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Implicit false belief across the lifespan: Non-replication of an anticipatory looking task

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ABSTRACT

Implicit false belief is often measured through anticipatory looking. While past research stipulates that children and adults have a fully developed implicit false belief understanding, there is a lack of consensus in recent findings. The goal of this study was to examine how adults and children perform on an anticipatory looking task to further our understanding of the variability in results across studies. The implicit false belief task featured a 3-second anticipatory looking period, during which we measured participants' looking behavior (first look and total looking time at the correct location). We failed to replicate previous findings, with neither group demonstrating an implicit understanding of false belief. However, performance varied depending on the measure examined, thus highlighting the importance of analyzing several variables when assessing false belief with anticipatory looking.

1. Introduction

Theory of mind is a foundational cognitive ability that makes possible the attribution of mental states to oneself and to others. This includes the aptitude to understand another person's beliefs, to recognize that these beliefs may be different from one's own, and to predict how this person will act based on his/her beliefs (Wimmer & Perner, 1983). The capacity to attribute a false belief to another individual (i.e., understanding that an individual holds a belief that is incongruent with reality) is an essential component of a theory of mind. It was initially proposed that this understanding develops around 4 years of age (Perner, Leekam, & Wimmer, 1987; Wellman, Cross, & Watson, 2001). A wealth of evidence has since confirmed that children before the age of 4 years do not succeed on tasks examining false belief. Over two decades ago, a milestone study by Clements and Perner (1994) provided empirical evidence showing that an implicit understanding might develop earlier, at approximately 2 years and 11 months. To measure false belief implicitly, the authors used a variation of the standard Sally-Anne false belief task (Wimmer & Perner, 1983) and measured the direction of the children's first look. They observed that children understand false belief, when measured implicitly, at a younger age than was traditionally believed.

The innovative method introduced by Clements and Perner (1994) was further developed and evolved into what is now known as the anticipatory looking paradigm. In contrast to the original task, instead of asking the participants where the protagonist will look for the object, these paradigms use an anticipatory looking period, during which the participants' looking behavior is analyzed to determine if they correctly expect/anticipate the protagonist's actions (Southgate, Senju, & Csibra, 2007). The question asked in the original paradigm (i.e., "where will [the protagonist] look for the object") may prompt the children to look (or point) where the

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object is actually located before fully processing the question. Southgate et al. (2007) created a video based on an anticipatory looking paradigm and tested implicit false belief understanding in 25-month-old toddlers ($N = 20$). In this video, a ball is placed in one of two boxes located in front of two doors. The protagonist is then distracted while a puppet retrieves the ball and leaves the scene with it. The two doors (areas of interest) light up and the scene freezes for an anticipatory looking period of 1750 ms. Following this period, the protagonist opens the door corresponding to the box in which she left the ball in order to retrieve it. The anticipatory looking period allowed for the investigation of the children's implicit understanding of false belief by examining the direction of the first look as well as the amount of time spent looking at both doors. As expected, a statistically significant proportion of infants (85%) correctly anticipated the protagonist's behavior, directing their first look towards the door above the box where the protagonist left the ball. Additionally, their total looking time to the correct door was almost twice as long as their looking time to the incorrect door during the anticipatory looking period; this difference was significantly above chance. The authors concluded that anticipatory looking tasks convincingly demonstrate that 25-month-old toddlers attribute false belief to another agent by correctly anticipating his/her future behavior.

Another study by Thoermer, Sodian, Vuori, Perst, and Kristen (2012) examined the same question by designing a similar task (the "autobox" task) with a group of forty-four 18-month-old infants. This anticipatory looking task included a self-moving car first shown moving from one garage to another, followed by a 3-second anticipatory looking period. The protagonist then reached for the car by opening the door above the garage corresponding to the car's location. During the test trial, once the car reached the garage, the protagonist was distracted as the car returned towards its initial location and then exited the scene. This was followed by a 3-second anticipatory period after which the protagonist opened one of the two doors in order to reach for the car. A ratio was calculated by dividing the time participants spent looking at the correct door by the sum of looking times at both the correct and incorrect doors. The resulting ratio could range from 0 to 1, where scores above 0.50 represented a preference for the correct door, and scores below 0.50, a preference for the incorrect door. In this study, 55% of 18-month-old infants successfully spent more time looking at the door corresponding to the protagonist's false belief, which reflects an understanding of false belief when using an implicit measure. Although not included in the original paper, when calculated, this success rate was not above chance, which is 50% ($p = 0.120$). In a recent study, the same implicit false belief task was administered to forty-four 18-month-olds who looked towards the correct door during the anticipatory looking period on average 57% of the time (Sodian et al., 2016). Similar to Thoermer et al. (2012), this percentage did not differ from chance ($p = 0.180$).

Schuwerk, Jarvers, Vuori, and Sodian (2016) attempted to replicate the findings reported with this task (Thoermer et al., 2012) with 21 children aged 7–8 years. They sought to compare the performance of children diagnosed with Autism Spectrum Disorder (ASD) to that of neurotypical children. Although it is well documented that children with ASD lack an explicit understanding of false belief (Baron-Cohen, Leslie, & Frith, 1985), the objective of the study was to assess whether children with ASD would also fail false belief when measured implicitly. The authors calculated a differential looking score (DLS) by subtracting the time spent looking at the incorrect door from the time spent looking at the correct door and dividing this difference by the time spent looking at both doors. Thus, the resulting DLS could range from -1 to 1, with negative scores reflecting a preference for the incorrect door and positive scores indicating a preference for the correct door. There was a sharp contrast in the performance of the neurotypical children when compared to the children with ASD. The neurotypical children showed a stronger bias toward the correct door ($DLS = 0.21$) than the children with ASD, who looked longer at the incorrect door ($DLS = -0.23$). Although the neurotypical children showed a stronger looking bias toward the correct door, this DLS was not statistically significantly above chance ($t(20) = 1.63$, $p = 0.118$; Schuwerk, personal communication, 2016). The DLS of the neurotypical children was only significantly above chance when both test trials were merged. Therefore, neurotypical children's performance on this task was weaker than that observed in the studies conducted by Southgate et al. (2007) and Senju, Southgate, White, and Frith (2009).

Although implicit false belief is traditionally assessed in infants and clinical populations (i.e., ASD), there are also some studies conducted on adult samples. Implicit false belief is believed to be a form of false belief tracking and is therefore believed to be stable across the lifespan. Thus, children and adults are expected to perform well on implicit false belief tasks because they should have a fully developed efficient system of false belief tracking (Apperly & Butterfill, 2009). Unexpectedly, the performance of neurotypical adults on anticipatory looking paradigms also varies considerably across studies. Some studies, using the task by Southgate et al. (2007), or variations of this task, reported that at least 90% of adult samples first looked towards the correct area of interest, demonstrating an implicit understanding of false belief (Low & Watts, 2013; Wang, Hadi, & Low, 2015). Similarly, Senju et al. (2009) and Senju (2012) reported that neurotypical adults' first look was directed towards the correct area of interest. However, Wang and Leslie (2016) also assessed adults on the same task and found that only 64% of the adults' first look was directed towards the correct location. Other studies with comparable sample sizes also failed to report high rates of false belief understanding in adults. For example, Schuwerk, Vuori, and Sodian (2015) used the same anticipatory looking task as Thoermer et al. (2012) in an adult sample ($N = 19$). The authors reported that 74% of adults first looked towards the correct location on the first test trial, a result just trending toward statistical significance. However, this decreased to 58% on the second trial. The lower passing rate on the second test trial could be due to a decrease in motivation given that this is the second time that they see the video (in addition to the two familiarization trials). Taken together, these results indicate that absolute rates of success in adult performance on this implicit false belief task are, like in children, inconsistent.

One important issue to consider when comparing results obtained from anticipatory looking tasks is the differences in task demands. Indeed, anticipatory looking paradigms can be divided into tasks of high vs. low demand (Wang & Leslie, 2016). In a high demand anticipatory looking paradigm, the object remains in the scene after being moved to a different location, as in the traditional Sally-Anne task (Baron-Cohen et al., 1985; Grosse Wiesmann, Friederici, Singer, & Steinbeis, 2016; Wang & Leslie, 2016). This task has more cognitive demands because the knowledge about the current location of the object must be inhibited as it is in competition