



Theories, structures and simulations in the research of early mentalizing

Action editor: Sebastien Helie

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Received 10 November 2015; received in revised form 25 March 2016; accepted 18 May 2016

Available online 24 May 2016

Abstract

The objective of this paper is to propose some new approaches that could be used in the research of the development of mindreading in infancy. I argue that the mentalizing system should be approached as a developing hierarchical structure that acquires the ability to orient attention to the most significant features in the environment. The development of this system could be described by a series of implicit theories that share a common structure which provides continuity over theory change. According to this view, the early stages which have a fundamental role for the development of mindreading would be described by low-level theories, but as infants become increasingly efficient in predicting behavior of observed agents the higher-order entities become prioritized due to their relevance. Infants thus gradually develop the ability to predict the behavior of others in situations involving attribution of mental states. I propose a strategy based on the analysis of attention deployment that could help to decide which of the alternative theories provides the most adequate account of the mentalizing system at a certain developmental stage. I also suggest that computational modeling could contribute to the research in this area. Simulations of looking behavior based on different ontologies could prove to be useful for choosing the most adequate theory as well as for advancing the understanding of mechanisms involved in the development of theory of mind.

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Keywords: Mentalizing; Cognitive development; False beliefs; Computational modeling

1. Introduction

At what age do children begin to understand that other people have thoughts? When do they find out that others have beliefs, which can be false? These are some of the most discussed questions in the current research on infant social cognition. For more than 20 years after Wimmer and Perner (1983) published their classical study it seemed that typically developing children acquired the ability to understand that others have minds in the fifth year of life. However, during the last decade a number of studies have shown that they may be able to think about minds of

others at much earlier age. Non-verbal experiments seem to provide evidence that infants can attribute false beliefs already at the age of 7 months (Kovács, Téglás, & Endress, 2010).

Currently there is much controversy surrounding the interpretation of the results of these experiments. Researchers have proposed a number of alternative interpretations (e.g., Apperly & Butterfill, 2009; Heyes, 2014a; Onishi & Baillargeon, 2005; Perner & Ruffman, 2005) and so far no consensus has been reached about the best explanation of the observed pattern of infants' looking behavior. The debate seems to have reached an impasse as proponents of each of the competing theories argue that their approach provides a complete account.

I suggest that some of the problems in the debate could be resolved if the mentalizing system was approached as a

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developing hierarchical structure which can be described by a sequence of implicit theories with an increasing predictive power. The continuity of the development could be explained on the basis of a common structure that is shared by theories with different levels of complexity. The shared structure could shed some light on the problem of interpretation of the pattern of looking behavior which is characteristic for the attribution of false beliefs and which has been observed both in infants and adults (Kovács et al., 2010). Apart from arguing for the continuity in the development of theory of mind I also suggest that it could be possible to decide which of the competing interpretations provides a more adequate account of the mentalizing system at a certain developmental stage. I argue that the research in this area would benefit from the application of computational modeling which could contribute to the understanding of the development of mindreading and it could also help to assess accuracy of the competing interpretations. There are several advantages to this approach, nevertheless, the use of computational modeling in this context is still quite scarce (e.g., Bello, 2011; Berthiaume, Shultz, & Onishi, 2013). In the last part of this paper I suggest a method based on the analysis of eye-tracking data which could help to decide between the competing interpretations of non-verbal false belief experiments.

2. Theories and structures

In this paper I argue for the view that theory of mind is a developing hierarchical structure that enables understanding and effective prediction of future behavior of observed agents. From this perspective, it seems plausible to look for similarities with the progress of scientific knowledge, since it concerns the development of explanatory and predictive frameworks that help us to understand the world in general. The analogy between theories developed by scientists and theories constructed by children has a long tradition and it is still a strong source of new research ideas. Discussion about this analogy has lasted for decades and a number of arguments have been formulated for and against its appropriateness. It is clear that there are differences between formalized theories and infants' intuitive theories (Leslie, 2000), but nevertheless there are also significant similarities that make the analogy still worth pursuing. One of the possible benefits of this approach is that some of the strategies that have proved to be useful in dealing with problems in one area could be applied to similar problems in the other area; and it seems that there are such problems that are common both to philosophy of science and to developmental psychology.

I will focus specifically on the development of theory of mind and I will try to look at the issues present in this area from the perspective of ideas proposed in philosophy of science aimed at explaining problems related to the development of scientific theories. I will argue that it is plausible to consider an option that the development of mindreading proceeds through a sequence of theories in a way that is

similar to progress in science. However, in that case the account of the development of mindreading faces the same problems as the ones that are present in the philosophy of science, for instance, how to explain theory change. In the history of science most of the past theories which were at some point considered to be successful and acceptable became later rejected and replaced by a new theory. According to proponents of the new theory the central theoretical terms of the previous one failed to refer and ontology of that theory was mistaken (such as in the shift from Fresnel's ether theory to Maxwell's electromagnetic theory). However, if the previous scientific theories were false (and in that case it is highly possible that also our current theories will turn out to be false), then it is very difficult to speak about any progress and continuity in science.

A strategy that has proved to be quite successful at addressing these issues is structural realism (e.g., Worrall, 1989). Structural realism enables to explain progress and cumulative character of science on the basis of continuity of a common structure that is retained across theory change. The abstract structure that has been retained allows to explain how the past theories could have led to correct predictions even though they were false and based on mistaken ontologies.

It is possible that there is a similar situation in the case of cognitive development – specifically in the case of theory of mind. There is no doubt that there are wide differences between infants' and adults' abilities to understand minds of others. Nevertheless, the infants' intuitive theory of mind enables to make surprisingly good predictions of behavior of others even in situations which require to take into account beliefs that do not correspond to the current state of affairs. The problem is how to explain the relationship between the infants' and adults' theories which are very different in terms of complexity and explanatory power, but lead to similar predictions. One of the options is to claim that they are completely different theories that refer to different types of entities. Another option is to say that both adults and infants use a theory with the same ontology – in this case both the rudimentary as well as the full-blown theory of mind refer to abstract entities of mental states.

However, the analogy with structural realism opens another option based on the assumption that the two theories lead to similar predictions because they share a similar structure. Such an approach allows to explain the continuity in the development even though it accepts that the theories have different content. From this point of view there is no requirement to assume that the two theories need to refer to entities placed at the same ontological level (e.g., beliefs) in order to explain why both of them are to a certain degree accurate. Early theories might refer to entities at a completely different level, but they can still be successful in predicting future events. The development of theory of mind could thus be viewed as a gradual process of formation of theories with increasing predictive power, while the continuity over the course of development could

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