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14-Month-olds anticipate others' actions based on their belief about an object's identity

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Abstract

Past research has accumulated evidence regarding infants' false-belief understanding, measuring their gaze patterns or active helping behaviors. However, the underlying mechanisms are still debated, specifically, whether young infants can compute that others represent the world under a certain aspect. Such performance requires holding in mind two representations about the same object simultaneously and attributing only one to another person. While 14-month-olds can encode an object under different aspects when forming first-person representations, it is unclear whether infants at this very age could also predict others' behavior based on their beliefs about an object's identity. Here, we investigate this question in a novel eye-tracking-based unexpected-identity task. We measured 14-month-olds' anticipatory looks combined with their looking time, using a violation-of-expectation paradigm. Results show that 14-month-olds look longer to an actor's reach that is incongruent with her false belief about the identity of an object compared to a congruent reach. Furthermore, infants correctly anticipated the actor's reach based on her false belief. Thus, as soon as infants represent dual identities they can integrate them in belief attributions and use them for consequent behavioral predictions. Such data provide evidence for the flexibility of false-belief attributions and support proposals arguing for infants' rich theory-of-mind abilities.

1 | INTRODUCTION

Infants grow up in a social world and are faced with a variety of behaviors that they will have to understand. To do so, it is important to realize that others' actions are in fact not guided by the reality, but by their representations about reality (an ability also termed as *theory of mind* [ToM], Baron-Cohen, Leslie, & Frith, 1985; Wimmer & Perner, 1983). A growing body of research targeting infants has suggested that they can understand others' behavior in terms of their goals (Woodward, 1998), and their beliefs (Onishi & Baillargeon, 2005). Early studies investigating belief attributions in infancy usually involved paradigms that rely on attributing false beliefs about the location of objects. Currently, it is still debated whether infants' abilities are restricted to encoding beliefs about locations, which are often explained by low-level mechanisms (as it was suggested by the two system theories, Apperly & Butterfill, 2009), or whether infants possess a flexible belief-attribution system that can also operate on the identity or aspect of an object as perceived by another person.

To test young infants' false-belief understanding, researchers have used different methods, like measuring looking duration in violation-of-expectation (VoE) paradigms (Kovács, Téglás, & Endress, 2010; Onishi & Baillargeon, 2005; Scott, He, Baillargeon, & Cummins, 2012; Scott, Richman, & Baillargeon, 2015) or anticipatory looks (Southgate, Senju, & Csibra, 2007). In tasks using VoE paradigms, infants are surprised and show longer looking times when actors behave incongruently with their beliefs compared to belief congruent behavior (Onishi & Baillargeon, 2005; Scott & Baillargeon, 2009). Further research suggested that from early on, infants show an understanding of others' mental states in a wide range of scenarios (for a review see Scott & Baillargeon, 2017), for example, involving false perceptions (Song & Baillargeon, 2008), false beliefs of a human (or non-human) agent about an object's location (Surian, Caldi, & Sperber, 2007), or about others' preferences based on their beliefs (Kampis, Somogyi, Itakura, & Király, 2013). Furthermore, infants also anticipate others' actions based on their false beliefs (Senju, Southgate, Snape, Leonard, & Csibra, 2011; Southgate et al., 2007; Thoermer, Sodian, Vuori, Perst, & Kristen, 2012). However, it is unclear what exact factors are important for successful performance on such tasks (for a review see Baillargeon, Buttelmann, & Southgate, 2018). Some studies failed to replicate previous findings regarding infants' successful performance on implicit ToM tasks (e.g., Yott & Poulin-Dubois, 2016; Zmyj, Prinz, & Daum, 2015); however, others replicated and broadened previous findings (e.g., Scott et al., 2015; Träuble, Marinović, & Pauen, 2010).

One of the current questions in the field is whether young infants are able to attribute to others beliefs about an object's identity, when the object can be represented in two different ways (e.g., Scott & Baillargeon, 2009; Scott et al., 2015). For example, in a helping study Buttelmann, Suhrke, and Buttelmann (2015) have used so-called 'deceptive objects' that have a misleading appearance (e.g., a box that looks like a book) and can be represented both as a book and as a box. To solve the task, infants needed to hold in mind two representations about the same object simultaneously (one for themselves and one for the protagonist who has experienced only the misleading appearance of the object in the false-belief condition). 18-month-olds helped the experimenter according to her belief about the object's identity, specifically when she asked for an object they brought her the one resembling what she believed the object to be (a book or a box). Whereas 17-month-olds also seem to understand others' beliefs about identity measured by their looking time (Scott et al., 2015), 2- to 3-year-olds do not show evidence for such an understanding in an interactive task (Fizke, Butterfill, van de Loo, Reindl, & Rakoczy, 2017), nor do 3- and 4-year-olds and adults in an anticipatory task (Low & Watts, 2013). However, in first-person reasoning, already 14-month-olds seem to represent such dual identities of a single object (Cacchione, Schaub, & Rakoczy, 2013). Thus, the question emerges whether

14-month-olds could also predict others' behavior based on their false beliefs about an object's identity, as early as they can encode these contents.

In the current study, we tested whether 14-month-old infants encode others' beliefs about an object's identity to investigate the above theoretical question on the one hand, and on the other hand, we also aimed to address another issue. Specifically, to assess the robustness of 14-month-olds' ability to understand and predict others' beliefs about an object's identity, we combined two paradigms: a VoE and an anticipatory-looking paradigm. Sometimes different measurements yield different results in young infants (Daum, Attig, Gunawan, Prinz, & Gredebäck, 2012). For instance, in a direct comparison of both measures within participants, infants already show an understanding of others' goals at around 9 months of age (or earlier) in VoE paradigms, whereas they seem to correctly anticipate others' behavior based on such goals only around the age of three in the anticipatory-looking paradigm (Daum et al., 2012, but see Cannon & Woodward, 2012, or Kim & Song, 2015, for data from 6-month-olds correctly anticipating others' goals using anticipatory measures only). The gap observed in the Daum et al. (2012) study involving direct comparisons might indicate a different sensitivity of the two methods, or it might be explained by the differential availability of specific processes at the two age groups (e.g., post hoc evaluation of others' goals vs. online predictions; Daum et al., 2012). In the present study, by using both VoE and anticipatory measures, we ask whether the two measures yield convergent data that would support the robustness of the investigated phenomenon. Earlier findings do not provide unequivocal evidence regarding whether infants are able to anticipate others' actions based on their beliefs as early as they show an understanding of others' beliefs in VoE paradigms. Whereas young infants interpret others' actions in terms of their beliefs already at 13 months in a VoE paradigm (Surian et al., 2007), evidence for anticipations based on false beliefs is reported only somewhat later, in 17–18-month-olds or older toddlers (Senju et al., 2011; Southgate et al., 2007; Surian & Geraci, 2012; Thoermer et al., 2012).

We developed a novel eye-tracking task combined with a VoE paradigm and measured (a) whether 14-month-olds take into account an actor's false beliefs about the identity of an object when they anticipate her actions and (b) whether this understanding is also reflected in their looking-time patterns when observing the actor reaching for the object resembling the apparent or the real identity of the deceptive object. Infants were exposed to belief scenarios in which an actor either knew about the two identities of a deceptive object (true-belief-control; e.g., a pen that looked like a cat) or was only aware of the appearance of the object (false belief; e.g., the object being a cat). Therefore, in the false-belief condition, infants have to understand how the actor represents an object, which is different from their own representation. If infants indeed have a rich understanding of others' false beliefs and can readily compute beliefs about an object's identity, we expect them to anticipate that the actor will reach in accordance with her false belief (i.e., for the cat, when she believed the object to be a cat) and also to show surprise (look longer) when the actor reaches incongruently to her false belief in the VoE trials (i.e., reaching for the pen, the object resembling the real identity, when not being aware that the cat is a pen).

2 | METHOD

2.1 | Participants

Seventy-two infants participated in the study. Twelve infants were excluded from the analyses because of crying, inattentiveness or fussiness, and for technical error, resulting in 60 infants (M_{age} = 14 months; 7 days; range = 13; 30–14; 18; 32 girls). Infants were randomly assigned to one of two test conditions (false-belief N = 31/true-belief-control N = 29). Infants were seated on their parent's lap during the

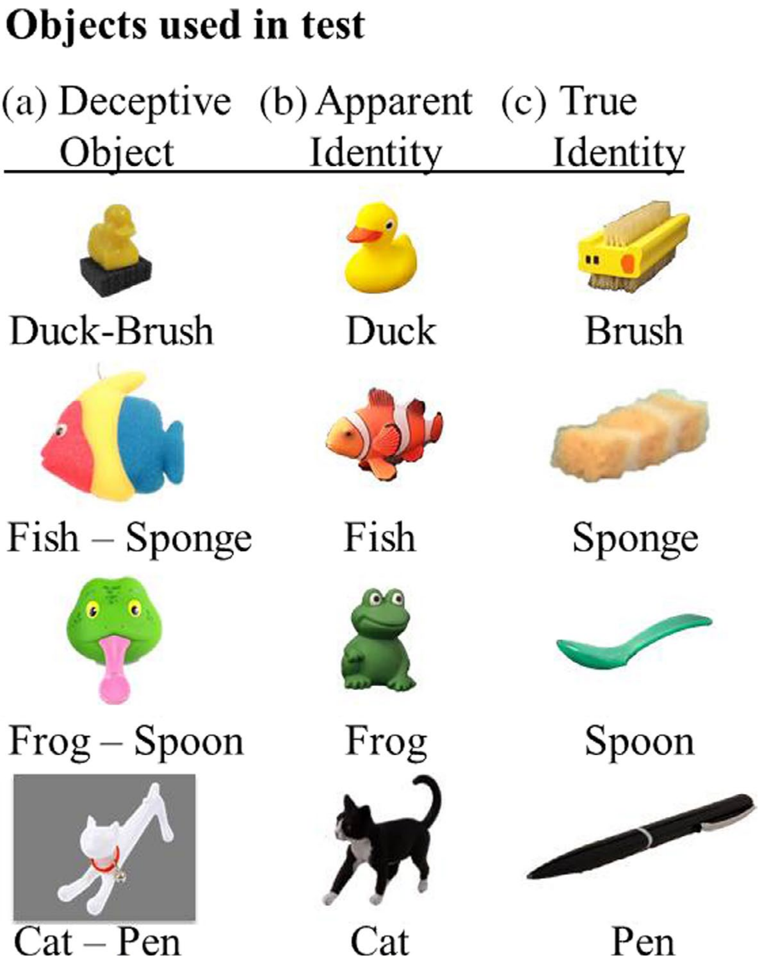

FIGURE 1 Materials used in the study. For each of the deceptive objects (column a), there were two test objects: one resembling the deceptive object's appearance (column b) and one resembling its real identity (column c)

study and received a small toy as a gift for participation. The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each infant before any assessment or data collection. All procedures involving human subjects in this study were approved by the United Ethical Review Committee for Research in Psychology, Hungary, and the study was conducted at the Cognitive Development Center, Central European University, Budapest.

2.2 | Materials

Infants watched short movies in the familiarization and the test phases. In each movie, an agent sat at a table, on which a blue occluder with two holes was placed. The familiarization objects were a ball and a car. In the test phase, we used four deceptive objects (e.g., a brush that looked like a duck, see Figure 1). Additionally, we used four further target objects resembling the appearance of the deceptive objects (e.g., a duck) and another four resembling their real identity (e.g., a brush, see Figure 1). We used cardboard to hide the target objects (see Supporting information for details regarding the

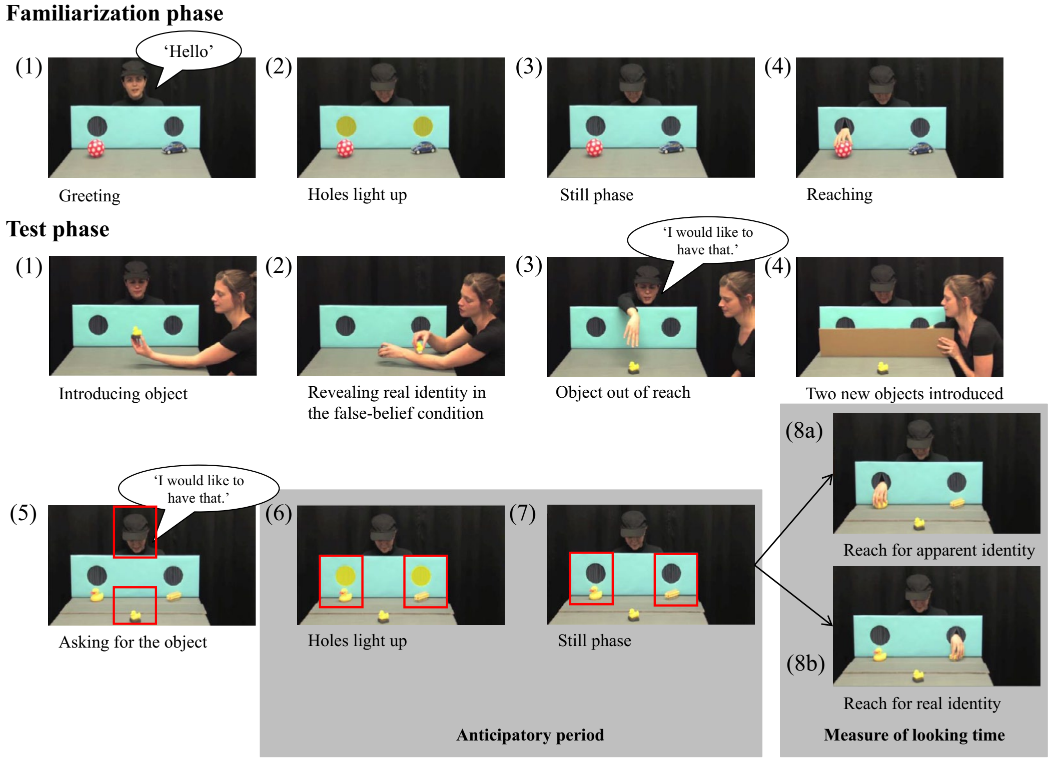

FIGURE 2 Schema reflecting the elements of the scenarios in the familiarization and test phases in the false-belief condition, where the agent was absent when the real identity of the object was revealed (see frame 2, the assistant reveals the brush at the bottom of the duck-shaped object and brushes her hand). The true-belief-control condition was identical except that the agent was present during this event and could see the real identity of the object. In the test trials, infants' anticipations were measured during the events depicted in frames 6–7. The target AOIs contained the objects resembling the apparent or the real identity of the deceptive object and their respective reaching holes (depicted by red rectangles). Infants' anticipations toward the target AOIs had to be preceded by a central gaze to the agent or to the deceptive object, illustrated as central AOIs in frame 5, red rectangles. AOI rectangles serve only for illustration purposes and were not displayed in the movies. In the first three test trials, no reaching occurred, while in the last two counterbalanced test trials, infants saw the agent reaching for the test object resembling the target's apparent (e.g., 8a) or real identity (e.g., 8b), and infants' looking time was measured

materials, S1.1). At the end, parents filled out a questionnaire regarding the infant's knowledge about the used target objects (see Supporting Information S1.2 and S5.1).

2.3 | Procedure

Infants sat on their parent's lap, approximately 60 cm away from a TOBII T60 XL eye-tracker monitor (with a sampling rate of 60 Hz), which had an inbuilt eye-tracker camera. For calibrations, we used TOBII's default infant calibration protocol. An external camera recorded the infants' looking behavior.

Infants were randomly assigned to a true-belief-control or a false-belief condition. They first took part in a familiarization phase consisting of five trials in which the agent reached for one of two objects through one of the holes of the occluder. Afterward, four test trials followed, which involved different deceptive objects. The procedure concluded with a fifth trial where we used the same deceptive object as in the fourth trial to allow for comparing looking times on these last two trials (see Supporting information for counterbalancing, S2).

The *familiarization* movies (each 7.44 s) involved the following steps (Figure 2): (a) The movies started with an agent sitting at a table, where an occluder with two holes was present through which the agent could reach for one of two objects placed on the table (a ball and a car). The agent greeted the infant and then looked down. (b) Then, the two holes of the occluder lit up and a sound was heard. (c) After a still phase of 2 s, (d) the agent reached through the hole behind the ball and grasped the ball. With these events, we aimed to familiarize infants with the general scenario and with the cues that precede specific events (e.g., after the holes lit up, the reaching takes place) that could trigger infants' anticipatory looks later in the test phase.

In the *test movies* (Figure 2) besides the agent, an assistant was also present and (a) showed a new object to the agent (e.g., a duck-looking object that later turned out to be a deceptive object). (b) Afterward, the agent either stayed (true-belief-control condition, TB-C) or left the scene (false-belief condition, FB) and the assistant demonstrated the real identity of the deceptive object (revealing that the duck was a brush and demonstrating its function). Thus, in the FB, the agent was not aware of the real identity of the object, while in the TB-C she was aware of both identities. The deceptive object was then placed in the middle of the table, out of the agent's reach. (c) The agent re-entered and tried to reach for the object, but did not succeed, saying “I would like to have that” by looking at the assistant. (d) Subsequently, the assistant looked to the agent and said “I have some of that here” and placed two new objects within the reach of the agent in front of the two holes, one resembling the apparent identity of the deceptive object (e.g., a duck) and one resembling its real identity (e.g., a brush). (e) Then, the agent said again “I would like to have that” and (f) the two holes lit up and the sound that preceded reaching in the familiarization was heard, but no reaching took place. (g) After a 2-s still phase, the movies of the first three test trials ended (each of 50.40 s). The fourth and fifth test trials (h) were as described above, except that the movies continued for another 1.56 s with the agent reaching for the object resembling the apparent identity of the deceptive object in one trial (congruent with the agent's belief about the object's identity in the FB condition, e.g., for the duck; Figure 2.8a) and for the object resembling its real identity in the other trial (incongruent with her belief in the FB condition, e.g., for the brush, see Figure 2.8b). Thus, in both conditions the fourth and the fifth trial was either a trial with a reach for the object resembling the apparent identity or the real identity of the deceptive object, order counterbalanced. The last frame of these movies was displayed for a maximum of 30 s measuring infants' cumulative looks or until they looked away continuously for more than 2 s.

In the test, we had two dependent measures: anticipatory looks and looking times. In the first four trials, we measured infants' anticipatory looks to the two areas of interest (AOIs) containing the target objects, toward which the agent could reach after the holes lit up (see Figure 1, frames 6–7). For correctly anticipating which object she would reach for, infants needed to understand that when the agent did not know that, for instance, the duck was a brush (FB) she would likely reach for the duck-like object, as this is what she wanted to reach for before. Second, in the last two trials we measured infants' looking time, comparing looking durations when infants see the agent reaching for the object corresponding to the apparent identity of the initial goal object and when reaching for the object corresponding to its real identity. If infants' looking time is modulated by the agent's false belief about the deceptive object's identity, infants should look longer (show surprise) when she reaches for the object resembling the real identity in the false-belief condition (when the agent only knew about the *apparent identity* of the object). In contrast, in the true-belief-control condition, where the agent knew about both identities, infants might not be biased toward either outcome and might find both outcomes possible. Therefore, in case both identities are salient, they could find both reaches equally likely. However, if function has prevalence, as was observed in older children (Booth & Waxmann, 2002), infants could expect the agent to reach based on the object's real identity (see Buttelmann et al., 2015; Gopnik & Astington, 1988).

2.4 | Coding

The AOIs were defined a priori by the pixels corresponding to the critical aspects of a specific scene (i.e., the agent, deceptive object, and the test objects with the respective reaching holes) and the areas around them, making sure that the AOIs are well separated and that the two object AOIs are comparable (see Figure 2 frames 5–7, red rectangles).

We analyzed infants' first anticipation in the test trials toward one of the two target AOIs (containing the objects resembling the apparent or the real identity of the deceptive object and their respective reaching holes, Figure 2 frames 6–7, red rectangles) that happened during the anticipatory period, that is, the time the holes lit up (see Figure 2 frame 6) and in the 2-s still phase (see Figure 2 frame 7). Anticipatory looks had to be preceded by a central gaze either to the agent AOI or to the deceptive object AOI. We used a conservative criterion for trial inclusion; specifically, there had to be recorded gaze data in more than 50% of the critical time period (i.e., the anticipatory phase, see Figure 2 in test frames 5–7). This resulted in an exclusion of 17.1% of trials (i.e., 21 trials in FB and 20 trials in TB-C condition) and in excluding seven infants (because they had no trials left to analyze, $N_{FB} = 4$, $N_{TB} = 3$). Additionally, other trials were excluded because infants looked away during critical events (when the real identity was demonstrated or when the agent reached toward the deceptive object, i.e., five trials in FB and six trials in TB-C) or because they did not reorient to the middle (i.e., looking neither at the agent nor the deceptive object as central AOIs, illustrated in Figure 2 frame 5) before looking at one of the two target objects in the anticipatory phase (8.8% of trials for each condition). In total, the eye-tracking data of 53 infants ($N_{FB} = 27$, $N_{TB\text{-}C} = 26$; mean number of anticipations across conditions = 2.2, $SE = 0.14$) reached the criteria to be included in the analysis.

Although there were five test trials, for anticipations we only analyzed the first four, because at the end of the fourth trial infants saw the agent reaching (for the object resembling the apparent or real identity of the deceptive object), which would have influenced their anticipation in the following fifth trial. The central AOI, where infants' gaze had to be before the anticipation period, was either the agent (10.6 × 12.3 cm) or the deceptive object (10.6 × 8.5 cm; see Figure 2 frame 5, red rectangles). Infants' first gaze to one of the two target objects was counted, falling into one of the target AOIs (that included the object and the respective reaching hole, each 10.6 × 12.4 cm (see Figure 2 frames 6–7 in the test phase). For each infant, we calculated the proportion of anticipatory looks to the two target AOIs.

For the looking-time analysis, we followed standard protocols for looking-time studies and coded offline the video recordings of infants' looking behavior at the end of trial four and five with Psycode (http://psy.ck.sissa.it/PsyCode/PsyCode.html). We used the videos to code the looking times to make sure we include all valid data, as the eye-tracker may not record gaze in case the child slightly changes position over the test trials. A second naïve observer coded 28% of the recordings. Inter-observer agreement was high ($r = 0.995$, $p \leq 0.001$). The last frame of these movies was displayed for a maximum of 30 s measuring infants' cumulative looks or until they looked away continuously for more than 2 s. Accordingly, infants were excluded from further analysis, if after the end of the scenario they looked the maximum of 30 s in both of the VoE trials ($N = 5$) or looked less than 2 s to one of the two movies at the beginning of the agent's reach ($N = 2$). Additional infants were excluded from the looking-time analysis if they were inattentive, crying, or fussy in one or both the trials ($N = 4$), due to parental interference ($N = 4$), experimenter error ($N = 1$), or because their looking times were more than two standard deviations away from the mean ($N = 3$, Téglás et al., 2011). In total, the looking

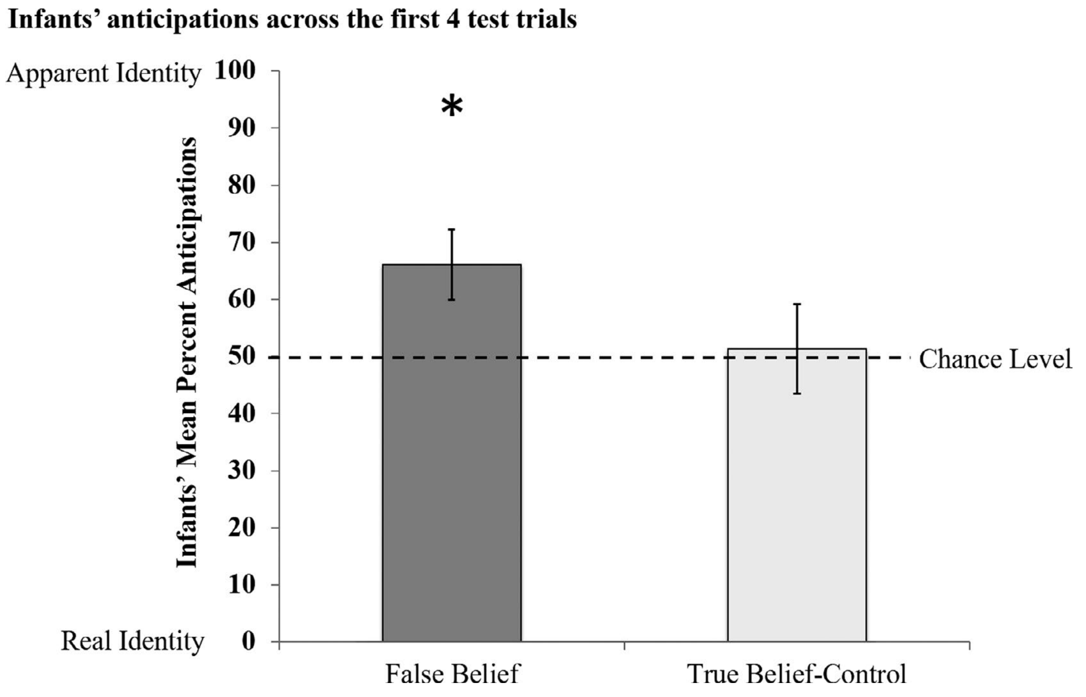

FIGURE 3 Infants' mean percent anticipation (and *SE*) to the object resembling the apparent identity of the deceptive object, across the first four trials in the false-belief condition (where she only knew about the apparent identity) and true-belief-control condition (where she was aware of both identities). Asterisk indicates significant difference compared to chance ($p < 0.05$)

times of 41 infants (18 in false-belief/23 in true-belief-control condition) reached the criterion to be included in the analysis. See Supporting information S3 on coding of the parental questionnaire.

We applied parametric tests whenever conditions for parametric testing were fulfilled, otherwise we used nonparametric tests; all *p*-values are two-tailed.

3 | RESULTS

3.1 | Anticipatory-look analysis

We analyzed infants' first anticipation in the first four test trials that was performed toward one of the two target AOIs (Figure 2 frames 6–7, red rectangles). In the false-belief condition, infants anticipated the agent to reach according to her belief about the object's identity above chance-level, that is, reaching more often for the object resembling the apparent identity across the four test trials (average percentage of first anticipatory looks, $M_{\text{apparent}} = 66.1\%$, $SE = 6.1$), $t(26) = 2.626$, $p = 0.014$, $d_z = 0.51$. In the true-belief-control condition, infants looked to a similar extent to the two object AOIs ($M_{\text{apparent}} = 51.3\%$, $SE = 7.8$), $t(25) = 0.163$, $p = 0.872$, see Figure 3. To exclude the possibility that looking behavior in the test phase was modulated by how much attention infants paid to the function demonstration in the respective conditions, we compared how much infants looked to the demonstration scenes (Figure 2, Test phase frame 2) in the true and the false-belief conditions. However, there was no difference in the amount of time infants in the two conditions spent looking at the screen during the demonstration ($M_{\text{false belief}} = 81.3\%$ overall looking, $M_{\text{true belief-control}} = 84.6\%$ overall looking, Mann–Whitney U-test $= 374.5$, $p = 0.267$, $N = 60$).

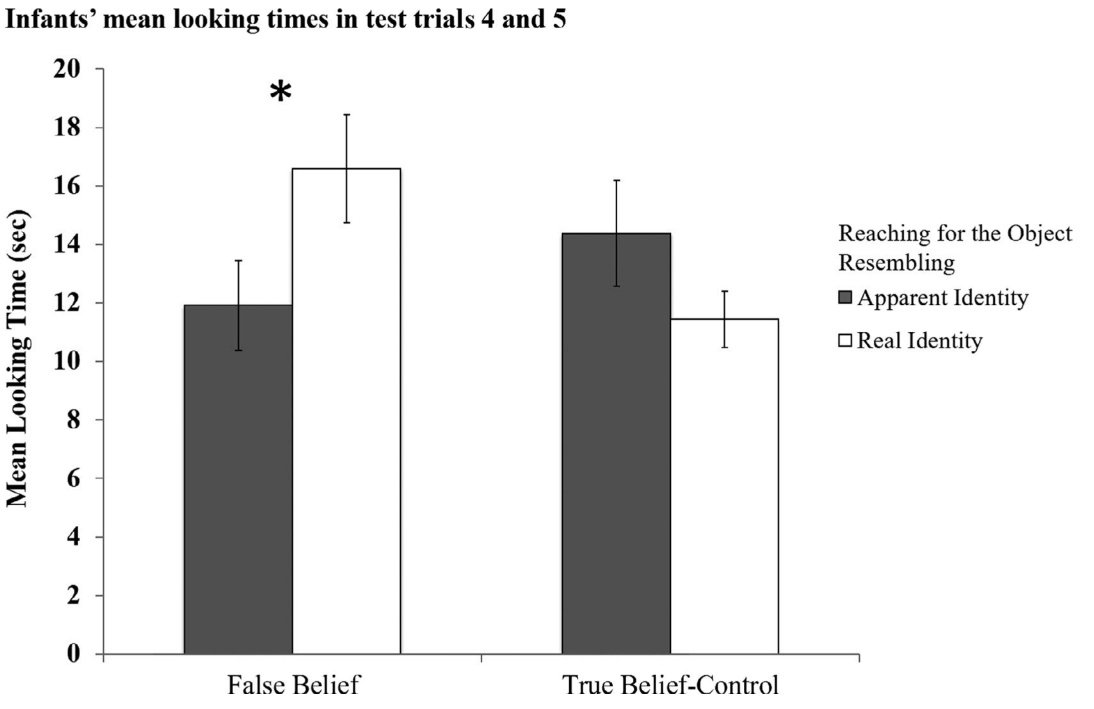

FIGURE 4 Infants' mean looking times (and *SE*) measured after the agent reached for the test object resembling the apparent identity or the real identity of the deceptive object in the false-belief and true-belief-control conditions. Asterisk indicates significant differences ($p < 0.05$)

Next, we asked whether infants switched gaze more often between the two target object AOIs in the TB-C compared to the FB condition, which would possibly reflect a lower confidence regarding to which object the agent will reach. We found a tendency for more switches in the TB-C (mean switch nr/trial = 1.1) than in the FB condition (mean = 0.8, Mann–Whitney U-test = 311.5, $Z = -1.704$, $p = 0.088$, see Supporting information S4.1).

3.2 | Looking-time analysis (VoE trials)

A repeated-measures ANOVA (Greenhouse–Geisser correction) with target object (reaching toward the object resembling apparent or real identity) as within-subjects factor, and condition (true belief-control, false belief) and trial order (reaching for the apparent identity object first - real identity object second or vice versa) as between-subjects factors revealed a significant target object × condition interaction, $F(1, 37) = 5.928$, $p = 0.020$, $\eta p^2 = 0.14$, with no other effects. Planned analysis showed that infants looked significantly longer at the agent reaching for the real-identity object than for the apparent-identity object in the false-belief condition ($M_{\text{apparent identity}} = 11.9$ s, $SE = 1.5$; $M_{\text{real identity}} = 16.6$ s, $SE = 1.9$), $t(17) = 2.275$, $p = 0.036$, $dz = 0.54$; whereas there were no significant differences in the true-belief-control condition, where looking patterns showed an opposite directionality ($M_{\text{apparent identity}} = 14.4$ s, $SE = 1.8$; $M_{\text{real identity}} = 11.4$ s, $SE = 1.0$), $t(22) = 1.354$, $p = 0.190$, see Figure 4.[1]

[1]We found no correlations when comparing infants' anticipations and looking durations nor when comparing their object knowledge and their looking behavior (see Supporting information S4.2 and S5.2).

4 | DISCUSSION

In the current study, we investigated infants' ability to understand others' beliefs about objects' identity using a novel eye-tracking paradigm combined with a VoE method. Specifically, we aimed to test whether 14-month-olds are able to predict others' behavior based on their false beliefs about the identity of an object and whether they can evaluate scenarios in which the agent acted congruently (i.e., reaching for an object resembling the apparent identity) or incongruently (i.e., reaching for an object resembling the real identity) with her false belief.

Results suggest that in the false-belief condition, where the agent represented the deceptive object based on its apparent identity (and not its real identity), infants predicted that the agent would reach for the object resembling the appearance of this deceptive object. This implies that infants are able to predict others' behavior by taking into account their false beliefs about an object's identity already at the very age when they themselves succeed in representing dual identities (Cacchione et al., 2013). However, in the true-belief-control condition they did not seem to have a clear prediction toward which object the agent would reach. As mentioned earlier, while older children seem to expect an actor to act based on the real identity (and the function) of a deceptive object (Buttelmann et al., 2015; Gopnik & Astington, 1988), infants in our study do not yet seem to be biased in this direction; specifically, function and shape (the object's appearance) seem to be equally salient for them when predicting true belief-based actions. The possibility that infants in the true-belief-control condition might consider both objects as valid options is also supported by a tendency for a higher number of gaze switches between the two objects in the true-belief-control as compared to the false-belief condition. The similar amount of anticipations toward the two objects in the TB-C condition also excludes the possibility that the pattern observed in FB is due to specific low-level factors (e.g., animal-like objects attract attention), as one would expect these low-level factors to play a role also in the TB-C condition.

Our results from anticipatory looking, which point to an understanding of others' false beliefs based on object identity, gained further support from infants' differential looking durations to the agent's false belief congruent (object resembling the apparent identity) and incongruent (object resembling the real identity) reaching. In these VoE trials, we found an interaction between condition (TB-C or FB) and target object (reaching toward the object resembling the apparent or real identity). Post hoc comparisons revealed that infants looked significantly longer to the reach that was incongruent with the agent's belief compared to the congruent reach only in the false-belief condition, indicating their surprise for when the agent reached for the object resembling the real identity of the deceptive object (about which she did not know). The looking-time differences in the true-belief-control condition did not reach significance, which corroborated by infants' anticipatory looking pattern, which point to the possibility that in the true-belief-control both outcomes might be likely.

The current findings that 14-month-olds understand and anticipate an actor's behavior based on her false beliefs about an object's identity cannot be explained by simple associations (DeBruin & Newen, 2012), or by novelty effects (Heyes, 2014), criticisms raised for some of the earlier ToM studies. Specifically, in the current setup it was not possible to make differential associations between the agent, the deceptive object and one of the target objects, since both target objects were seen at the same time at the very end of the scenario. Further, we can also exclude novelty effects that were raised as an explanation for infants' performance in VoE paradigms (Heyes, 2014). Specifically, it was argued that infants look longer to one event, because, for instance, the agent has not reached for that specific side or object before, and infants are therefore attracted by the novel action. However, in the current study, both target objects in the two conditions were novel, and the agent did not reach for either of the two objects earlier (see also Buttelmann et al., 2015 for a similar argument).

Some of the earlier studies targeting identity-based belief attributions in children did not find evidence for such abilities (e.g., Low & Watts, 2013). One possible difference between these studies and our study could be that our study design likely involved lower processing demands. More precisely, in our procedure infants could attribute a representation regarding the object's identity to the agent from the very beginning of the false-belief scenario when the object was shown to both. Later on, as the events unfolded, they only needed to update their own representation to encode the second aspect of the object. In contrast, the study of Low and Watts (2013) involved an object with differently colored sides (and opposing perspectives); however, in the false-belief condition this feature of the object was revealed to the child only in the absence of the agent. First, the child saw the red-sided object going to location A in the agent's presence, and then, in the agent's absence the object turned around and revealed its blue side. Thus, children could infer the agent's belief only retrospectively (in his absence) and attribute him a belief about a blue-sided object, while tracking the object from two conflicting perspectives, which may involve higher working memory (Carruthers, 2013, 2017) or episodic memory demands (Király, Oláh, Csibra, & Kovács, 2018).

While we believe that the data pattern we observe in the current study is best explained with the possibility that infants understand others' false beliefs about an object's identity, one might wonder whether infants attributed ignorance instead of false belief. However, an ignorance-based account would not explain infants' anticipations toward the target object resembling the apparent identity of the deceptive object in the false-belief condition. To make such anticipations, infants had to compute that this is how the person has encoded this object and that she is not aware of its second identity. Importantly, while such computations can also be referred to as attributing partial knowledge (Russell, 1987) they have been suggested to reflect the understanding of the aspectuality of belief representations (that reflect encoding the world under a certain, but not other aspect) and are radically different from pure ignorance attributions.

Our data suggest that as soon as infants can represent dual identities (Cacchione et al., 2013), they can also integrate them in false-belief attributions. While there is an ongoing debate regarding implicit measures in false-belief tasks, to our knowledge, there are no published studies targeting infants' anticipatory looks as well as their looking times in a single task that targeted their understanding of others' beliefs. A study from a related domain suggested that infants detect goal-incongruent behavior much earlier (as revealed by their looking times) compared to when they show correct anticipations based on an agent's goals (Daum et al., 2012). While finding out why in some cases "early competence is initially revealed by looking time, then by gaze" (Leslie, 2005, p. 460) is an interesting issue, the current study suggests that on the group level, 14-month-old infants display similar competencies in their ability to understand others' false beliefs, both after watching the actor displaying a behavior that is in/congruent with her false beliefs and when they have the opportunity to anticipate the actor's behavior. Our sample is likely rather small to tackle such relations on the individual level (see Supporting information S4.2); however, this can be a target for further research.

In sum, these results are more in line with proposals claiming that infants' ToM abilities seem to be flexible from early on (Baillargeon, Scott, & He, 2010; Kovács, 2016; Leslie, 1994) as it was reflected by infants' ability to understand others' beliefs about an object's identity. They detected others' belief-incongruent behavior and even predicted an agent's behavior already at the age of 14 months. This study contributes to a growing body of research, which points to the rich belief-attribution abilities of infants, which are central to proposals of a single mindreading system (e.g., Jacob, 2019), suggesting that infants' and adults' belief representations likely rely on similar processes and have similar representational underpinnings.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest with regard to the funding source for this study.

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