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Do 18-months-olds really attribute mental states to others? A critical test

Atsushi Senju[a], Victoria Southgate[a], Charlotte Snape[a,b], Mark Leonard[a] & Gergely Csibra[c]

[a]Birkbeck, University of London, London, UK
[b]University College London, London, UK
[c]Central European University, Budapest, Hungary

* Correspondence concerning this paper should be sent to Atsushi Senju, Centre for Brain and Cognitive Development, Birkbeck, University of London, Malet Street, London WC1E 7HX, UK; Tel: +44 207 631 6895; Fax: +44 207 631 6587; E-mail: a.senju@bbk.ac.uk

Abstract
The current study investigated whether 18-months-olds attribute opaque mental states when they solve false belief tests, or simply rely on behavioural cues available in the stimuli. Infants experienced either a trick blindfold that looked opaque but could be seen through, or an opaque blindfold. Then both groups of infants observed an actor wearing the same blindfold that they had themselves experienced, whilst a puppet removed an object from its location. Anticipatory eye movements revealed that infants who experienced the opaque blindfold expected the actor's action in accord with her having a false belief about the object's location, but infants who experienced the trick blindfold did not. The results suggest that 18-months-olds used self-experience with the blindfold to assess the actor's visual access, and updated her knowledge/belief state accordingly. These data constitute compelling evidence that 18-months-olds infer perceptual access and appreciate its causal role in altering epistemic states of others.

Keywords
Theory of mind, infants, eye-tracking, social cognition

Recent studies have reported that human infants are able to spontaneously understand that others' actions are driven by their beliefs about states of affairs in the real world, even when these beliefs are false (Buttelmann, Carpenter, & Tomasello, 2009; Kovács, Téglás, & Endress, 2010; Scott & Baillargeon, 2009; Song, Onishi, Baillargeon, & Fisher, 2008; Southgate, Chevallier, & Csibra, 2010; Southgate, Senju, & Csibra, 2007; Surian, Caldi, & Sperber, 2007). These findings have been met with scepticism because children at this age usually fail traditional explicit tests of false belief understanding, leading some to suggest that infants' success reflects a reliance on behavioural cues rather than mental state attribution (Perner & Ruffman, 2005). Such alternative explanations cannot be completely ruled out because all the above studies used behavioural cues to indicate the presence of true or false beliefs.

A possible way to address this charge is to create a paradigm in which different infants would attribute different mental states to exactly the same stimuli. An experimental manipulation that could lead to such an ideal experiment was originally proposed by Heyes (1998), and recently implemented by Meltzoff and Brooks (2008) to test the attribution of visual access in 18-months-olds. In that study, infants were provided with first-person

experience with either an opaque blindfold or a trick blindfold that appeared opaque but was in fact transparent. Infants who experienced the trick blindfold subsequently followed a blindfolded adult's gaze, but those who experienced the opaque blindfold did not, suggesting that infants' attribution of perceptual access to others is modulated by their own past experience of visual access.

In the current study, we investigated whether 18-month-olds would use their own past experience of visual access to attribute perception and consequent beliefs to others. Infants first received experience with a visually identical opaque or trick blindfold, and subsequently watched a video sequence in which an actor wore the same blindfold while an object was displaced in front of her. By measuring visual anticipation, we assessed whether infants own experience with the blindfold influenced their prediction of where the actor would search for the displaced object. Since the infant could not observe either themselves or others wearing the blindfold, they had no opportunity to acquire possible associations between blindfold-wearing and observable behaviours, and thus any differences in expectations that infants displayed following the different blindfold experiences would necessarily be the result of attributing unobservable mental states to others.

Methods

Thirty-six infants (13 female; aged 17.5 to 18.5 months, mean age 18.0 months) were randomly assigned to an Opaque (n=18) and a Trick (n=17) condition. Further 12 infants were also tested but excluded from the analyses because they did not show anticipatory saccades by the end of the familiarization trials (4; 2 in the Opaque and 2 in the Trick condition), looked away from the stimuli at the critical moment in the test trial (4; 2 in the Opaque and 2 in the Trick condition), did not look at either window on the test trial (3, 1 in the Opaque and 2 in the Trick condition), or did not complete the familiarization phase (1 infant in the Trick condition). During familiarization, the infants were introduced to one of two pairs of blindfolds, made of black cloth with a pink trimming around their edging to make them easily identifiable. The opaque and trick blindfolds were identical, apart from the absence of a thick mid-layer in the trick blindfold, which made it possible to see through. Infants were presented with various pictures and toys while the blindfold was interposed between their eyes and the objects, with the experimenter asking 'Where's the [object label]?' This familiarization lasted for 5 minutes, and provided the infants with experience about the optical properties of the opaque vs. the trick (see-through) blindfold.

During the test phase, infants watched a video sequence similar to the one used in Southgate et al. (2007), presented on a Tobii 1750 eye tracker. In the video, a female actor sat behind a panel with two windows, in front of which were placed two boxes. In the first two events, a small toy was seen on one of the boxes, then the windows were illuminated and a chime sounded simultaneously to indicate that the actor was going to reach through one of the windows. After a 1750-ms delay, the actor reached through the window toward the toy. In the third and fourth trial, a puppet appeared, opened the lid of one of the boxes, placed a toy into it, closed the lid and left the scene. Then the windows were illuminated, the chime sounded, and after a 1750 ms delay the actor reached through the window corresponding to the location of the toy. In the final (fifth) trial, the puppet placed the toy into the left-hand box, after which the actor put on the blindfold previously experienced by the infant. The puppet then removed the toy from the box and left the scene with it. Once the puppet had disappeared, the actor removed the blindfold, the windows were illuminated, and the chime sounded. (See the video in the supplementary material.)

Results

On the basis of the eye tracking data, we coded the direction of infants' first saccade following the illumination of the windows, and the differential looking score (DLS), which was calculated by subtracting total looking time to the right window from total looking time to the left window and dividing it by the total looking time to both windows (Senju, Southgate, White, & Frith, 2009). We found that 14 of the 18 infants made first saccades towards the left window in the Opaque condition (p= .031, g = .278, binomial test), while only 6 of the 18 infants did so in the Trick condition (p= .238, g = .167, binomial test). Thus, the location of first gaze was influenced by infants' experience with the blindfold (p= .018, ϕ = .447, Fischer's Exact Test). The DLS also significantly differed between groups ($t(33)$ = 2.668, p = .012, d =.871), being above zero in the Opaque condition (DLS = .39, $t(17)$ = 2.32, p = .03, d = .549), but not in the Trick condition (DLS = -.31, $t(17)$ = -1.53, p = .15, d = .360).

Discussion

That infants in the two conditions had different expectations about the actor's action after object displacement suggests that infants used self-experience with the blindfold to assess the actor's visual access, updated her belief state accordingly, and used this attribution for action prediction. Infants in the Opaque condition expected the actor to search in the left box, suggesting they attributed a false belief to the actor. Infants in the Trick condition, by contrast, did not show such a bias, suggesting that they did not attribute a belief about a specific location to the actor: As the object had been removed from the scene, the actor should have no strong basis on which to choose one box over the other. The current finding is inconsistent with the proposal that infants rely on behavioural cues available in the stimuli to make predictions (e.g., Perner & Ruffman, 2005) because the same video sequence was presented in both conditions. The current results strongly suggest that 18-months-olds pay attention to others' visual access to events and appreciate its causal role in altering belief states.

Meltzoff & Brooks (2008) offer several alternative explanations for how infants could go from first person experience with the blindfold to understanding its effects on another person. However, even the leanest interpretation of such first-to-third person extrapolation would entail the understanding of the unobservable mental state of seeing (Heyes, 1998; Penn & Povinelli, 2007; Meltzoff & Brooks, 2008). Thus, at the very least, infants encoded that the actor either could or could not see the displacement of the object when she wore the blindfold, and used this information to correctly anticipate her future behaviour. The current results cannot clarify whether the link between visual access and consequent behaviour is mediated by the attribution of an additional mental state concept, such as belief, by 18-months-old infants.

Nevertheless, the current finding makes a strong case that the emerging evidence of the capacity for mental state attribution in infants should not be dismissed or discarded as "precursors" of an adult theory of mind, relying on simpler, non-mentalistic processing. Our finding, considered together with the other studies of early belief attribution reviewed here, points to the existence of a genuine ability to attribute mental states from at least the middle of the second year of life, if not earlier (Kovács et al., 2010).

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