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Longitudinal evidence for 4-year-olds' but not 2- and 3-year-olds' false belief-related action anticipation

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ABSTRACT

Recently, infants younger than 2 years have been shown to display correct expectations of the actions of an agent with a false belief. The developmental trajectory of these early-developing abilities and their robustness, however, remain a matter of debate. Here, we tested children longitudinally from 2 to 4 years of age with an established anticipatory looking false belief task, and found a significant developmental change between the ages of 3 and 4 years. Children anticipated correctly only by the age of 4 years, and performed at chance at the ages of 2 and 3 years. Moreover, we found correct anticipation only when the agent falsely believed an object to be in its last rather than a previous location. These findings point towards the fragility of early belief-related action anticipation before the age of 4 years, when children start passing traditional false belief tasks.

1. Introduction

A milestone of Theory of Mind (ToM) development has long been assumed to occur around the age of 4 years, when children start passing traditional false belief tasks (e.g., Wellman, Cross, & Watson, 2001). In recent years, however, novel implicit false belief paradigms have shown that infants younger than 2 years of age already display correct expectations of how an agent with a false belief will act (e.g., Baillargeon, Scott, & He, 2010; Onishi & Baillargeon, 2005; Sodian, 2016; Southgate, Senju, & Csibra, 2007). These findings have caused an overhaul of our understanding of ToM abilities in infants, and have triggered one of the most controversial debates of developmental psychology: Why do children consistently fail traditional false belief tasks until the age of 4 years, if infants already understand others' false beliefs? The reasons for this discrepancy has been debated intensely. While some authors have argued for a continuity of the abilities measured by implicit and explicit false belief tasks (e.g., Baillargeon et al., 2010; Thoermer, Sodian, Vuori, Perst, & Kristen, 2012; Sodian, 2016), others have argued that different processes with different developmental trajectories might underlie the tasks (Apperly & Butterfill, 2009; Grosse Wiesmann, Friederici, Singer, & Steinbeis, 2016; Grosse Wiesmann, Schreiber, Singer, Steinbeis, & Friederici, 2017; Heyes, 2014; Perner & Roessler, 2012; Ruffman, 2014). The developmental trajectory of the early-developing abilities between infancy and preschool age, when children start passing the

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traditional false belief tasks, has not been studied to date, and could contribute to this debate. This question is all the more important, given that recent findings point to a certain fragility of the implicit false belief tasks (He, Bolz, & Baillargeon, 2012; Helming, Strickland, & Jacob, 2014; Kulke & Rakoczy, 2017).

So far, implicit false belief tasks have mainly been tested with infants and toddlers between the first and third year of life, but older children have rarely been tested on these paradigms. It remains unclear how performance on these tasks develops between toddlerhood at 2 years and preschool age around 3 and 4 years. Only a few studies have shown anticipatory looking in preschoolers (Clements & Perner, 1994; Grosse Wiesmann et al., 2016; Low, 2010), and, to our knowledge, no study has investigated how the same task develops from infancy until preschool age. Understanding the developmental trajectory of the early abilities from 2 years of age until 4, when children start passing the traditional false belief tasks, however, would inform about the nature of these abilities and their relation to the later-developing traditional false belief tasks. To address this question, we tested children longitudinally from 2 to 4 years with an established anticipatory looking false belief task. This allowed us to answer whether performance on the implicit false belief tasks remains stable once infants start passing these tests, or whether performance improves during early childhood, paralleling the performance breakthrough in the traditional explicit false belief tasks.

Moreover, in light of the recent debate about the fragility of implicit false belief tasks (He et al., 2012; Helming et al., 2014; Kulke & Rakoczy, 2017), the study allowed us to test how robust belief-related anticipatory looking is in 2-year-olds and in preschoolers. Current theoretical debates rely on the assumption that infants reliably show belief-congruent expectations (e.g., Apperly & Butterfill, 2009; Baillargeon et al., 2010; Heyes, 2014; Perner & Roessler, 2012; Ruffman, 2014). It is therefore crucial to know that these findings are robust, and to understand possible limitations of these findings. Potential fragility of performance in toddlers but not in older children that pass the traditional explicit false belief tasks could help bridge the gap between infants' early success in the implicit tasks and preschoolers' failure in the traditional tasks until the age of 4 years. Thus, both the developmental trajectory of implicit false belief tasks between infancy and preschool age and the robustness of performance on these tasks at different ages can contribute to solving the puzzle why these tasks are passed several years earlier than the traditional false belief tasks.

Arguably the most stringent support for infants' action anticipation based on attribution of false beliefs came from a particularly well-controlled anticipatory looking task by Southgate et al. (2007). In this study, 25-month-old children were shown to anticipate correctly where an agent who falsely believed an object to be in one of two empty boxes would search for the object. The authors constructed two false belief conditions (FB1 and FB2) that were orthogonal with respect to simpler non-belief-based strategies, such as, gazing at the first or last box the object had been in or at the last box the agent had attended to. Correct anticipation in both false belief conditions therefore ensured that children passed the test based on belief attribution and not due to these simpler associations. Similar anticipatory looking paradigms have been used at different ages between 18 months and 3 years (Clements & Perner, 1994; Gliga, Senju, Pettinato, Charman, & Johnson, 2014; Grosse Wiesmann et al., 2016; Low, 2010; Meristo et al., 2012; Senju, Southgate, Snape, Leonard, & Csibra, 2011; Surian & Geraci, 2012; Thoermer, Sodian, Vuori, Perst, & Kristen, 2012; Wang & Leslie, 2016). In the present longitudinal study, we therefore used this anticipatory looking false belief task (Southgate et al., 2007). To increase the sensitivity of the measure, and to make sure that an individual child did not pass the test because of a simpler strategy, we presented every child with both false belief trials, one trial of each of the two original conditions FB1 and FB2. This also allowed us to compare performance between the two conditions within subjects. Analyzing only the first trial, in turn, allowed us to compare performance in our study to the original study where every child performed only a single false belief trial, condition FB1 or FB2 respectively (Southgate et al., 2007).

By testing children longitudinally from 2 years until 4 years of age, we aimed at addressing the following questions: (1) How does belief-related anticipatory looking develop beyond the age of 2 years? Does performance remain comparable throughout preschool age, or is there an improvement on the implicit false belief tasks once children start passing the traditional explicit false belief tasks? (2) How robust is performance on implicit false belief tasks in 2-year-olds, and does robustness change with age? Is performance robust across different task conditions?

From the previous literature, we hypothesized that children would perform above chance at the age of 2 years. Further, we expected to find no difference in performance between the two different false belief conditions FB1 and FB2 based on the original study (Southgate et al., 2007). Concerning the developmental trajectory of performance between the ages of 2 and 4 years, the pattern was less clear from previous literature. Based on similar levels of performance in adults compared to previous infant studies (Senju, Southgate, White, & Frith, 2009), we expected to find either stable performance between the ages of 2 and 4 years or an increase in performance that we might be able to detect due to the higher sensitivity in our within-subject longitudinal design.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Eye-tracking data was acquired in three consecutive years, starting at the age of 2 years. In the first year, data was recorded from 52 toddlers (mean age: M = 2.55 years, SD = 0.32, range: 2.08–3.20 years), from which 6 data sets had to be excluded because the recording had to be interrupted before the first test trial (N = 3), data quality was insufficient to be analyzed (N = 2), or because of inattentiveness of the child on both test trials (N = 1). From these children, 26 returned in two consecutive years. In the second year, children had a mean age of M = 3.64 years (SD = 0.29, range: 3.07–4.12 years), and in the third year M = 4.49 years (SD = 0.34, range: 3.89–5.09 years). The mean difference between the measurement time points was 339 days (SD = 92 days). At the age of 3