# Exploring the Neural Correlates of Mind-Mindedness

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**Abstract**

Social cognition relies on our ability to understand the mental states of others, which in turn depends on the ability to spontaneously access appropriate contextual information about the person with whom we are interacting. One well-documented index of effective social interaction is the capacity for mind-mindedness - whether a person represents familiar people, such as their best friend, as mental agents with thoughts and feelings. This thesis consists of three studies designed to explore the behavioural and neural correlates of mind-mindedness. Studies 1 and 2 investigated the hypothesis that skills important for effective social interaction depend on the capacity for social memory, exploring this question in terms of how people are categorized and how effectively social information is retrieved. Study 1 revealed that individuals whose descriptions of their friends focused on their internal states had increased recognition for socially relevant cues. Study 2 links increased episodic memory capacity with greater levels of mind-mindedness. These results support the hypothesis that our capacity for social memory is an important component of mind-mindedness. Study 3 utilised functional magnetic resonance imaging (fMRI) to investigate the intrinsic organization that underpins mind-mindedness. Individual differences in mind-mindedness were linked to a stronger decoupling between the fronto-parietal cortex and the posterior cingulate cortex, a pattern that meta-analytic evidence suggests is linked to processes such as autobiographical and episodic memory. This analysis suggests that mind-minded representations of other people are reflected in the intrinsic organization of the posterior cingulate cortex, a process that may depend upon memory processes.

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## Author's Declaration

I hereby declare that I am the sole author of the doctoral thesis entitled "Exploring the Neural Correlates of Mind-Mindedness" and that the thesis has not previously been submitted for another degree at this or any other university. All sources are acknowledged as references. The work was completed under the supervision of Prof. Elizabeth Meins and Dr. Jonathan Smallwood. Part of the work was conducted in collaboration with others.

### Collaborations

*Chapter 2.* Sarah Fishburn took part in producing scores for inter-rater reliability during data analysis.

*Chapter 3.* Sarah Fishburn took part in producing scores for inter-rater reliability during data analysis. Hao-Ting Wang, Irene de Caso, Giulia Poerio, Tirso Gonzalez Alam, Mahiko Konishi, Sara Stampaccia, Charlotte Murphy, Mladen Sormaz, Glyn Hallam and Barbara Medea took part in elements of experimental design and data collection.

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# Chapter 1

## Towards a Component-Process Model of Mind-Mindedness

### 1.1. Spontaneous Thought and Memory: Components of Social Cognition

Social cognition is an essential cognitive resource in enabling humans to understand the world around them. It is largely dependent on the spontaneous deployment of mental resources towards interpreting, encoding and retrieving key elements of the complex event sequences that constitute everyday social interactions (Lewicki, Hill, & Czyzewska, 1992). Our social-cognitive faculties undergo rapid development from an early age. During the first year of life, human infants acquire the behaviour of social smiling (Anisfeld, 1982), returning a smile when one is given. Such behaviour demonstrates the intricate interdependency between social and cognitive processes from an extremely early phase of life. At around ten months of age, children become increasingly adept at comprehending other social cues such as eye contact and social gaze (Beier & Spelke, 2012) and understand concepts such as deceit and trickery by around 2.5 years (Reddy, 2008).

The development of the ability to understand social phenomena in this way denotes an increased ability in constructing robust and adaptive models of the mental states of others, or a representational Theory of Mind (ToM; Frith & Frith, 2005). Accordingly, our social cognition depends on the interaction of a number of diverse cognitive faculties in order to function. It requires the input of attentional faculties to enable the initial recognition of certain moments or actions in a complex event sequence as cues of social significance (Boggia & Ristic, 2015). It further requires the successful encoding of these social cues to memory in order to comprehend and provide an available reference for the personality, intentions and variance in the mental states of other people (Von Hecker, 2004).

Our knowledge of the mental states of others is also not bound to our immediate surroundings or present social context. We are able to mentalise, maintaining and updating a mental construct of another person in the face of dynamic interactions and changing sequences of events (Frith & Frith, 2006a). Our ability to attend towards social cues and context, and predict behaviour based on recalled information from similar past interactions, are key components in this process (Lee & Harris, 2013). Our overall capacity for long-term memory is therefore an essential component of our social cognition. Our memory does not simply serve to store a static sequence of past events, but to provide a resource which interfaces with our social cognition and allows us to navigate the complex arena of social experience (Spreng, 2013). Although social interactions may follow common cues and structures, they are extremely variable events and as such can be complex in trying to predict (Brown & Brüne, 2012).

There are also remarkable individual differences in our ability to successfully comprehend and respond to social stimuli, and some of these differences are associated with our ability to encode and retrieve socially-relevant information from memory in order to update our internal representation of the mental states of others. Ciaramelli, Bernardi, and Moscovitch (2013) have shown that memory for others' past experiences can significantly change our level of empathy and the valence we attach to events happening to them currently. This suggests that individuals retrieve memories of past social interactions with an individual to simulate their mental state in a similar, present situation. Accordingly, the integration of our capacity for ToM and our memory processes allows for a system capable of attending to socially significant events and utilising them to update models of the internal mental states of others (Mutter, Alcorn, & Welsh, 2006).

Social cognition and our tendency to mentalise are also prominent features in our spontaneous thought. Rumination on past interactions with others is a consistent factor in the content of our thoughts while mind-wandering. Ruby, Smallwood, Sackur, and Singer (2013) utilised thought-probing during the mind-wandering state combined with the technique of principal components analysis (PCA) in order to segment dimensions of subjectively experienced spontaneous thought into their principal components. Ruby et al. (2013) found that a significant and recurring component of subjective thoughts experienced during the mind-wandering state consists of fixation on the self, fixation on past interactions with others and fixation on the future. These results reveal the importance of spontaneous thought as a component of our social cognition by allowing the automatic retrieval of socially-relevant information from our long-term memory stores.

The ability to spontaneously cognise social information and rehearse the content of past interactions is an important foundation of our overall capacity for social cognition. Spreng (2013) suggests that the primary resource at our disposal in comprehending social phenomena is the ability to spontaneously retrieve memories of similar social situations in order to formulate an intuitive understanding of the wider social context and consistently update and adapt our mental models of individuals we interact with. Multiple studies utilising PCA to investigate dimensions of thought-probe responses during mind-wandering in a manner similar to Ruby et al. (2013) also consistently report that thinking about both past events and other people emerge as principal components of spontaneous thought (Medea et al., 2018; Poerio et al., 2017; Ruby, et al., 2013). It is unsurprising, then, that the retrieval of social information is prevalent in our spontaneous thought-patterns, allowing the processing of social cues and mental states in a manner more efficient than purely volitional memory retrieval.

Accordingly, the interplay of our spontaneous cognition and our memory processes is a fundamental component in our ability to mentalise. Senju (2012) highlights the importance of spontaneous thought in a functioning social cognition. Senju noted that many autistic-spectrum disorder (ASD) individuals show varying degrees of impairment in processing social cues, with the exception of a small minority of ‘high-functioning’ ASD individuals who consistently show a completely typical and unimpaired capacity for ToM while performing tasks under experimental conditions (Happé, 1995). Senju was of the opinion that the explicit nature of experimental tests of social cognition provided a degree of facilitation for these high-functioning ASD individuals in a manner that would not be present during naturalistic, everyday social interaction. By assessing the findings of both explicit and implicit measures of social cognition taken from a previous study (Senju, Southgate, White, & Frith, 2009), including false-belief attribution (a common assessment of ToM aptitude) and eye-gaze tracking, Senju observed that in the absence of explicit instruction, the perceived advantages of high-functioning ASD individuals in ToM assessments disappear. The review suggests that high-functioning individuals with ASD still possess a hindered ability to mentalise about others, even though this ability comes with a degree of ease when explicitly instructed to do so. The spontaneous nature of this evoking of mental states and its ability to interface with memory processes therefore not only facilitates immediate social interaction, but plays a significant role in our developmental trajectory. However, although such evidence demonstrates how atypical cognitive function impairs spontaneous social cognition in a clinical sample, it is not revealing of how individual differences in the general population account for relative skill or impairment at spontaneous social and mental state processing.

### 1.2. Origins of Mind-Mindedness

A useful construct for understanding individual differences in the spontaneous application of social cognition is mind-mindedness (Meins, 1997).Mind-mindedness is a non-conscious tendency to focus on mental and emotional states when interpreting the behaviour of, or describing, other people. Mind-mindedness can be described as a measure of our tendency to spontaneously mentalise, or recruit and utilise ToM, in representing or interacting with others. Greater and lesser degrees of mind-mindedness in an individual are characterised by references to the mental states of others when an individual is engaged in discourse with or when describing others. This measure is operationalised through a coding technique developed by Meins and colleagues (Meins & Fernyhough, 2015; Meins, Fernyhough, & Harris-Waller, 2014; Meins, Fernyhough, Russell, & Clark-Carter, 1998; Meins, Harris-Waller, & Lloyd, 2008), which calculates the proportion of mental and emotional characteristics used in describing another person; higher scores for mental state characteristics index greater mind- mindedness.

The concept of mind-mindedness has its origin in the field of developmental psychology. The description measure was first used to assess mothers' mind-mindedness about their preschool children (Meins et al., 1998), but the mind-mindedness construct has subsequently been developed to assess mind-mindedness in relation to preverbal infants and mind-mindedness in adult relationships. Early literature posits mind-mindedness as a construct that interfaces between behavioural and representational operationalisations of a relationship (Meins, 1997). As such, in order to be considered more mind-minded, a caregiver or any individual involved in a social interaction must form a representation of the internal mental state of another person and then have a heightened tendency to utilise that representation in order to interpret the behaviour of other people.

Aside from this scale of individuals being considered to be 'more' or 'less' mind-minded, later literature on mind-mindedness added further dimensions of measurement in the form of 'appropriate' and 'non-attuned' mind-minded comments. Meins, Fernyhough, Fradley, and Tuckey (2001) observed interactions between mothers and their 6-month-olds during sessions of play and transcribed the comments made by mothers towards their infants. All mothers talked about their infants' internal states to some extent, but crucially, they differed in the extent to which they could accurately 'read' what their infants were thinking or feeling. Appropriate mind-related comments indicate interpretations of the infant's internal state considered to be accurate (e.g., saying the infant *wants* the ball if she looks and gestures toward it), whereas non-attuned mind-related comments index misinterpretations of the infant's thoughts and feelings (e.g., saying the infant wants the ball when he is already engaged in playing with the teddy and has shown no interest in the ball).

Measured in this way, mind-mindedness can be characterised as a multidimensional construct, with the frequency of mental state comments indicating an overall all level of mind-mindedness, along with scores for appropriate mind-related comments and non-attuned comments. Aside from the usefulness of mind-mindedness as a measure of spontaneous mental state talk, both measures of appropriate and non-attuned mind-mindedness have been linked to developmental outcomes. Greater frequencies of appropriate mind-minded comments and lower frequencies of non-attuned mind-minded comments utilised by caregivers both independently predict secure attachment in children (Meins et al., 2001). This further dynamic of mind-mindedness and its implications for attachment highlight the importance of an increased tendency to spontaneously mentalise when interpreting the behaviour of others in facilitating close relationships, at least when observed in a caregiver-child dynamic.

The nature of mind-mindedness measurement is implicit, as during the observation of mother–infant interaction, no explicit instruction is given to mothers to express and interpret the behaviour of their children in terms of mental states. Neither are individuals instructed to talk about mental and emotional characteristics when given an open-ended invitation to describe their child, friend, or romantic partner. Mind-mindedness thus gives special insight into the everyday application of ToM in a non-experimental context, which allows the social-cognitive function of ToM to be assessed without the interfering influence of direct instruction. Accordingly, although mind-mindedness is a concept closely related to ToM, it is considered an altogether separate construct. For example, the tendency to describe others in mind-minded ways has been shown to be unrelated to individuals' performance on standard ToM tasks (Barreto, Fearon, Osório, Meins, & Martins, 2016; Meins, Fernyhough, Johnson, & Lidstone, 2006). In the same way, an individual utilising more mind-minded language does not necessarily mean their mental state comments would be considered more appropriate in their accurate interpretation of another's mental state. It has therefore been proposed that there is a competence–performance gap between individuals' ability to understand others' mental states (ToM) and the tendency spontaneously to invoke internal states when representing others (mind-mindedness) (Apperly, 2012; Meins et al., 2006).

### 1.3. Mind-Mindedness as Spontaneous Social Cognition

There is now a well-established literature showing that parental mind-mindedness is associated with a wide range of positive developmental outcomes in the child (see McMahon & Bernier, 2017, for a review). In contrast, attempts to identify the determinants and origins of mind-mindedness have shed little light on why some individuals are more mind-minded than others. There is no strong association between mind-mindedness and parents' socioeconomic status (SES) or educational attainment, indicating that it is not the case that mothers from higher SES or more educated backgrounds are more mind-minded than their lower SES or less educated counterparts (e.g., Bernier, McMahon, & Perrier, 2017; Bigelow, Power, Bulmer, & Gerrior, 2015; Laranjo & Bernier, 2013; McMahon, Camberis, Berry, & Gibson, 2016; Meins et al., 1998; Meins, Fernyhough, Arnott, Turner, & Leekam, 2011). Although severe mental illness is associated with lower levels of mind-mindedness (Pawlby et al., 2010; Schacht et al., 2017), there is no convincing evidence that variations in mental health observed in community samples relate to mind-mindedness (e.g., Fishburn et al., 2017; Meins et al., 2011). Similarly, child characteristics and behaviour do not appear to make parents more or less mind-minded. Mothers' appropriate and non-attuned mind-related comments are unrelated to infants' general cognitive ability, gender, and interactive behaviour (Fishburn et al., 2017; Meins et al., 2002; Meins et al., 2011). The overarching aim of this thesis is to explore the determinants of mind-mindedness in an entirely new way, investigating the cognitive and neural correlates of adults' mind-mindedness in relation to close friends.

Like many of the sophisticated faculties of social cognition, mind-mindedness appears to function as a form of higher-order thought consisting of multiple lower-order component processes. Multiple sources in the literature serve to identify spontaneous cognition as one of the central components of the process by providing the automatic retrieval of socially-relevant information about the mental states of others from memory stores (Bargh & Pietromonaco, 1982; Robinson & Swanson, 1990; Yang, Bossmann, Schiffhauer, Jordan, & Immordino-Yang, 2012; Spreng, 2013). Importantly, this process allows an individual to access information about the mental states of others at any point in time, even when not engaged in social interaction. The description method of measuring mind-mindedness as exemplified in the 'Describe a Friend' (DAF) task (Meins et al., 2014; Meins et al., 2008) effectively captures this phenomenon.

Unlike other methods of recording mind-mindedness which involve transcribing comments made while observing interactions between individuals, the Describe a Friend task (Meins et al., 2014; Meins et al., 2008) is administered in interview or questionnaire format, with participants being asked to think about a specific significant other and describe them. As with other measures of mind-mindedness, no explicit instruction is given on how to describe other individuals during the task and any mental state comments that are included are a result of an individual's internal mental narrative about a person rather than a prompt on what information to include. In this way, the Describe a Friend task serves as a useful operationalisation of mind-mindedness defined as the spontaneous tendency to mentalise when interpreting the behaviour of others (Meins, 1997). This task highlights how stored mental models of others are able to be accessed across time and in a variety of contexts purely by recalling socially-relevant information from memory. The assessment of mental state language use carried-out in the Describe a Friend task also demonstrates how important the interplay between spontaneous cognition and memory are in guiding our social cognition across time. Therefore, variance in our spontaneous cognition or in its ability to interface with memory systems not only leads to significant differences in how we interpret social phenomena, but also fundamentally alters the nature of the information that is recalled from past experiences and interactions.

Just as our spontaneous thought processes must function in such a way as to allow us to automatically access memory stores in order for mind-mindedness to develop and function, the efficacy of our memory processes in encoding relevant social information provides a database of information from which social content can be filtered into consciousness. A series of studies conducted by Meins et al. (2014) assessed the level of mental state language used in describing different individuals or objects: children, romantic partners, close friends, famous figures, or works of art. Concordance in mind-minded descriptions was observed across different close relationships (child and partner, partner and close friend), but mind-minded descriptions of a significant other were unrelated to mind-mindedness in descriptions of famous figures or works of art. Mind-minded language use was also found to be significantly higher when describing a significant other than when describing the other targets. The authors proposed that these results highlight the relational nature of mind-mindedness; that rather than being a general trait-like quality of personality, mind-mindedness is determined by the quality of specific inter-personal relationships.

The nature of mind-mindedness as a relational construct appears to suggest that this spontaneous focus on the mental states of another individual is more frequent when we are involved in an ongoing relational dynamic where we regularly interact with that individual, such as with a familiar in-group member (Gruenfeld, Mannix, Williams & Neale, 1996). When testing for levels of mind-mindedness, much work focuses primarily on interactions between caregivers and children, or on descriptions of close friends (Meins & Fernyhough, 2015; Meins et al., 2014; Meins, 1997), both categories of relationship which are close, familiar and long-term. Mind-mindedness may therefore represent an automatic form of mentalisation serving to facilitate and maintain closer social relationships by drawing on previous experiences to predict behaviour and decipher social contexts.

A potentially useful concept for understanding the implicit or automatic nature of mind-mindedness is the process of implicit social learning, a form of social cognition where past experiences such as social interactions influence the judgement of present situations in a manner an individual is not consciously aware of (Greenwald & Banaji, 1995). One of the primary functions of this form of implicit social cognition is thought to be the maintenance of a close in-group relational dynamic (Dunham, Baron & Banaji, 2008). Accordingly, it is reasonable to suggest that processes of implicit social learning may serve as constituent components of mind-mindedness by allowing memories of past experiences to be drawn on in an automatic and efficient manner, assisting in the deciphering of the potential intentions and motivations of other people.

As previously mentioned, mind-mindedness may be described as a non-conscious tendency to focus on mental and emotional states when interpreting the behaviour of, or describing, other people (Meins, 1997). Therefore, along with memories with which to draw upon potentially similar social contexts, individuals utilising mind-mindedness must therefore also become aware of initial social cues and signals from which to derive interpretations based on the mental states of others. Processes of implicit social learning have been shown to facilitate this implicit focus on social cues. A study performed by Hudson, Nijboer and Jellema (2012) compared individuals with a high intensity of autistic spectrum traits (High AQ) and individuals with a relative lack of autistic spectrum traits (Low AQ) on a measure of implicit learning for social information. Participants repeatedly observed two identities whose gaze and expression conveyed either a pro-social or an anti-social disposition. These identities were then employed in a gaze-cueing paradigm. Participants responded to a peripheral target that was spatially pre-cued by a gaze direction that was not predictive of target positioning. Analysis revealed that Low AQ individuals demonstrated a greater gaze-cueing effect for identities conveying a pro-social disposition. These findings relate to mind-mindedness in two interesting respects. Firstly, they demonstrate how the intentions and dispositions of other people can be learned implicitly from the reception of social cues in a manner that may help account for the implicit focus on mental states exemplified by mind-mindedness. Secondly, they provide evidence that pro-social dispositions or social cues facilitate processes of implicit social learning. These findings have interesting implications if we consider that heightened focus on mental states might be prevalent in closer relationships due to the repeated implicit social learning processes experienced from social cues we receive when interacting with other people.

Along with implicit social learning for social cues such as gaze and disposition, numerous other faculties of social cognition are carried out in an implicit, or automatic manner, such as action imitation (Rizzolatti & Craighero, 2004) and tracking the knowledge, goals and intentions of others (Frith & Frith, 2008; Sebanz, Knoblich & Prinz, 2003). Previous research has shown that representations about the mental perspectives of others are formed implicitly. When solving theory of mind problems such as a false belief task, Surtees and Apperly (2012) have shown that individuals are likely to automatically consider the perspectives of another individual even when aware that individuals' perspective is inaccurate or does not corroborate with our own. The mere presence of an ignorant person may interfere with response times and recall during memory tasks about an observed scenario, resulting in slower responses and greater occurrences of errors as the perspective of an individual lacking perfect knowledge of a situation is internally represented. Accordingly, it appears that an important factor in understanding the mental states of other people involves taking into account other peoples' knowledge and perspectives on an automatic or implicit basis. It has been suggested that these low-level automatic processes interact in order to produce behaviour that encourages efficient group interactions (Frith & Frith, 2008).

A wide variety of nonverbal social cues and signals are exchanged in every social interaction. Evidence suggests that our ability to predict behaviour based-upon these social cues we receive is related to the level of liking we have for another individual. An experiment performed by Heerey and Velani (2010) tested whether participants could learn to predict another person's behavior using nonverbal social cues. Participants played a computerized game of rock-paper-scissors against an avatar they believed was another participant. On some occasions, the avatar generated a predictive facial cue before making a play. Participants demonstrated a significantly greater win frequency for trials in which they received a social cue, even if they did not acquire explicit knowledge of the predictive nature of the cue. The degree to which participants could successfully predict the behaviour of the avatar related to their self-reported level of liking for the avatar. Interestingly, these findings demonstrate the importance of implicit learning processes in guiding behavior during social interactions. They also provide further evidence for the facilitation of implicit social learning from others in interactions with pro-social context, or in closer relationships.

Further literature also suggests that processes of implicit social learning interact and engage with memory to produce a system where implicitly learned social information may influence the form and content of the memories we access in order to interpret social interactions. Amodio and Ratner (2011) state that implicit social processes have long been explained by single-system models that, while addressing questions of information processing, fail to explain the interface of implicit social processes with behaviour in everyday interactions. They proscribe that a model of implicit social learning be adopted that accounts for the role of memory systems in enabling the accessing of knowledge about prior interactions in order to inform present behaviour. Different underlying memory processes, it is argued, may therefore contribute towards implicit social processes and vice-versa. In this way, it is possible that implicit social learning may in some instances result in increased focus on the mental states of others, utilising episodic memories of past similar social interactions with an individual in order to represent their mental states. Closer relationships may therefore allow for more regular instances of implicit social learning for various social cues that might communicate information about mental states to occur, as well as provide a greater reserve of memories of shared interactions with an individual to draw-upon. This being the case, it may be that mind-minded individuals have in some way implicitly learned or become proficient in recognising various social cues and signals, and subsequently utilise this information to provide an interpretation of the mental states and intentions of another person. Such interpretations of the mental states of others would naturally be more easily accomplished through having access to a wide range of previously shared memories and interactions such as those experienced in close personal relationships, which would in-turn partially account for the relational basis of mind-mindedness.

In terms of cognitive processes that might underpin mind-mindedness, the tendency to spontaneously fixate on the mental qualities and intentions of another individual is limited by the readiness of previous, direct social interactions with them to be retrieved from memory. These findings largely accord with the earlier opinion of Spreng (2013), who suggests that social cognition interacts with memory capacity at a fundamental level and that the successful retrieval of memories of past interactions with others is essential for interpreting and understanding the ever-changing flow of social context in our daily activities. The relational basis of mind-mindedness therefore reveals the necessity of effective memory encoding and retrieval processes for its functional operation. In all, previous research highlights how access to social information and context in order to predict behaviour (Lee & Harris, 2013) relies on a functional memory capacity. With use of functional memory systems, we are able to draw upon previous similar social scenarios we have experienced (Spreng, 2013), and the subjective content of spontaneous thought automatically attending to social information in memory (Ruby et al., 2013) suggests that social context, memory and spontaneous thought may all function as potential components and determinants of mind-mindedness. However, although mind-mindedness appears to constitute a form of higher-order thought, currently the component processes of the construct remain unclear. Investigating this question was the first aim of this thesis.

### 1.4. Neural Correlates of Mind-Mindedness

Although there is a substantial amount of behavioural evidence suggesting the role of memory and spontaneous cognition as essential facets of social cognition in general, previous research has not yet directly examined the neural correlates of mind-mindedness in the individual human brain. Previous work has investigated mind-mindedness on a neural and functional level in a longitudinal study investigating relations between mothers' mind-mindedness in infancy and children's brain connectivity at age 10. Dégeilh, Bernier, Leblanc, Daneault, and Beauchamp (2018) found that functional connectivity between the Default Mode Network (DMN; involved in introspective processing and social and affective cognition) and salience network (involved in detecting salient information and cognitive control) was associated with higher levels of mind-mindedness. This study provides the first evidence that early mind-mindedness is associated with children's processing of social cognition at a neural level. However, although previous work has established an association between mind-mindedness and functional variance in large-scale brain networks, as stated no current research directly investigates the neural correlates of mind-mindedness on an individual basis – addressing this goal is one of the unique contributions of this thesis.

Evidence gathered from previous research suggests that the frontoparietal cortex is specifically involved in producing internal representations of the mental states of others. Mitchell, Banaji and Macrae (2005) scanned participants using fMRI while they performed a task requiring them to associate words with one of two categories: people or dogs. For each target participants were required to judge whether word described a potential psychological state or a physical body part of the target, finding that greater mPFC activation accompanied judgments of psychological states compared to body parts regardless of whether the target was a person or a dog, indicating the role of the mPFC in representing the psychological states of others.

More recent research further evidences this fact. Moran, Jolly and Mitchell (2014) noted that when describing the behaviour of other people, a tendency to overemphasize underlying dispositions and personality traits often exists, known as the fundamental attribution error. The extent to which the fundamental attribution error results from a spontaneous processing of mental states was tested by having participants complete a task during fMRI where they were required to read a set of stories and judge whether a series of social behaviours carried-out by individuals were attributable to their internal disposition or to a situational factor. The researchers found that brain regions commonly associated with mental state inference, namely the mPFC, strongly predicted whether participants attributed behaviours to internal disposition. These results suggest that a heightened tendency to fixate on mental states when interpreting behaviour, facilitated through heightened mPFC activation, underlies the tendency for fundamental attribution error and further highlights the role of the mPFC as contributing towards spontaneous mentalisation.

Previous research also links the mPFC to social cognitive function through identifying its role in representing information about social stereotypes. Contreras, Benaji and Mitchell (2012) observed that when participants made judgements about social and non-social categories during fMRI, social judgements were specifically accompanied by heightened activation in brain regions associated with social cognition, including the mPFC, posterior cingulate and left temporo-parietal junction. These results suggest that social-stereotype information is represented distinctly from general semantic information, with dissociable patterns of activation involving the mPFC in navigating social scenarios.

A large degree of neuroscientific evidence suggests that communication between brain regions associated with both spontaneous thought generation and memory retrieval may possess a significant degree of influence over social-cognitive processes. A meta-analysis conducted by Mars et al. (2012) concluded that brain regions with activations sensitive to tests of social cognition share a significant degree of overlap with the DMN, specifically in medial-prefrontal and parietal brain regions. The authors propose that the remarkable degree of overlap between brain regions typically involved in social cognition and the ‘default system' suggests that the default-mode of cognitive function facilitates a predisposition towards spontaneous social cognition, and that the DMN contributes towards the dedication of idle mental resources towards social-cognitive processes. These findings suggest that DMN functioning may contribute towards the application of mind-mindedness, given that mind-mindedness fundamentally involves an involuntary or unconscious predisposition towards the processing of mental states.

Interestingly, the DMN has also been suggested to interact with memory systems in order to automatically retrieve social-contextual information from memory. Spreng et al. (2014) exposed participants to a series of social stimuli in the form of human faces. A portion of these faces were of anonymous, unknown individuals, while the rest were famous (presumably known) celebrities. After a period of distraction Spreng et al. (2014) had participants attempt to recall the series of faces during fMRI, and observed heightened activation in the posterior cingulate cortex (pCC), a major hub of the DMN, while recalling the famous faces, but not the faces of unknown individuals. The major implication of these findings is that, as participants had no knowledge about individual faces presented in the anonymous/unknown condition beyond the immediate physical features of the face, increased pCC activity in response to exposure to a known or famous face appears to reflect the retrieval of information other than encoded facial features. Spreng et al. (2014) accordingly assert that this observed pCC activity is heavily involved in enabling the automatic retrieval of social-contextual information about an individual from memory in response to the physical stimulus of an observed face. The DMN therefore appears to operate in a manner crucial for the successful development and execution of spontaneous social-cognitive faculties such as mind-mindedness by providing neural mechanisms (as observed in the pCC) allowing the interface of spontaneous cognitive and memory retrieval processes.

Previous literature accordingly provides evidence that the DMN interacts with areas responsible for the processing of social-cognitive information and that this interaction appears to be responsible for the manifestation and execution of a sizeable portion of the myriad automatic or non-volitional aspects of social cognition. However, the DMN is a large-scale interconnected neural network and it is currently unknown how brain regions responsible for social information processing integrate with the DMN in order to produce a workable spontaneous social cognition. Although the exact neural mechanisms responsible for the functioning of spontaneous social processes such as mind-mindedness are unknown, previous neuroscientific evidence suggests that the temporo-parietal junction (TPJ) may constitute a major neural component of mind-mindedness through the encoding of social cues and context and the subsequent relaying of this information to various nodes of the DMN.

The TPJ is often recruited when participants attempt explicit measures of social-cognitive capacity (such as ToM assessments) and appears to reflect an individual undertaking an act of deliberate and effortful mentalisation (Saxe & Kanwisher, 2003). However, literature highlighting the role of the TPJ in spontaneous social cognition is scarce. Anticevic, Repovs, Shulman, and Barch (2010) observed that the TPJ, while not part of the DMN, may exhibit heightened levels of functional connectivity with the DMN depending on task demands, specifically noting decreases in activation in both default and social-cognitive networks when performing demanding cognitive tasks. However, this observation offers no further information on what the resultant function of TPJ–DMN connectivity might be. Assaf et al. (2010) provide evidence that TPJ and default network interaction may be important for mentalisation about others through the association of abnormal DMN connectivity and long-term deficits in ToM ability (a task in which TPJ functioning is usually implicated; Saxe & Kanwisher, 2003). Specifically, individuals on the autistic spectrum with greater deficits in ToM ability have underdeveloped DMN functional connectivity patterns. The authors state that decreased connectivity between the DMN and the various sub-networks involved in social information processing may result in core deficits in ToM ability. Therefore it appears that healthy functional connectivity between DMN hubs and social-cognitive brain regions such as the TPJ underlies the ability to apply ToM in day-to-day scenarios in the long term.

Along with evidence gathered from classical fMRI methods, resting-state fMRI (rfMRI) provides a wealth of evidence suggesting heavy coupling between social-cognitive and default-mode networks. Taking the peak activation voxel co-ordinates for the TPJ reported by Saxe and Kanwisher (2003) as a seed region, a Neurosynth (Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011) meta-analysis reveals a large degree of functional connectivity between the TPJ and DMN nodes (see Figure 1.1), specifically revealing heightened connectivity between the TPJ, the pCC and the mPFC.

Figure 1.1. Functional Connectivity Maps for the Temporo-Parietal Junction and Default Mode Network.

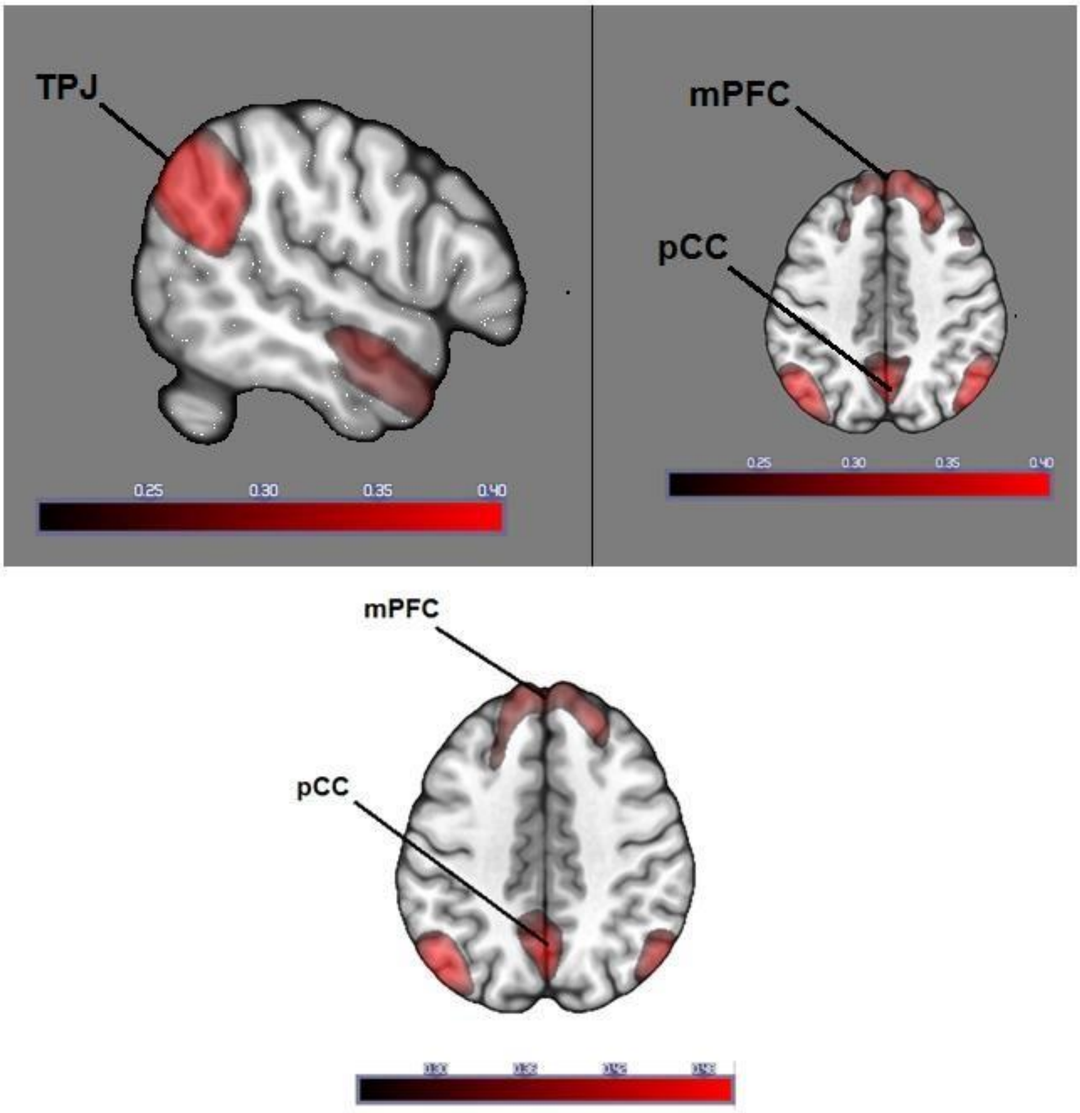


*Figure 1.1. (Top) The functional connectivity map for the Temporo-Parietal Junction (TPJ) based on the voxel seed region taken from Saxe and Kanwisher (2003) in Montreal Neurological Institute (MNI) space. Functional connectivity demonstrated between the TPJ, the pCC and the mPFC (Bottom). The functional connectivity map for the DMN based on a seed taken from Greicius, Krasnow, Reiss, and Menon (2003) in MNI space. Images thresholded at p < .05. Hotter colours denote regions of increased connectivity.*

A study conducted by Von dem Hagen et al. (2011) links reduced levels of resting-state functional connectivity between the DMN and social cognitive networks including the TPJ to impairment of the ability to mentalise in ToM assessments in individuals on the autistic spectrum. Such results complement the earlier findings of Assaf et al. (2010) by demonstrating that social-cognitive impairment may not only be traced to abnormal DMN intra-connectivity, but also how the DMN interacts and communicates with other networks in the resting brain. Such evidence highlights the importance of a constellation of disparate brain regions interacting effectively to produce a working social cognition, and suggests that connectivity between the TPJ and DMN may play an important role in producing the spontaneous aspects of social cognition seen in mind-mindedness. Mars et al. (2012) have furthered this perspective through a commentary on why brain networks associated with spontaneous thought generation might play such a significant role in social cognition, stating that "the largely unconstrained nature of social decision making, including its reliance on potentially multiple instances of recursive thinking might be one reason why social cognition relies on a network such as the DMN" (Mars et al., 2012, pp.7). The implications of this view suggest that the DMN may provide a means for spontaneous social-cognitive systems to operate in a manner much more efficient than purely volitional and effortful social memory retrieval. As a measure of spontaneous social cognition, mind-mindedness may therefore serve as a faculty facilitating this spontaneous aspect of social-cognition. Accordingly, the second major aim of this thesis is to investigate neuroimaging links with mind-mindedness in order to move towards an understanding of mind-mindedness as a form of higher-order social cognition, in terms of its neural components.

### 1.5. Thesis Aims: Deconstructing Mind-Mindedness

Given the mass of psychological and neuroscientific evidence linking our capacity for memory, the nature of our spontaneous thought, and the functioning of our social cognitive faculties, the central proposal in this thesis is that mind-mindedness can be deconstructed and better understood through the development of a component-process account of the construct, with the cognitive mechanisms enabling memory retrieval and spontaneous thought generation as fundamental sub-processes allowing the emergence of mind-mindedness as a form of higher-order thought. It is also proposed that that these subcomponents can be assessed utilising MRI techniques to identify the behaviour of the neural components of mind-mindedness under various forms of experimental manipulation. The two major aims therefore are to first identify the potential cognitive subcomponents of mind-mindedness through investigation of its behavioural correlates, then to implement neuroscientific techniques in order to identify the neural correlates of mind-mindedness.

The first major aim of outlining the behavioural correlates of mind-mindedness yields a two-fold benefit. Firstly, it allows the utilisation of a series of tests with the aim of triangulating areas where mind-mindedness utilises common cognitive resources with some other behavioural construct. Secondly, it aids in the translation of mind-mindedness from a largely qualitative measure into a component-process model which we can utilise to inform and elaborate upon fMRI results. If a number of essential cognitive subcomponents of mind-mindedness can be successfully identified through behavioural testing, then it becomes possible to develop measures and manipulations of mind-mindedness that might be possible to subsequently administer in future fMRI contexts. For example, previous research suggests the involvement of brain areas such as the pCC, mPFC and left-TPJ in social cognition generally (Mars et al., 2012), and the mPFC and pCC in mentalisation and memory encoding respectively. Understanding mind-mindedness as being composed of behavioural components that recruit these disparate brain regions will inform our subsequent interpretation of the neural network enabling mind-mindedness and the potential role of the various brain regions comprising it.

This initial stage will utilise the DAF task (Meins et al., 2014; Meins et al., 2008) in an interview format in order to examine levels of mental state language use carried-out when describing a friend from memory. The interview format of the DAF task allows for a simple task-paradigm which participants can complete in their own time and measures of spontaneous mental state language use can be gathered without need for the experimental observation of ongoing interactions. As such, of the two dimensions of mind-mindedness discussed previously, for the purposes of fulfilling the aim of exploring the neural correlates of mind-mindedness, the proportion of ‘appropriate’ and ‘non-attuned’ mind-minded comments will not be assessed. Only an individual’s tendency to be more or less mind-minded and spontaneously focus on mental states will be measured. Investigating this aspect of mind-mindedness as an initial inquiry is necessary when utilising the DAF task format as opposed to coding and observing interactions, as it is not possible to interpret the mental state language of participants as being appropriate or non-attuned in response to a social cue in an ongoing social scenario. This approach however may potentially yield answers essential for understanding mind-mindedness for the first time in terms of its component processes by linking mind-mindedness, defined as variance in the tendency to spontaneously mentalise, with potential behavioural correlates and underlying neural components

Parallel to this deconstruction of mind-mindedness into subcomponents, the second major aim involves directly comparing variance in levels of inter-network connectivity in the resting brain with DAF task scores for mind-mindedness in order to begin building a component-process model of the neural correlates of mind-mindedness. Techniques of rfMRI allow for the exploration of the direct association of mind-mindedness with functional networks in the resting brain by identifying brain regions associated with spontaneous social cognition, and implementing seed-based analysis techniques to produce connectivity maps between brain regions associated with variation in scores for conventional measures of mind-mindedness. The benefit of utilising rfMRI in this investigation is the ability to compare established measures of mind-mindedness with functional connectivity throughout the brain, providing a broad overview of large-scale brain networks and how they differ with variation in levels of mind-mindedness. Accordingly, the second major aim will be carried-out in three stages. The first stage being the administration of a battery of tests to participants that might reveal measures sharing a degree of behavioural correlation with mind-mindedness. The second stage is exploring these correlates to inform our search and interpretations when attempting to link neural mechanisms with variance in mind-mindedness. The third and final stage is taking standard measurements of mind-mindedness in the form of responses to the DAF task and exploring the direct neural correlates of the construct of mind-mindedness in the brain at rest.

# Chapter 2

## Study 1: Exploring the Behavioural Components of Mind-Mindedness

### 2.1. Introduction

Understanding the people with whom we interact helps place their behaviour in an appropriate context, allowing us to make sense of why they are behaving in a particular way (Higgins, 2000). Consequently, when we interact with another person, we often retrieve information from memory that is either specific to the individual in question, or has a more general relationship to our social world. When an individual's interpretation of another person's behaviour is guided by the recognition that the other person has an internal world rich with hopes and desires, the individual is demonstrating *mind-mindedness* (Meins, 1997). Mind-mindedness in relation to adults and children from preschool age onwards is assessed in terms of the individual's tendency spontaneously to focus on mental characteristics when given an open-ended invitation to describe a person (Meins, Fernyhough, Johnson, & Lidstone, 2006; Meins, Fernyhough, Russell, & Clark-Carter, 1998; Meins, Harris-Waller, & Lloyd, 2008).

A growing body of literature has demonstrated that parents' mind-mindedness is associated with a wide range of positive outcomes in the child. In particular, parental mind-mindedness is a positive predictor of children's own understanding of emotions and beliefs (Centifanti, Meins, & Fernyhough, 2016; Meins, Fernyhough, Arnott, Leekam, & de Rosnay, 2013; Meins et al., 1998), and is negatively correlated with reported parenting stress (Demers, Bernier, Tarabulsy, & Provost, 2010; McMahon & Meins, 2012). Research has also investigated mind-mindedness in relation to close friends in both children (Meins et al., 2006) and adults (Meins, Fernyhough & Harris-Waller, 2014; Meins et al., 2008). However, much less is known about the factors that determine whether or not an individual demonstrates mind-mindedness. Meins et al. (2006) reported that children's mind-

mindedness about their best friend was unrelated to their ToM abilities, and Barreto, Pasco Fearon, Osório, Meins, and Martins (2016) also reported the same null finding for the relation between parents' mind-mindedness and ToM performance. It has therefore been proposed that there is a competence–performance gap between ToM abilities and mind-mindedness—although an individual possesses the capacity to understand others' internal states, this is not sufficient for them spontaneously to represent others in terms of their internal states and thus demonstrate mind-mindedness (Apperly, 2012; Meins et al., 2006).

Previous research has investigated relations between mind-mindedness and mentalising abilities largely using measures of explicit mental representation, such as comparison between mind-mindedness and proficiency in ToM tasks (Meins, Fernyhough, Arnott, Leekam & de Rosnay, 2013;Meins, Fernyhough, Wainwright, Das Gupta, Fradley, & Tuckey, 2002). The aim of the present study was to investigate whether mind-mindedness relates to implicit mentalising abilities. Mind-mindedness can be described as a tendency to spontaneously mentalise (Meins et al., 2008; Meins et al., 2006; Meins et al., 1998; Meins, 1997), and therefore should in part depend upon the functioning of lower order processes of implicit cognition. Implicit social learning, a form of social cognition where past experiences such as social interactions influence the judgement of present situations in a manner an individual is not consciously aware of (Greenwald & Banaji, 1995), may play a role in contributing towards mind-mindedness as a constituent process. Dunham, Baron and Banaji (2008) have suggested that one of the major outcomes of social learning is to maintain stable relationships and a healthy group dynamic. Accordingly, processes of implicit social learning may contribute towards the spontaneous nature of mind-mindedness by encouraging focus on mental states in order to make sense of the many complex events we encounter during social interactions.

Social interactions are complex and dynamic events requiring the integration of information from memory systems in order to deduce context and form impressions of others (Mitchell, Macrae & Banaji, 2004). Processes of implicit social learning have been shown to interact and engage with memory to produce a system where learned social information may influence the form and content of the memories we access in order to interpret social interactions (Amodio & Ratner, 2011). This type of learning may in part explain why mind-minded individuals demonstrate an unconscious bias towards attending and subsequently assigning mental states to the social cues they receive when engaged in social interactions, or when describing close others. It is possible that implicit social learning processes may play a part in determining this increased focus on the mental states of others that is characteristic of mind-mindedness, allowing individuals to utilise memories of past similar social interactions and social cues in order to assign meaning to events occurring in the social world.

Evidence from cognitive neuroscience suggests that information from memory is important in various aspects of social cognition. Neuroimaging studies have shown that there is a close overlap between the neural recruitment that occurs during social cognition and systems that are important in conceptual (i.e., semantic) and autobiographical (i.e., episodic) memory (Schilbach, Eickhoff, Rotarska-Jaglela, Fink, & Vogeley, 2008). These studies highlight regions in the temporal lobe, medial prefrontal cortex (mPFC), and posterior cingulate that collectively constitute the DMN. Studies have also shown that the DMN is active during situations when we are not engaged in any explicit external task (Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001) and when states such as daydreaming or mind- wandering are common (McKiernen, D'Angelo, Kaufman, & Binder, 2006).

Previous work carried out by Bird, Keidel, Ing, Horner, and Burgess (2015) also highlights the role of the DMN, and in particular the posterior cingulate in encoding the complex information contained in social interactions to memory as a narrative. Bird et al. (2015) showed participants a series of video clips depicting 'complex event sequences';

many of these video clips portraying social interactions as examples of complex event sequences. Bird et al. (2015) gave participants the opportunity to mentally rehearse the content of a subset of these video clips during fMRI and found that forming a narrative about what was observed during the course of the events displayed, and subsequently rehearsing that narrative, greatly improved subsequent recall of the contents of the clip. Also, greater posterior cingulate activity was observed when participants were given the opportunity to rehearse the information depicted in the clips, suggesting that one role of the posterior cingulate is encoding events into narratives that may be accessed from memory. Given that mind-mindedness is expressed as a heightened tendency to spontaneously retrieve social information from memory when interpreting behaviour (Meins, 1997), it is possible that the posterior cingulate, and the related cognitive processes of event segmentation and narrative formation, play important roles as component processes of mind-mindedness, allowing us to string together social cues and events into coherent narratives about the mental states of others.

The mind-wandering experience characterised by increased DMN and posterior cingulate activity is also related to an increased frequency of socially-oriented content in subjective thought. Recent research demonstrates that the content of mind-wandering experiences often involve thoughts about other people (Ruby et al., 2013; Engert, Smallwood, & Singer, 2014), suggesting that the spontaneous thoughts that occupy our minds during the mind-wandering state may reflect a form of social cognition, albeit one that is generated entirely from information from memory. Consistent with this view, it has recently been shown that people who show high levels of social cognitive information during spontaneous thought generate high numbers of solutions to social problems (Ruby et al., 2013). Neuroimaging has suggested that forms of social affective spontaneous thoughts depend on the integration of information from regions of the temporal lobe that has a recognised role in memory (Smallwood et al., 2016).

Evidence gathered from Mitchell, Banaji and Macrae (2005) suggests that socially relevant information is stored in memory via functionally distinct networks from general semantic information. Although social cognition has been shown to share a large amount of common neural architecture with conceptual and autobiographical memory (Schilbach, Eickhoff, Rotarska-Jaglela, Fink, & Vogeley, 2008), Mitchell et al. (2005) reported greater mPFC activation accompanied judgments specifically pertaining to psychological states and not for more general associations involving body parts. These findings demonstrate the importance of encoding relevant social information to memory in order to navigate the world around us through showing the existence of distinct patterns of neural activity designed to help facilitate our understanding of social phenomena. Further, Meins et al. (2014) have shown that individuals demonstrate greater levels of mind-mindedness when describing individuals they know personally, as opposed to famous figures and works of art. These findings highlight the relational nature of mind-mindedness, and suggest that shared episodic memories of interactions with other people help facilitate mind-mindedness. Together, the findings of Mitchell et al. (2005) and Meins et al. (2014) present mind-mindedness as a form of higher-order cognition involving greater focus on the psychological states of others in order to facilitate and maintain social relationships with the people we share social interactions with.

The present study therefore sought to test whether two aspects of social memory are linked to mind-mindedness: semantic and episodic. First, we investigated whether individuals' implicit use of semantic information to understand a personally familiar individual was associated with mind-mindedness. To explore this issue, we asked participants to perform a modified implicit association test (IAT, Greenwald, McGhee and Schwartz (1998) in which they had to associate concepts related to mental and physical states with themselves, a personally familiar other (their best friend), a familiar person who they do not know personally (Lady Gaga) and a dynamic but non-living system (the weather). It was tested whether mind-mindedness would be associated with an increased reaction time when associating mental states with personally known others.

Second, we tested whether mind-mindedness is linked to better memory for social stimuli by assessing accuracy of recognition of social information in silent film clips using a similar design to that employed by Bird, Keidel, Ing, Horner, and Burgess (2015). The present study explored whether mind-mindedness was reflected in how social events are remembered and how this is linked to the generation of a narrative about the event. The silent movie clips included social interactions either between people or between animals. It was tested whether mind-mindedness would be associated with an increased recognition for human clips, containing a richer variety of socially-relevant information then animal clips. It was also tested whether an opportunity for rehearsal would further exaggerate this effect in more mind-minded individuals.

Mind-mindedness, unlike ToM, is of course measured implicitly, without any given instruction to focus on social (or any other) categories of information. A modified IAT therefore allows for an implicit measure of semantic bias, in order to investigate the extent to which mind-mindedness possesses an attitudinal component. The silent movies task implemented utilises a more explicit assessment of memory by asking participants whether they recognise information contained in video clips they have previously seen. However, during this test no instruction is given on what information to attend to and the measurement of accuracy levels for human/animal, or rehearsed/not rehearsed clips allows for an implicit assessment of whether individuals scoring higher in mind-mindedness show a bias towards remembering clips with more relevant social information included within them. Therefore, it was hypothesised that participants would show quicker reaction times when associating mental concepts with personally known others during the IAT due to socially-relevant information being encoded utilising neural networks distinct from general semantic processing (Mitchell et al. 2005), and that this effect would be exaggerated for participants scoring higher in mind-mindedness due to the relational nature of the construct in causing fixation on the mental states of known others (Meins et al., 2014). It was also hypothesised that participants would show increased recall for human clips compared to animal clips during the SMT, and that rehearsal of the content of these clips would improve later accuracy in tests of recognition for clip content for both animal and human clips. Finally, it was hypothesised that the bias towards recognition of content from human clips would be emphasised in individuals scoring higher for mind-mindedness.

In summary, the present study investigated the proposal that there is a competence–performance gap between ToM abilities and mind-mindedness by exploring relations between implicit mentalising and mind-mindedness. We also examined the proposal that mind-mindedness is a relational construct by investigating associations between mind-mindedness and the accuracy of recognition of social information about unknown targets.

## 2.2. Method

### 2.2.1. Participants

A total of 70 participants between the ages of 18 and 35 years (M = 20.77, SD = 4.49) were recruited for the study. Most participants recruited were psychology undergraduates. All participants recruited were native English speakers.

### 2.2.2. Materials and Methods

Participants completed three tasks in a single testing session, administered using a counterbalanced design. Participants were tested individually.

#### 2.2.2.1. Describe a Friend Task (DAF)

Mind-Mindedness was assessed using the Describe a Friend (DAF) task (Meins et al., 2008, 2014), administered via a computer. The Describe a Friend task (Meins et al., 2008, 2014) allows a measurement of the frequency with which information about the mental states of others is spontaneously referred to even when participants are not actively engaged in social interaction, making it a suitable candidate for a self-report style operationalisation of mind-mindedness.

Participants were presented with a blank screen with the instruction to think of a specific close friend and type a description of the friend in the text box. The on-screen instructions informed participants that they could (a) include any information about their friend they thought was relevant, (b) make their response as long or as short as they wished, and (c) take as long as they wished, but aim to spend around five minutes on the task.

Participant responses were later coded for mind-mindedness according to the Mind-Mindedness Coding Manual criteria (Meins & Fernyhough, 2015). The text was first divided into discreet descriptions that could be single words, phrases, or sentences. Each description was then placed into one of the following exhaustive and exclusive categories: (a) Mind-minded: references to the emotions, mental life, or intellect of the person being described (e.g., 'they enjoy meeting a challenge', 'she has a very active imagination'), including references to shared mental characteristics (e.g., 'we're often on the same wavelength', 'we both tend to overthink things'), (b) Behavioural: activities or interactions with others that can be interpreted on a purely behavioural level (e.g., 'he is usually the first to speak-up', 'she avoids long journeys when possible'), the person's occupation, or information about the subjects the person is studying (e.g., 'they recently started the second year of their degree', 'he currently works for a marketing company'), (c) Physical: any physical characteristics, including age, family relationships (e.g., 'she is 20 years old', 'he has two brothers'), references to style of dress, or judgements on attractiveness (e.g., 'he's a good-looking guy', 'she's very fashionable' ), (d) Self-referential: comments in which the primary reference is self-focused rather than describing the friend (e.g., 'I always look forward to our next meet-up', 'they have a certain way of making me laugh'), (e) Relationship: comments that focus on the relationship rather than either of the individuals involved (e.g., ''we are like sisters"), compare or contrast themselves with the friend (e.g., "we are opposites"), or describe when they met or how long they have known each other, or activities they carry out together, or (f)

General: miscellaneous comments not belonging to any of the above categories (e.g., where the person grew up or currently lives, stating the person's name), including non-specific value judgements (e.g., 'they don't always make the best choices', 'they have fantastic taste').

All descriptions were coded by a trained researcher who was blind to all other data, and a randomly selected 25% were coded by a second trained, blind researcher: inter-rater reliability was $\kappa = .95$. Participants received scores for each category as a percentage of the total number of descriptions produced in order to control for the amount written. Scores for mind-minded descriptions indexed participants' mind-mindedness in relation to their close friends, and scores for physical descriptions were selected to index participants' knowledge of their friends that did not emphasise internal states.

#### 2.2.2.2. Implicit Association Test (IAT)

The IAT was based on the procedure first outlined by Greenwald et al., (1998). Participants first completed a practise section where two categories, 'Mental' and 'Physical', were displayed at the top left and right-hand sides of the screen respectively. After a 3 to 5 second delay, a target word appeared in the centre of the screen and participants were required to associate the word with the left or right-hand category by pressing the left or right arrow button on their keyboard; response time (RT) was recorded. The word appearing in the centre was taken from a list of ten words; 5 'mental words' ('Intelligence, 'Wisdom', 'Logic', 'Attentiveness', 'Empathy') and 5 'physical words ('Agility' 'Athleticism', 'Dexterity', 'Speed', 'Strength'). The practice section ensured that participants understood the basics of the task, with the assumption that all 'mental words' would be associated with the 'Mental' category and that all 'physical words' would be associated with the 'Physical' category. Each word was displayed once, making the practise section consist of 10 trials. Each trial only progressed once the participant had given a response. Participants on average made the expected word/category associations.

After the practise section was completed, participants were required to associate the mental and physical words with four categories: ‘Self’, ‘Best Friend’, ‘Lady Gaga’, and ‘Weather’. The categories of self and best friend allowed an examination of how people differ in terms of how they categorise themselves and a close personal friend. Lady Gaga allows us to explore if any bias generalises to an individual who is not known personally, while the weather acts as a physical control condition.

Each category was compared with each of the others a total of four times in each block of testing, twice in a congruent manner and twice in an incongruent manner. According to the findings of Bradford, Jentzsch and Gomez (2015), individuals exercise considerably less cognitive effort when associating mental characteristics with themselves than with other people. In addition, according to Meins et al. (2014), mind-mindedness is highest when making judgements about people we know personally, followed by people we do not know personally, then finally inanimate objects. Therefore, congruent trials consisted of participants making word associations with mental concepts being primarily sorted with the Self category, then the Best Friend category, and so on while incongruent trials consisted of participants making word associations with mental concepts being primarily sorted with the Weather category then the Lady Gaga category, and so on.

Congruent trials required participants to associate mental words with the category hypothesised to be most associated with mental words, and associate physical words with the category hypothesised to be most associated with physical words. For example, it was hypothesised that mental words would be most easy to associate with the Self category, followed by the Best Friend category, then Lady Gaga, then Weather. Likewise, it was also hypothesised that physical words would be most easy to associate with the Weather category, followed by the Lady Gaga category, then Best Friend, then Self.
Incongruent trials required participants to associate mental and physical words with the category on-screen that would normally be least associable, for example associating mental

terms with the weather. In this way, it was hoped that semantic/implicit attitudinal association would be able to be measured along a dimension of 'relational closeness' from self, to a known other, to an unknown other, to a non-living process in a manner reflecting the categories of people/objects assessed in Meins' et al. (2014) earlier study. The IAT session consisted of two blocks containing 20 trials each (10 congruent trials and 10 incongruent trials). Average participant RT (in milliseconds) for congruent and incongruent trials across the three categories was recorded and used for the subsequent analyses.

**2.2.2.3. Silent Movies Task (SMT)**

In order to select the stimuli for the SMT, 20 participants rated a series of 48 movie clips for the purpose of identifying key moments in each clip that would be used to probe participants' memory for events. The movie clips were stripped of audio, ensuring participants only used visual information. Half of the movie clips (24) portrayed humans engaging in some form of interaction, the other half involved animals. All movie clips were sampled from YouTube content and lasted approximately 30 seconds. Participants were instructed to press a button every time an event occurred on-screen that they felt helped them understand the wider social context of the clip. This resulted in a dataset containing a number of important moments for each movie clip. For each clip, the most commonly chosen event was selected, and a still image of the frame was taken for later use as a stimulus in the main study. Any ambiguity about which time-point in a clip contained the most prominent event was resolved by selecting the event that was associated with the most visually clear frame (being free of motion blur, obfuscating objects in the foreground, etc.). Therefore, at the completion of this initial stage, a still image associated with the moment/event of most social significance from each movie clip was collected, giving a total of 48 still images.

The main aim of the SMT was to identify a participant's memory for scenes in the social and control silent movies. Following prior studies demonstrating that describing films improves memory (Bird, Keidel, Ing, Horner, and Burgess, 2015), we also explored whether the generation of a narrative has a particular impact on social films. The SMT had four stages. Participants first watched a set of silent clips involving either people or animals, after which they performed a short distraction task. They then described a set of clips, and finally completed a surprise memory task on material covered in the clips.

In the initial phase, participants watched half of the movie clips (12 animal and 12 human), selected at random. A title for each clip was displayed on-screen during movie presentation. After watching all 24 clips, participants performed a Stroop task to prevent mental rehearsal. Next, participants were asked to describe half of the clips they had seen (6 human and 6 animal). Participant descriptions of the movie clips were recorded using Microsoft Word and the procedure involved participants being shown nothing but the title of a clip at the top of the page, and instructions asking them to recall as much information as possible about the clip and type it in the blank space. This created two groups of the 24 clips that were shown to each participant: 12 clips that had been rehearsed and 12 clips that had not been rehearsed. Finally, participants underwent a recognition test that involved the still scenes rated for significance as determined by the pilot study. The scenes from all 48 clips were shown, so that participants had previously watched the associated movie clip for only half of the scenes, and furthermore, had only mentally rehearsed the content of a quarter of the movie clips associated with the scenes. Participants were required to indicate via the press of one of two keys whether they had previously watched the clip associated with the still image or not. SMT movies were assorted into two variables with two levels: a ‘description’ variable (not described clips and described clips) and a ‘species’ variable (animal and human clips). Recognition accuracy for rehearsed and non-rehearsed animal and human clips was then assessed by calculating the proportion of movie clips successfully remembered for each participant.

**2.3. Results**

**2.3.1. Descriptive Statistics and Preliminary Analyses**

Table 2.1 shows the descriptive statistics for all variables. Shapiro-Wilk tests showed data from all categories of the DAF task to be non-normally distributed with the exception of mind-minded descriptions, $p$ = .058; non-parametric bivariate correlations were therefore used in subsequent analyses involving these variables.

Table 2.1. Descriptive Statistics for All DAF Variables.

| | Mean | SD | Range |
|---|---|---|---|
| DAF mind-minded | .26 | .17 | .63 |
| DAF behavioural | .26 | .26 | .70 |
| DAF physical | .13 | .15 | .78 |
| DAF self-reference | .06 | .06 | .37 |
| DAF relationship | .18 | .18 | .71 |
| DAF general | .10 | .10 | .60 |

*Note: DAF = Describe a Friend. Scores for the DAF are proportions.*

Table 2.2 shows the results of correlation analyses for all DAF variables; alpha was adjusted to .003 (.05/15) for multiple comparisons. As shown in Table 2.2, there were negative correlations between behavioural and relationship response categories and self-reference and physical response categories. No significant relation was observed between mind-minded and physical DAF response categories, evidencing the suitability of the physical response category as a control comparison in subsequent analyses (see Table 2.2).

Table 2.2. Correlation Coefficients for All DAF Variables.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. DAF mind-minded | - | | | | |
| 2. DAF physical | -.22 | - | | | |
| 3. DAF relationship | -.36 | -.29 | - | | |
| 4. DAF behavioural | .01 | .09 | -.57* | - | |
| 5. DAF self-reference | -.22 | -.44* | .37 | -.30 | - |
| 6. DAF general | -.21 | -.10 | -.04 | -.25 | .08 |

* $p < .003$ (adjusted alpha level)

*Note: DAF = Describe a Friend task.*

Due to non-normal data distribution in the DAF mental and physical language variables, participants were accordingly also placed into 'high' and 'low' categories for mind-minded and physical descriptions scores based on a median split of the data. As a further sanity check to ensure that the decision to assort participant responses into groups of 'high' and 'low' use of mental language use did not lead to any misrepresentation of the data distribution, the DAF mental description category was again separated into four groups, displaying quartiles of response ranges, made-up of equal percentiles of responses in each group (labelled 'first quartile' to 'fourth quartile' from lowest-to-highest; see Figure 2.1). Further separation of the binarised mental language use group into quartiles revealed a relatively equal distribution of participants across the four groups, indicating that continuing with subsequent analyses utilising the binarised DAF groups would not simplify the dataset in a manner that missed out on more subtle relationships between the proportional distribution of mental state language use on the DAF.

Figure 2.1. Quartiles of DAF Task Mental Language Use.

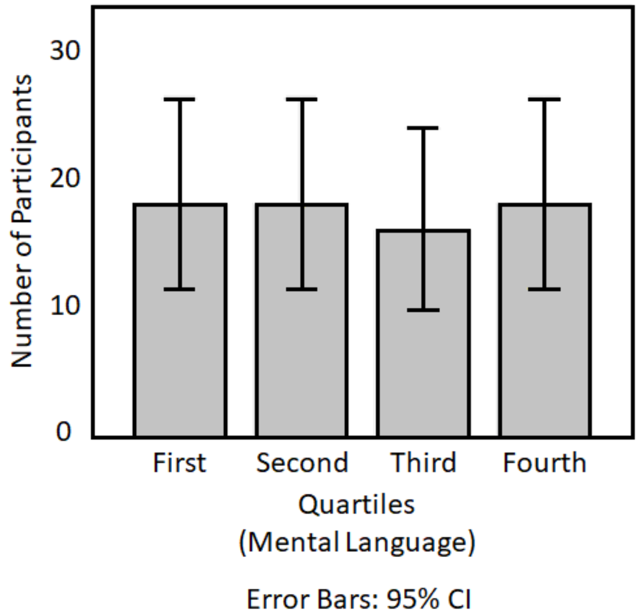


*Figure 2.1: Number of participants in each quartile of average mental language use during the DAF task. Number of participants is plotted on the y-axis. Quartiles of mental language use are plotted on the x-axis.*

Paired-samples t-tests were used to compare the mean RT for the congruent and incongruent levels of the six IAT conditions. For the following analyses related to the IAT, we controlled for the number of comparisons being made by adopting a $p$ value of < .008. Significant differences were observed between RTs in the Self/Best Friend condition, with participants taking longer to complete word associations during the incongruent category compared to the congruent category, $t(65) = 3.01$, $p =.004$, suggesting that participants found greater ease in performing congruent trials (matching mental and physical terms with their most obvious associates). The same pattern was true for the Self/Lady Gaga condition, $t(65) = 3.76$, $p < .001$, and the Self/Weather condition, $t(65) = 3.10$, $p = .003$. Similar differences were also seen for RTs between the congruent and incongruent trials for the Best Friend/Lady Gaga condition, $t(65) = 2.98$, $p = .004$, and the Best Friend/Weather condition, $t(69) = 3.91$, $p < .001$. No significant differences were found for the Lady Gaga/Weather condition, $t(56) = 0.24$, $p = .812$ (see Table 2.3 for descriptive statistics for all IAT variables and Figure 2.2 for all initial IAT results). These data confirm the hypothesis that participants show the strongest mental association with Self followed by the Best Friend (the person for whom they have most personal experience).

Table 2.3. Descriptive Statistics for All IAT Variables.

| | Mean (ms) | SD (ms) | Range (ms) |
|---|---|---|---|
| IAT self/best friend (congruent) | 1354.52 | 321.88 | 1660.00 |
| IAT self/best friend (incongruent) | 1460.48 | 377.91 | 1455.60 |
| IAT self/Lady Gaga (congruent) | 1204.99 | 264.82 | 1285.65 |
| IAT self/Lady Gaga (incongruent) | 1276.91 | 286.02 | 1344.75 |
| IAT self/weather (congruent) | 1119.33 | 246.18 | 1180.15 |
| IAT self/weather (incongruent) | 1216.44 | 367.41 | 1825.15 |
| IAT best friend/Lady Gaga (congruent) | 1101.53 | 279.66 | 1528.15 |
| IAT best friend/Lady Gaga (incongruent) | 1177.66 | 375.72 | 1640.60 |
| IAT best friend/weather (congruent) | 1027.83 | 275.16 | 1194.25 |
| IAT best friend/weather (incongruent) | 1104.23 | 313.12 | 1430.50 |
| IAT Lady Gaga/weather (congruent) | 1040.35 | 370.30 | 1631.05 |
| IAT Lady Gaga/weather (incongruent) | 1050.62 | 424.35 | 2582.45 |

Figure 2.2. IAT Response Times.

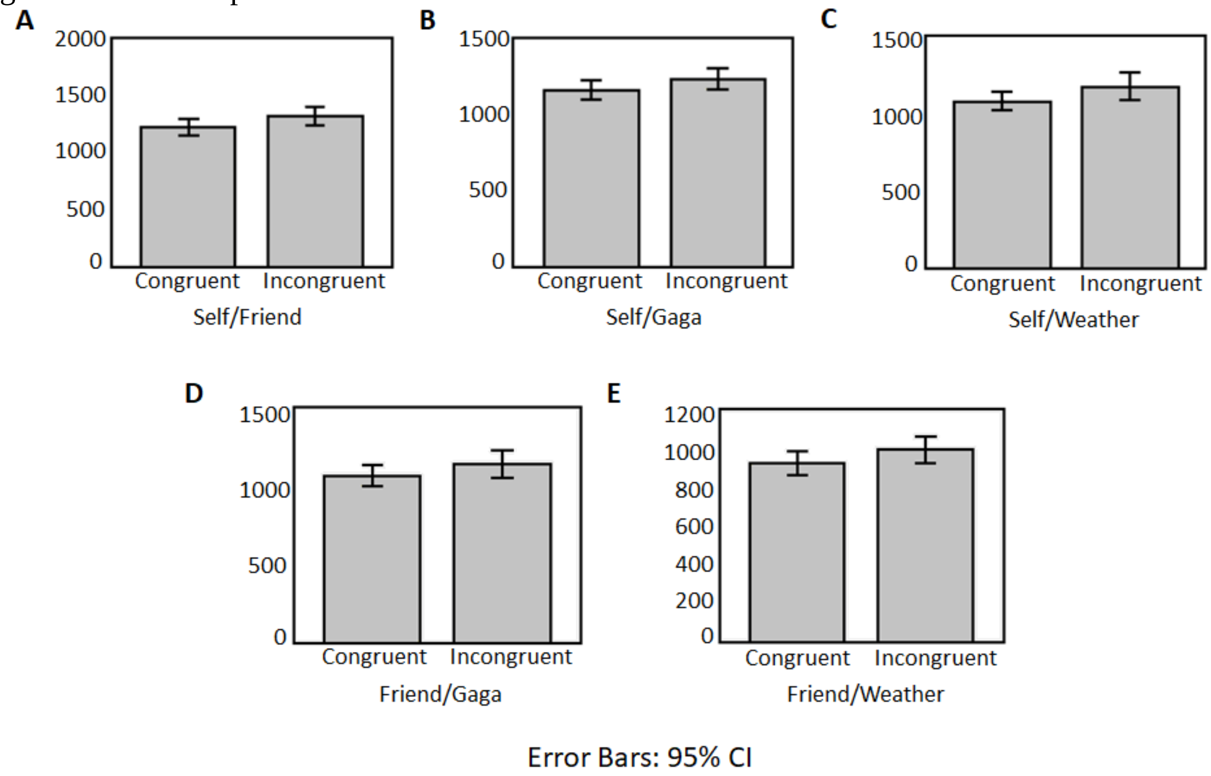


*Figure 2.2. A: Response time for Congruent and Incongruent presentations of the Self/Best Friend condition. Mean RT (milliseconds) is plotted on the y-axis. Congruent and Incongruent levels are plotted on the x-axis. B: Response time for Congruent and Incongruent presentations of the Self/Lady Gaga condition. Mean RT (milliseconds) is plotted on the y-axis. Congruent and Incongruent levels are plotted on the x-axis. C: Response time for Congruent and Incongruent presentations of the Self/Weather condition. Mean RT (milliseconds) is plotted on the y-axis. Congruent and Incongruent levels are plotted on the x-axis. D: Response time for Congruent and Incongruent presentations of the Best Friend/Lady Gaga condition. Mean RT (milliseconds) is plotted on the y-axis. Congruent and Incongruent levels are plotted on the x-axis. E: Response time for Congruent and Incongruent presentations of the Best Friend/Weather condition. Mean RT (milliseconds) is plotted on the y-axis. Congruent and Incongruent levels are plotted on the x-axis.*

With respect to the SMT, data for a single participant were removed for not following task instructions to a required level by failing to respond to a large number of clips. Rates of false-positives on the SMT recognition test were subtracted from correct responses to control for the effect of guessing, and overall proportional rates of correctly recognised clips were calculated. In order to understand the overall effect of mental rehearsal on recognition, a repeated measures ANOVA was performed with the species and description variables entered as two factors, with two levels each (Animal and Human and Not Described and Described respectively). Initial analyses revealed that mental rehearsal in the form of describing movie clips was found to significantly increase recognition for both human and animal videos, $F(1, 65) = 24.24$, $p < .001$, $\eta_p^2 = .272$ (see Table 2.4 for all SMT descriptive statistics and Figure 2.3 for initial SMT results), supporting the findings of Bird, Keidel, Ing, Horner, and Burgess (2015) regarding improved memory for complex event sequences. The split high and low usage-rate groups for both mental and physical language scores on the DAF task were then added as between participant factors for subsequent analyses.

Table 2.4. Descriptive Statistics for all SMT Variables.

| | Mean | SD | Range |
|---|---|---|---|
| SMT not described animal | .39 | .23 | .79 |
| SMT described animal | .43 | .19 | .98 |
| SMT not described human | .44 | .20 | .73 |
| SMT described human | .53 | .21 | .85 |

*Note: SMT scores are proportional.*

Figure 2.3. SMT Rehearsal Effect.

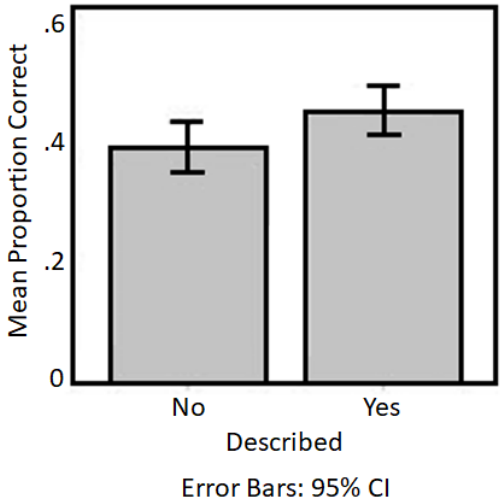


*Figure 2.3. Mean proportion of correct responses for clips with and without mental rehearsal. Mean accuracy (proportion correct) is plotted on the y-axis. The 'Not Described' and 'Described' conditions of the SMT are plotted left-to-right on the x-axis.*

### 2.3.2. Relations between Friend Descriptions and Implicit Association Test Performance

To control for multiple comparisons, a $p$ value of $< .002$ was adopted for the following correlations. As shown in Table 2.5, neither mental nor physical description scores exhibited a relationship with IAT variables, ($p$s $> .002$, ns), therefore to further attempt to understand whether IAT performance varied with differences in the DAF task, we conducted a separate repeated measures ANOVA in which the six IAT conditions were the dependent variables and congruency/incongruency was added as a fixed variable.

Table 2.5. Correlation Coefficients for Relations between IAT Variables and Mind-Minded and Physical Friend Descriptions.

| | DAF Mind-minded | DAF Physical |
|---|---|---|
| Self/best friend (congruent) | .21 | -.17 |
| Self/best friend (incongruent) | .29 | -.13 |
| Self/Lady Gaga (congruent) | .21 | -.12 |
| Self/Lady Gaga (incongruent) | .33 | -.01 |
| Self/weather (congruent) | .14 | -.10 |
| Self/weather (incongruent) | .19 | -.16 |
| Best friend/Lady Gaga (congruent) | .14 | -.11 |
| Best friend/Lady Gaga (incongruent) | .16 | -.09 |
| Best friend/weather (congruent) | .03 | -.06 |
| Best friend/weather (incongruent) | .11 | -.04 |
| Lady Gaga/weather (congruent) | .20 | .00 |
| Lady Gaga/weather (incongruent) | .21 | -.04 |

* $p < .002$ (adjusted alpha level)

*Note: DAF = Describe a Friend.*

For the following analysis, a $p$ value of < .008 was adopted to control for multiple comparisons across IAT variables. The high and low groups for both mind-minded and physical descriptions on the DAF task were added as between participant independent variables (see Table 2.6). At this stage the analysis yielded no significant relations between the six conditions of the IAT and levels of mind-minded or physical descriptions, regardless of a congruent or incongruent mode of presentation ($F$s < 3.49, $p$s > .05, ns).

Table 2.6. Descriptive Statistics for All IAT Scores (Milliseconds) by Split Mental Language Groups.

| | Low Mental *M (SD)* | High Mental *M (SD)* |
|---|---|---|
| IAT self/best friend (congruent) | 1316.77 (362.04) | 1396.32 (279.91) |
| IAT self/best friend (incongruent) | 1366.70 (385.65) | 1542.55 (378.53) |
| IAT self/Lady Gaga (congruent) | 1181.76 (299.11) | 1223.95 (230.05) |
| IAT self/Lady Gaga (incongruent) | 1215.83 (294.35) | 1328.55 (266.70) |
| IAT self/weather (congruent) | 1103.11 (256.13) | 1129.09 (239.52) |
| IAT self/weather (incongruent) | 1162.17 (315.33) | 1254.80 (406.82) |
| IAT best friend/Lady Gaga (congruent) | 1078.28 (303.93) | 1100.55 (217.92) |
| IAT best friend/Lady Gaga (incongruent) | 1125.38 (353.86) | 1201.47 (365.11) |
| IAT best friend/weather (congruent) | 1033.56 (272.95) | 1008.69 (275.04) |
| IAT best friend/weather (incongruent) | 1089.95 (300.05) | 1104.15 (324.32) |
| IAT Lady Gaga/weather (congruent) | 972.63 (310.13) | 1086.04 (404.91) |
| IAT Lady Gaga/weather (incongruent) | 1022.34 (457.50) | 1055.56 (378.65) |

### 2.3.3. Relations between Friend Descriptions and Silent Movies Task Performance

Initial bivariate correlations did not reveal significant relations between variables in the SMT and mind-minded or physical descriptions of friends (*p*s > .05, ns; see Table 2.7).

Table 2.7. Correlation Coefficients for Relations between SMT Variables and Mind-Minded and Physical Friend Descriptions.

| | DAF Mind-minded | DAF Physical |
|---|---|---|
| Not Described Animal | -.19 | -.05 |
| Described Animal | -.06 | -.15 |
| Not Described Human | .05 | .05 |
| Described Human | -.13 | -.01 |

* $p < .008$ (adjusted alpha level)

*Note: DAF = Describe a Friend.*

A repeated measures ANOVA was performed with two variables: ‘Species’ and ‘Description’. Each variable had two levels: Species denoted movie clips portraying either animal or human videos, Description denoted either movie clips that had not been previously rehearsed or movie clips that had been previously rehearsed. The high and low groups for both mind-minded and physical descriptions on the DAF task were added as between participant independent variables (see Table 2.8). Analysis revealed a significant main effect of Species on physical descriptions, $F(1, 65) = 4.11$, $p = .047$, $\eta_p^2 = .060$, with participants scoring higher for physical descriptions demonstrating increased recognition for human clips. A significant two-way interaction was also observed between high/low Species and Description on mind- minded descriptions, $F(1, 65) = 4.25$ $p = .043$, $\eta_p^2 = .061$. Individuals in the high group for mind-minded descriptions demonstrated increased recognition for human videos which had not been rehearsed compared to individuals in the low group for mind-mindedness. The difference score between human and animal movie clips was calculated by deducting mean proportional scores of correctly remembered animal videos from mean proportional scores of correctly remembered human videos, in order to assist with the further visualization of the main effect of physical language use on human and animal scores, and the interaction between mental language use, opportunity for rehearsal and human and animal scores (see Figure 2.4 for results of the comparisons between DAF task friend descriptions and SMT performance).

Table 2.8. Descriptive Statistics for All SMT Scores (Proportions) by Split Mental Language Groups.

| | Low Mental | High Mental |
|---|---|---|
| | M (SD) | M (SD) |
| SMT not described animal | .43 (.24) | .35 (.22) |
| SMT described animal | .44 (.19) | .42 (.19) |
| SMT not describe human | .45 (.18) | .45 (.22) |
| SMT described human | .57 (.19) | .51 (.22) |

Figure 2.4. SMT Mental and Physical Language Use.

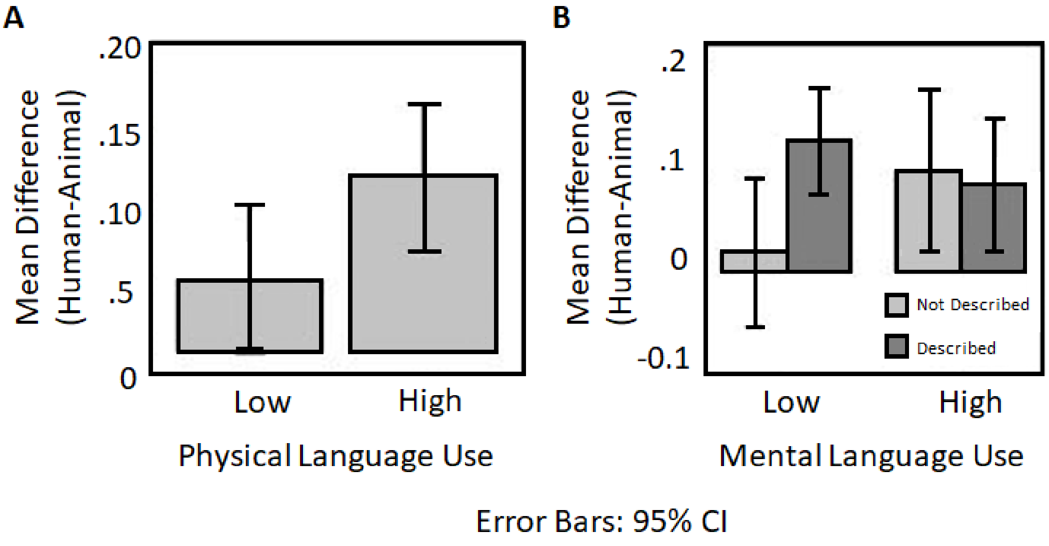


*Figure 2.4. A: Mean difference score between Human and Animal clips at both high and low levels of the physical language use group. Mean difference is plotted on the y-axis. Low and high levels of physical language use are plotted left-to-right on the x-axis. B: Mean difference score between Human and Animal clips for rehearsed and non- rehearsed clips at both low and high levels of the mind-minded description group. Mean difference is plotted on the y-axis. Low and high levels of mind-minded description are plotted left-to-right on the x-axis.*

## 2.4. Discussion

The results of the current study overall highlight a link between how we think about personally familiar people and how we retrieve and use social information from memory. No relationship was observed between mental language use and implicit attitudes assessed with the IAT. We found that people who described their friend in physical terms showed an overall bias for memory for human rather than animal videos. We also observed that people who described their friend in mental terms were more proficient at correctly remembering video clips portraying humans when no opportunity for rehearsal was given.

Initial correlation analysis of the DAF task sample revealed that people who referred to themselves more were less likely to talk about their friend's physical qualities. Some recent literature suggests that greater levels of self-referencing during encoding enhances recollection memory for physical objects (Durbin, Mitchell & Johnson, 2017). Therefore, it is possible that individuals more likely to describe their friends in self-referential terms would also be more likely to describe their physical qualities with reference to themselves, or their own attitudes as opposed to generally stating or listing physical traits. For example, during the coding process of the DAF task, a remark referring to a physical quality about a friend such as ‘He has blonde hair’ would be coded as an incidence of physical language use. A remark such as ‘His hair is lighter than mine’, however, would be coded as an incidence of self-reference. In this way, it is possible that individuals more prone to self-referencing in the DAF task would also be more likely to describe physical traits or characteristics in this way.

Correlation analysis for the DAF task also revealed a negative relationship between referring to the nature of the relationship between participants and their friends and referring to the behaviour of friends. Research conducted by Beike, Cole and Merrick (2017) investigating the effect of psychological closeness in relationships on memory suggests that as closeness increases in a relationship, we are more likely to remember events as shared ‘We’ memories; in which the shared nature of an event is emphasised in memory. Therefore, participants more likely to make statements about the nature and dynamic of their relationship with their best friend may be demonstrating this heightened sense of psychological closeness with heightened reference to such ‘We’ memories; being more likely to make relationship statements emphasising the shared ‘We play football’ as-opposed to the behavioural statement ‘She plays football’, for example.

In general, correlation analysis did not reveal any significant relationships between mental or physical language use on the DAF and IAT/SMT variables. These findings corroborate with subsequent analyses performed on IAT data, however they do not correspond with findings regarding the SMT. It could be the case that the relationship between levels of mind-mindedness and effective memory systems is a complex or otherwise non-linear one. Due to the fact that our DAF mental and physical language responses were not normally distributed, it is possible a threshold of mind-mindedness exists at which greater facilitation of the social memory skills utilised during the SMT occurs, better captured by subsequent ANOVA.

Our initial IAT analysis revealed that for five out of the six comparisons of congruent/incongruent trials, as hypothesised congruent trials yielded significantly quicker RTs compared to incongruent trials. Associating mental words to the self and physical traits to a best friend were significantly faster than the inverse. This effect could potentially be explained by the phenomenon known as 'Emotional Egocentricity Bias' (EEB; Riva, Triscoli, Lamm, Carnaghi & Silani, 2016), in which individuals are more likely to focus on their own mental states, and emotional and mental content related to the self. This effect occurs naturally throughout the lifespan, but is most often predominantly expressed in childhood (Begeer et al., 2016). Quicker congruent trials were also seen for comparisons between the self and a personally unknown other (Lady Gaga), the self and weather, and a personally known (best friend) and unknown (Lady Gaga) other. These findings therefore suggest that for five of the six comparisons, semantic associations during congruent trials were more readily facilitated. As hoped for, these initial findings also echo the relational gradient of mind-mindedness revealed by Meins et al. (2014), with spontaneous mental state language use occurring with most frequency in close relationships, such as with a best friend or known other, compared to an unknown other. These finding also corresponds with Meins' et al. (2014) observation that mental state language use occurs in greater frequency when referencing a living being (a personally unknown other) compared to a non-living object (a work of art). In all, initial IAT findings draw an interesting parallel with the relational aspects of mind-mindedness and how our social cognition facilitates thinking about the mental states of people we interact closely with.

Findings from the SMT indicated that narrative rehearsal significantly increased the rate of correct responses during the recognition task, supporting the findings of Bird, Keidel, Ing, Horner, and Burgess (2015) that given time to recall events helps consolidate the memory of that event as a narrative. One potential limitation of the SMT design opens an interesting avenue for future research in that participants were given an allotted time to recall and note down details of a subset of the clips they had seen. Coding techniques employed in the DAF task could be applied to these data in future studies to examine whether a relationship exists between participants' later performance in the recognition task and the manner in which they constructed narratives about the video clips observed during rehearsal.

One aim of the present study was, during analyses comparing IAT results and mental language use on the DAF, whether in a manner according with the findings of Mitchell, Banaji and Macrae (2005), mind-mindedness depended on social cognitive processes distinct from general attitudinal components and whether these processes influenced semantic associations along a hypothesised gradient of relational closeness. We observed no relationship between the proportional use of mental language on the DAF task and any of the IAT categories. The tendency to spontaneously fixate to a greater or lesser extent on mental features had no significant effect on the way in which mental features are automatically semantically associated with other people of varying degrees of closeness. This suggests that mind-mindedness does not possesses an attitudinal component, as mind- mindedness appears to arise from memories of specific interactions rather than being a symptom of a general conceptual association bias in favour of mental descriptions of others.

It is possible that the failure to reveal any significant relationship between mental language use and RTs in the IAT may be a reflection of task design. Initial paired-samples t-tests did not reveal, as hypothesised, that every comparison pair was successfully and significantly assorted into a 'congruent' and 'incongruent' condition; with no distinction with regard to RTs when associating words with an unknown other (Lady Gaga) or the weather. Bearing this in mind, it is very possible that when including DAF variables for subsequent analyses, the nature of the experimental design for the IAT was too simplistic to capture more complex and subtle effects involved in social cognition, and it may be the case that more effective designs capturing a gradient of relational closeness are needed to further investigate the attitudinal components of mind-mindedness. Taken together however, these findings highlight the importance of shared interactions with others, and the memory of these interactions in giving rise to mind-mindedness, supporting previous observations indicating that mind-mindedness is a quality of close relationships (Meins et al., 2014).

Also of interest is that when comparing DAF and SMT results, we observed that individuals more likely to use physical language during their DAF descriptions also showed an overall advantage for recognising video clips portraying humans. Previous studies have shown that a strong mental imagery results in a more effective visual working memory (Keogh & Pearson, 2011), therefore it is possible that individuals who focus on physical features and characteristics are more effective at recalling various visual cues portrayed in the human clips, such as distinct faces, outfits, props, and tools.

Finally, we found that as hypothesised, more mind-minded individuals, whose descriptions of their friends focused on their mental and emotional characteristics, showed a subtle bias towards the retrieval of social information from memory, resulting in better recognition for human clips. However, contrary to expectations, this effect was only observed in the absence of an opportunity for mental rehearsal. Whereas low mind-minded individuals remembered social videos better if they subsequently described them, individuals high on mind-mindedness tended to remember social videos well regardless of whether they had described them. Individuals low on mind-mindedness showed a pattern of retrieval from memory that suggests that, although they can gain a memorial benefit from the narrative structure of social interactions, they are less proficient at encoding this information ‘in the moment’, without the opportunity for rehearsal.

These findings also lends some support to the idea that perhaps individuals scoring higher for mind-mindedness have experienced some process of implicit social learning whereby they a drawn towards interpreting relevant social phenomena and cues in terms of mental states. The process by which participants demonstrating greater use of mental state language on the DAF task may be determined by a form of social learning that causes spontaneous or automatic processing of social information that participants are not aware of (Greenwald & Banaji, 1995). The finding that higher levels of mind-mindedness was associated with proficiency at encoding social cues in social interactions when denied the opportunity for mental rehearsal is perhaps telling, as it demonstrates an unconscious bias towards focus on socially-relevant information when forming narratives about events.

Without any explicit instruction of what information in the viewed clips to attend to, and with no prior knowledge of an upcoming test of recognition for the video clips, more mind-minded participants demonstrated a spontaneous bias towards the encoding of social information as they viewed the clips, which was subsequently more readily available for retrieval when participants were asked to perform an explicit measure of memory for the video clips. This interpretation would accord with the view of Amodio and Ratner (2011), who suggested that implicitly-learned associations with certain social signals can influence the memories we form about events. This type of implicit learning may in part explain why mind-minded individuals demonstrate an unconscious bias towards focus on mental states when trying to interpret the behaviour of other people.

One alternate possibility is that mind-minded individuals were also for some reason better at recognising the objects portrayed in the human video clips. However, when we consider mind-mindedness is a tendency towards focus on mental states (Meins, 1997). the finding that heightened mental state language use was related to better proficiency in memory for clips portraying human interactions, along with the relative ‘richness’ of relatable social interactions contained in the human video clips compared to the animal clips, suggests that mind-minded individuals possess a heightened tendency to encode social information when observing interactions. Altogether, we find that greater levels of mind-mindedness appear to be related to an increased proficiency for memory of social information. It is possible that this is because mind-mindedness assists in directing the schemata we utilise to describe and interpret social interactions (Kuethe, 1962) and this process was spontaneously enacted when mind-minded individuals watched films containing people.

**2.5. Conclusions**

Taken together, the results of our study provide evidence that mind-mindedness is linked to the way we represent other people in episodic memory. One intriguing implication of our findings is the potential role that social narratives play in explaining the increased attention to the mental lives of others that is characteristic of mind-mindedness. In our study, asking participants to describe a film clip led to a strong increase in memory for the clips, a manipulation that is thought to help structure information in memory as a narrative structure that endures for several weeks (Bird et al., 2015). Participants who were more mind-minded on the DAF task however, demonstrated increased proficiency for recognising clips rich in social cues without the opportunity for rehearsal. In this context, it is therefore possible that mind-minded individuals show enhanced social memory because they are more likely to represent social interactions in terms of a coherent narrative. Participants who exhibited greater mind-mindedness on the DAF task were also more likely to encode social information when viewing social interactions portrayed in video clips. It is possible to speculate that such implicit behaviours are acquired from previous social interactions and experiences in the manner suggested by Amodio and Ratner (2011), subsequently interacting with memory processes and influencing the manner in which we construct narratives about social interactions in memory. Neuroimaging studies have shown that the creation of narratives aids memory by activation within the DMN (Bird et al., 2015), a large- scale network that is also important for social cognition (Schilbach et al., 2008; Spreng, Mar, & Kim, 2009), providing evidence that social cognitive and memory processes may share the same neural substrate. Future work should focus on further examination of the link between mind-mindedness and memory. Namely, various forms of memory process should be compared against variance in levels of mind-mindedness in order to determine whether the construct shows a relationship with overall memory capacity or is specifically linked to a specific form of memory, i.e. episodic memory (Tulving, 1972), given the revealed link between mind-mindedness as recall for social events. Establishing such a link would serve as an important step in confirming memory as a component-process of mind-mindedness.

# Chapter 3

## Study 2: Mind-Mindedness, Memory and Psychological Wellbeing

### 3.1. Introduction

The capacity to make sense of other people's behaviour is an essential aspect of human cognition that depends on a complex set of underlying component processes and has broad implications for wellbeing. When we interact in a meaningful way with other people, we rely on information from memory when attempting to form an understanding of others' behaviour in the present moment (Higgins, 2000). Numerous sources of behavioural evidence support the notion that memory exerts a substantial influence on social cognition. For example, early research into the effects of stereotypes and heuristic processing undertaken by Macrae and Shepherd (1989) had participants listen to a number of incidents of criminal transgression, and demonstrated that providing stereotypically-consistent information about the purported criminal significantly influenced participants' tendency to judge that the suspect was involved in the crime. Providing this information also influenced recall of the incident details, with greater levels of recall for detail given about the crime committed. Further work undertaken by Macrae, Hewstone, and Griffiths (1993) found that during incidences of high task demand/high cognitive load, recall for stereotypically-consistent information is enhanced. Such findings demonstrate the way in which 'fast-acting' heuristic judgements based on social preconception may affect more long-term memory processes.

More recent work undertaken by Ciaramelli, Bernardi and Moscovitch (2013) found that memory of an individual's past experiences modulates their subsequent empathic responses. By providing participants with background information on the lives of two fictional characters, one having experienced a series of love/relationship-related failures and the other having experienced work-related failures, and requiring participants to appraise the present actions of these characters, participants were found to empathise more with the individual who had experienced a troubled love-life, demonstrating an inverse tendency for memory to influence social judgements. Schacter (1996) has highlighted that memories are constructed from fragments of information distributed across different brain regions, depending on influences operating in the present as well as the past. Accordingly, an influence on one of the many disparate brain regions involved in memory encoding and retrieval may cause lasting long- term outcomes for memory processing. Davidson, Drouin, Kwan, Moscovitch and Rosenbaum (2012), for example, have reported that amnesic patients are less likely to maintain close social relationships, giving further evidence in support of the close relationship between memory function and wider social-cognitive processes.

Neuroscientific evidence also demonstrates a large amount of shared neural circuitry between memory processes and social cognition. Mars et al. (2012) demonstrated a large degree of functional overlap between the Default Mode Network (DMN) and regions known to play an important role in socio-cognitive processing, including the posterior cingulate cortex (pCC), the medial prefrontal cortex (mPFC), and the left and right angular gyri (ANG). Consistent with a relation between memory and social processing, regions in the DMN, including the pCC, are associated with the consolidation of event narratives in memory. Bird et al. (2015) demonstrated that the pCC is recruited during the rehearsal of narratives for complex event sequences, such as social interactions. Recent evidence also suggests that there exist distinct patterns of neural recruitment depending on whether we are processing information related to ourselves or other people. For example, de Caso, Poerio, Jefferies, and Smallwood (2017) had participants undergo a self-reference task where a list of adjectives associated with either the self, a known other, or a nonsense syllable control condition was memorised and later recalled after delay. An increase in observed levels of functional connectivity between the frontoparietal network (FPN) and the hippocampus in the resting brain was associated with successful recall for self-relevant adjectives but not to ‘other’ or ‘syllable’ adjectives.

These findings indicate that distinct neural pathways may support memory processes that are important for social-cognition. These lines of evidence from the fields of psychology and neuroscience together suggest that social cognition depends in part on memories based on information learned about others through prior social interactions, allowing the intentions and motivations of other people to be better understood. Much of this episodic knowledge is automatically retrieved, not requiring conscious effort or deliberation (Jacoby, 1991), and effective functioning of this retrieval system is essential for making the fast, on-the-spot calculations necessary for interpreting the social behaviour of others.

Social cognitive processing also has important links to overall wellbeing. Deficits in social cognitive and memory function are a feature of many psychiatric disorders such as social anxiety disorder (Eysenck, Derakshan, Santos, & Calvo, 2007), autism spectrum disorders (Senju, 2013), and depression (Reynolds & Brewin, 1999; Riskind, Castellon, & Beck, 1989). Frith (1994) provided key evidence linking autism spectrum disorders (ASD) with an inability to represent the internal mental states of others, noting that ASD individuals demonstrate significant impairment during false-belief tasks (a task requiring the ability to view a situation from the perspective of another individual), with difficulty on false-belief tasks being associated with a more general difficulty in interpreting the thoughts and intentions of other people in day-to- day life. More recently, Senju (2013) noted that while individuals with ASD typically demonstrate impairment in the development of social interaction and communication, some ‘high-functioning’ ASD individuals showed a relatively unimpaired ability to process social information in a controlled experimental setting. In contrast, these high-functioning ASD individuals demonstrated consistent impairment in social interaction in daily life and accordingly struggled with spontaneous or non-explicit aspects of social cognition.

Deficits in social cognition are also observed in other psychiatric disorders. For example, anxiety disorders have been associated with poorer attentional control (Eysenck et al., 2007), which has functional consequences for social competency and episodic memory encoding (Kim & Mundy, 2012). Similarly, Attention Deficit Hyperactivity Disorder (ADHD) is linked to deficits in social skills that arise due to an inability to attend to appropriate social cues (Kofler, Rapport, Bolden, Sarver, Raiker, & Alderson, 2011). In addition, various aspects of wellbeing and depressive symptoms are also negatively related to social cognition, and may explain associated problems in interpreting the emotional and mental states of others (Weightman, Air, & Baune, 2014). Berman et al. (2011) have shown a tendency towards rumination, or cyclic, repetitive thinking when confronted with a negative social experience or stressor. Kashdan and Roberts (2007) found rumination to be associated with heightened levels of social anxiety, concluding that while rumination may begin as a short-term coping strategy by replaying events from a previous interaction, it may exacerbate maladaptive thought-patterns in socially anxious individuals, further impairing the overall ability and willingness to interact socially with others. Although rumination is often associated with negative thought-content, it is fundamentally characterised by a heightened level of focus on the perceived causes of one's affective state (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination appears to serve as a strategy for emotion regulation (Gruber, Eidelman, Johnson, Smith, & Harvey, 2011), however rumination may also enhance or amplify negative emotional states through causing the surrounding events to be indefinitely mentally replayed. In the context of social cognition, maladaptive ruminative tendencies can therefore lead to increased emphasis placed on negative aspects of our memories of social experiences and interactions.

Depressive symptoms also have adverse links with social cognition, linked to problems interpreting the emotional and mental states of others (Weightman et al., 2014). Berman et al. (2011) have also linked depression to a tendency towards rumination, or cyclic, repetitive thinking on negative or worrisome subjects. Rumination has been found to be associated with heightened levels of social anxiety (Kashdan & Roberts, 2007), which may lead towards impairment in the overall ability and willingness to interact socially with others without an effective coping strategy. Depression and its related patterns of thinking, therefore, may exert a significant negative influence on the social-developmental trajectory of an individual through causing negative association with social interaction and fixating on aspects of social interactions that may prevent us from making accurate judgements about the mental states of others.

Various social and environmental indicators also effect individual assessments about their overall quality of life and are predictive of a variety of social-developmental and wellbeing outcomes. Lim, Gleeson, Jackson and Fernandez (2014) observed that an individuals who reported overall higher levels of quality of life, and maintained a greater number of close social relationships possess an enhanced buffer against psychological distress. Various socio-economic and ecological factors also influence an individuals' overall quality of life, including income, social practices, crime and living environment (Hajduová, Andrejovský & Beslerová, 2014), leading to a variety of physical (Truthmann et al., 2017) and psychological (Postrado & Lehman ,1995) health outcomes. The presence of psychological and physical health issues in-turn may also influence the number of positive social interactions we partake in, and thus possess an overall influence on quality of life (Yanos, Rosenfield & Horwitz, 2001; Lyons, Sullivan Ritvo & Coyne, 1995).

Many measures of clinical and wellbeing outcomes also serve as indicators of memory deficits. Cognitive processes influencing the shifting and maintenance of attention, for example, may often lead to difficulty encoding information to memory. Individuals with ADHD represent a group with a severe deficit in working memory, attributed to impairment in frontal lobe functioning resulting in difficulty with sustained periods of attentiveness (Klingberg, Forssberg & Westerberg, 2002). Bolden, Rapport, Raiker, Sarver and Kofler (2012) have also observed deficits in short-term memory rehearsal for ADHD individuals. Deficits in attention and memory are of course not restricted to individuals with ADHD and may also result from more general maladaptive cognitive processes. Bigelsen, Lehrfeld, Jopp and Somer (2016) suggested that daydreaming, a common feature of everyday cognition, can occasionally possess maladaptive properties resulting in attention deficit. Various physical and psychological conditions therefore may have a bearing on attentional processes and subsequently possess predictive outcomes for memory function. Higher levels of mindful attention have also been demonstrated to correlate with enhanced performance on tasks of working memory (Morrison & Jha, 2015), further revealing the importance of attention in allowing us to retain information in memory.

Various other psychological health issues such as depression and anxiety have also been associated with negative consequences for memory. Brand, Jolles and Gispen-de Wied (1992) observed that depressed individuals displayed deficits in both recall and recognition memory when compared to controls. Reidy (2004) also identified a link between higher self-reporting scores for trait depression and trait anxiety (traits exhibiting a high degree of comorbidity, Wu & Fang, 2014) and deficits in memory recall ability. More recent work by Yao, Chen and Qian (2018) also associates greater levels of trait anxiety with deficits in visual working memory. Many such psychological health issues can also interact with chronic physical conditions, such as stress, which may also further contribute towards deficits in working memory (Morgan, Doran, Steffian, Hazlett & Southwick, 2006).

The present study is a large-scale individual difference study aimed at exploring the correlates of a specific aspect of social cognition: mind-mindedness (Meins, 1997). Mind-mindedness is a construct characterized by a tendency spontaneously to invoke internal states during social interactions or when recalling details of another person (Meins, Fernyhough, Fradley & Tuckey, 2001; Meins, Fernyhough, Russel & Clark-Carter, 1998). Accordingly, it exemplifies an aspect of social cognition that encapsulates a dependence on memory processes and spontaneous thought. Wide variations in individuals' tendency to describe significant others in mind-minded ways have been reported across a range of relationships: mothers' descriptions of their children (e.g., Meins et al., 1998), adoptive parents' and foster carers' descriptions of their adopted and foster children (Fishburn et al., 2017), adults' descriptions of close friends and romantic partners (Meins, Harris-Waller & Lloyd, 2008; Meins, Fernyhough, & Harris-Waller, 2014), children's descriptions of best friends (Davis, Meins, & Fernyhough, 2014; Meins et al., 2006). Mind-mindedness is thought to be a quality of close relationships rather than a trait (Meins et al., 2014), since it is most prevalent when describing personally familiar individuals, and mind-minded descriptions of significant others are unrelated to mind-minded descriptions of famous figures or works of art (Hill & McMahon, 2016; Meins et al., 2014).

Attempts to establish why some individuals are more mind-minded than others have largely drawn null findings. Studies focusing on caregivers' descriptions of their children have shown that there are no clear associations between mind-mindedness and caregiver SES, educational level, or occupational status (Fishburn et al., 2017; Lundy, 2013; Meins et al., 1998). Mind-mindedness has also been shown to be unrelated to depression in parents (Walker, Wheatcroft, & Camic, 2011) despite the debilitating effects of depression on multiple related components of social cognition, although mind-mindedness is lower in mothers hospitalised for severe mental illness compared with psychologically healthy controls (Schacht et al., 2017). Research has also shown that mind-mindedness is unrelated to ToM abilities both in childhood (Meins, Fernyhough, Johnson & Lidstone, 2006) and adulthood (Barreto, et al., 2016; Devine & Hughes, 2017). This suggests that ToM abilities are necessary but not sufficient for mind-mindedness, and that a distinction can be made between having the capacity to understand others' internal states and the tendency spontaneously to utilise this capacity when representing a person or their behaviour (Apperly, 2012; Meins et al., 2006).

Study 2 aims to assess the extent to which mind-mindedness relates to various components of social cognition—memory, attention, and spontaneous thought—and clinical measures that have been shown to influence these cognitive components of social cognition. To this end, the present study assessed mind-mindedness by requiring participants to provide open-ended descriptions of a close friend (Meins et al., 2008, 2014). We then examined whether variation in this score was related to individual differences in measures of memory. We also examined the relation of mind-mindedness to various measures of wellbeing and personality traits that have developmental outcomes for aspects of social cognition and memory, and therefore may be hypothesised to relate to mind-mindedness through effecting one or more of its component processes.

We compared performance on measures of memory in the form of a paired associates task (Karantzoulis, Scorpio, Borod, & Bender, 2011) as a means to assess whether measures of overall memory capacity in a context not explicitly socially-related may link with mind- mindedness. If the research carried-out by Meins et al. (2014) suggests that mind-mindedness is a relational construct, dependent on the closeness of a relationship we have with another person, then there is no reason to expect it would be related to a general memory capacity (i.e. declarative memory for objects or categorized information). Furthermore, if the earlier work of Meins (1997) also suggests that mind-mindedness is a tendency to spontaneously mentalise, or recruit and utilise ToM, in representing or interacting with others through spontaneously attending to mental states, then we have reason to suspect that it involves some process where the closeness of a relationship increases the frequency at which one spontaneously attends to mental state cues in social interactions and again, would show no relationship with general memory capacity, such as that captured by the paired associates task.

In contrast to this, we also examined the association of mind-mindedness with measures of incidental memory that arise through the process of ‘self’ and ‘other’ referencing during recognition using a self-reference task (de Caso et al., 2017). The self-reference task employed allows for the comparison of variation in levels of mind-mindedness along a relational gradient in a manner similar to that employed by Meins et al. (2014). The three conditions of comparison along this gradient consist of associations with the self, associations with a personally unknown other (Lady Gaga) and a control comparison requiring the counting of syllables. Together, these three conditions allow for assessment of recognition memory for words encoded with reference to the self, and more general declarative memory for judgements about a personally unknown famous figure and semantic memory pertaining to making judgements about the number of syllables in a word.

Memory appears to function as a component process of mind-mindedness. The nature of mind-mindedness arising from close relationships involving personal interactions (Meins et al. 2014) appears to underline the necessary prerequisite of having a well of episodic memories of shared experiences with another individual to draw-upon in order to predict assign and infer mental states. The previous findings of study 1 also revealed a link between greater levels of mind-mindedness and increased proficiency for encoding observed social interactions into memory. However, further testing is needed in order to help fully determine whether mind-mindedness is specifically dependent upon episodic memories of shared interactions with close others.

Previous work by Mitchell, Banaji and Macrae (2005) has revealed distinct neural activations, implicated in social cognitive measures and mentalisation, when judging psychological states about others or when making judgements about general social categories of people (Contreras, Benaji and Mitchell, 2012). Moran, Jolly and Mitchell (2014) also noted that when describing the behaviour of other people in general, a tendency to overemphasize underlying dispositions and personality traits often exists, known as the fundamental attribution error. Accordingly, due to the pervasive influence of social-cognitive factors on human relationships regardless of closeness, it becomes necessary to distinguish whether mind-mindedness might arise specifically from episodic memories of close and/or ongoing personal interactions with others, or general attributions of mental states to others, arising for example through access to a greater depth and variety of declarative memory and general knowledge about another person, including information that might pertain to their mental states (such as beliefs, preferences, etc.) and does not necessitate knowing them personally.

Declarative memory is a term denoting the ability to bring to mind factual and episodic information (Paller, 2009). As such, it involves the encoding and retrieval of personal information and memories (episodic memory) and general knowledge (Cristofori & Levin, 2015), including semantic memory (Baddeley, 1995). The self-reference effect refers to the increased facilitation of information encoding into memory when it in some way pertains to the self (Bentley, Greenaway & Haslam, 2017). Accordingly, we should observe bias towards encoding of self-related words as-opposed to the encoding of the Lady Gaga and syllables condition in a standard SRT. Importantly, of the three association conditions, none of them assessed memory for word associations with individuals personally known to participants; possessing episodic memories of previous interactions together.

Previous literature has shown mind-mindedness to be a relational construct, with greater levels of mind-mindedness being associated with closer relationships (Meins et al., 2014), suggesting that it is in some way dependent on the frequency of personal interactions we have with others, and the memories we encode from them. The results of Study 1 also lend support to this finding by revealing a relationship between mind-mindedness and the facilitation of episodic memory encoding for social information. Mind-mindedness therefore appears to necessitate the drawing-upon of prior experiences and interactions had with another individual, in order to formulate and then utilise a mental model with which we understand and predict social events within ongoing relationships. As such, mind-mindedness should rely upon episodic memory as a fundamental subcomponent in order that previous interactions may be recalled and applied to a given, ongoing interaction.

Studies investigating processes of implicit social learning have also demonstrated that our interpretations of social interactions may be in part formed by associations made outside of conscious awareness (Greenwald & Banaji, 1995). Mitchell, Macrae and Banaji (2004) have argued that social interactions are inherently complex and accordingly require the integration of information from memory systems in order to attempt to understand the behaviour of others. Amodio and Ratner (2011) have suggested that implicit learning processes and memory systems interact in order to allow an efficient method of interpreting social contexts by forming automatic associations with certain social signals and previous similar experiences stored in episodic memory. The previous finding of Study 1, that participants demonstrating greater levels of mind-mindedness possessed an automatic bias towards the encoding of social information, suggests a degree of implicit behaviour resulting in a focus on socially-relevant information and mental states.

Processes of implicit social learning have in fact been shown to facilitate an implicit focus on social cues and mental state information. Hudson, Nijboer and Jellema (2012) have previously demonstrated that the intentions and dispositions of other people can be learned implicitly from the reception of social cues in a manner that may help account for the implicit focus on mental states exemplified by mind-mindedness. Hudson et al. (2012) have also provided evidence that pro-social dispositions or social cues facilitate processes of implicit social learning. Accordingly, individuals may be more likely to attribute mental states to one-another when they are engaged in close, emotionally positive relationships. These findings have interesting implications if we consider that heightened focus on mental states might be prevalent in closer relationships due to the repeated implicit social learning processes experienced from social cues we receive when interacting with other people.

Heerey and Velani (2010) have also demonstrated that the level of personal liking we have for another individual is predictive of our ability to understand another person's behavior using nonverbal social cues. Heerey and Velani (2010) had participants play a computerized game of rock-paper-scissors against an avatar they believed was another participant. On some occasions, the avatar generated a predictive facial cue before making a play. Participants demonstrated a significantly greater win frequency for trials in which they received a social cue, even if they did not acquire explicit knowledge of the predictive nature of the cue. The degree to which participants could successfully predict the behaviour of the avatar related to their self-reported level of liking for the avatar. These findings accord with those uncovered by Meins et al. (2014) in suggesting that spontaneous focus on mental states and social cues arises as a quality of close relationships. Considered together, it becomes reasonable to suggest that mind-mindedness may be exemplified in close relationships due to levels of personal familiarity and the number of shared experiences we have with another person, at once providing opportunity for the facilitation of implicit learning processes encouraging focus on mental states and providing a wealth of episodic memories of an individual to draw upon when interpreting their behaviour.

Naturally then, it is possible to reasonably assume that contrary to the findings of Study 1, with mind-mindedness showing a relationship with the encoding of episodic social memories, in the current study, mind-mindedness would not possess any significant relationship with associations performed about 'Lady Gaga' in the self-reference task due to the lack of closeness in the 'relationship' between participants and Lady Gaga, and the absence of episodic memories of social interactions to draw upon to make judgements about a situation. Likewise, we would not expect any significant relationship between levels of mind-mindedness and associations involving the self or syllables; mind-mindedness being a measure of social cognition. The SRT therefore will allow for the assessment of whether according to the findings of Meins et al. (2014) and of Study 1, mind-mindedness is associated with relational closeness and dependent of access to episodic memories of previous social interactions, as-opposed to a general declarative and semantic memory capacity.

We also examined the links between mind-mindedness with different elements of wellbeing. Although previous research has found no explicit link between mind-mindedness and depression, previous researchers have suggested that deficits in mental-language use may arise from symptoms exhibiting comorbidity with depression, such as stress (Walker et al., 2011). Deficits in mental state talk have been observed in various clinical groups treated for mental illnesses (Schacht et al., 2017). However, little research so far has been performed on the relation of mental health and wellbeing to mind-mindedness in non-parent samples.

We compared mind-mindedness against a variety of clinical measures that could be hypothesised to possess a relationship with mind-mindedness or one of its lower-order components. We included a measure of depression administered through the Center for Epidemiologic Studies Depression Scale (CESD, Radloff, 1977). Although depression has various implications for social cognition and memory processes, previous research has shown no link between depression and frequency of mental state language use (Walker et al., 2011). Accordingly, no direct relationship between mind-mindedness and depression is hypothesised, although depression may still significantly correlate with other included variables, for example being associated with higher levels of anxiety and rumination, and thus indirectly influence other factors contributing towards mind-mindedness and social cognition in general.

We also included clinical measures of trait anxiety from the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) and ADHD from the Adult ADHD Self-Report Scale (Kessler et al., 2005) Due to them both influencing attentional processes and serving as negative predictors of working memory function (Yao, Chen and Qian, 2018; Klingberg, Forssberg & Westerberg, 2002) it is predicted that both trait anxiety and ADHD will be significantly negatively correlated with levels of mind-mindedness, as they impair the function of an essential cognitive component of mind-mindedness. For the same reasons, we also include measures of mindful attention gathered from the Mindful Attention Awareness Scale (Brown & Ryan, 2003), hypothesising that if attending to and encoding cues is a fundamental aspect of mind-mindedness, as scores for levels of mindful attention increase so will scores for mind-mindedness.

Further, we include questionnaire measures of autism from the ASQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) in order to assess whether the social-cognitive ramifications of ASD symptoms exhibit a relationship with mind-mindedness in individuals. Due to deficiencies in the ability to mentalise associated with ASD (Senju, 2013), it is predicted that levels of mind-mindedness will fall as total score on the ASQ rises. Among these clinical measures, we also finally include measures of rumination from the Rumination Response Scale (Nolen-Hoeksema & Jackson, 2001) and daydreaming from the Imaginal Processes Inventory (Singer & Antrobus, 1965) in order to investigate the link between mind-mindedness, spontaneous thought, and social cognition.

Ruby et al. (2013) have reported that social-cognition and memories about past interactions make up a significant portion of the content of spontaneous thinking, and emotional processing experiences also appear to be a common feature of mind- wandering (Marchetti, Koster, Klinger, & Alloy, 2016) and rumination (Gruber, Eidelman, Johnson, Smith, & Harvey, 2011). Furthermore, alexithymia, or an inability to accurately identify and articulate one's own experienced emotions, has been shown to be related to attachment security, a strong correlate of mind-mindedness (Meins et al., 2008). Accordingly, the extent to which mind-mindedness is related to the mind-wandering experience in various forms related to social-cognitive processing such as rumination and daydreaming is also investigated, with the prediction that scores for daydreaming and rumination will increase for participants scoring higher for mind-mindedness.

Five measures of wellbeing were also included from the World Health Organisation

Quality of Life Instruments (WHOQOL, World Health Organisation, 1997). Among these included measures were quality of life, environmental wellbeing, social relationships, physical and psychological health. All of these variables have been shown to influence the nature and number of our social relationships (Hajduová, Andrejovský & Beslerová, 2014; Lim, Gleeson, Jackson & Fernandez, 2014; Yanos, Rosenfield & Horwitz, 2001) and overall perception of quality of life, which serves as a predictor of healthy social development. As each of these measures of wellbeing is associated in some way with positive outcomes for social development, it is predicted that higher scores for mind-mindedness will coincide with increased scores in each of the five measures of wellbeing assessed by the WHOQOL. Accordingly, this section of analysis aims to determine the extent to which mind-mindedness may be associated with various measures of psychosocial health and wellbeing that have outcome effects on social development in non-parent groups.

## 3.2. Method

### 3.2.1. Participants

Participants were 157 individuals aged between 18 and 35 years (M = 20.28, SD = 2.67). All participants were native English speakers. Participants were undergraduate students who were recruited via the Department's online participant pool. Participants were paid £80 or an equivalent worth of course credit for completing a battery of behavioural tasks (across a total of four sessions). The study was approved by the relevant University Ethics Committees and conducted according to the principles expressed in the Declaration of Helsinki. All participants provided written informed consent.

### 3.2.2. Materials and Methods

Participants completed all sections of the study across four sessions, held on separate days over the course of one week. Participants completed a variety of behavioural tasks, each measuring variance in some form of higher-order cognitive function, with each session lasting around 2 hours. The order of behavioural tasks in each battery remained constant, but the administration of the three task batteries was counterbalanced across sessions. All behavioural measures were programmed and presented to participants using PsychoPy (Peirce, 2007, 2009). The study reported here specifically focuses on mind-mindedness data from the describe-a-friend task (Meins et al., 2014; Meins et al., 2008) and the questionnaire-based and behavioural data listed below.

**3.2.2.1. Describe a Friend Task (DAF)**.

Mind-Mindedness was assessed using the Describe a Friend (DAF) task (Meins et al., 2014; Meins et al., 2008), administered via a computer. Participants were presented with a blank screen with the instruction to think of a specific close friend and type a description of the friend in the text box. The on-screen instructions informed participants that they could (a) include any information about their friend they thought was relevant, (b) make their response as long or as short as they wished, and (c) take as long as they wished, but aim to spend around five minutes on the task. Participant responses were later coded for mind-mindedness according to the Mind- Mindedness Coding Manual criteria (Meins & Fernyhough, 2015). The text was first divided into discreet descriptions that could be single words, phrases, or sentences. Each description was then placed it into one of the following exhaustive and exclusive categories: Mind- Minded, Behavioural, Physical, Self-referential, Relationship, and General, in the same manner as Study 1 (See Chapter 2, Section 2.2.2.1).

All descriptions were coded by a trained researcher who was blind to all other data, and a randomly selected 25% were coded by a second trained, blind researcher: inter-rater reliability was $\kappa = .85$. Participants received scores for each category as a percentage of the total number of descriptions produced in order to control for the amount written. Scores for mind-minded descriptions indexed participants' mind-mindedness in relation to their close friends, and scores for physical descriptions were selected to index participants' knowledge of their friends that did not emphasise internal states.

**3.2.2.2. Ruminative Responses Scale (RRS)**.

The Ruminative Responses Scale (Nolen-Hoeksema & Jackson, 2001) is a widely used measure of trait rumination initially designed to assess rumination as a response-behaviour towards stress. The scale is comprised of 22 items measured along two axes of reflection and brooding respectively. Reflection can be defined as greater degree of introspection during rumination, whereas brooding represents a more maladaptive aspect of rumination with stronger links to negative thinking and depression. Higher scores in either of these categories lead to an increase in trait-rumination (overall tendency to ruminate) score. Participants were instructed on-screen to rate how often they engaged in a variety of ruminative activities on a four-point Likert response scale, with responses consisting of '1- almost never', '2 - sometimes', '3 - often', or '4 - almost always'. For example, a statement in the reflection subcategory might ask participants to indicate how often they 'go away by yourself and think about why you feel this way'; a statement in the brooding category might ask participants to indicate how often they think "What am I doing to deserve this?" Possible scores on the test range from 22 (answering '1- almost never' to every question) to 88 (answering '4 – almost always' to every question). Greater average scores between these two components denote a higher score for overall trait rumination.

**3.2.2.3. State-Trait Anxiety Inventory (STAI)**.

The State-Trait Anxiety Inventory is a 40-item self-reporting questionnaire measuring levels of anxiety along two gradients of state and trait anxiety, with possible scores ranging from 40-160 and higher scores indicating greater levels of state or trait anxiety (Spielberger et al., 1983). State anxiety refers to more transitory states of unease, tension, and stress, whereas trait anxiety is defined as an enduring disposition towards worry and discomfort (Spielberger & Sydeman, 1994). Participants respond by indicating either the intensity of a number of state anxiety-related items ('not at all', 'somewhat, 'moderately so', 'very much so'), or the frequency with which they experience various trait anxiety-related items ('almost never', 'sometimes', 'often', 'almost always') using a four-point Likert scale ('1- Not at all', '2 –

Somewhat', '3 – Moderately',' 4- Very Much'). Items assessing state anxiety consist of statements such as 'I feel upset' or 'I feel at ease'. Items assessing trait anxiety consist of statements such as 'I lack self-confidence' or 'I have disturbing thoughts'. The possible range of scores for both categories of state and trait anxiety respectively is 20-80.

#### 3.2.2.4. Center for Epidemiologic Studies Depression Scale (CESD).

The Center for Epidemiologic Studies Depression Scale (Radloff, 1977) consists of a short self-report-style questionnaire of 20 items assessing the frequency at which a variety of depressive symptoms have been experienced by an individual during the past week. Possible responses range between 'not at all', 'a little', 'some' and 'a lot'. Items consisted of statements such as 'I was depressed' or 'I had trouble keeping my mind on what I was doing'. Possible scores ranged from 0-60, with higher scores indicating greater frequency of occurrence for depressive symptoms.

#### 3.2.2.5. Autism Spectrum Quotient (ASQ).

The Autism Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) is a questionnaire consisting of 50 items assessing the extent to which individuals exhibit symptoms associated with autism and the wider autistic spectrum. Participants respond to items according to a forced-choice format ranging between 'definitely agree', 'slightly agree', 'slightly disagree' and 'definitely disagree'. Items cover five domains associated with the autistic spectrum: communication, social skills, imagination, attention to detail, and attention switching/tolerance of change. Items consisted of statements such as 'When I talk on the phone, I am not sure when it is my turn to speak' or 'I find social situations easy'. A total ASQ score was calculated as an average of scores in the five categories for us in subsequent analysis. Scores for the questionnaire range from 50-200. Higher scores indicate a higher autism spectrum quotient (ASQ).

#### 3.2.2.6. Adult ADHD Self-Report Scale (ASRS).

The Adult ADHD Self-Report Scale (Kessler et al., 2005), developed in conjunction with the World Health Organisation, consists of 18 questions consistent with DSM-IV criteria for symptoms of ADHD in adults. Participants indicate the frequency with which they experience a number of symptoms associated with ADHD along a Likert scale: ‘never’, ‘rarely’, ‘sometimes’, ‘often’, and ‘very often’. More positive responses are associated with greater frequency of ADHD symptoms. Items consist of statements such as ‘how often do you have difficulty wrapping-up the final parts of a project, even though the challenging parts are done?’ or ‘when you have a task that requires a lot of thought, how often do you avoid or delay getting started?’ Scores on the questionnaire range from 18-90, with higher scores indicating greater severity of ADHD symptoms.

**3.2.2.7. Imaginal Processes Inventory (IPI).**

The Imaginal Processes Inventory (Singer & Antrobus, 1965) assesses the frequency of occurrence of daydreaming and night-dreaming. It further grades these occurrences along three dimensions: how pleasant they are, how unpleasant/frightening they are, and how vivid they are. It consists of two parts; in part A participants respond to one of five possible answers in a forced-choice manner for each item (for a total of 24 items). Items consist of statements such as ‘I am awakened with the realization I have been dreaming’ or ‘When I have time on my hands I daydream’. Part B is longer, consisting of 319 items, participants respond to items along a Likert scale ranging between ‘definitely not true’, ‘usually not true’, ‘usually true’, and ‘very true/strongly characteristic of me’. Items in part B consist of statements such as ‘My mind seldom wanders while I am working’ or ‘If something is really on my mind I brood on it for hours on end’. Scores for daydreaming and not night-dreaming are included in analyses for the purposes of this study. After calculating scores for both parts, overall score (ranging from 344 to 1720) is calculated for daydreaming, with higher scores indicating greater frequency and intensity of daydreaming.

**3.2.2.8. Mindful Attention Awareness Scale (MAAS).**

The MAAS (Brown & Ryan, 2003) is a 15-item scale designed to assess receptive awareness, or attention to what is taking place in the present moment, a quality of consciousness predictive of a variety of self-regulation and wellbeing constructs. Participants indicate the frequency that they experience a range of related states of awareness using a Likert scale response system ranging between ‘almost always’, ‘very frequently’, ‘somewhat frequently’, ‘somewhat infrequently’, ‘very infrequently’, and ‘almost never’. Scores on the questionnaire range from 15-90. Examples of statements responded to include ‘I could be experiencing some emotion and not be conscious of it until some-time later’ or ‘I do jobs or tasks automatically, without being aware of what I’m doing’. Higher scores indicate greater levels of mindful attention.

#### 3.2.2.9. World Health Organisation Quality of Life Instruments (WHOQOL-100).

The World Health Organisation Quality of Life Instruments (World Health Organisation, 1997) consist of 100 items assessing overall quality of life across 5 domains: quality of life and general health, physical health, psychological health, social relationships, and environmental wellbeing. Participants respond to each item by indicating on a 5-point Likert scale either how frequently they have worried about their overall health over the last two weeks (an item example being ‘do you worry about your pain or discomfort?’), or how frequently they have experienced negative emotions/consequences of poor quality of life over the last two weeks (an item example being ‘how much do you enjoy life?’). Items consisted of statements such as ‘I was depressed’ or ‘I had trouble keeping my mind on what I was doing’. Higher scores across the 5 domains denote better overall quality of life. No total score is calculated for the questionnaire overall, with answers to each domain of experience being considered separately.

#### 3.2.2.10. Paired Associates Task (PA).

The Paired Associates Task measures a system of paired-associates learning (PAL; Karantzoulis et al., 2011) in which items are matched together so that the presentation of one will cue the recall of the other. The task serves as a measurement of associative/episodic memory. These tasks are divided into the following: visual–visual, verbal–verbal, and visual–verbal. For the purposes of the present study, the visual–visual and visual–verbal conditions were not included and participants were assessed within the verbal–verbal condition. In the verbal–verbal condition, the matched pairs are verbally presented (e.g., listening to the word 'hat' followed by the word 'cushion'). The task was administered over two experimental sessions (lasting around 8 minutes respectively), taking place on different days. The first session featured an initial association encoding phase and an immediate recall phase, the second session featured a delayed recall phase. Mean levels of accuracy and response time during the delayed recall session were measured and compared across participants for use in subsequent analysis.

**3.2.2.11. Self-Reference Task (SRT)**.

The Self-Reference Task measures the self-reference memory advantage across three conditions (de Caso et al., 2017) and involves an evaluation and a retrieval phase. The evaluation phase consists of two social conditions and one syllable count condition. In the social conditions, participants were asked to make decisions about associations between adjectives and one of two referents ('Self' or 'Lady Gaga'). In the syllable condition, participants indicated via a button press whether the word on-screen had less than three or three or more syllables. All words were selected from a pool of normalised personality trait adjectives with meaningfulness and likeability ratings (Anderson, 1968). An equal number of positive, negative, and neutral adjectives (40 adjectives/valence) with the highest meaningfulness ratings were used. Adjectives were presented sequentially on-screen and participants indicated whether each adjective applied to a referent or had three or more syllables by pressing 'Y' for 'yes' or 'N' for 'no'. For each participant, these 120 words were randomly divided into two lists of 60 adjectives. One list contained all the items involved during the encoding phase, the other list contained the items that would be used as foils during the retrieval phase. This first encoding phase list was divided into three lists of 20 items, assigned to one of the three conditions. The condition-specific lists were subdivided into two 10-item lists, one list per experimental block.

During the encoding phase, participants were presented with the lists in separate blocks in an ABCCBA order allowing control for order effects for each participant. The order in which each category was presented across participants was also counterbalanced. Each block was preceded by a screen indicating the condition and began after a button press. Stimuli were separated by an inter-stimulus interval of 5000ms during which participants were shown a blank screen with a fixation cross. Following the evaluation phase, participants were presented with a surprise retrieval test in which they were shown words sequentially on-screen and asked whether or not that word had been presented in the previous phase. This retrieval phase contained all the words from the previous stage plus an equal number of new words contained in the retrieval list. Items were presented in a randomized order and participants had to either press ‘O’ for ‘old’ if they believed the word had appeared before or ‘N’ for ‘new’ if they believed the word had not appeared before. The old/new responses judged as ‘old’ were followed by a source localization judgement in which participants had to indicate using arrow heads whether they thought the old word had been presented during the Self, Lady Gaga, or syllable-count condition. Accuracy and response time during the source-localisation judgement was recorded across the three conditions.

## 3.3. Results

### 3.3.1. Preliminary Analyses

Preliminary analysis was performed on the mental and physical language use variables from the DAF task in order to ascertain the appropriateness of subsequent multiple linear regression analysis. This stage of the analysis indicated normality of distribution of the residuals and homoscedasticity of data for mental and physical DAF variables. An initial correlation analysis was also performed, including all DAF task variables. To correct for multiple comparisons, an alpha level of .05/6 = 008 was adopted (see Tables 3.1 and 3.2 for descriptive statistics and correlation coefficients for the DAF task respectively). Physical language use on the DAF task was found to be significantly negatively correlated with mental language use, , $r_s = -.24$, *p* (corrected) = .01, relationship comments, $r_s = -.27$, *p* (corrected) = .01, self-reference comments, $r_s = -.34$, *p* (corrected) = < .001 and behavioural comments, $r_s = -.27$, *p* (corrected) = .01.Four participants were removed as outliers from the Self-Reference Task for accumulating scores greater or lower than 1.5 times the interquartile range, 13 participants were also removed as outliers from the Paired Associates Task for accumulating scores greater or lower than 1.5 times the interquartile range, for a total of 17 participants' scores being removed from further analysis in these two tasks. Mean number of words correctly remembered as 'old' in the Self-Reference Task were calculated for each participant. The proportion of correctly recalled associations at the delayed recall stage of the Paired Associates Task was also calculated for each participant as a measure of associative memory ability. Multiple linear regression and correlation analyses were then performed comparing levels of mental and physical language use on the DAF task against both questionnaire and behavioural measures.

Table 3.1. DAF Task Descriptive Statistics.

| | Mean | SD | Average Frequency Score |
|---|---|---|---|
| DAF Mind-minded | .20 | .17 | 2.42 |
| DAF Physical | .20 | .22 | 1.79 |
| DAF Relationship | .10 | .17 | 1.04 |
| DAF Behavioural | .28 | .21 | 3.00 |
| DAF Self-reference | .16 | .18 | 1.64 |
| DAF General | .06 | .09 | 0.79 |

*Table 3.1: The mean scores and standard deviations (SD) and total frequency of use scores for each of the six response categories for each variable included in the DAF task. Variables are displayed as rows, mean scores, SD and average frequency scores for each measure as displayed as columns.*

Table 3.2. DAF Task Correlations.

| | Mental | Physical | Relationship | Behavioural | Self-Reference | General |
|---|---|---|---|---|---|---|
| **Mental** | 1.00 | -.24* | -.27* | .22* | -.34* | -.12 |
| **Physical** | -.24* | 1.00 | -.27* | -.27* | -.34* | .16 |
| **Relationship** | -.27* | -.27* | 1.00 | -.44* | .33* | -.04 |
| **Behavioural** | .22* | -.27* | -.44* | 1.00 | -.36* | -.16 |
| **Self-Reference** | -.34* | -.34* | .33* | -.36* | 1.00 | -.01 |
| **General** | -.12 | .16 | -.04 | -.16 | -.01 | 1.00 |

*Table 3.2: Correlation coefficients for all DAF task variables. Note:* * indicates $p < .008$ *(adjusted alpha level, .05/6).*

### 3.3.2. Relations between Friend Descriptions and Psychological Well Being

A multiple linear regression analysis was performed in order to predict mind-mindedness based on scores for the various measures of psychological wellbeing (see Table 3.2 for descriptive statistics for Questionnaire variables). The various measures of trait rumination (RRS), trait anxiety (STAI), depression (CESD), Total (composite) ASQ score (ASQ), ADHD score (ASRS), daydreaming score (IPI), mindful attention score (MAAS), and the Quality of Life, Physical Health, Psychological Health. Social Relationships and Environmental Wellbeing subscales of the WHO Quality of Life Instruments (WHOQOL-

100) were added as predictor variables. No effects of multicollinearity were observed between predictor variables. A significant regression was observed, $F(11, 126) = 2.907$, $p = .002$, with an $R^2$ of .202. Levels of participant mind-mindedness on the DAF task were found to be significantly predicted by Trait Rumination score ($\beta < .01$, $p = .002$) and Daydreaming Frequency score ($\beta < .01$, $p = .035$). A trend towards significance for ASQ score as a predictor of mind-mindedness was also observed ($\beta = .01$, $p = .055$). Proportional scores for mental language use score on the DAF increased by .004 for every point increase in trait rumination score on the RRS and for every point increase in daydreaming frequency score on the IPI, whereas mental language use score on the DAF decreased by -.007 for every point increase in Total ASQ score (see Figure 3.1 for results). ADHD score on the ASRS was not found to be a significant predictor of mind-mindedness ($p > .05$, ns), Depression score on the CESD was not found to be a significant predictor of mind-mindedness ($p > .05$, ns), Mindful Attention scores on the MAAS was not found to be a significant predictor of mind-mindedness ($p > .05$, ns), Trait Anxiety scores on the STAI was not found to be a significant predictor of mind-mindedness ($p > .05$, ns), the Quality of Life, Physical Health, Psychological Health, Social Relationships and Environmental Wellbeing subscales of the WHOQOL-100 were not found to be significant predictors of mind-mindedness ($p > .05$, ns). No significant regression was observed for physical language use on the DAF task, and no significant predictors of physical language use were observed ($p > .05$, ns).

Table 3.3. Descriptive Statistics for Questionnaire and Wellbeing Measures.

| | Mean | SD |
|---|---|---|
| Total ASQ | 1.84 | 1.90 |
| Trait Rumination | 59.69 | 15.81 |
| Trait Anxiety | 2.38 | .22 |
| Depression | 23.43 | 12.11 |
| Daydreaming | 39.12 | 8.07 |
| ADHD | 2.79 | .50 |
| Mindful Attention | 3.65 | .68 |
| WHO Quality of Life | 8.30 | 1.16 |
| WHO Physical | 27.08 | 3.94 |
| WHO Psychological | 19.72 | 2.78 |
| WHO Relationships | 11.32 | 2.61 |

*Table 3.3: The mean scores and standard deviations (SD) for each measure of wellbeing. Variables are displayed as rows, mean scores and SD are displayed as columns.*

Figure 3.1. Regression Results for Questionnaire and Wellbeing Measures.

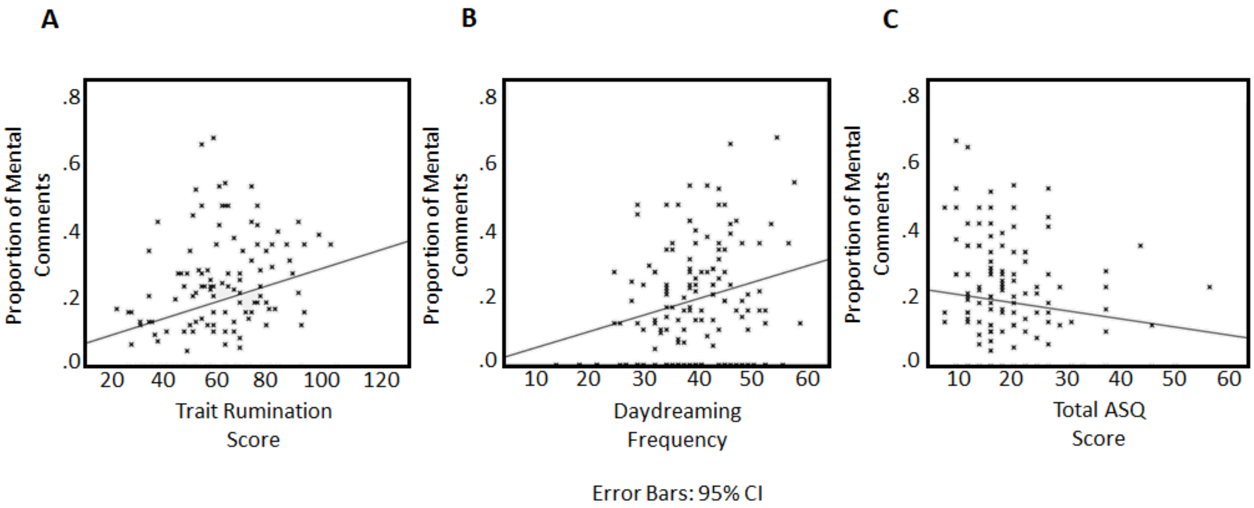


*Figure 3.1. A: Trait rumination score (mean score on the RRS) compared across lower and higher levels of mind-mindedness. Mean trait rumination score is displayed along the y-axis. Low and high levels of mind-mindedness are displayed along the x-axis. B: Daydreaming score (mean daydreaming score on the IPI) compared across lower and higher levels of mind-mindedness. Mean trait daydreaming score is displayed along the y-axis. Low and high levels of mind-mindedness are displayed along the x-axis.*

Correlation analysis was also performed comparing mental and physical language along with all questionnaire variables (see Table 3.4 for correlation coefficients). An adjusted alpha level of $p$ = .004 was adopted to control for multiple comparisons. A significant positive correlation was observed between mental language use and rumination $r_s$ = .32, $p$ (corrected) < .001 and a significant negative correlation was observed between mental language use and physical language use on the DAF task, $r_s$ = -.24, $p$ (corrected) = .03. Depression measures on the CESD were also observed to significantly correlate with a number of variables; possessing significant positive correlations with trait anxiety on the STAI, $r_s$ = .28, $p$ (corrected) = .01, and ADHD scores on the ASRS, $r_s$ = .37, $p$ (corrected) < .001 and possessing significant negative correlations with mindful attention on the MAAS, $r_s$ =- .32, $p$ (corrected) < .001, and the five subscales of the WHOQOL-100 - Quality of Life, $r_s$ = -.46, $p$ (corrected) < .001, Physical Health, $r_s$ = -.56, $p$ (corrected) < .001, Psychological Health, $r_s$ = -.54, $p$ (corrected) < .001, Social Relationships, $r_s$ = -.36, $p$ (corrected) < .001, and Environmental Wellbeing, $r_s$ = -.38, $p$ (corrected) < .001.

Rumination on the RRS was observed to possess significant positive correlations with depression on the CESD, $r_s$ = .58, $p$ (corrected) < .001, daydreaming on the IPI, $r_s$ = .36, $p$ (corrected) < .001, trait anxiety on the STAI, $r_s$ = .38, $p$ (corrected) < .001, and ADHD score on the ASRS, $r_s$ = .42, $p$ (corrected) < .001 and significant negative correlations with mindful attention on the MAAS, $r_s$ = -.34, $p$ (corrected) < .001, and the five subscales of the WHOQOL-100 - Quality of Life, $r_s$ = -.34, $p$ (corrected) < .001, Physical Health, $r_s$ = -.45, $p$ (corrected) < .001, Psychological Health, $r_s$ = -.42, $p$ (corrected) < .001, Social Relationships, $r_s$ = -.29, $p$ (corrected) < .001, and Environmental Wellbeing, $r_s$ = -.28, $p$ (corrected) = .001. Daydreaming on the IPI was found to possess a significant positive correlation with trait anxiety on the STAI, $r_s$ = .25, $p$ (corrected) < .03 and significant negative correlations with ADHD score on the ASRS, $r_s$ = -.29, $p$ (corrected) < .001, and the Psychological Health subscale of the WHOQOL-100, $r_s$ = -.36, $p$ (corrected) < .04. Scores for mindful attention on the MAAS were observed to have significant negative correlations with trait anxiety on the STAI, $r_s$ = -.29, $p$ (corrected) < .001, and ADHD score on the ASRS, $r_s$ = -.55, $p$ (corrected) < .001.

The Quality of Life subscale of the WHOQOL-100 was observed to have significant positive correlations with the Physical Health subscale of the WHOQOL-100, $r_s$ = .46, $p$ (corrected) < .001, the Psychological Health subscale of the WHOQOL-100, $r_s$ = .42, $p$ (corrected) < .001, the Social Relationships subscale of the WHOQOL-100, $r_s$ = .41, $p$ (corrected) < .001 and the Environmental Wellbeing subscale of the WHOQOL-100, $r_s$ = .48, $p$ (corrected) < .001. The Physical Health subscale of the WHOQOL-100 was observed to have significant positive correlations with the Psychological Health subscale of the WHOQOL-100, $r_s$ = .42, $p$ (corrected) < .001, the Social Relationships subscale of the WHOQOL-100, $r_s$ = .43, $p$

(corrected) < .001, and the Environmental Wellbeing subscale of the WHOQOL-100, $r_s = .49$, *p* (corrected) < .001, and a significant negative correlation with ADHD score on the ASRS, $r_s = -.35$, *p* (corrected) < .001.

The Psychological Health subscale of the WHOQOL-100 was observed to have significant positive correlations with mindful attention score on the MAAS, $r_s = .34$, *p* (corrected) < .001, the Social Relationships subscale of the WHOQOL-100, $r_s = .40$, *p* (corrected) < .001 and the Environmental Wellbeing subscale of the WHOQOL-100, $r_s = .38$, *p* (corrected) < .001, and a significant negative correlation with ADHD score on the ASRS, $r_s = -.26$, *p* (corrected) < .001. No other variables were found to significantly correlate after correcting for multiple comparisons (see Table 3.4).

Table 3.4. Correlation Coefficients for Questionnaire and Wellbeing Measures.

| | 1. DAF Mental | 2. DAF Physical | 3. Depression | 4. Daydreaming | 5. Trait Anxiety | 6. Rumination | 7. Quality of Life |
|---|---|---|---|---|---|---|---|
| **1** | 1.00 | -.24** | .12 | .21* | -.00 | .32* | -.19* |
| **2** | -.24** | 1.00 | .01 | -.21* | -.02 | -.07 | -.01 |
| **3** | .20 | .01 | 1.00 | .14 | .28** | .58** | -.46** |
| **4** | .21* | -.21* | .14 | 1.00 | .25** | .36** | -.06 |
| **5** | -.00 | -.02 | .28** | .25** | 1.00 | .38** | .05 |
| **6** | .32* | -.07 | .58** | .36** | .38** | 1.00 | -.34** |
| **7** | -.19* | -.01 | -.46** | -.06 | .05 | -.34** | 1.00 |
| **8** | -.07 | -.02 | -.55** | -.13 | -.04 | -.45** | .46** |
| **9** | -.03 | .12 | -.54** | -.24** | -.03 | -.42** | .42** |
| **10** | -.06 | .06 | -.36** | -.11 | .00 | -.29** | .41** |
| **11** | -.11 | .08 | -.39** | -.15 | .09 | -.28** | .48** |
| **12** | .02 | .05 | -.32** | -.22** | -.29** | -.34** | .21* |
| **13** | .20* | -.14 | .37** | .29** | .21* | .42** | -.21* |

Table 3.4 (Continued).

| | **8. Physical Health** | **9. Psych. Health** | **10. Social Relations** | **11. Env. Wellbeing** | **12. Mindful Attention.** | **13. ADHD** |
|---|---|---|---|---|---|---|
| **1** | -.07 | -.03 | -.06 | -.11 | .020 | .20* |
| **2** | -.02 | .12 | .06 | .08 | .053 | .14* |
| **3** | -.55** | -.54** | .36** | .39** | -.32** | .37** |
| **4** | -.13 | -.24** | -.11 | -.15 | .22** | .29** |
| **5** | -.04 | -.03 | .00 | .09 | -.29** | .21* |
| **6** | -.45** | -.42** | -.29** | -.28** | -.34** | .42** |
| **7** | .46** | .42** | .41** | .48** | .21* | -.21* |
| **8** | 1.00 | .42** | .43** | .49** | .20* | -.35* |
| **9** | .42** | 1.00 | .40** | .38** | .34** | -.26** |
| **10** | .43** | .40** | 1.00 | .30** | .01 | -.13 |
| **11** | .49** | .38** | .30** | 1.00 | .12 | -.20* |
| **12** | .20* | .34** | .01 | .12 | 1.00 | -.55** |
| **13** | -.35* | -.26** | -.13 | -.20* | -.55** | 1.00 |

*Table 3.4: Correlation coefficients for mind-mindedness (mental language use) and physical language use compared against all questionnaire variables. * indicates a significance level of p (uncorrected) <.05, ** indicates a significance level of p (uncorrected) < .01.*

### 3.3.3. Relations between Friend Descriptions and Memory

Initial analyses revealed the presence of a self-reference effect, with mean proportions of correct responses were significantly higher for the Self category compared to both the Lady Gaga category, t149) = 11.51, *p* (corrected) < .001, and the syllables category, t(149) = 11.60, *p* (corrected) < .001 (an alpha level of .05/3 = .017 was adopted to control for multiple comparisons, see Table 3.5 for descriptive statistics). As with the questionnaire measures, multiple linear regression analysis was performed to identify potential relationships between mind-mindedness measures and the two behavioural memory tasks: proportions of correct responses for delayed recall on the paired associates memory task and the three conditions of the SRT. No significant regression was observed for mental language use on the DAF task, and no significant predictors of mental language use were observed among the included behavioural measures (*p* > .05, ns). No significant regression was observed for physical language use on the DAF task, and no significant predictors of physical language use were observed (*p* > .05, ns).

In order to determine whether mind-mindedness may be related to differences in memory for self or others as referents respectively, a difference score between Self and Lady Gaga responses on the SRT was calculated by deducting the number of correct responses for the Lady Gaga condition from the number of correct responses for the Self condition, providing an indicator of magnitude for the previously-observed self reference effect for each participant. Correlation analysis was then performed comparing both mental and physical language use on the DAF task along with the calculated difference scores for Self and Lady Gaga. An alpha level of .02 (.05/3) was adopted to control for multiple comparisons. This stage of analysis revealed no significant relationship between magnitude of the self reference effect and mental, *p* (corrected) > .05, ns, or physical language use on the DAF task, *p* (corrected) > .05, ns.

Correlation analysis was also performed comparing mental and physical language along with all behavioural variables (see Table 3.6 for correlation coefficients). An adjusted alpha level of $p = .008$ was adopted to control for multiple comparisons. A significant negative correlation was observed between mental language use and physical language use on the DAF task, $r_s = -.22$, $p$ (corrected) = .04. A significant positive correlation was also observed between responses to the Self and Lady Gaga conditions on the SRT, $r_s = .42$, $p$ (corrected) = < .001. A significant positive correlation was also observed between responses to the Self and Syllables conditions on the SRT, $r_s = .35$, $p$ (corrected) = < .001. A significant positive correlation was also observed between responses to Lady Gaga and Syllables conditions on the SRT, $r_s = .92$, $p$ (corrected) = < .001.

Table 3.5. Descriptive Statistics for Behavioural Measures.

| | Mean | SD |
|---|---|---|
| Self (SRT) | .79 | .15 |
| Lady Gaga (SRT) | .63 | .19 |
| Syllables (SRT) | .62 | .19 |
| Recall (PA) | .56 | .26 |

*Table 3.5: The mean scores and standard deviations (SD) for each behavioural measure. Variables are displayed as rows, mean scores (proportion correct) and SD are displayed as columns.*

*Note: SRT = Self Reference Task, PA = Paired Associates*

Table 3.6. Correlation Coefficients for Behavioural Measures.

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| **1. Mental (DAF)** | 1.00 | -.22** | .07 | .10 | .18* | .13 |
| **2. Physical (DAF)** | -.22** | 1.00 | -.01 | -.05 | -.02 | -.01 |
| **3. Paired Associates** | .07 | -.01 | 1.00 | .05 | .13 | .12 |
| **4. Self (SRT)** | .01 | -.05 | .05 | 1.00 | .42** | .35** |
| **5. Lady Gaga (SRT)** | .18* | -.02 | .13 | .42** | 1.00 | .92** |
| **6. Syllables (SRT)** | .131 | -.01 | .12 | .35** | .92** | 1.00 |

*Table 3.6: Correlation coefficients for mind-mindedness (mental language use) and physical language use compared against all behavioural variables. * indicates a significance level of p (uncorrected) <.05, ** indicates a significance level of p (uncorrected) < .01.*

## 3.4. Discussion

The results of the current study simultaneously assist in the clarification of the link between mind-mindedness and memory processes, and reveals a relationship between mind-mindedness and measures of wellbeing. Spontaneously focusing on mental and emotional characteristics when describing a close personal friend was associated with greater levels of rumination and daydreaming; both involving self-generated processing. Mind-mindedness was also shown to have no relationship with memory for self, a personally unknown other or semantic memory. Taken together, our data suggest that in accordance with the findings of Meins et al. (2014) and of Study 1, mind-mindedness is dependent on the availability of episodic memories of previous social interactions and not related to general declarative and semantic memory capacity. Also in accordance with hypothesised outcomes is the finding that mind-mindedness possesses links to measures of capturing processes of self-generated thought, namely daydreaming and rumination.

Initial correlation analysis of the DAF task sample revealed that people who scored higher for mental state language use were less likely to talk about their friend's physical qualities. This finding is interesting as previous studies have observed no relationship between mental and physical language use. One factor to account for that may help explain this effect is the relatively large sample size of the present study compared to previous investigations into mind-mindedness, which may have revealed some underlying relationship between mental and physical language use. Some previous literature suggests that there exists a mutually inhibitory relationship between activity in brain regions associated with mentalisation and brain regions associated with external/physical cognition (i.e. thinking and reasoning about external physical inanimate objects), resulting in a tendency to either emphasise focus on mental or physical properties respectively (Jack et al., 2013). It may therefore be the case that individuals are more likely to preferentially focus on either mental or physical characteristics during the DAF task.

However, further investigation also reveals that physical language use on the DAF task did not demonstrate a significant negative correlation with mental language use alone, but with all categories of the DAF task aside from the 'general' category. Accordingly, there may be no specific relationship between mental and physical language use on the DAF task, but rather it may be that participants were likely to either interpret DAF task requirements as providing primarily physical descriptions in a manner that other DAF categories were not included, or as providing a more general background which would include usage of other DAF categories at the expense of providing physical descriptions.

Correlation analysis for the DAF task also replicated the findings of Study 1 by revealing a negative relationship between referring to the nature of the relationship between participants and their friends and referring to the behaviour of friends. In addition to this, relationship comments on the DAF task were positively correlated with self-reference comments, indicating that where participants were more likely to refer to themselves on the DAF task, they were more likely to also refer to the nature of their relationship with their friends. Conversely, where participants were more likely to describe the behaviour of their friends (and thus less likely to make relationship comments), they were less likely to refer to themselves. Together these findings grant further support to the view suggesting that participants were more likely to adopt a narrative reflecting shared 'We' memories when describing the behaviours of close friends (Beike, Cole & Merrick, 2017), entailing them being more likely to refer to themselves and the dynamic of the relationship between their close friends as-opposed to simply listing their friend's behaviours.

We also observed significant negative correlations between mental language use on the DAF task and both relationship comments and self-references. Previous work has found that processing the mental states of the self and close others share a large degree of functional overlap in the brain (Lombardo, Barnes, Wheelwright & Baron-Cohen, 2007) and accordingly the resources recruited during the DAF task to provide descriptions of a close other are likely to be allocated to constructing narratives from a self-referent or other-referent perspective, respectively. Finally, initial DAF correlations revealed that greater levels of mental language use on the DAF were positively correlated with behavioural language use. If mind-mindedness involves the spontaneous use of mentalisation to interpret behaviours as the work of Meins (1997) suggests, then it is possible that when completing the DAF task, participants more likely to describe the behaviour of their friend in terms of their mental states and motivations would draw upon a wider range of previous behaviours from memory in order to form the narrative of their friend's internal mental states.

Correlations also confirmed that higher scores for depression were associated with higher scores for anxiety and rumination, indicating the common comorbidity of these traits. Previous work suggests that rumination serves as a mediator between anxiety and depression, resulting in significant correlations between rumination, worry and depression (Muris, Roelofs, Rassin, Franken & Mayer, 2005). Increased scores for depression were also associated with lower scores for perceived quality of life, across all five subcategories. Quality of life, including environmental, health and social factors, possesses important situational determinants which illnesses such as depression can impact (Barge-Schaapveld, Nicolson, Berkhof & de Vries, 1999), resulting in lower subjective appraisal for overall quality of life.

Daydreaming also was found to be related to increased scores for both anxiety and rumination, both commonly co-occurring traits (Nolen-Hoeksema, 2000). Shrimpton, McGann and Riby (2017) observed that daydreaming can be separated into subcategories of ‘reflective’ (positive or constructive self-assessment) and ‘ruminative’ (negative or critical) focus, with increased rated ruminative focus being associated with greater levels of trait rumination and anxiety. Accordingly, individuals more inclined to towards ruminative thinking appear to demonstrate higher levels of ruminative focus when daydreaming, manifesting also in increased scores for trait anxiety. Higher levels of daydreaming were also associated with lower ratings for psychological health. Previous literature has labelled excessive frequency and intensity of daydreams as maladaptive daydreaming (Bigelsen, Lehrfeld, Jopp & Somer, 2016) which is in-turn associated with greater predisposition towards ADHD, OCD and depressive symptoms. These findings therefore further demonstrate that while daydreaming is an integral part of everyday cognitive function, at excessive levels of occurrence it may become associated with or symptomatic of detriments to psychological health.

The finding of increased scores for ADHD being associated with higher levels of trait rumination, greater frequency of daydreams and lower levels of mindful attention demonstrates a link between ADHD individuals and difficulty with sustained external attentional focus. Interestingly, higher ADHD scores on the ASRS were also associated with higher levels of depression, and lower scores overall for physical and psychological health quality of life measures. Statements pertaining to physical health on the WHOQOL covered areas such as ‘activities of daily living’, ‘reliance on medicinal substances’, ‘energy and fatigue’ and ‘work capacity’ whereas psychological statements covered areas such as ‘negative feelings’, ‘memory and concentration’ and ‘learning’. These associations appear to reflect the potential negative outcomes of ADHD in terms of disorganized or sporadic behaviour and difficulties with concentration (Harpin, 2004).

Greater scores for mindful attention were found to be associated with lower levels of anxiety, depression and rumination. Greater scores for mindful attention were also found to be associated with overall higher scores for psychological health. Previous research by Shapiro, Brown and Biegel (2007) has investigated the effects of Mindfulness-Based Stress Reduction (MBSR) therapy, involving training in mindful attention-based techniques, on training therapists. Participants involved in the program reported decreased levels of stress, negative affect, rumination, and state and trait anxiety. Overall, these findings suggest that greater levels of mindful attention are associated with increased positive psychological health perceptions.

Various quality of life measures were also seen to interrelate. As could be expected, higher overall subjective perceptions of quality of life were associated with the subcategories of physical and psychological health, environmental wellbeing and social relationships. Also, better ratings for physical health were associated with higher scores for psychological health, social relationships and environmental wellbeing. In turn, greater levels of psychological health were associated with higher scores for social relationships and environmental wellbeing. These findings accord with previous work utilising the WHOQOL, reporting such intercorrelations between the five subcategories as evidence of the internal consistency of the applied measures as predictors of different areas of quality of life (Skevington, 1999).

A trend towards significance was observed between mental language use on the DAF and total score for autism on the ASQ. This finding would support the hypothesised view of the present study that the myriad detriments to social cognitive ability in general, and mentalisation in particular, posed by intense autistic spectrum symptoms (Senju, 2013) would also lead to lower levels of mind-mindedness. ASD individuals therefore, with deficiencies in their ability to mentalise, appear to be demonstrating the extent to which mentalisation is a core component process of mind-mindedness, without which it fails to effectively emerge as a higher-order process.

The finding of greater levels of mind-mindedness being associated with an increased tendency to ruminate and daydream confirms a hypothesis of the present study and may capture the role of self-generated processes in the capacity to adopt a perspective on another individual that takes account of their internal states. Rumination is understood as repeated attention given towards goal-oriented thinking, characterised by a perceived failure in or anxiety about achieving those goals (Watkins, 2008), and social interactions and socially-relevant information can often be a cause of rumination. As mentioned previously, rumination appears to serve primarily as an emotion-regulation strategy (Gruber et al., 2011) and involves thinking about the perceived causes of one's affective state (Nolen-Hoeksema et al., 2008).

Rumination therefore largely seems to grow from a strategy for the avoidance of negative social consequences, however repeated negative rumination is considered maladaptive and not conducive towards psychological wellbeing. Zou and Abbott (2012) demonstrated that the degree of negative rumination experienced concerning a social interaction was significantly related to the self-perception and appraisal of participants concerning their performance in that social interaction. Earlier work has also shown that rumination over a social interaction is associated with the level of anxiety associated with that interaction (Kashdan & Roberts, 2006). Rumination has been found to enhance recall for negative information and produce bias towards the encoding of negative experiences (Kuo et al., 2012), therefore it has been argued that rumination in the context of social interaction is a quality of maladaptive problem-solving utilising a mechanism of automatic memory retrieval serving to encourage deeper levels of memory encoding for previous negative experiences. In many ways mind-mindedness also serves as a means to social problem-solving by facilitating interactions with the provision of relevant information, encouraging the development of flexible mental state models (Meins, 2013). Like rumination, mind-mindedness may also accomplish this in an automatic manner (Meins, et al., 1998, 2001).

At a cognitive level, our study suggests that although mind-mindedness may be partially-rooted in memory processes, it specifically draws-upon episodic memories, and in particular those linked to social information. We found no observable link between levels of mind-mindedness and the retrieval of information encoded incidentally with respect to making associations with Lady Gaga, information encoded incidentally with relation to the self, or information encoded through its phonological structure. The same was true for memory encoded with a view to subsequent recognition in an explicit manner (i.e. the Paired Associates Task). Previous work by Meins et al. (2014) comparing levels of mental state language use when describing one's best friend, a famous figure, or a work of art has shown that mind-mindedness is most expressed in close relationships, as-opposed to being a general trait-like construct applied equally across categories of social relationships. Being a facet of personal relationships, it appears that mind-mindedness relies on memories of past shared of similar experiences with another person, in order to create a mental model of an individual which we can utilise to explain and predict mental states (Liberman, 2007). This process necessitates drawing on our knowledge reserves about an individual in a manner that may be classified as a form of spontaneous social thought. Our study suggests that this information may be encoded to memory and subsequently drawn-upon in an automatic manner when mind minded people consider a personally known individual.

Previous studies analysing the components of the form and content of spontaneous thoughts at rest have shown that social cognition and recalling past social interactions form a large and consistent component of daydreaming (Engert et al., 2014; Ruby et al., 2013). Similarly, Spreng (2013) has argued that a fundamental and ongoing process involved in spontaneous thought is social cognition, or an attempt at building mental models of others based on interactions in order to navigate the social world more successfully. This process may be adaptive since Ruby et al. (2013) have observed that individuals who engage more heavily in social thinking during daydreaming produce high numbers of solutions to social problems. Viewed in this context, the observation of a relation between mind-mindedness and an increased tendency to daydream suggests that the construct of mind-mindedness represents an applied form of this spontaneous thought, dedicated to the task of assisting our interpretation of complex social cues and motivations.

Also as hypothesised, levels of mind-mindedness had no observable effect on the encoding of words associated with Lady Gaga in the SRT. Accordingly, when we consider the findings of the present study alongside evidence gathered from Study 1 suggesting that individuals scoring higher for mind-mindedness were more effective at encoding social information to memory, it appears that although the Lady Gaga condition represented a category pertaining to another individual, the case being that Lady Gaga represented a personally unknown other, about whom participants had no access to memories of shared interactions, meant that participants were not significantly more likely to refer to mental states in their descriptions, as they had little material with which to formulate a mental model from memory (Lieberman, 2007). The previous proposition of Meins et al. (2014) that mind-mindedness is formulated as a product of closer social relationships therefore appears to hold true, as we observed participants utilise cognitive faculties related to mind-mindedness when undergoing a memory recognition task for previously viewed social interactions, but not when engaged in a memory recognition task that involved generally associating terms with a personally unknown-other.

These findings therefore highlight the distinction between episodic memories for personal interactions with another individual and semantic knowledge with which we are able to categorise others with layers of associated meaning (Hampson, 1982). Previous research has suggested a distinct steam of processing between social-cognitive abilities such as mentalisation, and social semantic category judgements, implicating activity in the bilateral anterior temporal cortex along with the mPFC with the processing of social semantic categories (Zahn et al., 2007), and suggesting that the superior anterior temporal cortex plays a key role in social semantic information processing by providing abstract conceptual knowledge of social behaviours which can be combined with other cognitive processes such as mentalisation in order to provide a flexible interpretation of social interactions. Previous research investigating semantic knowledge for famous figures has further shown that the right temporal lobe has a privileged role for representing person-specific semantic knowledge and the left temporal lobe for general semantic knowledge (Snowden, Thompson & Neary, 2012). Accordingly, it can be reasonably suggested that the cognitive processes recruited when asking participants to make semantic associations with a famous figure (Lady Gaga) in the SRT during the present study were distinctly related to the representation of social semantic knowledge, and not of mental states, potentially explaining the absence of a relationship between mental language use on the DAF task and memory during the Lady Gaga condition of the SRT.

The findings of the present study also provide further insight into the potential nature of mind-mindedness as a quality of close social relationships. The observation that mind-mindedness appears to partially depend on the retrieval of relevant information about past interactions from episodic memory, as-opposed to being linked to a general memory capacity, suggests that mind-minded comments arise from the automatic retrieval of knowledge of shared past similar experiences. This viewpoint accords with that of Mitchell, Macrae and Banaji (2004), who stated that as social interactions are inherently complex, require the integration of memory processes in order to make sense of dynamic social interactions. Amodio and Ratner (2011) have further suggested that this process can occur implicitly, outside of the conscious awareness of the individual, whereby automatic associations with certain social signals are formed in a manner prompting the retrieval of previous similar experiences from memory. It is possible that individuals demonstrating greater levels of mind-mindedness have in some way implicitly learned to respond to certain social cues and events through engaging in mentalisation and drawing upon prior experiences in order to help form meaningful narratives about social interactions.

The form and nature of social relationships in terms of their closeness and mutual liking of individuals for one-another also has bearing on the manner in which we engage in social interactions and subsequently implicitly learn from them. Hudson, Nijboer and Jellema (2012) provided evidence that pro-social dispositions and social cues of positive emotional valence facilitate processes of implicit social learning. Accordingly, it may be the case that mind-minded individuals are more likely to attribute mental states to others when they are engaged in close, emotionally positive relationships due to this facilitative effect. Further work conducted by Heerey and Velani (2010) has also demonstrated that the subjectively-reported levels of personal liking we have for another individual are predictive of our ability to understand another person's behavior using nonverbal social cues. When these findings are considered alongside those of the present study, we may consider a potential explanation or the relational basis of mind-mindedness. It may be that mind-mindedness arises from behaviours learned implicitly during social interactions, serving to maintain close relationships with others in the face of complex and dynamic social events, by encouraging awareness of the intentions and emotions of other people across time.

Taken together, our findings suggest that mind-mindedness may reflect a construct in which social information about other individuals is automatically retrieved. We speculate that this may take the form of narratives focused on the mental processes of others, since this is the way that mind-mindedness is operationalised in the DAF task (Meins et al., 2008, 2014).

Narrative formation and rehearsal is one of the fundamental ways in which we are able to make sense of complex situations, such as social interactions and predicting the intentions of others. Previous work carried out by Bird et al. (2015) showed participants a series of video clips depicting 'complex event sequences'. Many of these video clips portrayed social interactions as examples of these sequences, finding that forming a narrative about what was observed during the course of the events displayed, and subsequently rehearsing that narrative, greatly improved subsequent recall of the contents of the clip. Narrative formation therefore facilitates the encoding of dynamic situations such as social interactions by providing a method of event segmentation, allowing for notable features of interaction to be stored and subsequently retrieved in working memory. Event segmentation involves parceling a stream of notable occurrences with definitive 'beginning' and 'end' boundaries (Zacks & Swallow, 2007), and subtle social cues are able to serve as markers for these event boundaries (Boggia & Ristic, 2015). The observed increased recall for socially-relevant information exemplified by mind-minded individuals therefore provides evidence for the increased salience of mental features when mind-minded individuals segment events into retrievable memories allowing for narrative formation in memory.

### 3.5. Conclusions

Together, the results of our study provide evidence that mind-mindedness is linked to both the manner in which we spontaneously retrieve socially-relevant information and the way we represent other people in episodic memory. Mind-minded individuals have been shown to engage more frequently in rumination and daydreaming, both being processes that depend on the self-generation of mental content (Zou & Abbott, 2012, Ruby et al., 2013, Engert et al., 2014). The cognitive mechanisms underlying the ruminative and daydreaming tendencies assessed by their corresponding questionnaire measures, therefore, appear to implicate processes of spontaneous or automatic social information retrieval (Greenwald & Banaji, 1995) as a component process of mind-mindedness, functions held in common with both rumination and mind-wandering. Mind-mindedness has also been shown to enhance incidental memory for social information (as discussed in Study 1) suggesting that part of what makes a person exhibit mind-minded behaviour is a tendency to form strong memory traces about socially-relevant information when interacting with other people. It is possible that mind-mindedness therefore reflects a pattern of cognition in which the tendency to self-generate experiences using social information from memory manifests in the form of a narrative in memory with focus on mental states. Accordingly, future work in this area should potentially focus on the nature of the overlap between these cognitive processes of memory, social cognition and spontaneous thought and language processes to explore how and why different people focus on the internal features of another individual, while others do not. Future studies could further explore the relationship between mind-mindedness, episodic memory and spontaneous thought by examining the neural basis of individual differences in mind mindedness in order to establish whether systems involved in this process also show functional overlap with systems involved in memory formation and spontaneous thought.

# Chapter 4

## Study 3: Exploring the Neural Components of Mind-Mindedness

### 4.1. Introduction

Social cognition arises from the interplay of multiple processes spanning the perceptual, cognitive, and social domains. To interact successfully with another person we must infer their internal states, a process known as mentalisation (Frith & Frith, 2006b), which is enriched by our semantic knowledge of the world and our prior interactions with specific individuals. For example, Perdue, Dovidio, Gurtman, and Tyler (1990) observed that by implicitly priming participants with pronouns denoting an 'in-group' or 'out-group' status, subsequent judgements about person descriptors can be altered, suggesting that semantic knowledge has an effect on the way we socially categorize others.

Episodic memory processes also function as major components of social cognition because the recollection of previous experiences helps support our conceptual models of other people (Hassabis et al., 2013). Consistent with this view, Davidson, Drouin, Kwan, Moscovitch and Rosenbaum (2012) reported that patients with amnesia are less likely to form and maintain social bonds. This study is one of many highlighting the necessity of a functional memory system for successfully navigating the social world. Our memories about other people allow us access to a mental history of their behaviour, which can influence our thoughts and behaviour in the present by providing a model of previous similar interactions which we may use to navigate the social world (Spreng, 2013). In line with this proposal, Ciaramelli et al. (2013) have shown that memory of an individual's past experiences modulates subsequent empathic responses towards them. These lines of evidence suggest that social cognition depends, in part, upon episodic and semantic knowledge based on prior social interactions, and when these different forms of representations are used appropriately they can help allowing us understand and correctly attribute motivations to another person.

Prior neuroimaging research has highlighted that social cognition is associated with neural processes in a variety of different brain networks. One system that has become a focus of research into social cognition is the so-called default mode network (DMN). Mars et al. (2012) demonstrated a large degree of functional overlap between the DMN and regions known to play an important role in socio-cognitive processing, including the posterior cingulate cortex (pCC), the medial prefrontal cortex (mPFC), and the left and right angular gyri (ANG). Consistent with a relation between memory and social processing, regions in the DMN, including the pCC, are associated with the consolidation of event narratives in memory. For example, Bird et al. (2015) demonstrated that the pCC is recruited during the rehearsal of narratives for complex event sequences, such as social interactions. The DMN has also been shown to exhibit a common pattern of neural activation for both reflection on the past and ToM abilities, with ToM tasks engaging lateral, and memory tasks engaging midline, DMN areas (Spreng & Grady, 2010), consistent with the view that memory systems are a central component of social cognition (Hassabis et al., 2013).

Other studies have highlighted the importance of the limbic network in social processing. A recent resting state study found that the ventromedial prefrontal cortex (vmPFC) plays an important role in memory for both self-relevant information and information about personally salient others, through its connectivity with other large-scale networks, including the DMN and the fronto-parietal network (FPN; de Caso et al., 2017). The limbic network is also likely to be important in social cognition because of its role in memory and emotional processing. Hariri, Bookheimer, and Mazziotta (2000) recorded increased activity in the left and right amygdala in response to a face-matching task involving pairing-off faces showing similar emotional states, with limbic responses specifically associated with the processing of frightened faces. Finally, studies have shown the involvement of regions associated with executive control, as supported by the FPN, in various aspects of social cognition. For example, studies have shown dual involvement of both the FPN and DMN in tasks of social problem solving (e.g., Spreng & Grady, 2010) and in situations when participants must maintain social information in working memory (Meyer & Matthew, 2012). However, recent work has suggested that the role of the FPN in social working memory may in fact reflect non-social processes that are engaged by the task demands, rather than the act of maintaining social information in-mind per se (Meyer, Taylor, & Lieberman, 2015).

The present study is a large-scale individual difference study aimed at exploring the neural correlates of a specific aspect of social cognition: mind-mindedness (Meins, 1997). Mind-mindedness is a construct characterized by a tendency to spontaneously invoke internal states during social interactions or when recalling details of another person (Meins et al., 1998, 2001). Mind-mindedness has been proposed to be a quality of close relationships rather than a trait (Meins et al., 2014), since it is most prevalent when describing personally familiar individuals, and mind-minded descriptions of significant others are unrelated to mind-minded descriptions of famous figures or works of art (Hill & McMahon, 2016; Meins et al., 2014).

Attempts to establish why some individuals are more mind-minded than others have largely drawn null findings. Studies focusing on caregivers' descriptions of their children have shown that there are no clear associations between mind-mindedness and caregiver SES, educational level, or occupational status (e.g., Fishburn et al., 2017; Lundy, 2013; Meins et al., 1998). Research has also shown that mind-mindedness is unrelated to ToM abilities both in childhood (Meins et al., 2006) and adulthood (Barreto et al., 2016; See Chapter 3, Section 3.1 for more details on mind-mindedness).

In the present study we assessed mind-mindedness in a large cohort of participants for whom measures of intrinsic organisation as assessed using resting state functional magnetic resonance imaging were available. Mind-mindedness was assessed by acquiring open-ended descriptions of a close friend, which were coded to determine the extent to which they spontaneously produced descriptions of mental states for these individuals. We compared these descriptions of the best friend to the functional organization of the brain at rest, focusing on the organization of large-scale networks that support different aspects of higher order cognition. It was hypothesised that significant variance in levels of functional connectivity related to levels of mind-mindedness would be observed for both the FPN and the DMN due to their respective involvement with the processing of multiple facets of social cognition (Meyer & Matthew, 2012; Spreng & Grady, 2010).

## 4.2. Method

### 4.2.1. Participants

Participants were 157 right-handed individuals aged between 18 and 35 years (M = 20.28, SD = 2.67). All participants were the same individuals tested in Study 2. All participants were native English speakers. Participants were undergraduate students who were recruited via the Department's online participant pool. Participants were paid £80 or an equivalent worth of course credit for completing the behavioural and fMRI scanning components of the study (a total of four sessions). Both components of the study were approved by the relevant University Ethics Committees. The study was conducted according to the principles expressed in the Declaration of Helsinki, and for both components, participants provided written informed consent.

For the purposes of a sanity check, an independent resting-state data sample of 140 right-handed participants between 18 and 35 years (Nooner et al., 2012) was also utilised for the purposes of determining the intrinsic organisation of any significant clusters. In this way, any brain regions with patterns of functional connectivity highlighted as demonstrating a significant relationship with mind-mindedness could be seeded in a totally separate sample of participants and the location of any revealed brain regions corroborated across the two datasets. This allowed us to provide independent validation of the result gained from the present study's sample.

### 4.2.2. Materials and Methods

Participants completed all sections of the study across four sessions, held on separate days, over the course of one week. In session one, the resting-state functional network of participants was acquired, along with structural and FLAIR scan data in a scanning session lasting around an hour in total. In sessions 2, 3, and 4, participants completed a battery of behavioural tasks, each measuring variance in some form of higher-order cognitive function, and lasting around 2 hours. Although a battery of tasks was administered, Study 2 assesses behavioural data from these other measures (See Chapter 3). Study 3 here specifically focuses on mind-mindedness data from the describe-a-friend task (Meins et al., 2008, 2014). The order of behavioural tasks in each battery remained constant, but the administration of the three task batteries was counterbalanced across sessions. All behavioural measures were programmed and presented to participants using PsychoPy (Peirce, 2007, 2009).

#### 4.2.2.1. Mind-Mindedness.

The describe-a-friend task (Meins et al., 2008, 2014) was used to assess mind-mindedness. The task was administered using a computer. Participants were informed that there were no right or wrong answers to the task, that they were free to describe their friend in any way they chose, and that there, while there was no time limit, they should aim to spend around 5 minutes on the task. Participants were then presented with a blank screen, with the following instruction: "Think of your best friend. If you have more than one, choose one of your best friends to think about. Use the space on the page below to describe your friend. You may write as much as you want".

Participant responses were later coded according to criteria in the Mind-Mindedness Coding Manual (Meins & Fernyhough, 2015). Each description was then placed it into one of the following exhaustive and exclusive categories: Mind-Minded, Behavioural, Physical, Self-referential, Relationship, and General, in the same manner as Study 1 (See Chapter 2, Section 2.2.2.1). All descriptions were coded by a trained researcher, and another trained researcher separately coded a randomly selected 25% of all transcripts; inter-rater reliability was κ = .85. Participants received scores for each category as a percentage of the total number of descriptions produced in order to control for the amount written (See Table 3.2). Scores for mind-minded descriptions indexed participants' mind-mindedness in relation to their close friends, and scores for physical descriptions were selected to index participants' knowledge of their friends that did not emphasise internal states

**4.2.2.2. Resting-State Acquisition.**

Structural and functional data were acquired using a 3T GE HDx Excite MRI scanner utilising an eight-channel phased array head coil (GE) tuned to 127.4 MHz, at the York Neuroimaging Centre, University of York. Structural MRI acquisition in all participants was based on a T1-weighted 3D fast spoiled gradient echo sequence (TR = 7.8 s, TE = minimum full, flip angle= 20°, matrix size = 256 x 256, 176 slices, voxel size = 1.13 x 1.13 x 1 mm). Resting-state activity was recorded from the whole brain using single-shot 2D gradient-echo-planar imaging (TR = 3 s, TE = minimum full, flip angle = 90°, matrix size = 64 x 64, 60 slices, voxel size = 3 x 3 x 3 $mm^3$, 180 volumes). Participants viewed a fixation cross with eyes open for the durations of the functional MRI resting state scan. A FLAIR scan with the same orientation as the functional scans was collected to improve co-registration between subject-specific structural and functional scans.

**4.2.2.3. Resting-State fMRI Analysis.**

Seed regions were networks defined by Yeo et al. (2011, see Figure 4.1). In order to assess a wide variety of connectivity networks associated with higher-order cognitive functions, networks 3-7 were specifically chosen as seed regions in the analysis. These networks included: 3 – the dorsal attention network, 4 – the ventral attention network, 5 – the limbic network, 6 – the fronto-parietal network and 7 – the default mode network. Networks

1 and 2 (the visual and somatomotor networks) were not included as seed regions, due to their association with the processing of largely lower-order, unimodal sensory representations.

Figure 4.1. Yeo Parcellation of Resting-State Brain Networks.

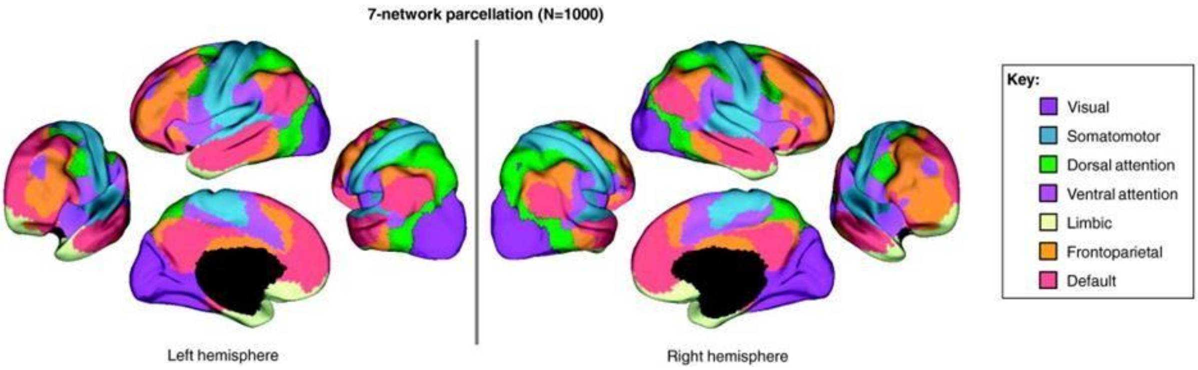


*Figure 4.1. The 7-sections liberal functional parcellation of resting-state brain networks. The 7 networks and their associated colours are 1) Visual (dark purple), 2) Somatomotor (blue), 3) Dorsal Attention (green), 4) Ventral Attention (light purple), 5) Limbic (White), 6) Fronto-parietal (orange) and 7) Default Mode Network (pink). Networks 3-7 are utilised as seed regions for the analysis.*

Functional and structural data were pre-processed and analysed using FMRIB's Software Library (FSL version 4.1, http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FEAT/; Jenkinson, Beckmann, Behrens, Woolrich, & Smith, 2012). Individual FLAIR and T1 weighted structural brain images were extracted using BET (Brain Extraction Tool). Structural images were linearly registered to the MNI-152 template using FMRIB's Linear Image Registration Tool (FLIRT). The resting state functional data were pre-processed and analysed using the FMRI Expert Analysis Tool (FEAT). The individual subject analysis involved: motion correction using MCFLIRT; slice-timing correction using Fourier space time-series phase-shifting; spatial smoothing using a Gaussian kernel of FWHM 6mm; grand-mean intensity normalisation of the entire 4D dataset by a single multiplicative factor; highpass temporal filtering (Gaussian-weighted least-squares straight line fitting, with sigma = 100 s); Gaussian lowpass temporal filtering, with sigma = 2.8s.

We extracted the time series from each of the masks and used these as explanatory variables in a functional connectivity analysis. In each analysis, we utilised a grey matter mask in MNI space to restrict our search from areas of white matter or CSF.

To control for multiple comparisons across the five seed network models investigated, we used a cluster forming threshold of $Z = 2.6$ and controlled our Type I error rate at an alpha value of $p < .01$ (controlling for the 5 models we tested in this experiment). For each model we explored patterns of functional connectivity that were associated with high levels of mind-minded descriptions, high levels of physical descriptions, and the interactions between both types of description. We uploaded unthresholded maps from our analyses onto Neurosynth (Yarkoni et al., 2011) at the following URL: http://neurovault.org/collections/1681/.

**4.3. Results**

Our analysis examines the relation between mind-mindedness and patterns of intrinsic functional connectivity. We related connectivity patterns of our seed regions to variation in different describe-a-friend response categories. For the purposes of the present study, the describe-a-friend mind-minded description category was utilised as the primary measure of mind-mindedness, with the physical description category being implemented as a control comparison since it describe pertinent features of the individual but that do not emphasise internal states (See Chapter 3, Table 3.2 for mean proportional and frequency scores on the DAF task). Due to non-normal data distribution we divided participants into groups based on whether they were above or below the median for both mind-minded and physical descriptions. This yielded four groups: low mental/low physical, low mental/high physical, high mental/low physical, and high mental/high physical.

Analysis revealed significant connectivity variance in the FPN. Group connectivity for the fronto-parietal seed region is displayed in Figure 4.2. Analysis revealed a significant increase in connectivity between the FPN and the pCC associated with lower levels of mind-minded descriptions on the describe-a-friend task (Cluster size – 737 contiguous voxels), $p$ (uncorrected) = .008 (see Figure 4.2). Extracted contrasts of parameter estimates (COPEs) revealed that mean connectivity between the pCC and the fronto-parietal network for individuals who demonstrated greater levels of mind-mindedness was significantly lower (Mean = -.22, SE = .03) than individuals with lower levels of mind-mindedness (Mean = -.04, SE = .03). Further analysis revealed no clusters showing significant connectivity variance in the Dorsal Attention Network, $p > .05$, ns. Also, no significant connectivity variance in the Ventral Attention Network was detected, $p > .05$, ns. No significant connectivity variance was detected in the Limbic Network, $p > .05$, ns. Lastly, no significant connectivity variance was detected in the DMN, $p > .05$, ns.

Figure 4.2. rFMRI Results.

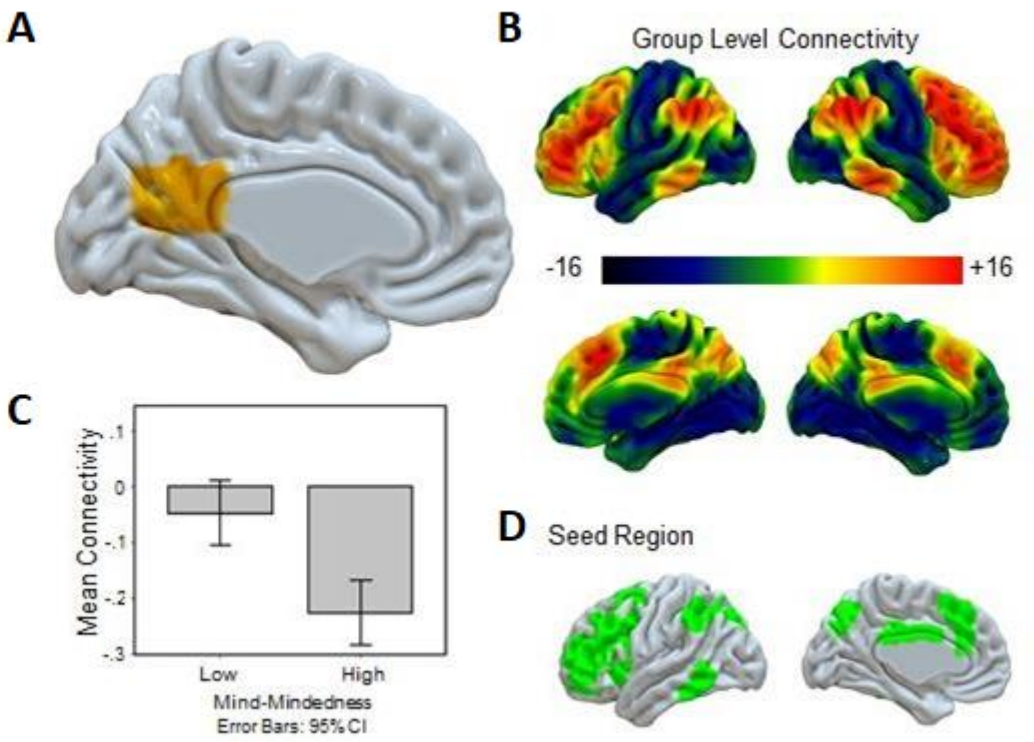


*Figure 4.2. A: The pCC cluster identified as having significantly decreased connectivity with the fronto-parietal network for more mind-minded individuals. B: Group level connectivity maps for the unthresholded pCC cluster seeded in the independent dataset of 140 participants (Nooner et al., 2012). C:Mean connectivity levels for COPEs extracted from the pCC cluster shown across lower and higher levels of mind-mindedness. D: A map of the fronto-parietal seed network showing decreased connectivity with pCC for more mind- minded individuals.*

As our mind-mindedness groups were organized into binarised groups, we performed a supplementary analysis in which we investigated the extent to which the relation between levels of mind-mindedness and fronto-parietal/pCC connectivity levels are continuous. This was performed in order to ascertain whether the binarised mental and physical groups conveyed an accurate representation of the range of scores on the DAF. We divided the describe-a-friend mind-minded and physical description categories into four groups each, displaying quartiles of response ranges, made-up of equal percentiles of responses in each group (labelled ‘first quartile’ to ‘fourth quartile’ from lowest-to-highest). A univariate ANOVA was performed with extracted COPES from the identified pCC cluster being entered as a dependent variable and the mental and physical language quartile groups entered as fixed factors. A significant relation was again observed between mind-minded descriptions and mean COPE levels, $F$ (3, 142) = 3.86, $p$ = .011 $\eta_p^2$ = .075. No significant relationship was observed between physical descriptions and mean COPE levels, $p$ > .05, ns. No significant interaction effect was observed between mind-minded descriptions, physical descriptions, and mean COPE levels, $p$ > .05, ns. Comparison of the first and second quartiles of the mind- minded category, t (78) = .046, $p$ = .964, ns, and the third and fourth quartiles t (75) = -.236, $p$ = .814, ns, revealed no significant differences (see Figure 4.3). This analysis suggests that the relation between levels of mind-mindedness and fronto-parietal/pCC connectivity levels is not continuous in nature. Given these results it is possible to see that DAF scores for mental and physical language use possess a threshold around the median range where scores diverge, indicating that our choice to collapse the DAF variables into binarised groups did not lead to any misrepresentation or misshaping of the dataset resulting in data loss.

Figure 4.3.Connectivity Levels for Extracted COPEs.

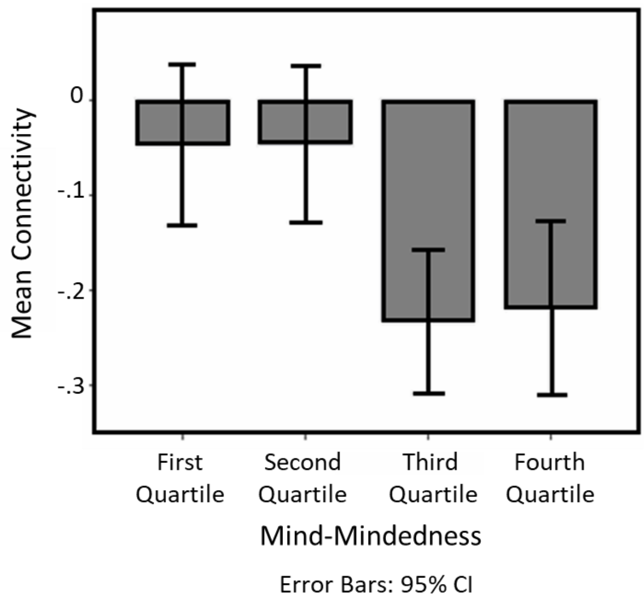


*Figure 4.3. Mean connectivity levels for COPEs extracted from the pCC cluster shown across levels of mind-mindedness spilt into quartiles.*

To determine the functional associations of the map linking the pattern of anti-correlation between the FPN and the pCC, we performed a formal meta-analytic decoding using Neurosynth. A list of most-associated terms was assembled with repetitions and references to non-cognitive phenomena removed. The results of this are reflected in the word cloud (see Figure 4.4), which indicates that the strongest associations were made between terms such as ‘memory’ and ‘social cognition’. This pattern is consistent with the hypothesised importance of social and memory processes in mind-mindedness.

Figure 4.4. Neurosynth Meta-Analysis for pCC Cluster.

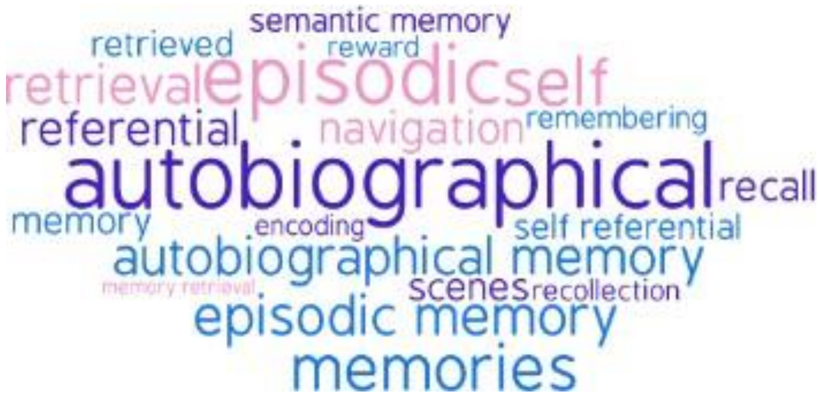


*Figure 4.4. Weighted word cloud of the 20 most commonly associated terms for the pCC cluster. Repeated terms and non-cognitive phenomena have been removed.*

**4.4. Discussion**

The results of the current study demonstrate a pattern of intrinsic brain organisation that is associated with mind-mindedness. Participants who spontaneously focus on mental and emotional characteristics when describing their close personal friends exhibited stronger decoupling between the fronto-parietal network and the medial parietal core of the default mode network (DMN) in the posterior cingulate cortex (pCC). The pCC is regarded as a central hub that can integrate signals from multiple different regions of cortex, including the FPN (Margulies et al., 2016; Leech, Braga, & Sharp, 2012; Miao, Wu, Li, Chen, & Yao, 2011; Fransson & Marrelec, 2008). Our data suggest that at rest, regions of fronto-parietal cortex tend not to be integrated into the DMN for people high on mind-mindedness.

Our observation suggesting that patterns of pCC integration are important in mind-mindedness is consistent with a large literature implicating this and other regions of the DMN in social cognition (see for example Schilbach et al., 2008). A key component of social cognition is mentalisation, the ability to interpret the mental states of other people (Frith & Frith, 2003). A meta-analysis carried-out by Fox, Spreng, Ellamil, Andrews-Hanna and Christoff (2015) highlighted several regions of the DMN recruited during tests of individuals' capacity to mentalise, including the posterior cingulate cortex, the medial prefrontal cortex, and the angular gyri. Mentalisation serves as a prime example of a social cognitive faculty which depends not only on attention to the external world, but a reliance on self-generated thought. As individuals cannot directly observe the thoughts of others, mentalisation requires the manipulation of internally-represented mental models of other people over time, independent of immediate external stimuli (Liberman, 2007). The pCC in particular has recently been shown to facilitate the encoding of narratives about complex events into memory (Bird et al., 2015), highlighting the importance of the pCC in the creation and maintenance of mental models and memories that would be important to understand events. Our findings build on these studies by illustrating how individual variation in levels of mind-mindedness depends on segregating the DMN connectivity from systems that are naturally important in performing complex goal orientated tasks in the here and now (Duncan, 2010).

Also of interest are our findings indicating that decreased connectivity between the FPN and pCC is associated with greater levels of mind-mindedness. Previous studies have highlighted the role of independent and interdependent self construals in how we view our relational closeness with others (Markus and Kitayama, 1991). Individuals with an independent self-construal, more prevalent in Western cultures (Markus and Kitayama, 2010, 1991), perceive that the self is separate from other people. In contrast, individuals with an interdependent self-construal, which is more prevalent in East Asian cultures (Markus and Kitayama, 1991, 2010), perceive that the self is connected with significant others. The FPN, and specifically its relationship to the DMN, has been observed to be influential in processing information related to an independent self construal. Research conducted by Li et al. (2018) showed that decreased connectivity between the FPN and the DMN is associated with the processing of interdependent self construals, emphasising the closeness of relationships with others. Therefore, as mind-mindedness appears to arise as a quality of close relationships (Meins, Fernyhough and Harris-Waller, 2014) it is feasible that the decreased FPN-pCC connectivity we observe as being related to higher levels of mind-

mindedness is at least in part due to the nature of mind-mindedness as processing information about others with whom we have close relationships.

Further research also links mPFC functioning with the wider DMN in order to produce multiple facets of social cognition. Li, Mai and Liu (2014) have demonstrated that the mPFC plays a key role in the social understanding of others, with sub-regions of the mPFC contributing differently to social-cognitive processing according to their role in different sub-systems of the DMN. The ventral mPFC connects with limbic and emotional processing regions, and assists with emotional engagement during social interactions. The anterior mPFC extends connections into posterior and anterior cingulate cortex architecture and is associated with self-other distinction. The dorsal mPFC has been shown to connect with the TPJ, primarily being associated with the understanding of the mental states of others. Li et al. (2014) suggest that this reflects the transfer of information processing from automatic or implicit cognitive processes to explicit cognitive processes, with social interactions of increased complexity.

A meta-analysis conducted by Mar (2011) has implicated a ‘mentalising network’ composed of the mPFC, pCC and bilateral TPJ in the encoding of the perspectives of other people when processing the narratives of stories. When considered alongside the findings of Bird et al. (2015), observing the role of the pCC in the encoding of narratives for complex event sequences, evidence suggests that the relationship between the mPFC and pCC appears to function as a major channel of information processing for the complex and dynamic event sequences experienced during social interactions. Altogether, these results indicate the importance of variance in connectivity levels between multiple sub-regions of the mPFC and various hubs of DMN connectivity in social-cognitive processing, and accords with the findings of the present study by providing further evidence for the mPFC and pCC as key contributors towards mind-mindedness.

Based on the results of our meta-analytic decoding (see Figure 4.4), it seems likely that the observed decoupling of the pCC from the FPN that is heightened in highly mind-minded individuals reflects the role that memory processes play in spontaneous forms of social cognition. The ability to make sense of another person's behaviour depends crucially on the capacity to place their behaviour in the appropriate context, and this in turn depends on our prior experience of the individual. As noted previously, research has shown that pCC-FPN decoupling is characteristic of the mind-wandering state (Raichle et al., 2001) in which social cognitive processes and thoughts about our experiences with other people play a prominent role (Engert et al., 2014). Our study suggests that mind-minded individuals show greater levels of this decoupling at rest. In this way, our study provides novel neurocognitive evidence that mind-mindedness, and likely other aspects of social cognition, is supported by memories of previous experiences and interactions we have gained through our lives.

Consistent with this view, the DMN has been linked to both the engagement of semantic memory (Binder, Desai, Graves, & Conant, 2009) and episodic memory (Vilburg and Rugg, 2012), and so it is an open question whether the pattern of neural organization we observed in our experiment reflects the role of general social knowledge, or episodic knowledge of specific individuals. In either case, our data suggest that memory plays an important role in mind-mindedness, and that this is likely to be supported by functional segregation between the DMN and the FPN. We speculate that this may correspond to a pattern of cognition in which memories regarding personally familiar individuals are activated in an automatic manner, a mechanism which could explain the spontaneous manner with which individuals high on mind-mindedness retrieve information about their friends.

**4.5. Conclusions**

In closing, it is worth considering the possibility that the pattern of connectivity we observe reflects the thoughts that participants experienced at rest. Recent work investigating the content of thoughts experienced in the resting state highlights the fact that a significant portion of these experiences involve thoughts about other people (Medea et al., 2016;

Smallwood et al., 2016; Ruby et al., 2013), suggesting that a consistent proportion of the thoughts that occupy our minds during the resting state may reflect a form of social cognition. Moreover, individuals who experience a greater prevalence of spontaneous social thoughts have been shown to exhibit greater proficiency at generating solutions to social problems (Ruby et al, 2013). Consistent with this view, prior studies have shown that the same region of pCC as we identified was linked to mind mindedness is more connected to regions in the temporal lobe at rest for participants who engage in high levels of spontaneous thoughts regarding other people, places, and times (Smallwood et al., 2016). Together, these lines of converging evidence suggest that one reason why we see a pattern of functional decoupling between the posterior cingulate cortex and the FPN at rest may be because this pattern of neural activity is linked to the expression of particular types of socially guided thoughts at rest that individuals with greater ratings for mind-mindedness produce.

# Chapter 5

# General Discussion

## 5.1. Overview

The experiments conducted during the course of this research revealed both constituent cognitive processes relating to mind-mindedness and the underlying neural processes involved associated with it as a form of higher-order cognition. Regarding the behavioural work conducted in Studies 1 and 2, the overall goal of this thesis was to create a battery of measures that captured variance in some cognitive process related to mind-mindedness, as a correlate or component process. This was performed with an end goal of triangulating and identifying sub-processes enabling and contributing towards some part of mind-mindedness. Regarding the neuroimaging work conducted in Study 3, the major aim was to utilise resting-state fMRI (rfMRI) to provide insight into the large-scale connectivity networks that constitute mind-mindedness. Together, the experiments performed in Studies 1 and 2 aimed to capture various aspects of cognition that might be involved with mind-mindedness, social interaction and memory, and to use this knowledge to guide our subsequent search for the neural correlates of mind-mindedness. The end goal of this aim was to explore whether it was possible to produce a component-process model of mind-mindedness that incorporates both psychological and neural processes.

Initial findings from Study 1 revealed a link between mind mindedness and increased rates of memory recall for narratives containing social information. This trend was present when participants were denied the opportunity for mental rehearsal of the narratives contained in the video clips. These findings suggest that mind-mindedness is dependent upon a capacity for the effective encoding and retrieval of event sequences in memory. Accordingly, Study 1 addresses and fulfils the first major goal of the thesis by identifying a link between memory and mind-mindedness.

Likewise, Study 2 investigated the potential link between mind-mindedness and a variety of clinical and questionnaire measures, and also examined the relationship between mind-mindedness and recognition memory for associations made between two referents (Self and Lady Gaga) and a control condition (Syllables) of the SRT respectively (de Caso et al., 2017). Study 2 worked to further elaborate upon the link between mind-mindedness and memory for social information previously established in Study 1. The primary aim of Study 2 was to ascertain whether mind-mindedness is linked specifically with episodic memories and knowledge about a person based on personal interactions, allowing for the utilisation of this information to inform the subsequent search for the neural correlates of mind-mindedness. The retrieval of this information allowed for an informed interpretation of neuroimaging results regarding areas revealed that might demonstrate common functional overlap between mind-mindedness, memory processes or other revealed behavioural correlates of the construct.

Study 2 revealed a link between mind-mindedness, heightened levels of rumination and daydreaming, and provided further evidence for the relational nature of mind-mindedness through demonstrating the absence of a relationship between mind-mindedness and descriptions of personally unknown others (Lady Gaga). The findings of Study 2 address the first goal of this thesis by demonstrating a behavioural link between rumination (a process associated with past-oriented thinking) and mind-mindedness and also demonstrating a connection between mind-mindedness and episodic memory. These findings suggest that episodic memory, as a processing stream for the encoding, storage and recall of scenes and events, is an important component of mind-mindedness. This association provides evidence that mind-mindedness may possess some common functional architecture with episodic memory processes in the brain.

Lastly, Study 3 sought to utilise fMRI methods to directly compare levels of mind-mindedness against variance in large-scale network connectivity in the resting brain with a view to addressing the second major goal of this thesis – exploring correlates of mind-

mindedness within individuals on a neural level. Study 3 revealed increased negative connectivity between the pCC and the FPN in the resting brain for individuals scoring higher in mind-mindedness. The pCC is often associated with both the emergence of spontaneous thought (Poerio et al., 2017) and the encoding of event sequences to memory (Bird et al., 2015). Therefore, finding that this area holds a connection with mind-mindedness fulfils the ambition of this thesis to provide evidence for components of mind-mindedness on both a behavioural and neural level by identifying common neural networks involved with the production of both a theorised component of mind-mindedness (episodic memory) and mind-mindedness itself. Study 3 fulfils the second major aim of this thesis directly by evidencing for the first time a large-scale functional connectivity pattern in the brain associated with levels of mind-mindedness within the individual.

**5.2. Findings from Study 1**

The results of Study 1 revealed a link between our social relationships with others and how we encode and retrieve information from memory. Interestingly, the link between mind-mindedness and memory established by the results of Study 1 appears to emphasise the encoding of social information into memory when forming narrative sequences about events. Although individuals scoring lower in mind-mindedness received an expected benefit to video clip recall, individuals more inclined to describe their friends in terms of mental characteristics demonstrated an overall benefit in recalling clips portraying human social interactions when no opportunity for rehearsal was granted. More mind-minded individuals therefore appear to be naturally adept at encoding the narrative structure of social interactions into memory.

These findings also demonstrate that mind-minded individuals appear to possess an implicit bias towards focusing on socially-relevant information when forming narratives about events. Participants who scored higher for mental language use of the DAF task demonstrated bias towards the encoding of social information as they viewed video clips, which was subsequently more readily available for retrieval in the absence of any opportunity for mental rehearsal of the information. This evidence suggests that mind-mindedness may arise from automatic learned responses, allowing spontaneous focus on social contexts and signals to influence the manner in which narratives are stored in memory (Amodio & Ratner, 2011). This type of implicit learning experienced during social interactions may in part explain why mind-minded individuals demonstrate an unconscious bias towards focus on mental states when interpreting the behaviour of other people.

Seen in this light, greater level of attention given to mental characteristics during the DAF task arguably provides a more readily available series of schemata (DiMaggio, 1997) for interpreting social phenomena and incorporating this information into memory. Bird et al. (2015) observed that the mental rehearsal of complex event sequences recruits the posterior cingulate cortex to assist in the consolidation of a narrative structure for those event sequences in memory. The posterior cingulate cortex therefore maintains a strong functional connection to the hippocampus and has also been observed to share a large amount of functional network with areas commonly recruited in measures of social cognitive ability, including the medial prefrontal cortex and the temporo-parietal junction (Frith, 2007). For more mind-minded individuals, the posterior cingulate may serve as a gatekeeper regulating the processing of information between these brain regions, allowing for a focus on social/mental information as the notable events transferred into memory. A neural network with such an arrangement would explain the link between heightened emphasis on mental qualities in a narrative produced about another person during the DAF task, fixation on social/mental cues and a subsequent benefit to recall even with limited opportunity for mental rehearsal.

Also noteworthy was our initial finding that individuals who scored higher in terms of their use of physical language when describing their friends during the DAF task had an overall greater memory for clips portraying human interaction in the SMT. It has been observed that recognition memory for objects facilitates the encoding of events into long-term memory stores through allowing the integration of location and recency information (Barker, Bird, Alexander, & Warburton, 2007). Keogh and Pearson (2011) have also shown that stronger mental imagery results in a more effective visual working memory. Accordingly, it may be the case that a tendency to fixate on the physical or visual features of a target as reflected by higher scores for physical language use on the DAF assisted recognition for human clips compared to animal clips due to the former possessing a greater number of recognisable objects such as clothing, furniture and props. Together, the findings of Study 1 highlight the importance of disparate cognitive processes, including memory and attention, working together in concert as common components producing the higher-order function of mind-mindedness necessary for the processing of complex social event-sequences.

**5.3. Findings from Study 2**

Having established a relation between functional memory systems and mind-mindedness in the first study, Study 2 further elaborates upon these findings by allowing us to investigate the relations between mind-mindedness and recognition memory for terms associated with either ‘self’ or ‘others’ in order to investigate whether  the expression of mind-mindedness may be generalised to include all ‘others’, both known and unknown, or whether it is dependent on closer relationships with known others in a manner proposed by Meins, Fernyhough and Harris-Waller, 2014). High levels of mind- mindedness were not associated with better recognition for targets encoded with reference to Lady Gaga. Also, no relationship was observed between mind-mindedness and memory for information that was encoded explicitly (in the paired associates task), or associated with the self, or through its phonological structure. Combining these findings with the previous study performed, showing a link between higher mind-mindedness and increased rates for the correct recognition of video clips containing human interactions, evidence suggests that mind-

mindedness consists in part of an increased tendency to encode socially-relevant information into long-term episodic memory, and to then drawn-upon it at a later point in time when forming narratives about the mental states and processes of others (Lieberman, 2007). Also, evidence suggests that individuals are also more likely to draw-upon these stored representations of the mental states of others when trying to form narratives or interpret the behaviour of close others, with whom we have commonly interacted, in a manner similar to that proposed by Meins et al. (2014).

The evidence gathered suggesting that mind-mindedness is partly dependent on episodic memories of shared interactions with another individual and does not constitute a general trait-like tendency to assign mental states to others, further suggests that the quality of the closeness of relationships allows for the emergence of mind-minded thought and behaviour. Heerey and Velani (2010) have shown that the level of personal liking held for another individual is predictive of the ability to understand their behaviour using nonverbal social cues. Hudson, Nijboer and Jellema (2012) have further provided evidence that positive social interactions facilitate the process of implicit social learning, and subsequently allow for greater proficiency in predicting the behaviour of other people. Accordingly, close interpersonal relationships may provide an ideal setting in which mind-mindedness may develop, arising as a spontaneous tendency to mentalise during social interactions or when thinking about close others.

Furthermore, findings from Study 2 show an association between mind- mindedness and measures of wellbeing; the tendency to ruminate and daydreaming frequency. Rumination, as a process involving recurring involuntary or spontaneous fixation on memories of past experiences (Poerio, Totterdell, & Miles, 2013), being associated with higher levels of mind-mindedness provides further evidence of a link between mind-mindedness, memory processes and spontaneous thought processes. Research also demonstrates that experiences of mind-wandering during the resting state involve frequent reference to social factors and other people (Ruby et al., 2013; Engert et al., 2014), consistent with the finding of Study 2 that daydreaming or mind-wandering is associated with increased tendency to spontaneous mentalise on the DAF task. The findings of this section of analyses for Study 2 together provide evidence for a link between mind-mindedness and increased tendency to engage in mind-wandering or spontaneous thought processes.

Together these results suggest that mind-mindedness is dependent upon a dynamic network of spontaneous thought and memory processes and that this form of applied social cognition is related to measurable outcomes of cognitive behaviour with real consequences for our socio-developmental trajectory. The finding of a link between greater levels of mind-mindedness on the DAF task and higher scores for rumination on the ruminative responses scale (RRS) elucidates the essential nature of mind-mindedness as a sophisticated social problem-solving process. Rumination is classified as a form of spontaneous thought-processing involving repeated attention being directed to the achievement of goals (Watkins, 2008). Although rumination is often considered a maladaptive tendency, associated with negative outcomes, Ciarocco, Vohs, and Baumeister (2010) have observed that the experience of rumination can lead to beneficial ends and may serve, in certain contexts, an adaptive purpose. They found that task-focused thinking after a perceived failure (ruminating about a negative experience in social interaction, for example) facilitates later task performance. Observed in this light, rumination serves as a spontaneous method of rehearsal about the negative aspects of a memory in order to avoid similar circumstances. (Kuo et al., 2012) have shown that rumination facilitates the encoding of negative experiences to memory, demonstrating the role of ruminative thought-processes in placing a particular emphasis on the manner in which events are segmented into memory in a manner similar to mind-mindedness. Mind-mindedness operates as a spontaneous form of social cognition arising out of an observation of, or recall of, social information about another person based upon previous interactions held with them (Meins, Fernyhough, Fradley, & Tuckey, 2001).

The previous findings of Study 1 also reveal the role of mind-mindedness in encoding social events to memory. Both mind-mindedness and rumination therefore appear to possess many common features in the manner in which they process information in the brain, however they serve to facilitate social relationships and task/goal-oriented behaviour respectively. Interestingly, although mind-mindedness is often treated as a universal positive in understanding the aims and intentions of others, having access to knowledge about the internal states of others brings with it not only predictive ability in social scenarios, but also an internalised knowledge of the thoughts and feelings of those we care about. Seeing that mind-minded individuals possess an increased tendency to ruminate suggests that access to this information about mental states, while beneficial in cementing social relationships, may bring with it greater attention to subtle social cues and accordingly, greater volumes of potential fuel for rumination when social interactions may not always be positive in nature. Although higher scores for mind-mindedness are generally considered positive, it may be possible that certain high levels of mind-mindedness are more pathological. Investigating in greater detail the actual content of mind-minded descriptions on the DAF task to establish whether they appear to portray social anxiety, paranoia, or other potentially pathological features may be an interesting avenue for future research.

**5.4. Findings from Study 3**

The results of Study 3 provide us for the first time with a perspective of the functioning of the neural networks underlying mind-mindedness on an individual basis, as informed by the resting-state neuroimaging data gathered and compared against variance in propensity towards spontaneous mental language use. A stronger negative correlation was observed between the fronto-parietal network (FPN) and the medial-parietal core of the default-mode network, the posterior cingulate cortex (pCC), associated with higher scores for mind-mindedness in the DAF task. Both the FPN and the pCC are evidenced to perform roles crucial to the tasks of attention and memory, and therefore are recruited in a variety of contexts including social cognition. The nature of the relationship between the FPN and pCC as exhibiting a greater level of resting ‘disconnection’ for mind-minded individuals also describes an interesting picture of mind-mindedness and how its underlying neuro-functional make-up reflects aspects of the typical resting brain.

The FPN forms a network involved in the selection of sensory contents and attenuation towards relevant environmental stimuli (Ptak, 2012). Regions of the dorsal frontoparietal network have also been proposed to engage in a variety of roles involving working memory and related mental processes, such as spatial attention and motor planning (Ptak, Schnider, & Fellrath, 2017). Although mind-mindedness entails the processing of abstract mental states and has no direct relation to concepts such as spatial awareness and other such kinematic phenomena, the ability to shift attention towards external stimuli, such as social cues and expressions, plays a fundamental role in constituting the ability to attenuate towards the mental states of others. Attentional control and direction coordinated by frontoparietal network activity therefore serves as a necessary precondition for effective mind-mindedness. Likewise, the pCC is implicated in facilitating aspects of cognition pertinent as necessary components of mind-mindedness. The pCC is regarded as a central hub integrating signals from multiple different regions of cortex, including the FPN (Margulies et al., 2016; Leech, et al., 2012; Miao, Wu, Li, Chen, & Yao, 2011; Fransson & Marrelec, 2008). The pCC also serves as the central processor for the default mode network, a brain network spanning a great deal of neural architecture involved in mentalisation (Fox et al., 2015), another essential cognitive subcomponent of mind-mindedness providing the ability to access encoded information about the mental states of other people across time (Liberman, 2007). The pCC itself has been shown to facilitate the encoding of narratives about complex events such as social interactions into memory (Bird et al., 2015), highlighting the importance of the pCC in the creation and maintenance of mental models and memories recruited during mentalisation as part of the application of mind-mindedness on the DAF task. Findings from the meta-analytic decoding performed by entering the revealed pCC cluster into Neurosynth (Yarkoni et al., 2011) to search for associated terms was also revealing of the link between the pCC and memory for social information. A list of most-associated terms was assembled with repetitions and references to non-cognitive phenomena removed, indicating that the strongest associations were made between terms such as 'memory' and 'social cognition'. These findings support the view that social and memory processes are important aspects of mind-mindedness.

Interestingly, the pattern of neuroimaging results obtained for more mind-minded individuals in the third study presents an exaggerated form of the connectivity relations observed between the DMN and the FPN in the resting brain. Previous studies have suggested that competitive relationships between the DMN and the FPN are intrinsically represented in the brain in the form of strong anti-correlations between spontaneous fluctuations in these networks (Uddin, Kelley, Biswal, Castellanos, & Milham, 2009) in a state known as 'perceptual decoupling' (Schooler, Smallwood, Christoff, Handy, Reichle, & Sayette, 2011). This relationship is typical of the resting-state of the brain, when no focus or engagement is given to an external task. The DMN, with central hubs such as the pCC exhibiting heightened activity during rest (Luo, Kong, Qi, You, & Huang, 2015), possesses functional overlap with many of the brain regions involved in social cognition (Mars et al., 2012). Social-cognitive problem-solving involving thinking about others, past interactions and future predictions have also been suggested to consist of a large part of the processing performed during the resting state (Schilbach et al., 2008). Recent research demonstrates that experiences of mind-wandering during the resting state often involve thoughts about the past and other people (Ruby et al., 2013; Engert et al., 2014), consistent with the view that social cognition is a major component of the thought processes performed during the resting state. The neuroimaging data gathered during the course of this study demonstrate that individuals scoring higher for mind-mindedness display an exaggerated form of this resting-state network connectivity, with a stronger anti-correlation between the pCC and FPN during states of rest. Given that in general this perceptual decoupling arising from interaction between the DMN and FPN is associated with a greater frequency of spontaneously-experienced social thinking, it is entirely plausible that the stronger levels of anti-correlation between the FPN and pCC observed in mind-minded individuals represent a greater general flexibility in attending to non-immediate information. This non-immediate information consisting of, in the case of mind-mindedness, episodic memories of others assisting in the formation of narratives about the social events around them and mental models of the social agents encountered.

**5.5. Limitations**

It is appropriate to acknowledge some of the methodological limitations of the studies performed and discuss how these limitations informed the structure and design of each subsequent experiment and the bearing they have on the interpretation of the experimental results gathered. One example of this would be the choice to split our continuous variables from the DAF task into binarised groups of 'high' and 'low' scores for both mental language and physical language categories. In undertaking this approach, the decision was made to simplify the dataset in collapsing the variables in order to explore mind-mindedness in a more in-depth manner and analyse results in line with a comparison of means. Mind-mindedness, as a form of higher-order cognition, is a complex construct with multiple contributing lower- order components. Accordingly, by fitting our mental language and physical language variables to median-split groups, we gained the ability to compare means across mental and physical language groups by performing analysis of variance enabling us to see potential interaction effects. One example of where this approach was deemed necessary was with our initial experiment, concerned with the link between mind-mindedness and memory. It is entirely possible that memory for social clips shown in the experiment could be modulated by memory for objects, or other physical or non-social information. Being able to observe any potential interaction between mental and physical language groups in response to experimental conditions was therefore deemed appropriate at the expense of possessing continuous data.

As a sanity-check, during Study 3 we performed a supplementary analysis in which we investigated the extent to which the relation between levels of mind-mindedness and fronto-parietal/pCC connectivity levels were continuous. The describe-a-friend mind-minded and physical description categories were separated into four groups each, displaying quartiles of response ranges, made-up of equal percentiles of responses in each group (labelled 'first quartile' to 'fourth quartile' from lowest-to-highest). A univariate ANOVA was performed with extracted COPES from the identified pCC cluster being entered as a dependent variable and the mental and physical language quartile groups entered as fixed factors. Comparison of the first and second quartiles of the mind-minded category and the third and fourth quartiles revealed no significant differences. This suggests that the relation between levels of mind-mindedness and fronto-parietal/pCC connectivity levels are not continuous in nature, instead possessing a threshold around the median range where scores diverge, indicating that our choice to collapse the DAF variables into binarised groups did not lead to any significant data-loss or misrepresentation caused by this treatment of the dataset. For all other intents and purposes, correlation analyses were included where appropriate across all three experiments where the continuous nature of the DAF variables was retained.

As mentioned previously, Study 1 carried with it the possibility that memory for social clips shown in the experiment could be modulated by memory for objects, or other physical or non-social information. The term 'recognition memory' has been adopted to describe the occurrence of memory recall facilitated by familiar objects (Barker et al., 2007). The more familiar an object is to an individual, or the more an individual has previous experiences with similar objects, the greater the rate of recall and recognition for memories involving these objects (Norman & O'Reilly, 2003). Therefore, the possibility that the video clips containing human interactions would better facilitate recognition due to their containing various familiar objects such as furniture, props and clothing was noted. However, as discussed previously in the chapter outlining Study 1, results suggest that it may be reasonably inferred that mind- minded individuals possessed an enhanced capacity for encoding the social information displayed in the human video clips, rather than being influenced by the physical objects displayed. As stated previously, mind-mindedness is a tendency towards focus on mental states (Meins, 1997). Accordingly, when considering the finding that heightened mental state language use was related to better proficiency in memory for clips portraying human interactions, along with the relative 'richness' of relatable social interactions contained in the human video clips compared to the animal clips, evidence suggests this is the case.

Study 2 was primarily concerned with triangulating what types of memory associations might be related to mind-mindedness and delving deeper into the memory component aspect of the construct. As such, where the first experiment focuses on analysing forms of episodic memory and event segmentation, the follow-up study also aimed to add a further level of investigation in which a comparison with variance in levels of mind-mindedness with proficiency in recognition memory across a relational gradient on the SRT in a manner similar to that explored by Meins et al. (2014). One notable issue with the use of the Self-reference task however, is that the same conditions of 'best friend', 'famous figure' and 'work of art' are not explored. Therefore, although it is possible to make comparisons between the 'Lady Gaga' and 'famous figure' conditions of the present study and the study conducted by Meins et al. (2014) respectively, the present does not capitalise on exploring the relational nature of mind-mindedness in a manner that allows for direct comparison along multiple stages of this relational gradient. Meins et al. (2014) pointed-out that levels of mind-mindedness are higher in descriptions of close friends, compared with those of famous individuals. Accordingly, adults are most likely to focus on mental characteristics with individuals they have a close personal relationship with and therefore the use of a famous figure instead may limit the degree to which individuals demonstrate mind- mindedness. Accordingly, future research conducted in this area would ideally further adapt the SRT, potentially also including a condition where associations pertaining to a 'Best Friend' were encoded, along with the three Self, Lady Gaga and Syllables conditions. In this way, a more direct parallel would be achieved with the study performed by Meins et al. (2014) and the extent to which mind-mindedness related to memory across all stages of self, a personally-known other, a famous figure and control condition could be assessed. Such a design could further explore the relational nature of mind-mindedness, potentially revealing any effects of mind-mindedness for recognition memory when a personally-known other is utilised as a referent.

A final point to mention here with regard to potential limitations concerns the nature of the neuroimaging study performed. Namely, the use of resting-state fMRI techniques provides a degree of cost weighted against benefit in that this approach does not subscribe to a task-based paradigm. A limitation brought with this approach consists of an inability to directly compare levels of mind-mindedness with associated neural activations in response to a specific task or condition. With regard to results gathered from the previous behavioural studies performed, this results in an inability to directly compare variance in mind-mindedness and changes in levels of neural activation with the recruitment of episodic memory processes during a task-based experimental paradigm. However, two pertinent aspects of mind-mindedness make resting-state fMRI a desirable and appropriate approach to take when investigating the neural components of the construct: the relative complexity of mind-mindedness as a form of higher-order cognition and the spontaneous or non-volitional nature of mind-mindedness as it is naturally employed. As previously mentioned mind-mindedness constitutes a complex social-cognitive process and must therefore rely on a wide and disparate array of brain regions serving as functional subcomponents (Spreng, 2013; Mars et al., 2012). Rather than applying focus on changes in levels of neural activation in a number of isolate brain regions in response to task conditions, resting-state fMRI therefore proves a desirable approach in that changes in connectivity levels across complex networks spanning the entirety of the cortex may be directly compared and contrasted with variance in levels of mind-mindedness.

The nature of mind-mindedness as a spontaneous form of social cognition also makes resting-state fMRI a desirable approach to take when investigating neural activity associated with the construct as any task-based paradigm employed here would not effectively replicate the circumstances in which mind-mindedness is employed. Spreng (2013) discusses how a number of social-cognitive calculations are spontaneously performed in the resting brain, during states of mind-wandering or with no explicit task instructions to follow. Mind-mindedness fits neatly into this category of spontaneous social cognition, being characterised as a focus on mental states without any explicit requirement or instruction to do so. In order to investigate how mind-mindedness utilises these brain networks commonly associated with spontaneous cognition it is therefore appropriate to investigate its neural components in a manner requiring no explicit task, such as resting-state fMRI. Accordingly, although this approach does not enable us to directly compare mind-mindedness against variance in brain activity in response to changing task conditions (such as a test of working memory) it does allow us to more authentically replicate the neural processes involved in spontaneous social cognition.

Although adopting this approach means that no direct comparison with memory processes may be drawn if the results of the neuroimaging study are considered in isolation, we are able to reasonably infer that the neural components of episodic memory are recruited as components of mind-mindedness through evidence gathered from previous work establishing the link between episodic memory and mind mindedness (as with the first two behavioural studies performed). Previous work highlighting the role of the observed significant cluster, the posterior cingulate cortex, in encoding complex event narratives such as social interactions into memory (Bird et al., 2015) also provides strong evidence of a link with memory. Furthermore, the sanity check performed using Neurosynth also strongly associates the posterior cingulate with episodic memory, overall allowing for a rational assertion of this region observed as being involved in the functional make-up of mind-mindedness with memory processes. In order to further investigate the link between mind-mindedness, the pCC and episodic memory, task-based fMRI paradigms further assessing this link may prove a beneficial avenue for future research.

### 5.6. Interpretation of Findings

Taken together, the results of our inquiries into the neural correlates of mind-mindedness provide evidence that mind-mindedness is linked to the way other people are represented in episodic memory, and the extent to which those representations facilitate mind-mindedness is moderated according to the closeness of a relationship. Furthermore, mind-minded individuals possess a stronger than average anti-correlation of functional connectivity between the frontoparietal network and posterior cingulate cortex in the resting brain; a pattern of connectivity associated with engagement of the pCC in tasks related to working memory recall (Piccoli et al., 2015). The results gathered collectively demonstrate the associations between mind-mindedness, spontaneous thought and social cognition at a neural and functional level.

The state of mind-wandering or spontaneous thought, where attention is diverted towards internally-generated stimuli, is characterised by the emergence of the default mode network, with the pCC acting as a central hub (Mason et al., 2007). Both social cognition (in the form of thoughts about other people) and thinking about the past form a consistent component of thoughts experienced during the mind-wandering state (Ruby et al., 2013; Ruby, Smallwood, Engen & Singer, 2013). The pCC, noted for its involvement in the encoding of complex event narratives into long-term memory (Bird et al., 2015) can therefore be proposed to serve as a processing gate abstracted away from immediate memory or 'default mode' networks allowing communication between these two areas of processing, that results in the heightened saliency of socially-relevant information in the mind-wandering state. Interestingly, the fact that the behavioural studies performed point out two features of cognition common to mind-minded individuals, greater efficacy at encoding social information in memory and also a greater propensity towards rumination—links the functioning of the construct to the wider neural foundations for social cognition, memory and spontaneous thought in general. Therefore as rumination serves as an example of past-oriented spontaneous thought (Poerio et al., 2013), which is often associated with a critical appraisal of one's social performance (Zou & Abbott, 2012), it is likely that it shares a considerable degree of overlap in neural circuitry with mind-mindedness. Individuals who are more intuitively aware of subtle social cues and the intentions of others have access to a richer variety of social information which they may use to assess their past actions in social scenarios. Therefore, although mind-mindedness serves to facilitate social interactions by providing a trove of social knowledge with which to contextualise an event, in sharing many neural and behavioural commonalities with rumination, it appears that the outcomes for a mind-minded individual may also bring a risk of fixation on negative social experiences and an increased tendency to ruminate about past interactions.

Crucially, in exploring the components of mind-mindedness, the neuroimaging results show that mind-minded individuals possess a stronger anti-correlation of functional connectivity between the posterior cingulate cortex and the frontoparietal network in the resting brain. This pattern of connectivity is often associated with a load-dependent cognitive processing (Raichle, 2015; Gao & Lin. 2012). Recent work has demonstrated anti-correlation between the pCC and frontoparietal network when engaged in tasks requiring the maintenance and manipulation of working memory contents (Piccoli et al., 2015), and current opinion in the field is that the default mode network communicates with working memory systems via the posterior cingulate's anti-correlation with parietal and prefrontal brain regions in situations requiring access to stimulus-independent thought, such as episodic memories of past interactions, allowing a state of perceptual decoupling (Schooler et al., 2011). Furthermore, Poerio et al. (2017) have pointed out the functional heterogeneity of the DMN and its comprising regions engaged in memory and social planning, suggesting that the wider role of this state of DMN-frontoparietal decoupling is to allow memory representations of previous episodes to become salient and inform conscious experiences and decisions.

Mitchell, Macrae and Banaji (2004) have previously suggested that information from long-term episodic memory stores is integrated into working memory in order to assist in the interpretation of social contexts. The evidence gathered so far appears to suggest that mind-minded individuals are more inclined to encode social information into memory and this may therefore partially account for the increased tendency for individuals to spontaneously utilise more mental state language and assign social and emotional contexts to behaviours. Amodio and Ratner (2011) have also suggested that processes of implicit learning and memory systems interact during social interactions in a manner allowing for the automatic retrieval of previous similar experiences stored in episodic memory in response to certain social cues and contexts. Accordingly, it may be that processes of implicit social learning contribute towards the spontaneous nature of mind-mindedness by encouraging focus on mental states and their implied social consequences, this being accomplished in a manner outside the conscious awareness of individuals.

Such a viewpoint would attest to the relational nature of mind-mindedness by suggesting that the decoupled state allows us to attend to memories of previous social interactions with an individual in order to better facilitate a current interaction. Such a cognitive process would prove invaluable in maintaining long-term close relationships that continue across distance and time, for example. Given that investigation has yielded a clear behavioural connection between mind-mindedness and memory for socially-relevant information, and neuroimaging evidence linking greater levels of mind-mindedness to exaggerated pCC-frontoparietal decoupling, the neural components of mind-mindedness appear to reside in large part with the role of the pCC in encoding events into long-term memory (Bird et al., 2015). Also, the wider role of the pCC as a hub of the DMN appears to contribute towards the production of mind-mindedness through the regulation of its connectivity with the frontoparietal network—modulating the propensity for social-cognition and socially-relevant memories to spontaneously occur.

**5.7. Conclusions**

Over the course of the studies performed, a clear picture has begun to emerge about the cognitive subcomponents associated with mind-mindedness as a form of complex higher- order cognition. Among these components, the results gathered have continually pointed-out an effective episodic memory as an important correlate of mind-mindedness. Alongside a propensity for describing events in terms of their social or mental dynamics, mind-minded individuals have been shown to possess an advantage at encoding events containing human interactions to memory even without the opportunity for mental rehearsal, suggesting that they are intuitively encoding event-sequences in terms of the social information contained therein. Amodio and Ratner (2011) have suggested that implicitly learned associations we form during social interactions can subsequently influence the memories we form about events. It is possible that in such a way mind-minded individuals develop or implicitly acquire a tendency to automatically focus on the mental states of others when encoding to memory the complex event sequences experienced during social interactions.

In terms of the neuroimaging data gathered, an arrangement of resting-state connectivity consisting of stronger anti-correlation between the prefrontal cortex and posterior cingulate is characteristic of more mind-minded individuals. This pattern of connectivity is typical of states of perceptual decoupling, where episodic memories of past events and social calculations constitute a major proportion of the mental processing performed. Accordingly, this stronger level of anti-correlation between the frontoparietal network and the posterior cingulate observed in mind-minded individuals may explain the increased tendency for mind-minded individuals to spontaneously represent interactions with others in terms of their social dynamics. Such a neural configuration may allow for a greater degree of flexibility in attending to information not bound to the present moment, such as memories of past interactions with others, in order to help make sense of complex and dynamic human relationships.

## References

Amodio, D. M., & Ratner, K. G. (2011). A Memory Systems Model of Implicit Social Cognition. *Current Directions in Psychological Science, 20*(3): 143-148. doi: 10.1177/0963721411408562.

Anderson, N. H. (1968). Likableness ratings of 555 personality-trait words. *Journal of Personality and Social Psychology, 9*(3), 272-279. doi: 10.1037/h0025907.

Anisfeld, E. (1982). The onset of social smiling in preterm and full-term infants from two ethnic backgrounds. *Infant Behavior and Development, 5*(2-4): 387-395. doi: 10.1016/S0163-6383(82)80048-9.

Anticevic, A., Repovs, G., Shulman, G. L., & Barch, D. M. (2010). When less is more: TPJ and default network deactivation during encoding predicts working memory performance, *Neuroimage, 49*(3), 2638-2648. doi: 10.1016/j.neuroimage.2009.11.008.

Apperly, I. A. (2012). What is “theory of mind”? Concepts, cognitive processes and individual differences, *The Quarterly Journal of Experimental Psychology, 65*(5): 825-839. doi: 10.1080/17470218.2012.676055.

Assaf, M., Jagannathan, K., Calhoun, V. D., Miller, L., Stevens, M. C., Sahl, R., … Pearlson, G. D. (2010). Abnormal functional connectivity of default mode sub-networks in autism spectrum disorder patients, *Neuroimage, 53*(1): 247-256. doi: 10.1016/j.neuroimage.2010.05.067.

Baddeley, A. (1995). Working memory. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 755-764). Cambridge, MA, US: The MIT Press.

Barge-Schaapveld, D. Q., Nicolson, N. A., Berkhof, J., & de Vries, M. W, (1999). Quality of life in depression: daily life determinants and variability. *Psychiatry research, 88*(3): 173-189. doi: 10.1016/S0165-1781(99)00081-5.

Bargh, J. A., & Pietromonaco, P. (1982). Automatic information processing and social perception: The influence of trait information presented outside of conscious awareness on impression formation. *Journal of Personality and Social Psychology, 43*(3): 437-449. doi: 10.1037/0022-3514.43.3.437.

Barker, G. R., Bird, F., Alexander, V., & Warburton, E. C. (2007). Recognition memory for objects, place, and temporal order: a disconnection analysis of the role of the medial prefrontal cortex and perirhinal cortex. *The journal of neuroscience, 27*(11): 2948- 2957. doi: 10.1523/JNEUROSCI.5289-06.2007.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism- spectrum quotient (AQ): evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of autism and developmental disorders, 31*(1): 5-17. doi: 10.1023/A:1005653411471.

Barreto, A. L., Pasco Fearon, R. M. Osório, A., Meins, E., & Martins, C. (2016). Are adult mentalizing abilities associated with mind-mindedness?, *International Journal of Behavioral Development, 40*(4): 296-301. doi: 10.1177/0165025415616200.

Begeer, S., Bernstein, D. M., Aβfalg, A., Azdad, H., Glasbergen, T., Wierda, M., & Koot, H. M. (2016). Equal egocentric bias in school-aged children with and without autism spectrum disorders. *Journal of Experimental Child Psychology, 144*: 15-26. doi: 10.1016/j.jecp.2015.10.018.

Beier, J. S., & Spelke, E. S. (2012). Infants' Developing Understanding of Social Gaze. *Child Development, 83*(2): 486-496. doi: 10.1111/j.1467-8624.2011.01702.x.

Beike, D. R., Cole, H. E., & Merrick, C. R. (2017). Sharing specific "we" autobiographical memories in close relationships: The role of contact frequency. *Memory, 25*(10): 1425-1434. doi: 10.1080/09658211.2017.1313990.

Bentley, S. V., Greenaway, K. H., & Haslam, S. A. (2017). An online paradigm for exploring the self-reference effect. *PLoS One, 12*(5): e0176611. doi: 10.1371/journal.pone.0176611.

Berman, M. G., Peltier, S., Nee, D. E., Kross, E., Deldin, P. J., & Jonides, J. (2011). Depression, rumination and the default network. *Social cognitive and affective neuroscience*, *6*(5): 545-555. doi: 10.1093/scan/nsq080.

Bernier, A., McMahon, C. A., & Perrier, R. (2017). Maternal mind-mindedness and children’s school readiness: A longitudinal study of developmental processes. *Developmental Psychology, 53*(2): 210-221. doi: 10.1037/dev0000225.

Bigelow, A. E., Power, M., Bulmer, M., & Gerrior, K. (2015). The Relation between Mothers’ Mirroring of Infants’ Behavior and Maternal Mind-Mindedness. *Infancy, 20*(3): 263-282. doi: 10.1111/infa.12079.

Bigelsen, J., Lehrfeld, J. M., Jopp, D. S., & Somer, E. (2016). Maladaptive daydreaming: Evidence for an under-researched mental health disorder. *Consciousness and cognition, 42*: 254-266. doi: 10.1016/j.concog.2016.03.017.

Binder, J., R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where Is the Semantic System? A Critical Review and Meta-Analysis of 120 Functional Neuroimaging Studies. *Cerebral Cortex*, *19*(12): 2767-2796. doi: 10.1093/cercor/bhp055.

Bird, C. M., Keidel, J. L., Ing, L. P., Horner, A. J., & Burgess, N. (2015). Consolidation of complex events via reinstatement in posterior cingulate cortex. *Journal of Neuroscience, 35*(43): 14426-14434. doi: 10.1523/JNEUROSCI.1774-15.201.

Boggia, J., & Ristic, J. (2015). Social event segmentation. *The Quarterly Journal of Experimental Psychology, 68*(4): 731-744. doi: 10.1080/17470218.2014.964738.

Bolden, J., Rapport, M. D., Raiker, J. S., Sarver, D. E., & Kofler, M. J. (2012). Understanding Phonological Memory Deficits in Boys with Attention-Deficit/

Hyperactivity Disorder (ADHD): Dissociation of Short-term Storage and Articulatory Rehearsal Processes. *Journal of Abnormal Child Psychology, 40*(6): 999-1011. doi: 10.1007/s10802-012-9619-6.

Bradford, E. E. F., Jentzsch, I., & Gomez, J-C. (2015). From self to social cognition: theory of mind mechanisms and their relation to executive functioning. *Cognition*, *138*: 21-34. doi: 10.1016/j.cognition.2015.02.001.

Brand, A. N., Jolles, J., & Gispen-de Wied, C. (1992). Recall and recognition memory deficits in depression. *Journal of affective disorders, 25*(1): 77-86. doi: 10.1016/0165-0327(92)90095-N.

Brown, E. C., & Brüne, M. (2012). The role of prediction in social neuroscience. *Frontiers in Human Neuroscience, 6*: 147. doi: 10.3389/fnhum.2012.00147.

Brown, K. W., & Ryan, R. M. (2003). The Benefits of Being Present: Mindfulness and Its Role in Psychological Well-Being. *Journal of Personality and Social Psychology, 84*(4): 822-848. doi: 10.1037/0022-3514.84.4.822.

Centifanti, L. C. M., Meins, E., & Fernyhough, C. (2016). Callous-unemotional traits and impulsivity: distinct longitudinal relations with mind-mindedness and understanding of others. *Journal of Child Psychology and Psychiatry, 57*(1): 84-92. doi: 10.1111/jcpp.12445.

Ciaramelli, E. Bernardi, F., & Moscovitch, M. (2013). Individualized Theory of Mind (iToM): When Memory Modulates Empathy. *Frontiers in Psychology*, *4*: 4. doi: 10.3389/fpsyg.2013.00004.

Ciarocco, N. J., Vohs, K. D., & Baumeister, R. F. (2010). Some Good News About Rumination: Task-Focused Thinking After Failure Facilitates Performance Improvement. *Journal of Social and Clinical Psychology, 29*(10): 1057-1073. doi: 10.1521/jscp.2010.29.10.1057.

Contreras, J. M., Banaji, M. R., & Mitchell, J. P. (2012). Dissociable neural correlates of stereotypes and other forms of semantic knowledge. *Social cognitive and affective neuroscience, 7*(7): 764-770. doi: 10.1093/scan/nsr053.

Cristofori, I., & Levin, H. S. (2015). Chapter 37 – Traumatic brain injury and cognition. In J. Grafman, & Salazar, A. M. (Eds.), *Traumatic Brain Injury, Part II* (pp. 579-611). Amsterdam, Netherlands: Elsevier. doi: 10.1016/B978-0-444-63521-1.00037-6.

Davidson, P. S., Droin, H., Kwan, D., Moscovitch, M., & Rosenbaum, R. S. (2012). Memory as social glue: close interpersonal relationships in amnesiac patients. *Frontiers in Psychology, 3*: 531. doi: 10.3389/fpsyg.2012.00531.

Davis, P. E., Meins, E., & Fernyhough, C. (2014). Children with Imaginary Companions Focus on Mental Characteristics When Describing Their Real-Life Friends. *Infant and Child Development, 23*(6): 622-633. doi: 10.1002/icd.1869.

de Caso, I., Poerio, G. L., Jefferies, E., & Smallwood, J. (2017). That's me in the spotlight: neural basis of individual differences in self-consciousness. *Social Cognitive and Effective Neuroscience, 12*(9): 1384-1393. doi: 10.1093/scan/nsx076.

Dégeilh, F., Bernier, A., LeBlanc, É., Daneault, V., & Beauchamp, M. H. (2018). Quality of maternal behaviour during infancy predicts functional connectivity between default mode network and salience network 9 years later. *Developmental cognitive neuroscience, 34*: 53-62. doi: 10.1016/j.dcn.2018.06.003.

Demers, I., Bernier, A., & Tarabulsy, G. M. (2010). Maternal and child characteristics as antecedents of maternal mind-mindedness, *Infant Mental Health Journal, 31*(1): 94- 112. doi: 10.1002/imhj.20244.

Devine, R. T., & Hughes, C. (2017). Let's Talk: Parent's Mental Talk (Not Mind-mindedness or Mindreading Capacity) Predicts Children's False Belief

Understanding. *Child Development*, doi: 10.1111/cdev.12990.

DiMaggio, P. (1997). Culture and cognition. *Annual Review of Sociology*. *23*: 263–287. doi: 10.1146/annurev.soc.23.1.263.

Duncan, J. (2010). The multiple-demand (MD) system of the primate brain: mental programs for intelligent behaviour. *Trends in Cognitive Sciences, 14*(4): 172-179. doi: 10.1016/j.tics.2010.01.004.

Dunham, Y., Baron, A. S., & Banaji, M. R. (2008). The development of implicit intergroup cognition. *Trends in cognitive sciences, 12*(7): 248-253. doi: 10.1016/j.tics.2008.04.006.

Durbin, K. A., Mitchell, J. P., & Johnson, M. K. (2017). Source memory that encoding was self-referential: the influence of stimulus characteristics. *Memory, 25*(9): 1192-1200. doi: 10.1080/09658211.2017.1282517.

Engert, V., Smallwood, J., & Singer, T. (2014). Mind your thoughts: Associations between self-generated thoughts and stress-induced and baseline levels of cortisol and alpha- amylase. *Biological Psychology, 103*: 283-291. doi: 10.1016/j.biopsycho.2014.10.004.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7*(2): 336-353. doi: 10.1037/1528- 3542.7.2.336.

Fishburn, S., Meins, E., Greenbow, S., Jones, C., Hackett, S., Biehal, N., … Wade, J. (2017). Mind-Mindedness in Parents of Looked-After Children. *Developmental Psychology, 53*(10): 1954-1965. doi: 10.1037/dev0000304.

Fox, K. C. R., Spreng, R. N., Ellamil, M., Andrews-Hanna, J. R., & Christoff, K. (2015). The wandering brain: Meta-analysis of functional neuroimaging studies of mind- wandering and related spontaneous thought processes. *Neuroimage, 111*; 611-621. doi: 10.1016/j.neuroimage.2015.02.039.

Fransson, P., & Marrelec G. (2008). The precuneus/posterior cingulate cortex plays a pivotal role in the default mode network: Evidence from a partial correlation network analysis. *Neuroimage, 42*(3): 1178-1184. doi: 10.1016/j.neuroimage.2008.05.059.

Frith, C. D. (2007). The social brain?. *Philosophical transactions of the Royal Society of London, 362*(1480): 671-678. doi: 10.1098/rstb.2006.2003.

Frith, C. D., & Frith, U. (2005). Theory of Mind. *Current Biology, 15*(17): 644-645. doi: 10.1016/j.cub.2005.08.041.

Frith, C. D., & Frith, U. (2006a). How we predict what other people are going to do. *Brain Research, 1079*(1): 36-46. doi: 10.1016/j.brainres.2005.12.126.

Frith, C. D., & Frith, U. (2006b). The neural basis of mentalizing. *Neuron, 50*(4): 531-534. doi: 10.1016/j.neuron.2006.05.001.

Frith, C. D., & Frith, U. (2008). Implicit and explicit processes in social cognition. *Neuron, 60*(3): 503-510. doi: 10.1016/j.neuron.2008.10.032.

Frith, U. (1994). Autism and theory of mind in everyday life. *Social Development, 3*(2): 108- 124. doi: 10.1111/j.1467-9507.1994.tb00031.x.

Gao, W., & Lin, W. (2012). Frontal Parietal Control Network Regulates the Anti-Correlated Default and Dorsal Attention Networks. *Human Brain Mapping, 33*(1): 192–202. doi: 10.1002/hbm.21204.

Greenwald, A. G., & Banaji, M. R. (1995). Implicit Social Cognition: Attitudes, Self-Esteem and Stereotypes. *Psychological Review, 102*(1): 4-27. doi: 10.1037//0033-295X.102.1.4.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test, *Journal of Personality and Social Psychology, 74*(6): 1464-1480. doi: 10.1037/0022-3614.74.6.1464.

Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2003). Functional connectivity in the resting brain: a network analysis of the default mode hypothesis, *Proceeding of the National Academy of Science of the United States of America, 100*(1): 253-258. doi: 10.1073/pnas.0135058100.

Gruber, J., Eidelman, P., Johnson, S. L., Smith, B., & Harvey, A. G. (2011). Hooked on a feeling: rumination about positive and negative emotion in inter-episode bipolar disorder. *Journal of abnormal psychology, 120*(4): 956-961. doi: 10.1037/a0023667.

Gruenfeld, D. H., Mannix, E. A., Williams, K. Y., & Neale, M. A. (1996). Group composition and decision making: How member familiarity and information distribution affect process and performance. *Organizational Behavior and Human Decision Processes, 67*(1): 1-15. doi: 10.1006/obhd.1996.0061.

Hajduová, Z., Andrejovský, P., & Beslerová, S. (2014). Development of Quality of Life Economic Indicators with Regard to the Environment. *Procedia – Social and Behavioral Sciences, 110*: 747-754. doi: 10.1016/j.sbspro.2013.12.919.

Hampson, S. E. (1982). Person memory: A semantic category model of personality traits. *British Journal of Psychology, 73*(1): 1-11. doi: 10.1111/j.2044-8295.1982.tb01784.x.

Happé, F. G. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development, 66*(3): 843–855. doi: 10.2307/1131954.

Hariri, A. R., Bookheimer, S. Y., & Mazziotta, J.C. (2000). Modulating emotional responses: effects of a neocortical network on the limbic system. *Neuroreport, 11*(1): 43-48. doi: 10.1097/00001756-200001170-00009.

Harpin, V. A. (2005). The effect of ADHD on the life of an individual, their family, and community from preschool to adult life. *Archives of Disease in Childhood, 90*:

i2-i7. doi: 10.1136/adc.2004.059006.

Hassabis, D. R., Spreng, R. N., Rusu, A. A., Robbins, C. A., Mar, R. A., & Schacter, D. L. (2013). Imagine All the People: How the Brain Creates and Uses Personality Models to Predict Behavior. *Cerebral Cortex, 24*(8): 1979-1987. doi: 10.1093/cercor/bht042.

Heerey, E. A., & Velani, H. (2010). Implicit learning of social predictions. *Journal of experimental Social Psychology*, *46*(3): 577-581. doi: 10.1016/j.jesp.2010.01.003.

Higgins, E. T. (2000). Social cognition: learning about what matters in the social world. *European Journal of Social Psychology*, *30*(1): 3–39. doi: 10.1002/(SICI)1099-0992(200001/02)30:1<3::AID-EJSP987>3.0.CO;2-I.

Hill, S., & McMahon, C. (2016). Maternal Mind-Mindedness: Stability Across Relationships and Associations with Attachment Style and Psychological Mindedness. *Infant and Child Development*, *25*(5): 391-405. doi: 10.1002/icd.1947.

Hudson, M., Nijboer, T. C., & Jellema, T. (2012). Implicit social learning in relation to autistic-like traits. *Journal of autism and developmental disorders*, *42*(12): 2534-2545. doi: 10.1007/s10803-012-1510-3.

Jack, A. I., Dawson, A. J., Begany, K. L., Leckie, R. L., Barry, K. P., Ciccia, A. H., & Snyder, A. Z. (2013). fMRI reveals reciprocal inhibition between social and physical cognitive domains. *Neuroimage, 66*: 385-401. doi: 10.1016/j.neuroimage.2012.10.061.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30*(5): 513-541. doi: 10.1016/0749-596X(91)90025-F.

Jenkinson, M., Beckmann, C. F., Behrens, T. E., Woolrich, M. W., & Smith, S. M.

(2012). FSL. *Neuroimage*, *62*: 782-90. doi: 10.1016/j.neuroimage.2011.09.015.

Karantzoulis, S., Scorpio K., Borod J. C., Bender H. A. (2011) Paired-Associate Learning. In J. S. Kreutzer, J. DeLuca, & B. Caplan. (Eds.), *Encyclopedia of Clinical Neuropsychology*. New York, NY, US: Springer.

Kashdan, T. B., & Roberts, J. E. (2007). Social anxiety, depressive symptoms, and post-event rumination: Affective consequences and social contextual influences. *Journal of Anxiety Disorders, 21*(3): 284-301. doi: 10.1016/j.janxdis.2006.05.009.

Keogh, R., & Pearson, J. (2011). Mental Imagery and Visual Working Memory, *PLoS ONE, 6*(12): e29221. doi:10.1371/journal.pone.0029221.

Kessler, R. C., Adler, L. A., Barkley, R., Biederman, J., Conners, C. K., Faraone, S. V., … Zaslavsky, A. M. (2005). Patterns and predictors of ADHD persistence into adulthood: Results from the National Comorbidity Survey Replication. *Biological Psychiatry, 57*(11): 1442-1451. doi: 10.1016/j.biopsych.2005.04.001.

Kim, K., & Mundy, P. (2012). Joint Attention, Social-Cognition, and Recognition Memory in Adults. *Frontiers in Human Neuroscience, 6*: 172. doi: 10.3389/fnhum.2012.00172.

Klingberg, T., Forssberg H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of clinical and experimental neuropsychology, 24*(6): 781-791. doi: 10.1076/jcen.24.6.781.8395.

Kofler, M. J., Rapport, M.D., Bolden, J., Sarver, D. E., Raiker, J. S., & Alderson, R. M. (2011). Working memory deficits and social problems in children with ADHD. *Journal of Abnormal Child Psychology, 39*(6): 805–817. doi: 10.1007/s10802-011- 9492-8.

Kuethe, J. L. (1962). Social schemas and the reconstruction of social object displays from memory. *The Journal of Abnormal and Social Psychology, 65*(1): 71-74.

doi: 10.1037/h0048463.

Kuethe, J. L. (1962). Social schemas and the reconstruction of social object displays from memory. *The Journal of Abnormal and Social Psychology, 65*(1): 71-74. doi: 10.1037/h0048463.

Kuo, J. R., Edge, I. G., Ramel, W., Edge, M. D., Drabant, E. M., Dayton, W. M., & Gross, J. J. (2012). Trait Rumination Is Associated with Enhanced Recollection of Negative Words. *Cognitive Therapy and Research, 36*(6): 722-730. doi: 10.1007/s10608-011- 9430-7.

Laranjo, J., & Bernier, A. (2013). Children's expressive language in early toddlerhood: links to prior maternal mind-mindedness. *Early Child Development and Care, 183*(7): 951- 962. doi: 10.1080/03004430.2012.699964.

Lee, V. K., & Harris, L. T. (2013). How social cognition can inform social decision making. *Frontiers in Neuroscience, 7*: 259. doi: 10.3389/fnins.2013.00259.

Leech, R., Braga, R., & Sharp, D. J. (2012). Echoes of the brain within the posterior cingulate cortex. *Journal of Neuroscience, 32*(1): 215-222. doi: 10.1523/JNEUROSCI.3689- 11.2012.

Lewicki, P., Hill, T., & Czyzewska, M. (1992). Nonconscious acquisition of information. *American Psychologist, 47*(6): 796-801. doi: 10.1037/0003-066X.47.6.796.

Li, L. M. W., Luo, S., Ma, J., Lin, Y., Fan, L., Zhong, S., Yang, J… Wu, X. (2018). Functional connectivity pattern underlies individual differences in independent self-construal. *Social Cognitive and Affective Neuroscience, 13*(3): 269-280. doi: 10.1093/scan/nsy008.

Li, W., Mai, X., & Liu, C. (2014). The default mode network and social understanding of others: what do brain connectivity studies tell us. *Frontiers in human neuroscience, 8*: 74, doi: 10.3389/fnhum.2014.00074.

Liberman, M. D. (2007). Social Cognitive Neuroscience: A Review of Core Process. *Annual Review of Psychology, 58*: 259-289. doi: 10.1146/annurev.psych.58.110405.085654.

Lim, M. H., Gleeson, J. F., Jackson, H., & Fernandez, K. C. (2014). Social relationships and quality of life moderate distress associated with delusional ideation. *Social Psychiatry, 49*(1): 97-107. doi: 10.1007/s00127-013-0738-3.

Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., & Baron-Cohen, S. (2007). Self-referential cognition and empathy in autism. *PLoS One, 2*(9): e883. doi: 10.1371/journal.pone.0000883.

Lundy, B. L. (2013). Paternal and Maternal Mind-mindedness and Preschoolers' Theory of Mind: The Mediating Role of Interactional Attunement. *Social Development, 22*(1): 58-74. doi: 10.1111/sode.12009.

Luo, Y., Kong, F., Qi, S., You, X., & Huang, X. (2016). Resting-state functional connectivity of the default mode network associated with happiness. *Social Cognitive and Affective Neuroscience, 11*(3): 516–524. doi: 10.1093/scan/nsv132.

Lyons, R. F., Sullivan, M. J. L., Ritvo, P. G., & Coyne, J. C. (1995). *Sage series on close relationships. Relationships in chronic illness and disability*. Thousand Oaks, CA, US: Sage Publications, Inc.

Macrae, C. N., & Shepherd, J. W. (1989). Stereotypes and social judgements. *British Journal of Social Psychology, 28*(4). doi: 10.1111/j.204-8309.1989.tb00875.x

Macrae, C. N., Hewstone, M., & Griffiths, R. J. (1993). Processing load and memory for stereotype-based information. *European Journal of Social Psychology, 23*(1). doi: 10.1002/ejsp.2420230107.

Mar, R. A. (2011). The Neural Bases of Social Cognition and Story Comprehension. *Annual Review of Psychology, 62*:103-134. doi: 10.1146/annurev-psych-120709-

145406.

Marchetti, I., Koster, E. H. W., Klinger, E., & Alloy, L. B. (2016). Spontaneous Thought and Vulnerability to Mood Disorders: The Dark Side of the Wandering Mind. *Clinical psychological science, 4*(5): 835-857. doi: 10.1177/2167702615622383.

Margulies D. S., Ghosh, S. S., Goulas, A., Falkiewicz, M., Huntenburg, J. M., Langs, G., … Smallwood, J. (2016). Situating the default-mode network along a principal gradient of macroscale cortical organization. *Proceedings of the National Academy of Sciences of the United States of America, 113*(44): 12574-12579. doi: 10.1073/pnas.1608282113.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review, 98*(2): 224-253. doi: 10.1037/0033-295X.98.2.224.

Markus, H. R., & Kitayama, S. (2010). Cultures and Selves: A Cycle of Mutual Constitution. *Perspectives on psychological science, 5*(4): 420-430. doi: 10.1177/1745691610375557.

Mars, R. B., Neubert, F., Noonan, M. P., Sallet, J., Toni, I., & Rushworth, M. F. S. (2012). On the relationship between the "default mode network" and the "social brain". *Frontiers in Human Neuroscience, 6*: 189. doi: 10.3389/fnhum.2012.00189.

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering minds: the default network and stimulus-independent thought. *Science, 315*(5810): 393-395. doi: 10.1126/science.1131295.

McKiernan, K. A., D'Angelo, B. R., Kaufman, J. N., & Binder, J. R. (2006). Interrupting the "stream of consciousness": an fMRI investigation. *Neuroimage, 29*(4): 1185-1191. doi: 10.1016/j.neuroimage.2005.09.030.

McKiernan, K. A., D'Angelo, B. R., Kaufman, J. N., Binder, J. R. (2006). Interrupting the "stream of consciousness": an fMRI investigation. *Neuroimage, 29*(4): 1185-1191. doi: 10.1016/j.neuroimage.2005.09.030.

McMahon, C. A., & Bernier, A. (2017). Twenty years of research on parental mind-mindedness: Empirical findings, theoretical and methodological challenges, and new directions. *Developmental Review, 46*: 54-80. doi: 10.1016/j.dr.2017.07.001.

McMahon, C. A., & Meins, E. (2012). Mind-mindedness, parenting stress, and emotional availability in mothers of pre-schoolers, *Early Childhood Research Quarterly, 27*(2): 245-252. doi: 10.1016/j.ecresq.2011.08.002.

McMahon, C. A., Camberis, A. L., Berry, S., & Gibson, F. (2016). Maternal mind-mindedness: relations with maternal-fetal attachment and stability in the first two years of life: findings from an Australian prospective study. *Infant Mental Health Journal, 37*(1): 17-28. doi: 10.1002/imhj.21548.

Medea, B., Karapanagiotidis, T., Konishi, M., Ottaviani, C., Margulies, D. S., Bernasconi, A., … Smallwood, J. (2018). How do we decide what to do? Resting-state connectivity patterns and components of self-generated thought linked to the development of more concrete personal goals. *Experimental Brain Research, 236*(9): 2469-2481. doi: 10.1007/s00221-016-4729-y.

Meins, E. (1997). Security of attachment and maternal tutoring strategies: Interaction within the zone of proximal development. *British Journal of Developmental Psychology*, *15*(2): 129-144. doi: 10.1111/j.2044-835X.1997.tb00730.x.

Meins, E. (2013). Sensitive attunement to infants' internal states: operationalizing the construct of mind-mindedness. *Attachment & human development, 15*(5-6): 524-544. doi: 10.1080/14616734.2013.830388.

Meins, E., & Fernyhough, C. (2015). *Mind-mindedness coding manual*, *Version 2.2*.

Unpublished manuscript. York, UK: University of York.

Meins, E., Fernyhough, C., & Harris-Waller, J. (2014). Is mind-mindedness trait-like or a quality of close relationships? Evidence from descriptions of significant others, famous people, and works of art, *Cognition, 130*(3): 417-427. doi: 10.1016/j.cognition.2013.11.009.

Meins, E., Fernyhough, C., Arnott, B., Leekam, S. R., & de Rosnay, M. (2013). Mind-mindedness and theory of mind: mediating roles of language and perspectival symbolic play. *Child Development, 84*(5): 1777-1790. doi: 10.1111/cdev.12061.

Meins, E., Fernyhough, C., de Rosnay, C., Arnott, B., Leekam, S. R., & Turner, M. (2011). Mind-mindedness as a Multidimensional Construct: Appropriate and Nonattuned Mind-Related Comments Independently Predict Infant-Mother Attachment in a Socially Diverse Sample. *Infancy, 17*(4): 393-415. doi: 10.1111/j.1532- 7078.2011.00087.x.

Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking maternal sensitivity: mothers' comments on infants' mental processes predict security of attachment at 12 months. *Journal of Child Psychology and Psychiatry, 42*(5): 637- 648. doi: 10.1111/1469-7610.00759.

Meins, E., Fernyhough, C., Johnson, F., & Lidstone, J. (2006). Mind-mindedness in children: Individual differences in internal-state talk in middle childhood. *British Journal of Developmental Psychology, 24*(1): 181–196. doi: 10.1348/026151005X80174.

Meins, E., Fernyhough, C., Russel, J., & Clark-Carter, D. (1998). Security of Attachment as a Predictor of Symbolic and Mentalizing Abilities: A Longitudinal Study. *Social Development, 7*(1): 1-24. doi: 10.1111/1467-9507.00047.

Meins, E., Fernyhough, C., Wainwright, R., Clark-Carter, D., Das Gupta, M., Fradley, E., & Tuckey, M. (2003). Pathways to Understanding Mind: Construct Validity and Predictive Validity of Maternal Mind-Mindedness, *Child Development, 74*(4): 1194- 1211. doi: 10.1111/1467-8624.00601.

Meins, E., Fernyhough, C., Wainwright, R., Das Gupta, M., Fradley, E., & Tuckey, M. (2002). Maternal mind-mindedness and attachment security as predictors of theory of mind understanding. *Child Development, 73*(6): 1715-1726. doi: 10.1111/cdev.12061.

Meins, E., Harris-Waller, J., & Lloyd, A. (2008). Understanding alexithymia: Associations with peer attachment style and mind-mindedness. *Personality and Individual Differences, 45*: 146-152. doi: 10.1016/j.paid.2008.03.013.

Meyer, M. L., & Matthew, D. L. (2012). Social working memory: neurocognitive networks and directions for future research. *Frontiers in Psychology, 3*: 571. doi: 10.3389/fpsyg.2012.00571.

Meyer, M. L., Taylor, S. E., & Lieberman, M. D. (2015). Social working memory and its distinctive link to social cognitive ability: an fMRI study. *Social Cognitive and Affective Neuroscience, 10*(10): 1338-1347. doi: 10.1093/scan/nsv065.

Miao, X., Wu, X., Li, R., Chen, K., & Yao, L. (2011). Altered connectivity pattern of hubs in default-mode network with Alzheimer's disease: an Granger causality modeling approach. *PLoS One, 6*(10): e25546. doi: 10.1371/journal.pone.0025546.

Mitchell, J. P., Banaji, M. R., & Macrae, C. N. (2005). General and specific contributions of the medial prefrontal cortex to knowledge about mental states. *Neuroimage, 28*(4): 757-762. doi: 10.1016/j.neuroimage.2005.03.011.

Mitchell, J. P., Macrae, C. N., & Banaji, M. R. (2004). Encoding-specific effects of social cognition on the neural correlates of subsequent memory. *The Journal of neuroscience, 24*(21): 4912-4917. doi: 10.1523/JNEUROSCI.0481-04.2004.

Moran, J. M., Jolly, E., & Mitchell, J. P. (2014). Spontaneous Mentalizing Predicts the Fundamental Attribution Error. *Journal of Cognitive Neuroscience, 26*(3): 569-576. doi: 10.1162/jocn_a_00513.

Morgan, C. A., Doran, A., Steffian, G., Hazlett, G., & Southwick, S. M. (2006). Stress-Induced Deficits in Working Memory and Visuo-Constructive Abilities in Special Operations Soldiers. *Biological Psychiatry, 60*(7): 722-729. doi: 10.1016/j.biopsych.2006.04.021.

Morrison, A. B., & Jha, A. (2015). Mindfulness, attention, and working memory. In *Handbook of Mindfulness and Self-Regulation* (pp. 33-46). New York, NY, US: Springer. doi: 10.1007/978-1-4939-2263-5_4.

Muris, P., Roelofs, J., Rassin, E., Franken, I., & Mayer, B. (2005). Mediating effects of rumination and worry on the links between neuroticism, anxiety and depression. *Personality and Individual Differences, 39*(6): 1105-1111. doi: 10.1016/j.paid.2005.04.005.

Mutter, B., Alcorn, M. B., & Welsh, M. (2006). Theory of mind and executive function: working-memory capacity and inhibitory control as predictors of false-belief task performance. *Perceptual and Motor Skills, 102*(3): 819-835. doi: 10.2466/pms.102.3.819-835.

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology, 109*(3): 504-511. doi: 10.1037/0021-843X.109.3.504.

Nolen-Hoeksema, S., & Jackson, B. (2001). Mediators of the Gender Difference in Rumination. *Psychology of Women Quarterly, 25*(1): 37-47. doi: 10.1111/1471-6402.00005.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky. S. (2008). Rethinking Rumination. *Perspectives on psychological science, 3*(5): 400-424. doi: 10.1111/j.1745-

6924.2008.00088.x.

Nooner, K. B., Colcombe, S. J., Tobe, R. H., Mennes, M., Benedict, M. M., … Milham, M. P. (2012). The NKI-Rockland Sample: A Model for Accelerating the Pace of Discovery Science in Psychiatry. *Frontiers in Neuroscience, 6*: 152. doi: 10.3389/fnins.2012.00152.

Norman, K. A., & O'Reilly, R. C. (2003). Modeling hippocampal and neocortical contributions to recognition memory: a complimentary-learning-systems approach. *Psychological review, 110*(4): 611-646. doi: 10.1037/0033-295X.110.4.611.

Paller, K. A. (2009). Memory Consolidation: Systems. In L. R. Squire (Ed.), *Encyclopedia of Neuroscience* (pp. 741-749). Cambridge, MA, US: Academic Press. doi: 10.1016/B978-008045046-9.00770-1.

Pawlby, S., Fernyhough, C., Meins, E., Pariante, C. M., Seneviratne, G., & Bentall, R. P. (2010). Mind-mindedness and maternal responsiveness in infant-mother interactions in mothers with severe mental illness. *Psychological medicine, 40*(11): 1861-1869. doi: 10.1017/S0033291709992340.

Peirce, J. W. (2007) PsychoPy - Psychophysics software in Python. *Journal of Neuroscience Methods, 162*(1-2): 8-13. doi: 10.1016/j.jneumeth.2006.11.017.

Peirce, J. W. (2009) Generating stimuli for neuroscience using PsychoPy. *Frontiers in Neuroinformatics, 2*: 10. doi: 10.3389/neuro.11.010.2008.

Perdue, C. W., Dovidio, J. F., Gurtman, M. B., & Tyler, R. B. (1990). Us and them: Social categorization and the process of intergroup bias. *Journal of Personality and Social Psychology, 59*(3): 475-486. doi: 10.1037/0022-3514.59.3.475.

Piccoli, T., Valente, G., Linden, D. E., Re, M., Esposito, F., Sack, A. T., & Di Salle, F. (2015). The Default Mode Network and the Working Memory Network Are Not Anti- Correlated during All Phases of a Working Memory Task. *PLoS ONE.*

*10*(4): e0123354. doi: 10.1371/journal.pone.0123354.

Poerio, G. L. Sormaz, M., Wang, H., Margulies, D. S., Jefferies, E., & Smallwood, J. (2017). The role of the default mode network in component processes underlying the wandering mind. *Social Cognitive and Affective Neuroscience, 12*(7): 1047-1062. doi: 10.1093/scan/nsx041.

Poerio, G. L., Totterdell, P., & Miles, E. (2013). Mind-wandering and negative mood: does one thing really lead to another?. *Consciousness and Cognition, 22*(4): 1412-1421. doi: 10.1016/j.concog.2013.09.012.

Postrado, L. T., & Lehman, A. F. (1995). Quality of life and clinical predictors of rehospitalization of persons with severe mental illness. *Psychiatric Services, 46*(11): 1161-1165. doi: 10.1176/ps.46.11.1161.

Ptak, R. (2012). The frontoparietal attention network of the human brain: action, saliency, and a priority map of the environment. *The Neuroscientist, 18*(5): 502-515. doi: 10.1177/1073858411409051.

Ptak, R., Schnider, A., & Fellrath, J. (2017). The Dorsal Frontoparietal Network: A Core System for Emulated Action. *Trends in cognitive sciences,* 21(8): 589-599. doi: 10.1016/j.tics.2017.05.002.

Radloff, L. S. (1977). The CES-D Scale: A Self-Report Depression Scale for Research in the General Population. *Applied Psychological Measurement, 1*: 385-401. doi: 10.1177/014662167700100306.

Raichle, M. E. (2015). The brain's default mode network. *Annual review of neuroscience, 38*: 433-447. doi: 10.1146/annurev-neuro-071013-014030.

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America, 98*(2): 676-682. doi: 10.1073/pnas.98.2.676.

Reddy, V. (2008). *How Infants Know Minds*. Harvard, MA, US: Harvard University Press.

Reidy, J. (2004). Trait anxiety, trait depression, worry, and memory. *Behaviour research and therapy, 42*(8): 937-948. doi: 10.1016/j.brat.2003.07.005.

Reynolds, M., & Brewin, C. R. (1999). Intrusive memories in depression and posttraumatic stress disorder. *Behaviour Research & Therapy, 37*(3): 201-215. doi: 10.1016/S0005- 7967(98)00132-6.

Riskind, J. H., Castellon, C. S., & Beck, A. T. (1989). Spontaneous causal explanations in unipolar depression and generalized anxiety: Content analysis of dysfunctional- thought diaries. *Cognitive Therapy and Research, 13*(2): 91-108. doi: 10.1007/BF01173267.

Riva, F., Triscoli, C., Lamm, C., Carnaghi, A., & Silani, G. (2016). Emotional egocentricity bias across the life-span. *Frontiers in Aging Neuroscience, 8*: 74. doi: 10.3389/fnagi.2016.00074.

Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual review of neuroscience, 27*: 169-192. doi: 10.1146/annurev.neuro.27.070203.144230.

Robinson, J. A., & Swanson, K. L. (1990). Autobiographical memory: The next phase. *Applied Cognitive Psychology, 4*(4): 321-335. doi: 10.1002/acp.2350040407.

Ruby, F. J. M., Smallwood, J., Engen, H., & Singer, T. (2013). How Self-Generated Thought Shapes Mood – The Relation between Mind-Wandering and Mood Depends on the Socio-Temporal Content of Thoughts, *PLoS ONE, 8*(10): e77554. doi: 10.1371/journal.pone.0077554/.

Ruby, F. J. M., Smallwood, J., Sackur, J., & Singer, T. (2013). Is self-generated thought a means of social problem solving?, *Frontiers in Psychology, 4*: 962. doi: 10.3389/fpsyg.2013.00962.

Saxe, R., & Kanwisher, N. (2003). People thinking about people: the role of the temporo- parietal junction in “theory of mind”, *Neuroimage*, *19*(4): 1835-1842. doi: 10.1016/S1053-8119(03)00230-1.

Schacht, R., Meins, E., Fernyhough, C., Centifanti, L. C. M., Bureau, J. F., & Pawlby, S. (2017). Proof of concept of a mind-mindedness intervention for mothers hospitalized for severe mental illness. *Development and psychopathology, 29*(2): 555-564. doi: 10.1017/S0954579417000177.

Schacter, D. L. (1996). *Searching for Memory: The brain, the mind, and the past.* New York, NY, US: Basic Books.

Schacter, D. L., Gilbert, D. T., & Wegner, D. M. (2011) Semantic and episodic memory. In B. M. Hood, Schacter, D. L., Wegner, D. M., & Gilbert, D. T. (Eds.), *Psychology: Second Edition*, (pp 240-241). New York, NY, US: Worth, Incorporated.

Schilbach, L., Eickhoff, S. B., Rotarska-Jaglela, A., Fink, G. R., & Vogeley, K. (2008). Minds at rest? Social cognition as the default mode of cognizing and its putative relationship to the “default system” of the brain, *Consciousness and Cognition, 17*(2): 457-467. doi: 10.1016/j.concog.2008.03.013.

Schooler, J. W., Smallwood, J., Christoff, K., Handy, T.C., Reichle, E. D., & Sayette, M. A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends in Cognitive Sciences. 15*(7): 319-326. doi: 10.1016/j.tics.2011.05.006.

Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others’ actions: just like one’s own? *Cognition, 88*(3): 11-21. doi: 10.1016/S0010-0277(03)00043-X.

Senju, A. (2012). Spontaneous theory of mind and its absence in autism spectrum disorders. *Neuroscientist, 18*(2): 108-113. doi: 10.1177/1073858410397208.

Senju, A. (2013). Atypical development of spontaneous social cognition in autism spectrum disorders. *Brian & development*, *35*(2): 96-101. doi: 10.1016/j.braindev.2012.08.002.

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind Eyes: An Absence of Spontaneous Theory of Mind in Asperger Syndrome. *Science, 325*(5942): 883–885. doi: 10.1126/science.1176170.

Shapiro, S. L., Brown, K. W., & Biegel, G. M. (2007). Teaching self-care to caregivers: Effects of mindfulness-based stress reduction on the mental health of therapists in training. *Training and Education in Professional Psychology, 1*(2): 105-115. doi: 10.1037/1931-3918.1.2.105.

Shrimpton, D., McGann, D., & Riby, L. M. (2017). Daydream Believer: Rumination, Self-Reflection and the Temporal Focus of Mind Wandering Content. *Europe's journal of psychology, 13*(4): 794-809. doi: 10.5964/ejop.v13i4.1425.

Singer, J. L., & Antrobus J. S. (1965). Eye movements during fantasies: imagining and suppressing fantasies. *Archives of General Psychiatry, 12*: 71–76. doi: 10.1001/arch- psyc.1965.01720310073009.

Skevington, S. M. (1999). Measuring quality of life in Britain: introducing the WHOQOL-100. *Journal of psychosomatic research, 47*(5): 449-459. doi: 10.1016/S0022-3999(99)00051-3.

Smallwood, J., & Schooler, J. W. (2015). The Science of Mind Wandering: Empirically Navigating the Stream of Consciousness, *Annual Review of Psychology, 66*: 487-518. doi: 10.1146/annurev-psych-010814-015331.

Smallwood, J., Karapanagiotidis, T., Ruby, F, J. M., Medea, B., de Caso, I., Konishi, M., … Jefferies, E. (2016). Representing representation: Integration between the temporal lobe and the posterior cingulate influences the content and form of spontaneous thought. *PLoS ONE, 11*(4): e0152272. doi:10.1371/journal.pone.0152272.

Smith, E. R., & DeCoster, J. (2000). Dual-Process Models in Social and Cognitive Psychology: Conceptual Integration and Links to Underlying Memory Systems.

*Personality and Social Psychology Review, 4*(2): 108-131. doi: 10.1207/S15327957PSPR0402_01.

Snowden, J. S., Thompson, J. C., & Neary, D. (2012). Famous people knowledge and the right and left temporal lobes. *Behavioural Neurology, 25*(1): 35-44. doi: 10.3233/BEN-2012-0347.

Spielberger, C. D., & Sydeman, S. J. (1994). State-Trait Anxiety Inventory and State-Trait Anger Expression Inventory. In M. E. Maruish (Ed.), *The use of psychological testing for treatment planning and outcome assessment*, (pp. 292-321). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spreng, R. N. (2013). Examining the role of memory in social cognition. *Frontiers in Psychology, 4*: 437. doi: 10.3389/fpsyg.2013.00437.

Spreng, R. N., & Grady, C. L. (2010). Patterns of brain activity supporting autobiographical memory. Prospection, and theory of mind, and their relationship to the default mode network. *Journal of Cognitive Neuroscience, 22*(6): 1112-1123. doi: 10,1162/jocn.2009.21282.

Spreng, R. N., DuPre, E., Selarka, D., Garcia, J., Gojkovic, S., Mildner, J., … Turner, G. R. (2014). Goal-congruent default network activity facilitates cognitive control, *Journal of Neuroscience, 34*(42): 14108-14114. doi: 10.1523/JNEUROSCI.2815-14.2014.

Spreng, R. N., Mar, R. A., & Kim, A. S. (2009). The common neural basis of autobiographical memory, prospection, navigation, theory of mind, and the default mode: a quantitative meta-analysis. *Journal of Cognitive Neuroscience, 21*(3): 489- 510. doi: 10.1162/jocn.2008.21029.

Surtees, A. D., & Apperly, I. A. (2012). Egocentrism and automatic perspective taking in children and adults. *Child development, 83*(2): 452-460. doi: 10.1111/j.1467-8624.2011.01730.x.

Truthmann, J., Mensink, G. B. M., Bosy-Westphal, A., Hapke, U., Scheidt-Nave, C., Schienkiewitz, A. (2017). Physical health-related quality of life in relation to metabolic health and obesity among men and women in Germany. *Health and Quality of Life Outcomes, 15*(1): 122. doi: 10.1186/s12955-017-0688-7.

Tulving, E. (1972). Episodic and semantic memory. In Tulving, E., & Donaldson, W. (Eds.), *Organization of Memory*, (pp. 381–403). New York, NY, US: Academic Press.

Uddin, L. Q., Kelly, A. M., Biswal, B. B., Castellanos, F. X., & Milham, M. P. (2009). Functional connectivity of default mode network components: correlation, anticorrelation, and causality. *Human brain mapping, 30*(2): 625-637. doi: 10.1002/hbm.20531.

Vilburg, K. L., & Rugg, M. D. (2012). The neural correlates of recollection: transient versus sustained FMRI effects. *Journal of Neuroscience, 32*(45): 15679-15687. doi: 10.1523/JNEUROSCI.3065-12.2012.

Von dem Hagen, E. A. H., Stoyanova, R. S., Baron-Cohen, S., & Calder, A. J. (2011). Reduced functional connectivity within and between ‘social’ resting state networks in autism spectrum conditions. *Social Cognitive and Affective Neuroscience, 8*(6): 694- 701. doi: 10.1093/scan/nss053.

Von Hecker, U. (2004). Disambiguating a Mental Model: Influence of Social Context. *The Psychological Record, 54*(1): 27-43. doi: 10.1007/BF03395460.

Walker, T. M., Wheatcroft, R., & Camic, P. M. (2011). Mind-mindedness in parents of pre- schoolers: a comparison between clinical and community samples. *Clinical child psychology and psychiatry, 17*(3): 318-335. doi:

10.1177/1359104511409142.

Watkins, E. R. (2008). Constructive and Unconstructive Repetitive Thought. *Psychological Bulletin, 134*(2): 163-206. doi: 10.1037/0033-2909.134.2.163.

Weightman, M. J., Air, T. M., & Baune, B. T. (2014). A Review of the Role of Social Cognition in Major Depressive Disorder. *Frontiers in Psychiatry, 5*: 179. doi: 10.3389/fpsyt.2014.00179.

World Health Organisation. (1997). *WHOQOL—Measuring Quality of Life.* Geneva, Switzerland: World Health Organisation.

Wu, Z., & Fang, Y. (2014). Comorbidity of depressive and anxiety disorders: challenges in diagnosis and assessment. *Shanghai Archives of Psychiatry, 26*(4): 227-231. doi: 10.3969/j.issn.1002-0829.2014.04.006.

Yang, X., Bossmann, J., Schiffhauer, B., Jordan, M., & Immordino-Yang, M. H. (2012). Intrinsic Default Mode Network Connectivity Predicts Spontaneous Verbal Descriptions of Autobiographical Memories during Social Processing. *Frontiers in Psychology, 3*: 592. doi: 10.3389/fpsyg.2012.00592.

Yanos, P. T., Rosenfeld, S., & Horwitz, A. V. (2001). Negative and Supportive Social Interactions and Quality of Life Among Persons Diagnosed with Severe Mental Illness. *Community Mental Health Journal, 37*(5): 405-419. doi: 10.1023/A:1017528029127.

Yao, N., Chen, S., & Qian, M. (2018). Trait anxiety is associated with a decreased visual working memory capacity for faces. *Psychiatry research, 270*: 474-482. doi: 10.1016/j.psychres.2018.10.018.

Yarkoni, T., Poldrack, R. A., Nichols, T. E., Van Essen, D. C., & Wager, T. D. (2011). Large-scale automated synthesis of human functional neuroimaging data. *Nature Methods, 8*(8): 665-670. doi: 10.1038/nmeth.1635.

Yeo, B. T., Krienen, F. M., Sepulcre, J., Sabuncu M. R., Lashkari D., Hollinshead M.,

… Buckner, R. L. (2011). The organization of the human cerebral cortex estimated by intrinsic functional connectivity. *Journal of Neurophysiology, 106*(3): 1125-1165. doi: 10.1152/jn.00338.2011.

Zacks, J. M., & Swallow, K. M. (2007). EVENT SEGMENTATION. *Current Directions in Psychological Science, 16*(2): 80-84. doi: 10.1111/j.1467-8721.2007.00480.x.

Zahn, R., Moll, J., Krueger, F., Huey, E. Garrido, G., & Grafman, J. (2007). Social concepts are represented in the superior anterior temporal cortex. *Proceedings of the National Academy of Sciences of the United States of America. 104*(15): 6430-6435. doi: 10.1073/pnas.0607061104.

Zou, B., & Abbott, M. (2012). Self-perception and rumination in social anxiety. *Behaviour research and therapy, 50*(4): 250-257. doi: 10.1016/j.brat.2012.01.007.