

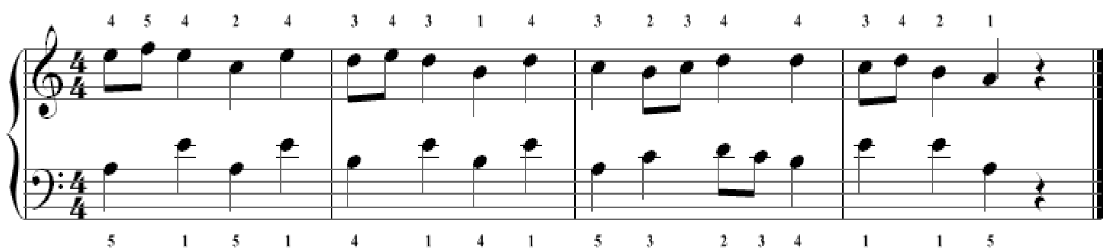


Level 4 Transfer Piece

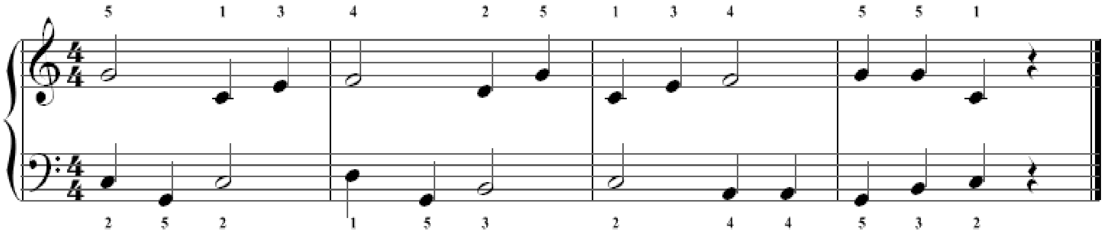
Level 3 Training Piece



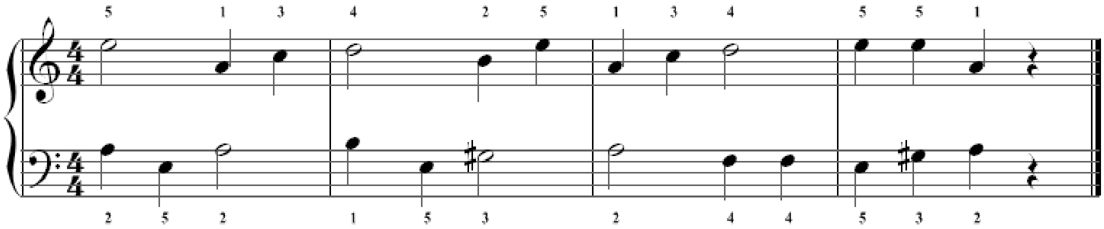
Level 3 Transfer Piece



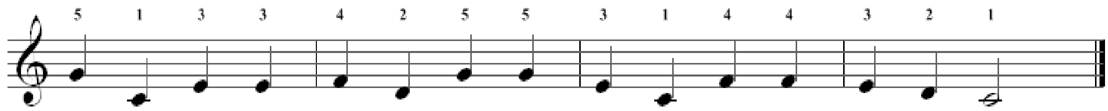
Level 2 Training Piece



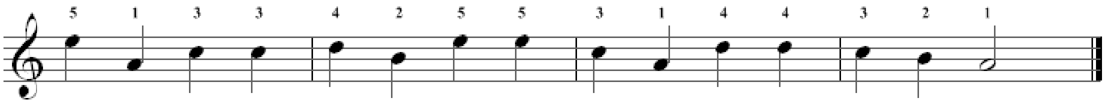
Level 2 Transfer Piece



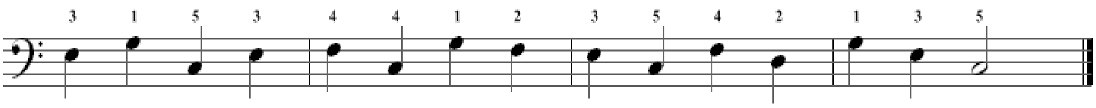
Level 1 Training Piece Right Hand



Level 1 Transfer Piece Right Hand



Level 1 Training Piece Left Hand



Level 1 Transfer Piece Left Hand