

# How to Construct a Minimal Theory of Mind

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## Abstract

What could someone represent that would enable her to track, at least within limits, perceptions, beliefs including false beliefs, and other propositional attitudes? An obvious possibility is that she might represent these very propositional attitudes as such. It is sometimes tacitly or explicitly assumed that this is the only possible answer. However we argue that several recent discoveries in developmental, cognitive, and comparative psychology indicate the need for other, less obvious possibilities. Our aim is to meet this need by describing the construction of a minimal theory of mind. Minimal theory of mind is rich enough to explain systematic success on tasks held to be acid tests for theory of mind cognition including many false belief tasks. It is also extensible in ways that can explain a wide range of findings from non-human animals and human infants that are sometimes presented as evidence for full-blown theory of mind cognition. Yet minimal theory of mind does not require representing propositional attitudes, or any other kind of representation, as such. Minimal theory of mind may be what enables those with limited cognitive resources or little conceptual sophistication, such as infants, chimpanzees, scrub-jays and human adults under load, able to track, within limits, facts about perceptions and beliefs.

**Keywords:** Theory of Mind, False Belief, belief, perception, development, comparative

# 1. Introduction

What could someone represent that would enable her to track, at least within limits, perceptions, beliefs including false beliefs, and other propositional attitudes? One answer is obvious: she might track these things by virtue of representing them as such, that is, by representing perceptions, beliefs, and other propositional attitudes as such. Our aim in what follows is to identify another, less obvious answer. There is a form of cognition—minimal theory of mind—which does not involve representing propositional attitudes as such but does involve representing simpler, relational mental states which could, within limits, enable one to track propositional attitudes such as beliefs. Minimal theory of mind is rich enough to enable systematic success on tasks held to be acid tests for theory of mind cognition including many false belief tasks. As we will explain, this has consequences for interpreting a range of findings concerning infants', adults' and nonhumans' performances on theory of mind tasks. It may help us to understand what enables those with limited cognitive resources or little conceptual sophistication, such as infants, chimpanzees, scrub-jays and human adults under load, to track, within limits, facts about perceptions and beliefs.

In this section we defend explain our question; in the next sections we introduce the findings which motivate facing it before starting to answer it in the fourth section.

Some may find our question initially incomprehensible. Could abilities to track false beliefs (say) really involve anything other than representing false beliefs? To see the possibility of a positive answer it may help to consider a non-mental analogy. What could someone represent that would enable her to track, at least within limits, the toxicity of potential food items? Here the most straightforward answer (she could represent their toxicity) is clearly not the only one. After all, someone might track toxicity by representing odours or by representing visual features associated with putrefaction, say. Suppose Sinéad has no conception of toxins but represents the odours of food items and treats those with foul odours as dangerous to eat, so that she would not normally offer them to friends or family nor conceal them from competitors. This brings nutritional and competitive benefits obtaining which depends on facts about toxicity. If Sinéad tends to behave in this way because of these benefits, representing odours enables her to track, in a limited but useful range of cases, toxicity. Our question, put very roughly, is whether belief has something like an odour.

To make the question more precise it is useful to distinguish theory of mind abilities from theory of mind cognition. A *theory of mind ability* is an ability that exists in part because exercising it brings benefits obtaining which depends on exploiting or influencing facts about others' mental states. To illustrate, suppose that Hannah is able to discern whether another's eyes

are in view, that Hannah exercises this ability to escape detection while stealing from others, that Hannah's ability exists in part because it benefits her in this way, and that Hannah's escaping detection depends on exploiting a fact about other's mental states (namely that they usually cannot see Hannah's acts of theft when Hannah doesn't have their eyes in view). Then Hannah has a theory of mind ability. (This is not supposed to be a plausible, real-world example but only to illustrate what the definition requires.) An ability to *track* perceptions or beliefs (say) is a theory of mind ability which involves exploiting or influencing facts about these states. By contrast, *theory of mind cognition* involves representing mental states or processes as such. And *full-blown* theory of mind cognition involves representing propositional attitudes such as beliefs, desires and intentions to construct reason-giving, causal explanations of action. The distinction between theory of mind abilities and theory of mind cognition matters because the facts about other minds which theory of mind abilities exploit are not necessarily the facts which are represented in theory of mind cognition. To return to the illustration, Hannah is able, within limits, to exploit facts about what others perceive without representing perceptions as such. She has a theory of mind ability while possibly lacking any theory of mind cognition.

It should be uncontroversial that some theory of mind abilities do not necessarily involve any theory of mind cognition at all. Our question concerns abilities to track what others perceive and believe, including their false beliefs; these have been central in psychological research. Can anything less than full-blown theory of mind cognition explain systematic success on a range of false belief tasks? We do not aim to argue that someone could track beliefs, true and false, without any theory of mind cognition at all. Our concern is rather with the construction of a minimal form of theory of mind cognition. As we shall explain, minimal theory of mind does involve representing belief-like states, but it does not involve representing beliefs or other propositional attitudes as such.

The notion that some abilities to track perceptions or beliefs involve only on theory of mind cognition which does not involve representing perceptions or beliefs as such is not entirely novel. To mention only those we draw most directly on, Gomez (2007, p. 730) has emphasized primitive intentional relations to objects established by gaze, O'Neil and Doherty have separately discussed a notion of engagement with objects (Doherty 2006; O'Neill 1996), Call and Tomasello (2005, p. 58) have suggested that chimpanzees track the 'likely target' of others' visual access and understand something about its effects on behaviour, and Whiten (1994; 1996) uses the notion of an 'intervening variable' to explain primitive theory of mind notions. These are illuminating ideas and what follows can be seen as an elaboration and partial synthesis of them. The result—minimal theory of mind—is unlike its precursors in that it is rich enough to explain systematic success on a range of false

belief tasks. Our approach is novel in this and others respects to which we return (in the Conclusion) after presenting the substance of our account.

## 2. Motivation

Our question is theoretical: it concerns not what anyone does represent but what someone could represent that would enable her, at least within limits, to track perceptions, beliefs and other propositional attitudes. The motivation for facing up to this question is, of course, partly empirical.

Consider ordinary adult humans. Since they can represent beliefs and other propositional attitudes as such, it is natural to assume that such representations underpin their abilities to track perceptions and beliefs. But is this natural assumption correct?

To see that it might not be, consider a further question. Is tracking others' perceptions and beliefs automatic? Roughly speaking, a process is *automatic* if whether it occurs is to a significant degree independent of its relevance to the particulars of the subject's motives and aims. (Note that a process may occur spontaneously without thereby being automatic.) Some evidence suggests that, for ordinary adult humans, belief tracking is automatic. For example, Kovács et al. (2010) asked adults to identify the location of a ball. They found that adults were significantly slower to identify the ball's location when an onlooker had a false belief about the location of the ball, even though the onlooker's belief was not relevant to the task at all. Relatedly, Samson et al. (2010) provide evidence that identifying what another perceives is automatic; this finding is indirectly supported by evidence that tracking others' perceptions is not disrupted by a secondary executive task (Qureshi et al. 2010). Taken together, these findings suggest that, at least in adults, tracking others' perceptions and beliefs is sometimes automatic.

But there is also a body of evidence supporting a different conclusion. Back & Apperly (2010) found that subjects are significantly slower to answer an unexpected question about another's belief when that belief is false compared to when it is true (see also Apperly et al. 2006). This suggests that, at least in adults, belief tracking is not automatic. There is also evidence that, even in relatively simple situations, using facts about others' beliefs is not automatic (Keysar et al. 2003; Apperly et al. 2010). The case for nonautomaticity is indirectly supported by evidence that tracking perceptions and beliefs—and even merely holding in mind what another believes, where no inference is required—involves a measurable processing cost (Apperly et al. 2008, 2010), consumes attention and working memory in fully competent adults (Apperly et al. 2009; Lin et al. 2010; McKinnon & Moscovitch 2007 experiments 4-5), may require inhibition (Bull et al. 2008) and makes demands on executive function (Apperly et al. 2004; Samson et al. 2005). These find-

ings, taken together, suggest that tracking others' perceptions and beliefs is sometimes not automatic.

The question was whether, in adult humans, tracking perception and belief is automatic. If we assume, further, that either all such processes are automatic or else none are, then the evidence creates a conflict. This conflict cannot easily be explained away by appeal to simple methodological factors or extraneous task demands. For instance, it may be tempting to suppose that the conflict can be explained by distinguishing between linguistic and nonlinguistic tasks. But belief ascription may fail to be automatic even on some nonlinguistic tasks (e.g. Apperly et al. 2004), and we know of no reason to assume that belief ascription could not be automatic on some linguistic theory of mind tasks (such as those where spontaneous tracking is already established, e.g. Ferguson & Breheny (2012)).

If the conflict is not a methodological artefact, how should we interpret the evidence? Perhaps it should be taken at face value. This means we must reject the assumption that tracking others' perceptions and beliefs is either always automatic or else always nonautomatic. In other cases, such as number and causation, it is already quite widely accepted that, in adult humans, some abilities to track these things are automatic whereas others are not.<sup>1</sup> The evidence suggests that the same may be true for perception and belief. In adult humans, some theory of mind abilities involve automatic processes whereas others depend on nonautomatic processes.

A closely related view has already been elaborated and defended in more detail by Apperly & Butterfill (2009), although their argument complements ours by drawing primarily on developmental and comparative research. According to them, adults may enjoy efficient but inflexible forms of theory of mind cognition in addition to the full-blown form which involves representing beliefs and other propositional attitudes as such. While aspects of this conjecture have already been tested (Samson et al. 2010; Schneider et al. 2011; Surtees et al. 2011), it raises two complementary questions (as Apperly & Butterfill themselves note).

First, why isn't tracking belief and perception always automatic? Consider what is involved in representing beliefs and other propositional attitudes. On any standard view, propositional attitudes form complex causal structures, have arbitrarily nestable contents, interact with each other in uncodifiably complex ways and are individuated by their causal and normative roles in explaining thoughts and actions (Davidson 1980, 1990). If anything should consume working memory and other scarce cognitive resources, it is surely representing states with this combination of properties. So even without knowing in any detail how theory of mind cognition is implemented, it is

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<sup>1</sup> On number: Trick & Pylyshyn (1994); on causation: Michotte (1963), Scholl & Nakayama (2004).

plausible that some feature, or combination of features, of the propositional attitudes makes full-blown theory of mind cognition demanding.<sup>2</sup> A possible explanation, then, is this. Tracking perception or belief is not always automatic because it sometimes involves representing propositional attitudes as such, which typically or always places demands on working memory, attention and executive function that are incompatible with automaticity.

Second, how could tracking perceptions or beliefs ever be automatic? If we assumed that such tracking always involved propositional attitudes as such, this question would present a puzzle. For, as we saw, representing propositional attitudes as such generally places demands on working memory, attention and executive function that are incompatible with automaticity. In some cases these demands might be overcome through automatization in something like the way that initially effortful numerical operations can through practice become automatic.<sup>3</sup> However, almost nothing is known about to what extent, if any, automatization occurs in theory of mind. And in any case automatization can only explain the automaticity of routine inferences. So it is possible that automatization, although perhaps important, does not fully explain the automaticity of some of adult humans' perception- and belief-tracking abilities. A full explanation may depend on showing that tracking perceptions and beliefs can be done without representing beliefs or other propositional attitudes as such.

This is a source motivation for our question about what someone could represent that would enable her to track perceptions and beliefs. The existence of both automatic and nonautomatic tracking of perceptions and beliefs in human adults suggests (without decisively showing, of course), contrary to a natural assumption mentioned above, that not all of their abilities to track perceptions and beliefs involve representing propositional attitudes as such.

### 3. More motivation

Further motivation for our question comes from evidence for theory of mind abilities in young children and infants. Children in their second year use pointing to provide information to others (Liszkowski et al. 2006) in ways

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<sup>2</sup> Several hypotheses about which feature of the propositional attitudes explains why full-blown theory of mind cognition is cognitively and conceptually demanding have been defended (e.g. Birch & Bloom 2007; Doherty & Perner 1998; Leslie et al. 2005; Lewis 1994; Perner 1991; Perner et al. 2002; Russell et al. 1991; Sabbagh 2006). More than one feature may contribute. We are agnostic about which feature or features are to blame.

<sup>3</sup> On the automatization of simple sums, see LeFevre et al. (1988). For the suggestion that something similar might happen concerning mental states, see Suddendorf & Whiten (2003).

that reflect a partner's ignorance or knowledge (Liszkowski et al. 2008), as well as providing more information to ignorant than knowledgeable partners when making requests (O'Neill 1996). One-year-old children also predict actions of agents with false beliefs about the locations of objects (Onishi & Baillargeon 2005; Southgate et al. 2007) and choose different ways of interacting with others depending on whether their beliefs are true or false (Buttelmann et al. 2009; Knudsen & Liszkowski 2011; Southgate et al. 2010). And in much the way that irrelevant facts about the contents of others' beliefs modulate adult subjects' response times, such facts also affect how long 7-month-old infants look at some stimuli (Kovács et al. 2010).

What do these infants and young children represent that enables them, within limits, to track others' beliefs and other propositional attitudes? The most straightforward answer would be to suppose that they represent perceptions, beliefs and other propositional attitudes as such (e.g. Leslie 2005; Song et al. 2008). But this answer faces several objections. A body of evidence suggests that representing beliefs requires conceptual sophistication, for it has a protracted developmental course stretching over several years (Wellman et al. 2001; Wimmer & Perner 1983) and its acquisition is tied to the development of executive function (Perner & Lang 1999; Sabbagh 2006) and language (Astington & Baird 2005). Infants and young children are deficient in these. Development of reasoning about beliefs in humans may also be facilitated by explicit training (Slaughter & Gopnik 1996) and environmental factors such as siblings (Clements et al. 2000; Hughes & Leekam 2004). This is evidence that representations of belief in humans typically emerge from extensive participation in social interactions (as Hughes et al. 2006 suggest). If any of this is right, we must reject the hypothesis that infants are representing beliefs or other propositional attitudes as such.

In principle an alternative would be to suppose that infants' and young children's abilities to track perceptions and beliefs do not involve any theory of mind cognition at all but are instead based on representations of nonintentional behaviour only. It is arguably possible in principle to explain some belief-tracking abilities by appeal to hypothetical behaviour reading capacities (Perner 1990; Perner & Ruffman 2005; Ruffman & Perner 2005). But there are several objections to the claim that the full range of even infants' abilities to track perceptions and beliefs could be explained in this way (Song et al. 2008; Apperly & Butterfill 2009). And what is currently known about humans' actual behaviour reading capacities suggests that they are unlikely to explain systematic success on false belief tasks.<sup>4</sup>

Here, then, is a second source of motivation for our question about what someone could represent that would enable her, within limits, to track per-

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<sup>4</sup> Key studies include Newtonson & Engquist (1976), Byrne (1999), Baldwin & Baird (2001), Saylor et al. (2007) and Baldwin et al. (2008).

ceptions and beliefs. As we have seen, there are significant if not decisive objections to the two best developed conjectures about infant theory of mind abilities, the conjecture that these involve representing beliefs and other propositional attitudes as such and the conjecture that these involve representing nonintentional behaviour only. These objections, while not decisive, justify exploring alternatives.

Theory of mind abilities are not only found in humans. For instance, scrub-jays can selectively re-cache their food in ways that deprive competitors of knowledge of its location (Clayton et al. 2007), and chimpanzees can both select routes to approach food which conceal them from a competitor's view (Hare et al. 2006) and also retrieve food using strategies that optimize their return given what a dominant competitor has seen (Hare et al. 2001). There is debate about the cognitive underpinnings of these abilities (e.g. Povinelli & Vonk 2004; Penn & Povinelli 2007; Tomasello & Call 2005; Call & Tomasello 2008). If it is not yet known precisely what explains these abilities and if the available evidence does not already tightly constrain the space of admissible conjectures, then the construction of a minimal theory of mind may be relevant to these debates. For the conjecture that minimal theory of mind explains chimpanzees' or scrub-jays' abilities to track perceptions or beliefs can be empirically distinguished from conjectures about representations of nonintentional behaviour only and from conjectures about representations of perceptions, beliefs and other propositional attitudes as such (as we explain in section \*\*\* below).

## 4. The need for a constructive approach

Davidson ...

Davidson might be right about ordinary, commonsense psychology.

So a constructive approach is needed. \*\*\*

## 5. Minimal theory of mind

In this section we identify concepts and principles necessary for constructing a form of theory of mind cognition. We begin with someone, call her Lucky, capable of representing nonintentional behaviour only and ask what more is needed for minimal theory of mind cognition. We describe Lucky's progress with a series of five principles. The principles are constructed in such a way that it would be coherent to suppose that Lucky has the abilities codified by the first  $n$  principles only. They are not intended to represent a developmental or evolutionary progression. The principles can also be extended to explain more sophisticated theory of mind abilities than those considered



here. We restrict ourselves to these five principles because they are sufficient to explain success on some well-known false belief tasks.<sup>5</sup>

We aim to provide the core elements of a computational theory in Marr’s sense (1982, pp. 15-29) where our computational theory, unlike the standard full-blown theory of mind which hinges on beliefs, desires and other propositional attitudes, is one that could be realised in a cognitively efficient manner without requiring conceptual sophistication.<sup>6</sup> There are multiple ways in which this computational theory might be implemented. We shall not discuss how the theory might be implemented here other than to note that it seems unlikely that the principles formulated below are represented explicitly. It is valuable to articulate the computational theory in some detail before formulating and testing conjectures about implementation.

## 5.1. First principle

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Until now Lucky has been aware only of object-directed actions. A further basic unit of action in theory of mind cognition is goal-directed action. To illustrate, a paradigm goal-directed action would be drinking from a bottle, which typically involves multiple object-directed actions such as first grasping a bottle and then lifting a bottle. Many predictions do not directly concern object-directed actions but rather goal-directed actions. Awareness of goal-directed actions is therefore an important further step in acquiring minimal theory of mind cognition.

The term ‘goal-directed action’ can be used to mean several things. One is intentional action. This notion is no use for constructing a minimal theory of mind. To represent intentional actions as such you also have to represent intentions and related propositional attitudes such as beliefs (?). Constructing a minimal theory of mind requires a basic notion of goal-directed action. We take the units of goal-directed action to be collections of one or more object-directed behaviours. We stipulate that for an outcome, *g*, to be the goal of a collection of object-directed behaviours is for it to occur in order

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<sup>5</sup> In standard false belief tasks, “[t]he subject is aware that he/she and another person [call him Maxi] witness a certain state of affairs *x*. Then, in the absence of the other person the subject witnesses an unexpected change in the state of affairs from *x* to *y*” (Wimmer & Perner 1983, p. 106). The test concerns whether the subject realises that Maxi will falsely believe *x* to obtain. In many cases the states of affairs, *x* and *y*, differ only with respect to the location of an object (e.g. Onishi & Baillargeon 2005; Southgate et al. 2007; Träuble et al. 2010). As we go on to discuss, our proposal for a minimal theory of mind could easily be extended to cover a range of other cases; but importantly there are also false belief tasks success on which cannot be explained by minimal theory of mind cognition (see section \*\*\*).

<sup>6</sup> To provide a computation theory in Marr’s sense is not to imply that its implementation will involve computational processes.

to bring about  $g$ ; that is,  $g$  is the function of this collection. Here ‘function’ should be understood teleologically. On the simplest teleological construal of function, for an action to have the function of bringing about  $g$  would be for actions of this type to have brought about  $g$  in the past and for this action to occur in part because of this fact (see further ?????). Lucky needs some ability to track the functions of things (in this sense of ‘function’) so that she can distinguish from among all the outcomes of an action those which are its goals.<sup>7</sup>

This is not an account of full-blown goal-directed action. It is what someone who has only a minimal grasp of goal-directed action might understand. Representing goals in this sense does not require representing representations because such goals are non-representational. Representing goals only involves representing outcomes as functions of behaviours.

To illustrate the difference between object-directed and goal-directed actions, consider a scrub-jay repeatedly caching and re-caching a worm (we take our inspiration from studies such as Emery & Clayton, 2001). The outcome of this collection of object-directed caching behaviours is (let’s say) that an observer is deprived of information about the location of the worm. This is not an outcome of any of the constituent object-directed behaviours taken individually. It is only an outcome of the collection considered as a whole. The significance of the whole sequence can only be appreciated by Lucky once she is equipped to represent goals.

The first principle, then, is that object-directed actions form larger units of action which are directed to goals. This second principle is sufficient to explain some cases of imitative learning, which can be defined as attempting to reproduce the actions necessary to achieve a goal (?).

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<sup>7</sup> Note that the requirement is not that Lucky understands the theoretical account of functions, only that she can distinguish between things which have different functions in this theoretical sense of ‘function’. A wide variety of research supports the claim that young children, non-human primates and corvids track the functions of things (including ?, ?, ?, ? and ?).

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