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Brief article

Do people automatically track others' beliefs? Evidence from a continuous measure

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ABSTRACT

Recent findings suggest that tracking others' beliefs is not always effortful and slow, but may rely on a fast and implicit system. An untested prediction of the automatic belief tracking account is that own and others' beliefs should be activated in parallel. We tested this prediction measuring continuous movement trajectories in a task that required deciding between two possible object locations. We independently manipulated whether participants' belief about the object location was true or false and whether an onlooker's belief about the object location was true or false. Manipulating whether or not the agent's belief was ever task relevant allowed us to compare performance in an explicit and implicit version of the same task. Movement parameters revealed an influence of the onlooker's irrelevant belief in the implicit version of the task. This provides evidence for parallel activation of own and others' beliefs.

1. Introduction

Tracking the mental states of others is a key ingredient for successful social interaction. The ability to represent and understand others' mental states is referred to as Theory of Mind (ToM), and is often measured with the false belief task (Baron-Cohen, Leslie, & Frith, 1985; Wimmer & Perner, 1983). A central issue concerning the nature of ToM is whether people automatically track others' beliefs, or whether such belief tracking relies on a more deliberate system. Recent studies have provided evidence for automatic belief tracking in infants (Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007; Surian, Caldi, & Sperber, 2007) and adults (Kovács, Téglás, & Endress, 2010; Schneider, Bayliss, Becker, & Dux, 2012). To reconcile these findings with the fact that reasoning about others' beliefs has a protracted developmental trajectory, is sometimes effortful and error-prone (Saxe, 2005), Apperly and Butterfill (2009) proposed a two systems account. On this account, a limited range of belief attribution is accomplished by a fast and efficient, yet inflexible system (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010) that is complemented by a later developing, deliberate, and slower system.

How the fast and implicit system works and how much it resembles other types of automatic processing (Apperly, 2011) is still unclear. The present study addressed two key questions in this regard. First, an untested prediction following from the assumption of a fast and automatic system for tracking beliefs is that multiple beliefs will be activated in parallel. Most of the studies on belief tracking so far have relied on discrete measures that only reflect the outcome of a decision process. Recent work has incorporated response times and proportional looking times (e.g. Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006; Back & Apperly, 2010; Kovács et al., 2010; Low & Watts, 2013; Schneider et al., 2012), but these measures do not directly

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reveal how conflicts between one's own and others' beliefs are resolved online. Mouse tracking is optimally suited to study online decision processes (e.g., Freeman & Ambady, 2009; Freeman, Ambady, Rule, & Johnson, 2008; Freeman, Dale, & Farmer, 2011; McKinstry, Dale, & Spivey, 2008; Spivey, Grosjean, & Knoblich, 2005; Wojnowicz, Ferguson, Dale, & Spivey, 2009). Here, we studied the mouse cursor's trajectories participants produced to reach the correct object location out of two possible locations while another agent had either the same or a different belief about the object's location. If people hold their own and the agent's belief in mind in parallel, the veridicality of their own belief as well as the belief of the agent should influence the online decision process about the object location, even when the agent's belief is irrelevant and never explicitly mentioned.

A second aim of the present study was to compare the relative influence of own and others' beliefs on the decision making process. Kovács et al. (2010) found that participants were just as fast to detect an object when they had a false belief but an onlooker had a true belief about the object's presence as they were when they had a true belief themselves. Only when both beliefs were false did participants show slower detection times. These results suggest a winner-takes-all model, as the belief representation (be it one's own belief or others' beliefs) that allows the fastest response may fully drive behavior. However, this finding is at odds with findings showing egocentric biases in mental state attribution (e.g., Birch & Bloom, 2003; van Boven & Loewenstein, 2003) and may not generalize to implicit belief tracking in more complex settings.

Finally, different tasks have been used to study implicit and explicit belief tracking, making it difficult to compare the way the two postulated systems operate. In the present study, we directly compared performance on an implicit and an explicit version within a single task setting.

2. Methods

2.1. Participants

81 right-handed students (61 women, 20 men, mean age of 21.7 years, SD = 8.41) participated in the study for course credit. Forty participants were assigned to the implicit belief tracking group and 41 participants to the explicit belief tracking group. We replaced one participant in the explicit group due to failure to complete the task correctly. We ran 51 participants (26 in the implicit group, and 25 in the explicit group) at Radboud University in Nijmegen, the Netherlands. The remaining participants were tested at Rutgers University in Camden, NJ, USA.

2.2. Experimental setup and procedure

Participants watched short movies (see Fig. 1) in which we manipulated the expected location of two objects for the participant and an agent who was present for parts of the movies (similar to Kovács et al.) By including two objects and two object locations, we could measure the influence of the participant's and the agent's belief on the decision process. We instructed participants that they needed to follow the location of one of these objects (a ball), and that the agent could not see what happened when she was absent from the scene.

We manipulated whether the participant and the agent had a true or false belief about the objects' locations at the end of the movie. There were four experimental conditions; true–true (T–T) when both had a true belief, true–false (T–F) when only the participant had a true belief, false–true (F–T) when only the agent had a true belief, and false–false (F–F) when both had a false belief.

At the end of each movie, participants heard a tone (50 ms, 600 Hz) and then were to move to the relevant object as quickly as possible. At the tone, both objects were still behind their occluders. Once the participants moved the mouse cursor upwards by 50 pixels, the occluders dropped and the location of the objects was revealed. Participants had to move the mouse cursor sideways by 252 pixels and upwards by 538 pixels from the start location to get to the target. Because the relevant object was always present, participants always produced a response.

To test whether or not participants tracked the agent's beliefs automatically, we incorporated two groups in our experimental design. Participants in the explicit group were told that they needed to keep track of the agent's beliefs, as they sometimes needed to indicate where the agent thought the relevant object was located. No such mention was made for the implicit group, and the agent's belief was always task-irrelevant.

We recorded responses at 65 Hz with a Logitech G500 mouse (1:1 mapping). Participants started a trial by pressing the left mouse button, while the mouse sat on a marked cross on the table (aligned with and 40 cm forward from the center of the computer monitor). All participants used their right hand to respond. Participants only received feedback when they provided an incorrect response (a 500 Hz tone played for 100 ms), or when they took more than 3000 ms to respond. The latter trials were repeated in a randomized order at the end of the experiment.

Participants completed a set of practice trials before starting the experiment. They then completed 24 trials per condition in a randomized order. In half of these trials for each condition, the objects switched locations in Phase 2 (while the agent was present). We included this variation to control for potential curvature effects due to uncertainty about object locations that may result from differences in location switches across conditions. For the explicit group, we introduced an additional 16 veridicality trials (four trials per condition) in which participants indicated where they thought or where the agent thought the relevant object was located. This was indicated in Phase 4 by the word "YOU" for own belief or "SHE" for the agent's belief in the center of the display that stayed visible until the response was completed. On all other trials, participants indicated the location of the ball, as in the implicit condition. The veridicality trials were randomly interspersed, implying that participants in the explicit group needed to track the agent's belief in every trial in the experiment.

Segments of the movie clips were either 2 (agent (dis)appearing), 3 (objects changing position or returning to their initial position), or 4 (objects entering the scene)