



Higher-order mentalising and executive functioning[☆]



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ABSTRACT

Higher-order mentalising is the ability to represent the beliefs and desires of other people at multiple, iterated levels – a capacity that sets humans apart from other species. However, there has not yet been a systematic attempt to determine what cognitive processes underlie this ability. Here we present three correlational studies assessing the extent to which performance on higher-order mentalising tasks relates to emotion recognition, self-reported empathy and self-inhibition. In Study 1a and 1b, examining emotion recognition and empathy, a relationship was identified between individual differences in the ability to mentalise and an emotion recognition task (the Reading the Mind in the Eyes task), but no correlation was found with the empathy quotient, a self-report scale of empathy. Study 2 investigated whether a relationship exists between individual mentalising abilities and four different forms of self-inhibition: motor inhibition, executive inhibition, automatic imitation and temporal discounting. Results demonstrate that only temporal discounting performance relates to mentalising ability; suggesting that cognitive skills relevant to representation of the minds of others' are not influenced by the ability to perform more basic inhibition. Higher-order mentalising appears to rely on the cognitive architecture that serves both low-level social cognition (emotion recognition), and complex forms of inhibition.

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1. Introduction

The ability to understand the recursively embedded mindstates of other people (variously known as theory of mind, mentalising or mind-reading) is an important product of human evolutionary history that has profound implications for the way we interact with our world (e.g. Tomasello, Carpenter, Call, Behne, & Moll, 2005). Being able to interpret the mental states of others is likely to have dramatically improved the human capacity to engage with complex social networks, thus allowing the development of larger social groups, facilitating cultural knowledge exchange, and contributing dramatically towards our success as a species (e.g. Dunbar, 2003; Frith & Frith, 2010). During human evolutionary history, mentalising likely developed alongside other forms of social functioning and more general executive abilities (Schulz, 2009). There has been a long running debate as to whether theory of mind is a distinct (modular) cognitive capacity in its own right (a domain specific phenomenon) or essentially just an emergent property of underlying aspects of executive function such as memory, causal reasoning, and inhibition (a domain general phenomenon)

(Barrett & Dunbar, 2003; Carlson, Moses, & Breton, 2002; Carlson, Moses, & Hix, 1998; Davis & Pratt, 1995; Leslie, Friedman, & German, 2004; Leslie & Polizzi, 1998).

While there is compelling evidence for some role of executive functioning in mentalising, the evidence remains somewhat ambiguous and subject to dispute. Formal theory of mind (the ability to believe that someone else believes something) is the first stage in a recursive series of belief states known as the levels (or orders) of intentionality whose limit, in normal human adults, appears to lie at around fifth order (i.e. A believes that B believes that C believes that D believes that E believes something) (Dennett, 1983; Kinderman, Dunbar, & Bentall, 1998; Stiller & Dunbar, 2007). These higher order competences appear to have significant implications for adult sociality: individual differences in mentalising are correlated with the size of adult social networks (Powell, Lewis, Roberts, García-Fiñana, & Dunbar, 2012; Stiller & Dunbar, 2007), as well as the social skills of older children (Liddle & Nettle, 2006) and adults (Corcoran, Mercer, & Frith, 1995; Kerr, Dunbar, & Bentall, 2003). However, the relationship between executive functioning and mentalising has only been studied in 3–6 year old children with second order intentionality (e.g. Carlson, Moses, & Claxton, 2004), and it is unclear whether this relationship is still relevant to adults, who are capable of higher levels of intentionality.

Whether or not executive function competences are involved in the development of theory of mind in young children, there remain two separate possibilities for the subsequent development of higher order competences: (1) these might be scaffolded by formal theory of mind

Abbreviations: RMET, Reading the Mind in the Eyes task; EQ, empathy quotient.

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(and hence represent some kind of modularised recursion) or (2) the higher orders may explicitly depend on individual differences in executive function skills to maintain their multi-level recursive structure. Higher order mentalising improves throughout development to the end of adolescence (Henzi et al., 2007; Keulers, Evers, Stiers, & Jolles, 2010; Liddle & Nettle, 2006), suggesting that formal theory of mind is a first stage in the development of this process. However, the fact that there is significant individual variation in mentalising competences in adults, with the upper limit varying across fourth to sixth order intentionality (Powell, Lewis, Dunbar, García-Fiñana, & Roberts, 2010; Stiller & Dunbar, 2007), tends to favour the second explanation – and would fit better with the evidence that theory of mind itself is dependent on a child's executive cognition skills. However, neither of these possibilities has been tested as yet and therefore neither can be dismissed outright.

In addition to the possible role of executive function in the development of higher order mentalising skills, one could envisage potential roles for other aspects of 'hot' cognition such as empathy or emotion recognition. In so far as empathising and emotion recognition require one to put oneself in another's place and/or be able to recognise their internal emotional state, both facilitate thinking about mindstates. Emotion state recognition, at least, has a long developmental trajectory, and may not become automated until early adulthood (Deeley et al., 2008). The current paper explores relationships between mentalising, emotion state recognition and a key component of executive function (inhibition). Working memory, a conventional executive function skill, has previously been shown to be correlated with mentalising skills (Stiller & Dunbar, 2007), and here it is treated simply as a confound.

1.1. Higher-order mentalising

Premack and Woodruff (1978) originally described 'theory of mind' in chimpanzees as the ability to impute mental states to oneself and others, in order to make predictions about future behaviour. This ability was subsequently explored as a competence that can be applied recursively, involving the representation of several 'levels' of mindstates iterated within each other (e.g. 'Jane believes that John thinks that Sarah wants to...'). Basic false-belief tasks test second-order mentalising (or theory of mind, as conventionally defined), assessing whether it is possible for one person to recognise that someone else can hold beliefs that differ from their own. Non-human primates typically fail on these tasks (Call & Tomasello, 1999, 2008; Krachun, Call, & Tomasello, 2010; but see O'Connell & Dunbar, 2003; Cartmill & Byrne, 2007), and human infants appear to also fail before a certain age (e.g. Apperly & Butterfill, 2009, although there is some controversy regarding the age at which this might occur: e.g. Apperly, 2012; Heyes, 2014), suggesting that the step from first- to second-order mentalising is important. Normally developed adults, however, can deal with a much larger number of iterated mindstates and in many everyday cases it is essential to understand complexity far beyond the false beliefs of one other individual. For example, Yoshida, Seymour, Friston, and Dolan (2010) claim that to complete even a basic cooperative task subjects have to believe that the other believes that they intend to cooperate (i.e. three orders). Linguistic communication arguably requires interlocutors to go one level beyond this, to fourth order, or even to fifth order in the case of more advanced exchanges (especially irony and sarcasm: see Papp, 2006; Sperber, 1994). Similar arguments can be made for activities such as being part of a religious community (Dunbar, 2003), exhibiting moral reasoning (Shultz & Dunbar, 2014), proactive thinking (Bateman & Crant, 1993; Kirby, Kirby, & Lewis, 2002), and appreciating and producing literature (Carney, Wlodarski, & Dunbar, 2014; Dunbar, 2005; Zunshine, 2006).

The crucial importance of the developmental and evolutionary step from first- to second-order mentalising has resulted in a tendency to test adult ability solely at these levels, without explicitly exploring individual differences in performance at higher levels (Ahmed & Stephen Miller, 2011; Bull, Phillips, & Conway, 2008; Gregory et al., 2002; Lough, Gregory, & Hodges, 2001; Phillips et al., 2011; Santiesteban

et al., 2012). These types of assessment are likely to be subject to a ceiling effect and, additionally, fail to capture the considerable variation in individual mentalising skill (Kinderman et al., 1998; Powell et al., 2010; Stiller & Dunbar, 2007), thus limiting comparison with other cognitive abilities. However, a test that is specifically designed to assess variability in performance during higher-order mentalising was introduced by Kinderman et al. (1998). In this test, participants read a story containing several levels of iterated mental states, and answer comprehension questions of varying complexity regarding these iterated mental states. This approach has demonstrated individual variability in performance, which has been shown to relate to social attribution (Kinderman et al., 1998), estimates of social network size (Lewis, Rezaie, Brown, Roberts, & Dunbar, 2011; Powell et al., 2014, 2012; Stiller & Dunbar, 2007), and volume of the orbital prefrontal cortex (Lewis et al., 2011; Powell et al., 2014, 2010), with women performing better than men on average (Powell et al., 2010; Stiller & Dunbar, 2007). Tests adapted for use with children have also demonstrated that performance relates to aspects of general social competence, as rated by teachers (Liddle & Nettle, 2006). These findings suggest that the test taps into cognitive abilities which are relevant to how individuals interact in their everyday social and cultural life.

Given that mentalising ability above level two is unique to humans, reaches adult-level competence relatively late in development (Dunbar, 2013; Henzi et al., 2007), and is associated with crucial parts of social cognition and sophisticated cultural behaviours (including language, religion, and literature), it is important to look at higher-order mentalising as an ability distinct from simple false belief attribution. In what follows, we investigate three skills that might support higher-order mentalising: empathy, emotion recognition, and inhibition.

1.2. Mentalising, emotion recognition and empathy

Intuitively, we might expect a relationship to exist between the ability to represent the mental states of other people and the ability to read their emotions and experience empathy. However, this depends on what theory of mind is, and which factors play a role in its development during childhood. 'Simulation theory' (e.g. Gallese & Goldman, 1998) argues that we mentally enact the mental states of other people in order to understand their thought processes, while 'theory theory' (e.g. Gopnik & Wellman, 1992, 2012) claims that we go through a more cognitive process of thinking through what someone might do, and why, in order to determine their mental state. While Simulation theory predicts that empathy is an important part of the ability to mentalise, this is not necessarily the case for theory theory (it would be possible to accurately theorise about the mindstate of another person without experiencing any empathy with them, or even necessarily detecting their emotions). Similarly, psychologists studying empathy have identified a number of separate components (Davis, 1983), which can be more broadly grouped into 'affective' and 'cognitive' empathy, which are distinguishable on the basis of self-report and represent the tendency to feel the emotions of others compared with the ability to theorise about their behaviour (Reniers et al., 2011). These two sets of theories both highlight a fundamental difference between immediate 'hot' cognition, and slower, more theoretical cognition. The two methods of understanding others are not mutually exclusive; it is likely that we use both 'hot' cognition (emotion recognition and affective empathy) and theorising during any mentalising task (Apperly & Butterfill, 2009), with variability along a continuum dependent on development (Frith, 2012) and our familiarity with an individual and the situation involved (c.f. Beckes, Coan, & Hasselmo, 2013; Wilkinson & Ball, 2012).

If empathising skills play a role in mentalising in adults we would expect there to be a robust relationship between performance on tasks that index these two abilities. While there have been some previous investigations into the relationship between various forms of

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