Can theory of mind grow up? Mindreading in adults, and its implications for the development and neuroscience of mindreading.

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Introduction.

Why would one study theory of mind in adults? This question would seem ridiculous in almost any other domain of cognition. Yet in more than thirty years of exciting research on mindreading, studies of children and non-human animals have had such a strong grip on the theoretical imagination that it may be difficult even to notice that we do not know how adults do it, let alone to appreciate why we might care. To see how anomalous this situation is, just imagine asking the same question in relation to language or reasoning, or cognition of number, space or causality. In these cases, and for almost any other topic in cognition, there is a long history of research in adults that has yielded core bodies of empirical phenomena and cognitive models that aim to account for them. Yet, despite regular claims for the importance of mindreading for important things that adults do – such as everyday social interaction and communication, moral and legal reasoning - little attention has been paid to how mindreading abilities might need to be implemented in order to perform such roles. However, in recent years this situation has begun to change rapidly. In the first part of this chapter I shall survey this growing literature and advance the view that we need to think of adults as having “two systems” for mindreading.

The absence of cognitive models of mindreading in adults also has unattended consequences in the fields where research has been flourishing. Developmental studies, for all the insights they have given, continue to be conducted with little attention to the mature system that development yields. Indeed, there is almost no research beyond 6 or 7 years of age, as if there were nothing more to mindreading than the ability to pass tests for the minimal possession of key mindreading concepts. And neuroscientific studies, for all their impressive convergence on a “mindreading network” of brain regions, have been limited in their ability to identify the functional contribution of different regions, because unlike other topics in cognitive neuroscience, there have been very limited cognitive accounts of the functions that might be performed. Later in the chapter I shall discuss how the growing literature on the cognitive basis of mindreading in adults offers new perspectives on neuroscientific and developmental research.

When do we mindread?

Before diving into the findings, it is worth reflecting on what work we believe that mindreading actually does in adults. The success of empirical research on mindreading has led to a tendency in the field to see mindreading everywhere, so that every communicative exchange and every social interaction is often thought to be mediated by cascading inferences about thoughts, desires, knowledge and intentions. Interestingly, this tendency runs against some early discussions of mindreading, which emphasised that inferences about mental states were likely to be cognitively demanding, and only made when necessary (e.g., Perner, 1991). It is also inconsistent with suggestions that a great deal of co-ordinated communication can be achieved without mindreading inferences (e.g., Breheny, 2006; Pickering & Garrod, 2004). And it has resulted in recent accusations of “theory-of-mind-ism” in research on social interaction, and to suggestions that the “theory of mind” paradigm should be abandoned entirely (e.g., Hutto, 2009; Leudar & Costall, 2009). I believe that a sober assessment of this situation requires us to acknowledge two things. On the one hand, we should not assume that mindreading is at work in a given situation just because the situation can be glossed in such terms. For example, when one person holds a door open for another person whose hands are occupied, it is an open question whether the helper infers the helped person’s intention to open the door themselves, and careful work would be necessary to distinguish this from the possibility that the helper instead acted on the basis of a social script about door-opening. On the other hand, it is undoubtedly true that we do frequently ascribe mental states to each other, and it is important to understand how and when we do so. The main focus of this chapter will concern this latter point.

It is beyond doubt that in everyday activities we regularly represent the mental states of others. We often tell one another what we think, want or know directly, and in order for this to be understood the listener must, of course, represent these mental states. We also routinely appeal to such mental states when we want to explain or justify the actions of ourselves or others (Malle, 2008). Such circumstances may be relatively trivial, as when I tell you of my desire for beer. But they may also be much more serious, as when we evaluate the guilt or innocence of a defendant in a court of law by considering whether their actions were intentional or accidental, and performed in knowledge or ignorance of their consequences. Viewed this way, mindreading clearly has the potential to be as flexible and as complicated as any other problem of reasoning, and has precisely the wrong characteristics for processing in a specialised cognitive module (Apperly, 2010; cf. Fodor, 1983; 2000). To the degree that this is correct we should expect mindreading to be relatively effortful, drawing on limited resources for memory and executive control.

On the other hand, it is also commonly supposed that mindreading serves a critical role in fast-moving social interaction and competition, enabling us, for example, to work out what a speaker is talking about on the basis of their eye gaze and to execute competitive bluffs and counter-bluffs in sport. Of course, we must be cautious against theory-of-mind-ism, and remember that mindreading may not always be necessary. But there seem good prima facie reasons for supposing that mindreading inferences are indeed made in some such circumstances. And to this degree we should expect mindreading to show at least some key characteristics of a modular process (e.g., Fodor, 1983, 2000; Leslie, 2005), to be relatively effortless, and to make few demands on memory or executive control. For otherwise the demands of mindreading might detract from our ability to perform the main task at hand, such as acting on a speaker’s request or passing the ball to the best person.

What should be clear, however, is that there is a tension between the requirement that mindreading be extremely flexible on the one hand, and fast and highly efficient on the other. Such characteristics tend not to co-occur in cognitive systems, because the very characteristics that make a cognitive process flexible – such as unrestricted access to the knowledge of the system – are the same characteristics that make cognitive processes slow and effortful. Instead, flexibility and efficiency tend to be traded against one another. This trade-off is reflected in Fodor’s distinction between “modular” versus “central” cognitive processes (Fodor, 1983, 2000). And this need for a trade-off is why, in domains as diverse as reasoning (Evans, 2004), social cognition (Gilbert, 1998) and number cognition (Feigenson, Dehane & Spelke, 2004) researchers often propose that human adults have two types of cognitive process operating in that domain, which make complementary trade-offs between flexibility and cognitive efficiency. The above examples suggest that there are good reasons for expecting the same thing for mindreading, and this will be my working hypothesis in the following sections (see Apperly & Butterfill, 2009; Apperly, 2010 for a fuller discussion).

How can we study mindreading in adults[[1]](#endnote-1)?

Research on children is dominated by questions about the nature and origins of our conceptual understanding of mental states (e.g., Baillargeon, Scott & He, 2010; Perner, 1991; Wellman, Cross & Watson 2001). Typical pass/fail tasks designed to test this conceptual understanding, such as false belief tasks (Wimmer & Perner, 1983) or visual perspective-taking tasks (Flavell, Everett, Croft & Flavell, 1981), are of no use for studying adults because nobody really doubts that a typical adult has such basic mindreading concepts. Researchers have taken several approaches to this problem.

One solution to this problem is to test mindreading concepts that are more subtle or complex, where there might plausibly be some variation among adults. For example, there is evidence that older children and adults advance through a series of increasingly sophisticated theories about the origins and nature of knowledge (e.g., Chandler, Boyes & Ball, 1990; Kuhn, 2009; Robinson & Apperly, 1998). However, such studies are limited by the fact that sophisticated concepts are unlikely to be representative of the mindreading that might underpin many of our everyday social interactions. Other work has shown variation in adults’ ability to understand stories about social situations involving white lies, bluffing, sarcasm, irony or faux-pas (Happe, 1994). Understanding such situations surely requires inferences about the mental states of the story characters. However, it is unclear whether it requires concepts that are more “advanced” than those of younger children. Instead, I would suggest that such tests identify variance in adults’ ability to *apply* such concepts in a flexible, context-sensitive manner. This ability is as vital for everyday mindreading as possessing the concepts in the first place, and plausibly has both an extended developmental course and variability in the mature system of different adults.

A second approach to studying mindreading in adults follows a broad tradition that seeks insights into the nature of adults’ reasoning by examining the heuristics and biases that are apparent in their everyday judgements and decisions. Such studies may pose mindreading problems where the “right” answer is somewhat uncertain, such as judging how another person will make a difficult perceptual discrimination, or interpret ambiguous verbal messages (e.g., Epley et al., 2004). Or in tasks with a clear “right” answer – such as predicting the incorrect search of someone with a false belief about an object’s location – researchers may ask participants to rate their certainty about their answer (e.g., Birch & Bloom, 2007; see also Mitchell, Robinson, Isaacs & Nye, 1996). Findings from these studies suggest that adults’ judgements about others are prone to biasing interference from their own perspectives; a phenomenon variously labelled “egocentric bias” (Nickerson, 1999), “reality bias” (Mitchell et al., 1996), and “curse of knowledge” (Birch & Bloom, 2007). Such effects may be most apparent when adults are put under time pressure (Epley et al., 2004), or when placed under a concurrent memory load (Lin, Keysar & Epley, 2010). These studies yield valuable insights into the cognitive basis of mindreading, by suggesting that unbiased, non-heuristic mindreading may require time and cognitive effort. However, they give limited insights into why this might be the case, and whether all processing steps in mindreading are cognitively effortful, or only some.

A third approach to studying mindreading in adults uses tasks that require simple judgements about beliefs, desires and visual perspectives that are conceptually similar to those used in studies of young children. Following methods widely adopted in cognitive psychology these tasks enable the measurement of adults’ response times across many repeated trials, and so avoid the problem that adults make few errors on such tasks. For example, in one early study of this kind, German and Hehman (2006) presented adults with multiple trials of a belief-desire reasoning task, which showed adults to be slower to make judgements when a character had a false belief rather than a true belief, and when s/he had a negative rather than a positive desire. Because these tasks are simple and repetitive, they may lack the subtlety, sophistication and uncertainty of much everyday mindreading, which is captured by the tasks described above. But they have two significant advantages. Firstly, they enable much more fine-grained questions to be asked about the component processes of mindreading. For example, it may be possible to ask whether working memory is necessary for the process of inferring a mental state or the process of using that information to guide social interaction, or both. Secondly, they require simple mindreading concepts similar to those required in most developmental and neuroscientific studies, and so may provide a stronger link to studies of these different participant groups than the methods described above.

In the following sections I combine evidence from each of these approaches in to illustrate what we are learning about the complex nature of mindreading in adults. These findings motivate the suggestion that mindreading can be *both* flexible and effortful, and inflexible, effortless and even automatic.

Mindreading as flexible but effortful thinking.

Discussion about the cognitive basis of mindreading has largely consisted in debates between advocates of simulation-theory, theory-theory and modularity theory (e.g., Davies & Stone, 1995a, 1995b), which can appear somewhat insular when viewed from outside. The broader literature on cognition in adults already has extensive bodies of research on different aspects of “thinking”, including formal and practical reasoning (Byrne, 2005 ; Johnson-Laird, 1987) and online comprehension during conversation and reading (Garnham, 1987; Pickering & Garrod, 2004). The limited contact between this literature and research on mindreading is truly surprising, because it is almost trivially true that information about mental states – what people know, think, intend, etc. – can and does feature in all aspects of reasoning, decision-making and discourse processing. Put another way, mindreading is not something we tend to do in isolated and disinterested bouts. Rather, it is an activity that is useful mainly by being part of our everyday thinking and comprehension. These literatures are therefore an obvious place to look for expectations about how at least some aspects of mindreading will be achieved.

There are, of course, many alternative accounts of reasoning, decision-making and comprehension that differ in important ways. However, common themes are 1) that such thinking involves the on-line construction of some form of mental model of the situation under consideration, 2) models can include information explicitly mentioned (e.g., by the speaker, the story, or in the task instructions) and information from inferences beyond the given information, 3) model construction and maintenance is demanding of limited resources for memory and executive control, 4) consequently, what information is represented or inferred will depend upon what memory and executive resources are available, and on whether the thinker takes it to be worthwhile or relevant to elaborate the model. These themes provide a set of expectations about the characteristics of adults’ thinking about thoughts, and there is good evidence to suggest that mindreading does indeed fit these expectations in many circumstances.

*Many components of mindreading are effortful.* The focus of research on the ages at which children first demonstrate critical mental state concepts might lead to the supposition that the later use of such concepts showed little interesting variability. Yet a number of studies now suggest that mindreading problems that are hardest when children first pass developmentally sensitive tasks (such as false belief versus true belief problems) continue to require the most cognitive effort for older children and adults. As already mentioned, German and Hehman (2006) presented adults with short stories from which they had to infer a character’s belief and desire in order to predict their action. German and Hehman (2006) found that adults were slower (and more error-prone[[2]](#endnote-2)) on trials that required thinking about false beliefs and negative desires, compared with true beliefs and positive desires, which is the same pattern of relative difficulty observed in 3- to 6-year-old children on developmentally sensitive tasks (e.g., Leslie, German & Polizzi, 2005). This finding clearly suggests that psychologically relevant parameters, such as the valence of belief and desire, influence the effort adults must put in to solving mindreading tasks. However, in common with most mindreading tasks in the developmental literature, the task required adults to infer the character’s mental states from the story, to hold this information in mind and to use it in combination with further facts from the story in order to predict the character’s action. This leaves it unclear which of these component processes required cognitive effort.

Further studies have gone some way to isolating these distinct components from one another. Apperly et al. (2011) adapted the belief-desire paradigm and obviated the need for participants to infer the character’s mental states by stating these directly. Participants read sentences describing which one of two boxes contained some hidden food, which box the character thought contained the food (his belief could be true or false), and whether he wished to find or avoid the food. All participants had to do was hold this information briefly in mind, and then combine it to predict which box the character would open (e.g., if he had a false belief and a desire to avoid the food he would open the box containing the food on the mistaken belief that this box was empty). Although participants no longer had to infer the character’s mental states the valence of his belief (true versus false) and desire (positive versus negative) nonetheless influenced their performance. In a further study, Apperly et al. (2008) obviated both the need to infer a character’s mental states and the need to predict their action. Participants read sentences describing the colour and location of a hidden ball and a character’s belief about this situation, and responded to a probe picture that simply required them to recall either belief or reality. Again, false belief trials were harder for participants than a baseline “neutral” belief trial, suggesting that the mere fact of having to hold someone’s false belief briefly in mind comes at a measurable processing cost.

Using a rather different paradigm in which participants made rapid judgements about the simple visual perspective of a character standing in a room, Samson et al. (2010) were able to study the demands of mindreading inferences independent of demands associated with holding such information in mind or using it for further inferences. They found that participants were slower to judge the character’s perspective when it was different from the participants’, suggesting that, like young children, adults experienced egocentric interference when they made judgements about someone else’s perspective. Complementary evidence coms from Keysar et al. (2000), who were able to study participants’ ability to *use* information about someone else’s perspective under conditions designed to minimise the demands of inferring this information or holding it in mind. These authors examined adults’ ability to take account of someone’s visual perspective when following their instructions to move objects around a simple array. The instructor could not see all of the items in the array, and so participants had to rule out these items as potential referents for instructions. Importantly, since participants were given ample time to identify these items, and since the array was in full view throughout the trial, any failure to take account of the instructor’s perspective should not be due to difficulty with inferring that perspective or holding that information in mind for an extended period of time. Rather the potential difficulty in this task is with *using* the information about the instructor’s perspective to guide interpretation. In fact, adults are surprisingly error-prone on this task, and indeed they are more error-prone at using the instructor’s perspective than at a comparison condition in which they must interpret instructions according to an arbitrary, non-social rule (Apperly et al., 2010).

In sum, recent work shows that it is possible to separate component processes in mindreading – including inferring mental states, holding this information in mind, and using this information. The evidence suggests that these processes may each contribute to making mindreading cognitively effortful. In the next section I review evidence suggesting that much of the variation in “effort” across mindreading problems reflects the differential recruitment of cognitive resources for memory and executive function.

*Mindreading frequently depends on memory and executive function.* The broader literature suggests that adults’ success on reasoning and comprehension tasks is frequently correlated with their success on tests of memory and executive function, that success is impaired if participants must simultaneously perform a second task that taxes memory or executive function, and that it may also be impaired in old age (e.g., McKinnon & Moscovitch,2007). A growing literature suggests that the same pattern is typically true for mindreading.

By using a pre-test to select adults with low versus high working memory spans, Linn, Keysar & Epley (2010) found that adult participants with lower spans were less likely to use their mindreading abilities when following instructions from a speaker with a different visual perspective. By looking for between-task correlations German and Hehman (2006) found that adults’ performance on their belief-desire task was related to performance on tests of inhibitory control, processing speed and working memory, with the most important factors being inhibitory control and processing speed. This study also found that elderly participants (over the age of 60) performed less well than young participants at belief-desire reasoning. Similarly, Phillips et al. (2011) found that elderly adults performed less well than young adults on false belief tasks (though not true belief tasks), and that this difference was partially mediated by group differences in working memory performance (see also Mckinnon & Moscovitch, 2007, for similar results). Other studies using tasks that require more subtle or complex mindreading have revealed inconsistent evidence of group differences between younger and older participants, and inconsistent evidence of relationships with other cognitive abilities. However, for the reasons discussed earlier, the demands on mindreading made by more complex tasks are confounded with a range of other requirements on memory, executive function, and context-sensitive processes. This complexity may explain the inconsistent patter of results observed (see e.g., Rakoczy et al., 2012 for a recent summary and discussion).

Dual task methods can go beyond correlational studies to provide evidence that concurrent performance of a memory or executive task impairs performance on a mindreading task. This approach has found evidence that mindreading can be impaired by a concurrent working memory task (McKinnon & Moscovitch, 2007) as well as by tasks that tax inhibition and task switching (Bull, Phillips and Conway, 2008) and verbal repetition (Newton & de Villiers, 2007). However, although these studies show impaired mindreading performance, the tasks used do not make it possible to discern whether participants’ difficulty was with mindreading inferences, holding such information in mind or using the information to make inferences about behaviour. Two recent studies make some progress on this question. Linn, Epley & Keysar (2010) found that adults placed under memory load were less able to use information about a speaker’s perspective when following their instructions. And Qureshi, Apperly and Samson (2010) found that a concurrent inhibitory control task increased adults’ egocentric interference when judging another’s visual perspective.

In sum, although there is some variation across studies, and some uncertainty about the precise relationships revealed, these studies converge with the evidence from patients with brain injury (see Chapter \*\*\*) on the conclusion that mindreading often requires memory and executive function.

*Mindreading inferences are non-automatic, and sensitive to context and motivation.* It is sometimes stated, simply as a matter of fact, that mindreading inferences are “automatic”, suggesting that we cannot help but ascribe mental states when given a stimulus that affords such inferences (e.g., Friedman & Leslie, 2004; Sperber & Wilson, 2002; Stone, Baron-Cohen, & Knight, 1998). Yet, from the perspective of the broader literature on adults’ thinking, this claim is surprising. For although there is plenty of evidence that adults routinely and rapidly make inferences that go beyond the information given in a reasoning or comprehension task, it is equally clear that these inferences are not obligatory or stimulus-driven, but are instead dependent on participants’ motivation for devoting cognitive resources to this aspect of the task (e.g., Sanford & Garrod, 1998; McKoon & Ratcliff, 1998; Zwaan & Radvansky, 1998). Only recently has evidence begun to bear on this question in relation to mindreading.

Apperly et al. (2006) presented participants with video scenarios involving a target character who came to have either a true or a false belief about the location of a hidden object. These stimuli clearly afforded mindreading inferences about the character’s beliefs, but the instructions only required participants to keep track of the location of the hidden object. Our interest was in whether participants would automatically track the character’s belief even though they had no specific reason for doing so. Critical data came from probe questions presented at unexpected points in the videos, which showed participants to be relatively fast at answering questions about the location of the hidden object (which they were instructed to track) but significantly slower to answer matched questions about the character’s false belief (which they had not been instructed to track). No such difference in response times to belief and reality probes was found in a second condition in which participants were instructed to track the character’s belief, suggesting that the difference observed in the first condition arose because participants had not inferred the character’s belief automatically. Importantly, this finding does not imply that adults only infer beliefs under instruction! Two further studies indicate that varying the scenarios or the context can lead participants to infer beliefs spontaneously (Back & Apperly, 2010; Cohen & German, 2009), and this is a good thing, since the real world does not typically furnish us with explicit prompts to mindread. But evidence of spontaneous inferences should be distinguished from the claim that mindreading inferences are made in an automatic, stimulus-driven manner, because if inferences are spontaneous then this opens up questions about the contextual conditions that determine the frequency and nature of mindreading.

Important insight into the potential for mindreading to be influenced by contextual factors comes from a study by Converse et al. (2008). These authors administered a pre-test in which participants were induced to be in either a happy or a sad mood, and then tested participant’s vulnerability to egocentric interference from their own perspective in two different ToM paradigms. Consistent with the view that happy people rely on more heuristic processing, whereas sad people undertake more deliberate processing, these authors found that happy participants showed significantly greater egocentric biases than sad participants. This study not only suggests that mindreading is non-automatic, but that researchers should pay much more attention to the factors that influence the propensity for mindreading, including characteristics of the participant (such as mood) and characteristics of the target, such as their race, sex or class, or other dimensions of similarity and difference to the participant.

It is also important to recognise that the proposition that mindreading inferences are not strictly automatic does not entail that they are typically very slow and effortful. A number of studies arising out of the psycholinguistic tradition suggest that this need not be the case. For example, although there is robust evidence that listeners may fail to take account of the simple perspective of a speaker when interpreting what they say (e.g., Keysar et al. 2001), participants are less likely to look at objects that cannot be seen from the speaker’s perspective (e.g., Nadig & Sedivy, 2002), suggesting that information about the speaker’s perspective has some cognitive effects (see also Ferguson & Breheney, 2012, for related findings regarding false beliefs). This has led to the suggestion that participants’ errors might arise from difficulty with integration of information about the speaker’s perspective with linguistic processing of their message (Barr, 2008). However, recent evidence suggests that even such integration of another’s perspective need not be very effortful or time-consuming, particularly when no compelling alternative interpretation is available from one’s own perspective (Ferguson & Breheney, 2011).

Altogether, there is direct evidence to suggest that mindreading frequently occurs spontaneously. In a wide range of circumstances people clearly do not need to be explicitly directed to take account of what other people see, think or feel. Nonetheless, these inferences are not automatic, and the likelihood of spontaneous mindreading depends on the context and on the participant’s mood. The broader literature on inferences made during discourse provides compelling grounds for thinking that future work will find that the likelihood of spontaneous mindreading, as well as the extent of elaboration of such inferences, will depend on participants’ motivation and on the availability of cognitive resources for memory and executive control.

*Summary.* The view of mindreading that emerges from research reviewed in the sections above is as follows. At one extreme end of the scale, exemplified by a jury’s deliberations about the evidence for and against a defendant having acted knowledgably and intentionally, mindreading may be truly slow, deliberative and effortful. But the general literature concerning inferences made online during comprehension should lead us to expect that many mindreading inferences may often be made without too much deliberative scratching of chins, and used quickly enough to keep up with an unfolding discourse or text. Nonetheless, such mindreading will require cognitive effort and will depend on the availability of the necessary motivation and cognitive resources.

Mindreading as a cognitively efficient, but inflexible and limited process.

Discussions about the possible automaticity of mindreading typically underestimate how difficult it is to determine that a cognitive process is performed in an automatic manner (e.g., Moors & De Houwter, 2008). For example, it is certainly not sufficient to show that mindreading occurs without instruction, or even that it occurs relatively quickly. For as already described, much cognitive processing can occur spontaneously and quite rapidly, but the fact that it does so only when participants are appropriately motivated and have sufficient resources suggests that such processing is not automatic. However, there are good reasons in principle for thinking that at least some mindreading needs to be less like “thinking” and more like perception in character. To this degree, we should expect mindreading processes to be less dependent on participants’ motivations or cognitive resources, and also to be more limited in their scope than the ones described so far. Recent research also lends support to this view of mindreading.

*Evidence that mindreading may occur when unnecessary or unhelpful.* One characteristic of processes that are more perception-like or modular is that they occur at least somewhat independently of participants’ motivation or purpose, and may even interfere with their primary objectives. Evidence from three different paradigms suggests that mindreading may sometimes show such characteristics.

Zwickel (2009) presented participants with very simple animations of isosceles triangles that appeared to be moving in a random fashion, in a simple goal-directed fashion (e.g., one triangle chased another), or in a complex goal-directed fashion (e.g., one triangle coaxed another). Previous research has found that participants’ spontaneous descriptions of these animations differ, with simple and complex goal-directed animations eliciting descriptions of goals, and only complex goal-directed animations eliciting descriptions of more complex mental states (Abell, Happe & Frith, 2000). During the animations a dot occasionally appeared on one or other side of a triangle and participants’ explicit task was to judge whether the dot appeared to the left or the right. On half of the trials the triangle happened to be pointing upwards when the dot appeared, and on the other half it happened to be pointing downwards. Of course, this was strictly irrelevant to the participants’ task of making left-right judgments of the dots. However, in the two goal-directed conditions participants were slower to make left-right judgements for downward-facing triangles than for upward-facing triangles, whereas there was no such effect for the random movement condition. This effect can be understood if we suppose that participants not only viewed the scene from their own point of view, but also “took the perspective” of the triangles in the goal-directed conditions but not in the random condition. Of course for upward-facing goal-directed triangles, the triangle’s left or right was aligned with the participant’s own left and right, whereas the left side of a goal-directed downward-facing triangle was on the participants’ right side, and vice versa. Thus, participants’ slow left-right judgments for downward-facing goal-directed triangles can be understood as being the result of interference from task-irrelevant processing of the triangle’s “perspective”. It is notable that this effect was largest of all for the complex goal-directed animations. But it is not clear whether this was because these stimuli invited the richest ascriptions of mental states, or because these stimuli gave the more compelling sense of animacy. Nor is it clear whether participants are processing the triangle’s physical, spatial perspective, or whether they are, in some sense, attributing a psychological, visual perspective to the triangle. Either would be sufficient to support a left-right distinction. Importantly, though, this does appear to be a case in which some form of perspective-taking is occurring independently of participants’ purposes, and in fact interferes with their performance on the main task.

A second paradigm converges on the same conclusions, this time in the case of very simple visual perspective-taking. Samson et al. (2010) presented participants with pictures of a room with dots on the wall, and an avatar positioned in the room such that he either saw all of the dots (so his perspective was congruent with participants’) or he saw a subset of the dots (so his perspective was incongruent with participants’). On the trials that are critical for the current discussion, the avatar’s perspective was irrelevant because participants were simply asked to judge how many dots they saw in the room from their own “self” perspective. Nonetheless participants’ responses were slower when the avatar’s perspective happened to be incongruent rather than congruent with their own. This effect was apparent when participants’ “self” judgements were mixed with other trials on which they made explicit judgments about the avatar, and also in a further experiment in which participants only ever made judgements about their own perspective. In the latter case, the avatar’s perspective was entirely irrelevant to the entire task, and yet participants appeared to process his perspective, and this caused interference when it differed from their own.

A third paradigm converges on related conclusions, this time for processing of belief-like states[[3]](#endnote-3). Kovacs et al (2010) presented participants with animations in which a ball rolled around a scene, sometimes appearing to remain behind an occluding wall, and sometimes rolling out of the scene. The animations also included an agent who witnessed different parts of the event sequence across trials and ended up either with the same belief as the participant about the ball’s presence or absence, or the opposite belief. However, the agent was irrelevant to the participants’ task, because participants were simply required to press a response button if the ball was behind the wall when the wall was lowered at the end of the animation. The ball was in fact equally likely to be present irrespective of whether it had appeared to remain or to leave the scene during the animation. Unsurprisingly, adults were faster to detect the ball when the animation led them to expect the ball to be present than when they expected it to be absent. Importantly, though, this effect was modulated by the irrelevant beliefs of the agent: when the ball was unexpectedly present from the participants’ point of view participants were faster to detect it if the agent happened to believe that it was present and slower to detect it when the agent happened to believe it was absent. In this case, processing of the agent’s perspective was actually helpful, rather than unhelpful, but nonetheless it was clearly irrelevant to participants’ main task of detecting balls appearing behind the wall, suggesting that it was relatively stimulus-driven and automatic.

*Evidence that mindreading is cognitively efficient.* A second characteristic of perception-like, modular processing is that it makes few demands on domain-general resources for its operation. One way to test this experimentally is to see whether effects such as those just described persist even when participants’ resources are taxed by another task.

Qureshi, Apperly & Samson (2010) presented Samson et al.’s visual perspective-taking task either alone or at the same time as a task that taxed executive control. Their rationale was that participants’ irrelevant processing of the avatar’s perspective might nonetheless be consuming of executive resources, and if this were so then the secondary task should reduce this irrelevant processing and so reduce the interference that participants suffered when judging their own perspective. In fact this study found that the secondary task *increased* interference from the avatar’s irrelevant perspective, suggesting that calculating his perspective was cognitively efficient, and that executive control was instead required for resisting interference from this perspective.

Evidence for the same conclusion comes from Schneider et al. (in press). These authors monitored adults’ eye fixations while viewing video scenarios in which the character in the video came to have either a true or a false belief about an object’s location. Although adults always knew the object’s true location, and although the character’s beliefs were apparently irrelevant, adults nonetheless spent longer looking at the incorrect location for the object when this was where the character incorrectly believed the object was located, compared with when the character had a true belief. Importantly, adults showed no awareness of tracking the character’s beliefs, and this evidence of “implicit” processing was replicated in a second study in which participants simultaneously performed a distracting secondary task.

The findings from these two studies suggest that simple visual perspective-taking and simple belief ascription not only occur in a relatively automatic manner, but also can be cognitively efficient so that these processes are not disrupted by a secondary task.

*Evidence that mindreading is limited.* A third characteristic of perception-like, modular processing is that automaticity and efficiency do not come for free, but are gained at the expense of limits on the kinds of problem that can be solved. A well-studied example is the ability of infants, children, adults and many non-human species to track the precise numerosity of items in a set (see e.g., Feigenson, Dehane & Spelke, 2004). This ability is cognitively efficient, but also extremely limited, in that it can only “count” to 3. Importantly, such limitations are not merely a correlate of modular processing; limits reflect the way in which modular processing manages to be efficient, by restricting itself to processing of just some kinds of information (e.g., Fodor, 1983; 2000). It follows that, to the degree that mindreading shows other characteristics of modular processing, we should expect it also to be limited to some problems but not others.

A recent study that fits with this expectation of limited processing was conducted by Surtees, Butterfill and Apperly (2012; see also Low & Watts, in press, described later). These authors tested whether Samson et al.’s (2010) finding that adults automatically process *what* items were seen by an avatar in a cartoon room would extend to *how* items were seen by the avatar. In their task the avatar faced out of the room, sitting behind a table on which digits could appear. Digits such as the number “8” are rotationally symmetrical, and so would appear the same to both the avatar and the participant. These trials were compared with others using digits such as the number “6” that would look like a “six” to one viewer and a “nine” to the other. Recall that Samson et al. (2010) found that participants were slower to judge *what* they themselves could see when the avatar saw something different. In contrast, Surtees, Butterfill & Apperly (2012) found no evidence that adults were slower to judge *how* the digit appeared to them when it happened to appear differently for the avatar. Naturally, we must be cautious about drawing strong conclusions from these negative findings, but nonetheless this study provides preliminary evidence fitting with the expectation that automatic mindreading will be limited in its scope.

Interim summary: Two systems for mindreading in adults?

The foregoing sections show that recent research has greatly extended the methods available for studying mindreading in adults. However, on key questions about the cognitive characteristics of mindreading the results emerging from this work point in quite different directions. Some evidence suggests that mindreading shows the characteristics of flexible but effortful thinking, while other evidence suggests that it shows the characteristics of efficient but inflexible modular processing. What are we to make of these findings? There is certainly some wisdom in the view that we should be cautious. Many of the paradigms described are novel, at least within the mindreading literature, and most findings reported are relatively new. Any new field of enquiry is likely to produce a higher than average number of anomalous findings, and in five or ten years there might be a much better evidence base to suggest that mindreading is more like thinking than perception, or vice versa.

However, I think there are good grounds for taking both characterisations of mindreading seriously. Firstly, the findings from adults may be relatively new, but the evidence comes from multiple tasks and approaches that provide reassuring convergence suggesting that both characterisations of mindreading have merit. Secondly, the evidence base is potentially much broader if we also look to studies of children and infants. Here too we find good grounds for supposing that mindreading has the characteristics of effortful thinking when studied in children (e.g., Carlson & Moses, 2001), but also apparently contradictory evidence that it has more perception-like qualities when studied in infants (Baillargeon et al., 2010). Thirdly, such apparently contradictory results abound in psychological research in other cognitive domains, such as number and physical cognition, social cognition and general reasoning (e.g., Evans, 2003; Feigenson et al., 2004; Gilbert, 1998). And in these other domains this apparent contradiction is resolved by supposing that adults actually operate with “two systems”, each having distinct processing characteristics. For these reasons it seems at least plausible to hypothesise that adults implement two kinds of solutions for mindreading, consisting both of flexible processes for “thinking” about the minds of others, and a number of modules that pull off the same trick in a cognitively efficient manner for a limited subset of mindreading problems (e.g., Apperly & Butterfill, 2009; Apperly, 2010).

Understanding the cognitive basis of mindreading in adults is surely a worthwhile project in its own right. However, it also has further utility in informing our understanding of development and neural basis of mindreading. In the final sections of this chapter I shall explore some important implications of the emerging evidence about the multi-faceted nature of mindreading in adults.

Implications for development.

The growing literature on mindreading in adults should have a significant impact on studies of development for several reasons. Firstly, it is producing new methods based upon the measurement of response times that can be adapted for use with “older” children who pass standard developmental tests of mindreading. Such methods suggest that children’s use of information about the minds of others becomes significantly more accurate through middle childhood and adolescence (Dumontheil et al., 2010; Epley, Morewedge & Keysar, 2004), that different belief-desire reasoning problems continue to vary in difficulty even after children first “pass” the tasks (Apperly et al., 2011), and that 6-year-olds show just the same degree of automatic perspective-taking as adults (Surtees & Apperly, 2012). Secondly, the cognitive basis of mindreading in adults can assist with interpretation of developmental findings. For example, there is good evidence that adults who have severely impaired grammar as a result of brain injury may nonetheless be able to pass both 1st and 2nd order mindreading tasks (e.g., Apperly et al., 2006; Varley & Siegal, 2000; Varley, Siegal & Want, 2001). This suggests that developmental associations between grammar and mindreading (e.g., Milligan, Astington & Dack, 2009) cannot be the result of grammar having a constitutive role in the mature mindreading system that children are developing, but must instead be due to grammar serving a role in the developmental construction of mindreading (Apperly, Samson & Humphreys, 2009). Such conclusions are difficult to reach without evidence from adults. Thirdly, the adult system is the end-point that any adequate theory of development must be able to explain. It should be clear from the complex picture of the adult system described above that developmental accounts focusing only on when infants or children should be credited with basic mindreading concepts are in danger of seriously underestimating their explanatory task. This is so because such accounts often have rather little to say about what happens after children pass basic experimental paradigms. In the following paragraphs I will consider in very broad terms what questions a two-systems account of mindreading in adults should make us ask about development.

*How do adults acquire two systems for mindreading?* As described in other chapters of this volume, most research on mindreading in children focuses on 2- to 6-year-olds and suggests that the ability to make correct judgements about other people’s beliefs, desires and intentions has a protracted developmental course. Not only is there good evidence of incremental acquisition of an increasingly sophisticated conceptual grasp of mental states (Wellman & Liu, 2004), but progress appears to depend critically on developments in both language, and executive function and memory (e.g., Carlson & Moses, 2001; Milligan, Astington & Dack, 2009). Although such research seldom looks much beyond early childhood, it seems natural to see this as charting the early development of the adult system for mindreading that has the characteristics of flexible but cognitively effortful thinking.

Because of this well-known body of findings in children, much excitement has attended recent evidence suggesting that infants are also capable of mindreading, at least when tested using methods that allow this ability to be observed in eye movements, looking time or other spontaneous behaviours, rather than in overt judgements (see e.g., Baillargeon et al., 2010 for a recent review). Much of the excitement concerns the simple possibility that mindreading might be observed at much younger ages than previously thought. However, just as interesting from a cognitive point of view is the fact that infants’ mindreading must be cognitively efficient, since infants have few resources for language or executive control. The findings from infants remain somewhat controversial (e.g., Hutto, Herschbach & Southgate, 2011; Perner, 2010), but for current purposes I shall work with the hypothesis that infants are indeed mindreading in some meaningful sense. Instead, the question on which I would like to focus is how the abilities of infants are related to those of older children and adults.

*Figure 1. Alternative relationships between the mindreading abilities of infants, children and adults. In panel (a) the mindreading abilities infants become progressively integrated with language, executive function and knowledge over the course of development, giving rise to the flexible but effortful abilities of adults. Some of these abilities are then automatised into efficient but inflexible routines. In panel (b) the mindreading abilities of infants remain largely intact into adulthood, where they enable adults to perform some mindreading in an efficient but inflexible manner. Young children undergo a protracted process of learning to reason about the minds of others. This developmental process requires language, executive function and accumulating knowledge and gives rise to the flexible but effortful mindreading abilities of adults. The dashed lines suggest that this model is compatible with the abilities of infants having some influence on the development of children’s reasoning about mental states, and with adults automatising some of their effortful mindreading abilities. (NB. I am grateful to Oliver Poole and Lionel Apperly for allowing their photographs to be used.)*

*The infant system grows up.* The dominant view among researchers studying mindreading in infants appears to be that infants’ abilities will be essentially continuous with the full-blown mindreading abilities of older children and adults (e.g., Baillargeon et al., 2010; Leslie, 2005). That is to say, infants possess foundational mindreading concepts and abilities that are, at first, only “implicit” and only observable via indirect experimental methods. However, over developmental time, and with increasing availability of language, executive function and critical social knowledge, children become increasingly able to use these concepts in flexible and sophisticated ways, and to use them as the basis for explicit judgements. This developmental pattern is depicted in the top panel of Figure 1, and is clearly plausible as an account of the relationship between the abilities of infants and adults. However, one important consequence of this proposal is that although infants’ abilities may start out being cognitively efficient, they will clearly not remain so once they have been integrated with language, executive function and an ever-increasing database of knowledge. This follows from Fodor’s (1983, 2000) analysis, which holds that it is precisely the absence of such integration that explains how modular processing can be cognitively efficient.

This means that there must be some additional developmental explanation of the cognitively efficient mindreading abilities of adults. One potential way in which this might occur is that certain mindreading problems that are both sufficiently frequent and sufficiently regular in their demands will become automatised into routines. For example, it might be that over developmental time most people encounter the need to calculate what someone sees with sufficient frequency that this becomes automatised, so that “what someone sees” is calculated whenever we see an agent apparently attending to objects in her visual field.

*The infant system remains intact.* Importantly, though, this is not the only possible set of developmental relationships. As depicted in the bottom panel of Figure 1, another possibility is that the abilities observed in infants remain intact and uncluttered by demands upon language or executive control, so that they continue to support cognitively efficient mindreading into adulthood. On this account, although the infant system may provide critical support, flexible and effortful mindreading would develop as a quite separate process, perhaps in much the way envisaged by developmental psychologists before the recent findings from infants. Of course, this hypothesis does not preclude the possibility that some initially effortful mindreading might become automatised over developmental time. But only on this hypothesis will adults inherit at least some of their efficient capacities for mindreading from infants.

Clearly, these accounts present quite different views of the developmental origins of adults’ two systems for mindreading. So how might we decide between them? Although the most popular current suggestion is that the infant system grows up, it is noteworthy that many other domains of cognition, such as number, physical cognition, agency and causality, there is good evidence for the alternative account, that infant abilities remain intact into adulthood (for a recent extensive review and discussion, see Carey, 2009). Of course, these precedents alone are insufficient to show that the same will be true for mindreading. But Carey’s account does indicate where decisive evidence might be found; in the nature of the limits on efficient mindreading observed in infants and adults. Recall from earlier that efficient mindreading in both infants and adults will necessarily come at the cost of inflexible limits on the kinds of information that can be processed. In adults this will be the case irrespective of whether efficient mindreading abilities are inherited from infants, or whether they are automatised. However, if adults’ efficient abilities arise as a result of automatisation, then there is no reason to suppose that these limits will be the same as those observed in infants. If, on the other hand, adults inherit efficient mindreading abilities from infants, then they should show similar limits. This is the case for number cognition, where both infants’ and adults’ capacities for precise enumeration are limited to 3 items. As Carey (2009) points out, such “signature limits” are a powerful device for detecting whether infants and adults are using the same cognitive processes to solve a problem. With Stephen Butterfill and I have argued elsewhere that there is indeed preliminary evidence for such a signature limit in the abilities of infants and the efficient abilities of adults, which both may be restricted to process relations between agents and objects, rather than agents and propositions (Apperly, 2010; Apperly & Butterfill, 2009; Butterfill and Apperly, in press). And this proposal has received recent support from Low and Watts (in press) who find evidence that young children’s “implicit” understanding of false belief allows them to ascribe false beliefs about an object’s location but not about an object’s identity. But this specific proposal matters less in the current context than the general proposition that there is more than one way in which the mindreading abilities of infants can develop through childhood into those we observe in adults, and that there are viable ways of distinguishing between these developmental hypotheses.

Implications for understanding the neural basis of mindreading

Research on the neural basis of mindreading has been strongly influenced by traditional developmental approaches, with two notable consequences. Firstly, the tasks employed typically involve presentation of stories or cartoons that resemble tests of young children’s explicit reasoning about mental states, and so these tasks should be expected to test adults’ “thinking” about mental states. Secondly, studies are typically premised on the assumption that mindreading consists primarily in the domain-specific ability to understand and represent mental states (e.g., Frith & Frith, 2003; Saxe, Carey and Kanwisher, 2004). Thus, although a number of brain areas are commonly held to constitute a “mindreading” brain network, notably including medial prefrontal cortex (mPFC), temporal poles and bilateral temporo-parietal junction (TPJ), debate has typically been limited to which of these areas is most selectively involved, and might therefore qualify as the location of the neural seat of mindreading. Perhaps the clearest evidence emerging from this line of thinking comes from a series of studies by Saxe and colleagues (e.g., Saxe & Kanwisher, 2003; Saxe & Powell, 2006). These authors first identified brain areas that survived a very neat contrast between activation observed while participants responded to short stories concerning false beliefs versus false photographs, and then tested which of these areas were most selectively activated during other judgements about mental states in contrast to other judgements, including personal preferences, personality, physical appearance. These studies consistently find that right-TPJ shows the largest and most selective activation for mental states, whereas other areas of the “mindreading network” either show lower activations, or activations for a wider range of judgements. This pattern has led to suggestions that r-TPJ is *the* domain-specific neural basis of mindreading (e.g., Saxe, 2006).

This interpretation of these studies remains highly contested (e.g., Decety & Lamm, 2007; Mitchell, 2008; Legrand & Ruby, 2009), but it is not my current interest to enter into this debate. Studies of the cognitive basis of mindreading, reviewed above, clearly do nothing to rule in or rule out the possibility that there are genuinely domain-specific representations and processes involved in mindreading. However, they do suggest very clearly that there is a great deal more to mindreading than possessing specialised mindreading concepts or representations. At the very least, doing useful work with such concepts will involve the ability to make flexible inferences in a context-sensitive manner, to do this within the context of a mental model of the on-going situation, and all the while to resist interference from self perspective. These considerations suggest that the benefits of tightly-controlled subtractive methods for identifying neural activation that could be specific to mindreading will likely come at a cost. In particular, they risk causing researchers to overlook functional and neural processes that are less specific, but equally essential to a full understanding of mindreading. Therefore I will briefly focus on studies using different methods, which cast light on the broader neural basis of mindreading.

Medial prefrontal cortex features prominently among the other neural regions implicated in mindreading. However, in the broader literature mPFC is also implicated in a range of other tasks, including generation of temporary integrated representations of events, and imposing structure on otherwise vague or uncertain problems (see e.g., Legrand & Ruby, 2009). As discussed above, mindreading frequently requires context-sensitive inferences, made on the fly, using limited information about the situation. Might it be, then, that mPFC is involved in serving this role for mindreading? In a recent study, Jenkins and Mitchell (2009) presented participants with mindreading tasks that orthogonally varied whether the scenarios concerned a character’s mental states or their preferences, and whether a specific mindreading inference was relatively clear, given the context, or whether the situation was more ambiguous. Consistent with other work, this study found that r-TPJ was selectively sensitive to the difference between scenarios involving mental states rather than preferences, whereas mPFC was not selectively sensitive to this difference. In contrast, mPFC was sensitive to the difference between scenarios involving clearly-specified rather than ambiguous inferences, whereas r-TPJ was not. Naturally, this finding must be interpreted with some caution given how little agreement there is on the functions of mPFC in general (see e.g., Legrand & Ruby, 2009), or the functional necessity of mPFC for mindreading in particular (e.g., Bird et al., 2004). Nonetheless it serves to illustrate how it is possible to go beyond asking which regions of the “mindreading network” are most specifically involved in mindreading, in order to understand how the multiple functional requirements of mindreading are fulfilled.

Not only is it the case that commonly-used subtractive methods bias researchers to ask just one kind of question about regions of the “mindreading network”, but they also risk leading researchers to overlook additional functional and neural processes that might be critically necessary for mindreading. One such illustration comes from the case study of a patient, WBA, who, following a stroke, sustained a right frontal lesion that only showed limited encroachment on regions of the “mindreading network” but encroached substantially on brain regions frequently implicated in cognitive control (Samson et al., 2005). WBA showed impairment on a range of neuropsychological tests for working memory and executive function, including inhibitory control. Across a range of mindreading tasks he showed a pronounced tendency for “egocentrism”, responding on the basis of his own belief, desire or perspective, rather than that of the other person. Nonetheless, on a false belief task designed to reduce the tendency for egocentrism by reducing the salience of participants’ self-perspective, WBA was able to perform successfully. These results indicate that having the ability in principle to think about someone else’s perspective is not nearly sufficient for reliable mindreading. To put that ability into practice in a typical range of circumstances also requires the ability to inhibit interference from one’s own perspective, and this ability was impaired by WBA’s right frontal lesion. This conclusion receives converging support from several fMRI and ERP studies using designs that that manipulate demands on self-perspective inhibition within the context of a mindreading task (e.g., McCleery et al., 2011; van der Meer et al., 2011; Vogeley et al., 2001). These studies show lateral frontal brain regions – notably inferior frontal gyrus – being recruited in the service of mindreading. Such activation is not observed in the most tightly-controlled subtraction designs – such as the comparison between false belief and false photograph tasks – because the relevant activation is subtracted out.

What I hope this brief section illustrates is that emerging evidence on the cognitive basis of mindreading in adults has significant consequences for how neuroscientific investigations of mindreading are designed and interpreted. The large number of studies that seek to identify the neural basis of domain-specific mindreading processes make a valuable contribution to understanding. However, there are strong grounds for thinking that this will be just one part of a full account of the neural basis of mindreading.

General conclusion.

For more than thirty years research on our ability to understand agents in terms of mental states has been remarkably productive, but at the same time surprisingly narrow in its scope. We have learned a great deal about how and when children first come to mindread, the degree to which these abilities are shared with other species, and, most recently, the neural basis of some aspects of mindreading. But we have only scratched the surface of understanding the mature abilities that children develop, and how adults use these abilities on-line as they communicate and socialise, or talk, read and think about mental states. This situation is changing rapidly, and it is motivating changes in how we conceptualise mindreading. In addition to answering questions about who has mindreading concepts and when they have them, an adequate theory of mindreading must explain how we ever make use of such abilities. In particular, it must explain how we manage to be both extremely subtle and sophisticated mindreaders, yet simultaneously achieve at least some mindreading rapidly enough to keep up with fast-moving social interactions. I hope to have made the case that mindreading in adults is not merely a fast-emerging new sub-topic in the mindreading literature, but that it is providing critical new insights about the nature of mindreading itself.

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1. For most of the current chapter I will be concerned with methods and findings from typical, neurologically intact adults. Chapters \*\*\*\*\* discuss research on adults using neuropsychological and neuroimaging methods. [↑](#endnote-ref-1)
2. Even when using very simple mindreading tasks, adult participants do show residual errors. For simple tasks these errors clearly do not reflect a lack of the relevant concepts. Usually, they are either random, with no systematic condition differences, or they follow the same pattern of variation across conditions as are observed in response times. In what follows, I will not mention errors unless they show something interestingly different from response times. [↑](#endnote-ref-2)
3. It is a moot point whether adults or infants in such paradigms are representing beliefs per se, or simpler belief-like states (Apperly & Butterfill, 2009). However, what is critical here is that interference arises in a situation where the agent has a false belief, rather than a different visual perspective. [↑](#endnote-ref-3)