

Representing beliefs: A matter of perspective awareness and counterfactual reasoning?

Children take a very important step towards social understanding when they are able to represent a belief. There is an ongoing discussion about whether this ability is an early emerging, modular process or whether it is a gradually evolving set of cognitive processes which may result from an interaction between genetics and environment (see Ruffman & Perner, 2005). For example, it has been shown that one year old infants can correctly predict the action of an agent who has a false belief about the location of an object (Onishi & Baillargeon, 2005; Southgate et al., 2007). On the other hand, performance on the classical false belief task (Wimmer & Perner, 1983) lies below chance when children are 41 months old, and reaches above chance when children turn 48 months (see Wellman et al., 2001). The present symposium will cover different positions in this discussion. The first two papers in the symposium will address the question of which cognitive processes underpin the ability to represent a belief based on evidence from developmental and functional neuroimaging research. The third paper highlights an apparent inconsistency between the claim made by the first two papers and the claim that infants can represent beliefs from around their first birthday and attempts to resolve the apparent inconsistency by considering the possibility that there are different ways of representing a belief. Taken together, the three papers show that being able to represent beliefs involves being able process perspective differences and reason counterfactually, and that (properly understood) these findings are not only consistent with evidence of mindreading in infants but may also illuminate the nature of infants' competence.

The first paper (Matthias Schurz) tries to distinguish different cognitive processes that contribute to theory of mind reasoning based on findings from functional neuroimaging. Brain regions engaged by different types of activation tasks used to study theory of mind are meta-analyzed and compared. An attempt to delineate cognitive components of theory of mind

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Comment [1]: „Talks’? (if changed here, it needs changing throughout)

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Comment [2]: Maybe it would be good to have a sentence here that describes an overall conclusion that we all roughly agree about. Here is my attempt to write one, in case you agree that it would be a good idea to have one.

reasoning is made by dividing activation tasks in those which require processing of a perspective difference and those which do not. By perspective difference, the author refers to "... a difference in content between different representations of a particular thing (an object, scene or an event)" (Perner et al., 2002). A well known example of a theory of mind task which creates a perspective difference is the false belief task, where a protagonist's belief contrasts with the participant's own view of reality. Popular examples of theory of mind tasks which do not create perspective differences are tasks which ask participants for a mental-state judgement based on the a picture of a human face or tasks which present moving triangles (participants view animations of simple geometrical shapes moving in a way that implies intentional actions). Results of the meta-analyses show areas of activation common to theory of mind tasks with and without perspective, and also areas only activated by one or the other type of task. Interestingly, the brain areas selectively engaged by theory of mind tasks which present a perspective difference are also engaged by processing of perspective differences in other domains. For example, the same brain area shows increased activation for "remember" judgements (which require distinguishing a previous encounter from the present encounter of a stimulus) compared to "know" judgements in episodic memory tasks. The paper also discusses whether understanding perspective differences is a prerequisite for understanding false belief.

The second paper (Eva Rafetseder) more specifically addresses the question of whether counterfactual reasoning is a necessary and/or sufficient precondition of reasoning with false beliefs. That counterfactual reasoning is a necessary condition is suggested in a developmental study by Riggs et al. (1998). They used stories such as the Maxi story: Maxi puts chocolate into the table drawer (location 1). He then goes to the playground. In his absence, his mother uses a piece of chocolate for her cake but then does not put it back into the drawer but puts it into the cupboard (location 2). Children are then asked a false belief question ("Where will Maxi look for his chocolate?") and a counterfactual question ("If

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Comment [3]: This isn't ideal: the main issues are whether
(i) A is a prerequisite of B; and whether
(ii) A is sufficient for B
and there isn't much on whether
(iii) necessarily, A is a prerequisite of B
So I don't think it's right to qualify
'precondition' with 'necessary'.
How about dropping the issue of sufficiency
and just having 'whether counterfactual
reasoning is a prerequisite for reasoning
about false beliefs'?

mother had not baked a cake, where would the chocolate be?”). Performance was highly correlated ($r = .86, p < .001$, study 2). Moreover, children solved significantly more counterfactual questions (59%) than false belief questions (43%) which is compatible with the suggestion that counterfactual reasoning is a prerequisite for understanding false belief based actions.

However recent findings indicate that children’s correct answers to counterfactual questions are not always based on counterfactual reasoning (CFR) but sometimes involve using only basic conditional reasoning (BCR: Rafetseder, Cristi-Vargas, & Perner, 2010), i.e., applying universally quantified conditionals that express general regularities. Use of CFR tends to emerge not before the age of 6 years. Two studies investigated how children perform on false-belief tasks when controlling for answers based on BCR. Both studies found a highly significant correlation ($r = .58$) between children using CFR to answer the counterfactual question and their correct answers to the false belief question. Moreover, hardly any children gave correct answers to the belief and wrong answers to the counterfactual question, suggesting that counterfactual reasoning is a prerequisite for predicting actions based on false beliefs.

The third paper (Stephen Butterfill) takes the findings of the first two papers as a starting point. According to these findings, being able to represent false beliefs involves being able to (i) process perspective differences or (ii) reason counterfactually (or both). However, infants around their first birthday cannot process perspective differences nor reason counterfactually; but they can pass some false belief tasks (Onishi & Baillargeon, 2005; Southgate et al., 2007). It is argued that this discrepancy cannot be explained merely by distinguishing between implicit and explicit representations of false beliefs in part because one-year-old infants also succeed on false belief tasks which involve actively helping others,

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Comment [4]: I suggest cutting this because it’s not about ER’s research

interpreting their utterances and pointing to provide information (Buttelman et al., 2009; Knudsen & Liszkowski, 2011; Southgate et al., 2010).

In order to explain this discrepancy it may be necessary to take into account that representations of beliefs can have different levels of complexity. An analogous example for differences in the complexity of representations is provided: In order to represent the efficiency of a car, one can merely use the driven distance in relation to fuel consumption. However, one could also use a more accurate measure which relates force to fuel consumption. Similarly, representations of beliefs can vary in terms of their complexity, and different false belief tasks may require different levels of representational elaboration. In addition, it is suggested that the early mastery of some false belief tasks involves only one representational system while the late mastery of the other false belief tasks involves multiple representational systems. This can be seen in analogy to children's ability to understand numerosity: infants have a vague sense of quantity (e.g., they can discriminate between small and large sets of objects) already before they learn to count (by which they become able to precisely discriminate between large numerosities).

Based on the latter two arguments, the third paper offers an integrative framework on the cognitive underpinnings of belief representation: Infants from one year of age *can* represent false beliefs using *comparatively simple measure* in a *modular process*. However, infants at that age cannot represent false beliefs using *comparatively sophisticated measures* in a *non-modular processes*. This additionally requires the ability to (i) process perspective differences or (ii) reason counterfactually (or both), as the first two papers demonstrate.