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Original Article

The ease and extent of recursive mindreading, across implicit and explicit tasks

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ABSTRACT

Recursive mindreading is the ability to embed mental representations inside other mental representations e.g. to hold beliefs about beliefs about beliefs. An advanced ability to entertain recursively embedded mental states is consistent with evolutionary perspectives that emphasise the importance of sociality and social cognition in human evolution: high levels of recursive mindreading are argued to be involved in several distinctive human behaviours and institutions, such as communication, religion, and story-telling. However, despite a wealth of research on first-level mindreading under the term Theory of Mind, the human ability for recursive mindreading is relatively understudied, and existing research on the topic has significant methodological flaws. Here we show experimentally that human recursive mindreading abilities are far more advanced than has previously been shown. Specifically, we show that humans are able to mindread to at least seven levels of embedding, both explicitly, through linguistic description, and implicitly, through observing social interactions. However, our data suggest that mindreading may be easier when stimuli are presented implicitly rather than explicitly. We argue that advanced mindreading abilities are to be expected in an extremely social species such as our own, where the ability to reason about others' mental states is an essential, ubiquitous and adaptive component of everyday life.

> *"Humans have the ability to represent representations… This meta-representational ability is as distinctive of humans, and as important in understanding their behaviour, as is echolocation for bats"* (Sperber, 1997, p.69).

1. Introduction

Mindreading is the ability to mentally represent others' mental representations. It is also known as mental metarepresentation, or theory of mind. Recursive mindreading is the ability to embed further levels of mental representation inside existing mental representations (e.g. I think$_0$ that you believe$_1$ that he thinks$_2$ that she wants$_3$… and so on; subscripts count the number of metarepresentations[3]). An intuitive and commonly held view is that high-level recursive mindreading (i.e. beyond first or second level) is cognitively demanding, and perhaps beyond normal human abilities (e.g. Clark, 1996; Gómez, 1994). Yet theoretical explanations of many important human behaviours and institutions, such as communication, religion, story-telling, and culture itself either argue or assume that humans can and do process high levels of recursive mindreading routinely and without difficulty (Dunbar, 2003, 2008; Sperber, 2000a; Tomasello, 2008). Furthermore, our natural ecology is a social one, in which both collaboration and competition are everyday activities (Byrne & Whiten, 1989; Dunbar, 2003; Humphrey, 1976). In such an environment, the ability to monitor and manage one's social environment, by reasoning about the motives and intentions of others, keeping track of others' relationships, deciding who to trust, and so on, is of critical importance. From this perspective, we should expect humans to be able to process mental (meta)representations with relative ease, at least when those representations are encountered within this social ecology.

There is a large literature on various aspects of first-level mindreading (e.g. the ability to reason about the mental state of another: I think$_0$ that you believe$_1$ some proposition). This includes, most prominently, its development in children (Baillargeon, Scott, & He, 2010; Wellman, Cross, & Watson, 2003), its role in some social cognitive disorders (Baron-Cohen, 1995; Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012), and its presence or absence in non-human primates (Call & Tomasello, 2008; Premack & Woodruff, 1978). In contrast, there is far less research dealing specifically with recursive

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[3] There is inconsistency in the mindreading literature regarding how to count the levels. Some studies include the focal individual's perspective; others exclude it. This is the difference between counting the number of representations (I think$_1$ that Mary thinks$_2$…) or only the number of metarepresentations (I think$_0$ that Mary thinks$_1$…). Most adult studies use the former practice, whereas the developmental literature uses the latter. We follow this latter practice in this paper.

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mindreading, despite its theoretical importance for human social life. The handful of studies in adults that do exist report a prominent drop in performance after four levels of recursive mindreading (Kinderman, Dunbar, & Bentall, 1998; Lyons, Caldwell, & Shultz, 2010; Stiller & Dunbar, 2007). There is also a small literature on second- and third-level tasks in children's development, which finds that the ability to perform these higher-level tasks emerges later in development than competence in first-level tasks (see Miller, 2009 for a review).

However, previous research on high-order recursive mindreading may have significantly underestimated the extent of human recursive mindreading abilities, for at least two reasons. First, the stimuli used in previous studies have a number of shortcomings serious enough to raise doubts about their validity. We detail these issues in the next section. Second, previous studies tested recursive mindreading ability only explicitly, by presenting stimuli either as text to be read, or narration to be heard, and by testing understanding with direct questions, and not implicitly, by presenting stimuli as social events to be observed, and testing understanding by measuring reactions to those events. It may be the case, especially given the ecological perspective outlined above, that human mindreading abilities are fully expressed only when they are employed within social contexts i.e. when encountered implicitly (as opposed to being encountered as explicit, disembodied descriptions of those same contexts). This possibility is supported by findings in the developmental literature which shows that children pass implicit first-level mindreading tasks (false belief tasks) far earlier than they do equivalent explicit tasks: around the first birthday vs. around the fourth birthday (see Baillargeon et al., 2010 for a review of implicit false-belief tasks). Precisely what causes this dramatic difference is an unresolved issue in developmental psychology, but whatever the explanation, these results show that the mode of presentation can make a dramatic difference to performance, at least in children. Based on this finding, we might expect that adult performance on recursive mindreading tasks could also be facilitated by implicit presentation.

In sum, recursive mindreading plays an important role in explanations of many major human behaviours, yet there are reasons to think that we may not currently know or appreciate the full extent of this ability in adult humans. In this paper, we present a new study of recursive mindreading, which has two major advances on previous research. First, we use new stimuli designed to avoid the various methodological issues we have identified in previous studies (detailed below). Second, we use a 2×2 design of implicitly and explicitly presented stories, crossed with implicitly and explicitly presented questions. As such, the key novelty here is the use of implicit stimuli, which have not previously been used in the study of recursive mindreading in adults. We expected that, at least in conditions featuring implicit presentation, participants would succeed at recursive mindreading tasks at levels higher than those reported in previous studies. Correspondingly, our design includes questions of up to seven levels of mental metarepresentation, three levels higher than the typical level of successful performance in previous tasks (e.g. Kinderman et al., 1998; Lyons et al., 2010; Stiller & Dunbar, 2007).

2. Problems with previous research

Previous studies of recursive mindreading ability used versions of the Imposing Memory Task (IMT)[4] (e.g. Kinderman et al., 1998; Lyons et al., 2010; Stiller & Dunbar, 2007). The IMT has also been widely used as a measure of mindreading ability in studies designed to identify brain regions involved in mindreading (e.g. Lewis, Rezaie, Brown, Roberts, & Dunbar, 2011; Powell, Lewis, Dunbar, García-Fiñana, & Roberts, 2010), in studies designed to investigate the relationship between mindreading and various cognitive disorders (e.g. Frith & Corcoran, 1996; Kerr, Dunbar, & Bentall, 2003), and in studies designed to investigate the relationship between mindreading ability and other aspects of social psychology, in both adults and children (e.g. Henzi et al., 2007; Liddle & Nettle, 2006; Nettle & Liddle, 2008; Paal & Bereczkei, 2007; Sylwester, Lyons, Buchanan, Nettle, & Roberts, 2012). The IMT involves stories which are read aloud to participants, followed by a series of true-or-false or forced-choice mentalising questions, designed to test participants' understanding of the levels of recursive mindreading involved. Control questions are designed to test participants' ability to remember details of the stories that are unrelated to mental states, but which contain a matched number of elements to be remembered. We analysed the stimuli used in the IMT[5] and identified five main problems that, collectively, are significant enough to cast doubt on the conclusions drawn in these studies regarding the extent of human recursive mindreading ability. We describe these issues in the following paragraphs. A full breakdown of which of these criticisms apply to which questions in the IMT is provided as supplementary information (available on the journal's Website at www.ehbonline.org).

2.1. Broken conceptual chains

In some cases, mental questions are constructed in a way that allowed them to be processed in 'chunks', rather than as a single metarepresentational unit. For example, the following sentence is intended to test fourth level mindreading: 'Simon imagined$_1$ that Betty wanted$_2$ to marry Edward but that Edward really wanted$_3$ to marry Susan, whom Jim would like$_4$ to have married' (here and elsewhere in this paragraph, we have omitted the participant's own mental state, which, if we had included it, would have had the subscript 0 (i.e. 'The participant believes$_0$ that Simon imagined$_1$…')). However, this sentence does not contain one continuous chain of mental representations. Rather, it consists of three statements, joined by logical relationships: (i) Simon imagined$_1$ that Betty wanted$_2$ to marry Edward; (ii) Simon imagined$_1$ that Edward really wanted$_2$ to marry Susan; and (iii) Simon imagined$_1$ that Jim would like$_1$ to have married Susan. Consequently, constructions of this sort do not test 4th level mindreading; they test the conjunction of multiple cases of 2nd level mindreading. 13 of 50 mental questions in the IMT are constructed like this.

2.2. Simple substitution

Some stimuli are constructed in such a way that the entire sentence did not need to be processed in order to be answered correctly. An example is the forced choice between 'The girl whose car Simon works on practices dance with the person who is a loan officer in Edward's bank' and 'The girl whose car Simon works on practices dance with the person who is a computer consultant in Edward's bank' (from Rutherford, 2004). The only difference here is between 'loan officer' and 'computer consultant'. In many cases, one of these alternatives simply did not appear in the story at all. As such, the question can be answered by simply spotting the unfamiliar item: the full sentences, and the complex propositions they convey, do not need to be understood. This occurs in 6 of 50 control questions, and 1 of 50 mental questions.

[4] Although based on the IMT, some of the later studies do not use the name IMT. Here, we use IMT to refer to all studies based on the same general idea, and set of questions used.

[5] With one exception, none of the currently published studies that we are aware of provide a complete list of the specific questions used. The exception (Liddle & Nettle, 2006) used a version modified for children. We therefore analysed the complete set of IMT questions sent to us by R. Dunbar. This set of questions is an updated version of the materials used in the earliest IMT studies, and forms the basis for the materials used in later studies. As such, the items we analysed are representative of the stimuli used in this literature.