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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 46(0)

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Publication Date
2024

Peer reviewed

Communication-based belief attribution: Do infants encode better others' beliefs induced via communication or the ones induced via visual cues?

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Abstract

Studies suggest that infants track others' beliefs based on visual information (Scott & Baillargeon, 2017 but see Dörrenberg, Rakoczy, Liszkowski, 2018). However, research targeting whether infants understand that others' beliefs can be induced via communication is scarce, although most of the human belief-repertoire is acquired via communication. We presented eighteen-month-olds (Experiment1:N=34; Experiment2-replication:N=35) with a false belief (FB) scenario where the initial belief was induced via communication, aiming to measure their informative pointing (for an agent mistaken about a toy's location compared to a true belief scenario). Instead of more pointing to the toy's current location, in the FB condition we found an unexpected 'altercentric' effect: infants pointed more to the empty location where the agent *falsely believed* the object to be). Next, we asked whether infants show different altercentric effects for visually induced beliefs (Experiment3: N=35). Results replicated the altercentric effect, suggesting a potentially stronger encoding of visually induced beliefs.

Keywords: theory of mind; false belief understanding; pointing; altercentricism; social cognition

Introduction

Humans and other species readily rely on first-hand evidence (i.e., direct perception) to acquire knowledge about the social and physical world. First-hand evidence, however, is not always sufficient to learn new information, and humans, in fact, acquire a great part of their knowledge based on communication. Research has pointed to a strong tendency to trust communicated information in early childhood, aiding the transmission of cultural knowledge (Csibra & Gergely, 2009; Harris & Koenig, 2006; Heyes, 2016; Tomasello, 2016). Young children strongly rely on verbal (e.g., verbal testimony; Jaswal, 2010; Ma & Ganea, 2010; Jaswal et al., 2014) and non-verbal (e.g., pointing; Mascaro & Kovacs, 2022) communicative cues even when these cues conflicting with their first-hand experience. From infancy onwards, children seem to successfully evaluate communicated information based on the knowledge states and reliability of an informant (Begus & Southgate, 2012; Koenig & Echols, 2003; Koenig & Woodward, 2010) or the reliability of an informant's affective signals (e.g., positive or negative facial expressions; Chow, Poulin-Dubois, & Lewis, 2008; Poulin-Dubois, Brooker, & Polonia, 2011, Stenberg, 2013).

Studies suggest that infants may also be able to evaluate others' knowledge states (e.g., knowledge and ignorance, true and false beliefs) in third-party interactions, as well as in communicative interactive settings. Previous research using various measures such as looking times (Kovacs, Teglas &, Endress, 2010; Onishi & Baillargeon, 2005), anticipatory looks (Southgate, Senju, & Csibra, 2007; Thoermer, et al., 2012), active behavior (Buttelmann, Carpenter, & Tomasello, 2009; Knudsen & Liszkowski, 2012a; Southgate, Chevallier, and Csibra, 2010) or neural measurements (Hyde et al., 2018; Kampis et al, 2015; Southgate & Vernetti, 2014) suggest that infants could track others' epistemic states (specifically, their false beliefs).

More recent studies have not replicated the effects, observed in certain paradigms (e.g., Dörrenberg et al., 2018; Kampis et al., 2021; Kulke et al., 2018, Powell et al., 2018), or have provided alternative explanations (e.g., Priewasser et al., 2018). Notably for the questions addressed in the present research, some of the paradigms that have been replicated (Kiraly et al, 2018; 2023) rely on communicative interactions. However, surprisingly, all previous studies have involved situations in which the false belief of the interlocutor was in fact visually induced. Thus, whether infants can form representations about others' beliefs solely triggered by communication, where they cannot rely on visual information, to our knowledge, was not previously investigated. In addition, if they can form such belief representations, one can also explore the question of whether young infants encode stronger communication-induced or visually-induced belief representations.

Earlier research suggests that once infants have attributed a belief based on what an agent has seen, they can use third-party communication to update the earlier belief attributions (Song et al., 2008; Tauzin & Gergely, 2018). However, in these studies, the formation of an initial false belief representation was induced by visual and not communicated information (e.g., infants *saw* that the agent *herself* put a ball in a box; Song et al., 2008), and therefore one may argue that the initial belief attribution may be open to three-way association or registration-based low-level accounts between an agent, an object and a location (Apperly & Butterfill, 2009; Perner & Ruffman, 2005), that do not entail belief attribution. However, importantly, communication-based belief induction would not be open to such explanations as

In L. K. Samuelson, S. L. Frank, M. Toneva, A. Mackey, & E. Hazeltine (Eds.), *Proceedings of the 46th Annual Conference of the Cognitive Science Society.*

the agent and the infant do not see the object at a location, they are only told that the object is there.

To explore infants' tracking of others' beliefs induced via communication, we relied on a paradigm developed by Knudsen and Liszkowski (2012b), which found that 18- and 24-month-old infants corrected others' false beliefs by pointing in a communicative context. However, in that study, the agent's belief was computed relying on direct perception of what an agent has seen, and not communication. Specifically, after the agent herself placed an object in a certain location, the location of the object was changed by a confederate with the agent either being absent (False Belief, -FB condition) or present (True Belief, -TB). When the agent came back, infants pointed more to the current location of the object in the FB than in the TB condition, which was taken as evidence for i) tracking the agent's epistemic states and for ii) modulating their own communicative behavior to correct others' mistaken actions. Thus, in the current study, our first aim was to investigate i) and ii) in a context in which a belief is attributed based on communication (i.e., Experiment 1 and 2: replication).

Our second aim was to investigate whether the way the belief is induced (i.e., via visual information vs. communicated information) influences infants' encoding of others' beliefs, possibly reflected in a difference in their pointing responses. Considering that communication plays a crucial role in the acquisition of new information (Csibra & Gergely, 2009; Harris & Koenig, 2006; Heyes, 2016; Tomasello, 2016), beliefs induced via communicated information could be encoded stronger than beliefs induced via visual information. Alternatively, visually-induced beliefs may be encoded stronger, as infants can readily encode what others can see and jointly looking at an object could facilitate encoding (Luo & Baillargeon, 2007; Luo & Johnson, 2009; Manea et al., 2023). To test whether the format of belief induction (visual or communicative) affects infants' communicative pointing differently, we run a version of the current task where the belief was visually induced in Experiment 3.

Experiment 1

In Experiment 1, infants were presented with scenarios where the false belief was induced via communicated information. We measured infants' spontaneous-pointing responses in FB and TB conditions, and predicted that infants would point more to the current location (i.e., corrective pointing; Knudsen & Liszkowski, 2012b) when the agent is mistaken about the current location of the object.

Participants

Thirty-four 18-month-old infants participated from German-speaking households (mean age = 18; 15; range = 17;30 – 19;00; 14 females) in Experiment 1. Eleven additional infants were tested but excluded from the analyses due to fussiness (N = 5), or lack of interest (i.e., no pointing in the spontaneous-pointing/direct question phases; N = 6). A post hoc power analysis (G*Power) was also conducted to determine whether a sample size of 34 provided sufficient power to detect a medium-sized effect for Wilcoxon signed-rank tests. With N = 34 participants and $\alpha = \beta = .05$, the statistical power to detect the observed effect size ($d_z = 0.52$) equalled to 0.82. Thus, our sample size of 34 provided sufficient power to reject the null hypothesis.

Materials and Design

A piece of grey cardboard (60*15*40cm) was used as the occluder. For the warm-up trials, a blue owl-shaped jumping toy with a clockwork mechanism was used. For each of the four test trials, a similar size (4*4*5cm) but different animal-shaped jumping toy was used in a fixed order. For the hiding places, three identical blue paper cups were used (see Fig.1).

Each condition (FB and TB) included two trials and infants received trials from both conditions in a within-subject design, 4 test trials in total. The order of the FB and TB conditions was counterbalanced across infants (FB;TB;FB;TB and TB;FB;TB;FB). The initial hiding location of the object and experimenter's (E; a male experimenter) subsequent pointing to the initial hiding location of the object (the baited cup at the left or right end) were counterbalanced across infants. Either the right-end or left-end cup contained the toy that alternated across four trials (initial hiding location of the object: L-end;R-end;L-end;R-end and R-end;L-end;R-end;L-end). The seating side of the agent (A; a female confederate) at the table with respect to infants (Left/Right) was counterbalanced across infants.

Warm-up trials

The warm-up trials aimed to familiarize infants, sitting on parents' lap, with the hiding game and the fact that when the agent (A) sat at the experimenter (E)'s place, she aimed to find the jumping toy under the cups and plays with it in a communicative manner. E first showed three identical cups to both A and the infant and said "Look! They are empty." All communication took place in German. Then A took the jumping toy (i.e., a blue owl) out of the toy bag and gave it to E. E said "Look! I put it here!" and hid the jumping toy under one of the three cups while both A and infants were watching. After the hiding, A said "There it is! I would like to play with it!" Then both A and E stood up and A sat down in E's place while E was standing next to A. A rotated the clockwork mechanism on the jumping toy that then independently moved for about 10 seconds. While the toy was moving, both A and E looked at it with interest and expressed liking (e.g., smiling, vocalizing, clapping hands). The same warm-up trial was repeated with the two remaining cups (see Figure 1).

Test trials

Hiding phase In the hiding phase, A took one of the jumping toys (e.g., a green frog) out of her bag and gave it to E. Then E placed an occluder on the table to hide the toy invisibly from A and the child. First, E showed the jumping toys to both A and infants above the occluder. Then he said "Look! I'm hiding it.", after which A said "Aha, OK." to confirm that she had witnessed the hiding. E placed the toy under the cup at one of the sides (e.g., the right end) while both A and infants were prevented from seeing where the toy was by the occluder. Then E placed the occluder back under the table. After that, A looked at the infants and said, “Hmm, I could not see where it is. Where could it be?”.

Belief-induction phase In the FB condition, E pointed to the cup that contained the object (referred to as the initially baited cup later in this manuscript) and said, “The toy is here”. A said, “Aha, OK.”, leaned forward, touched the top of the pointed cup without opening, and tapped on it. She announced “Oh, I need to go out, but I will be back in a bit. Then we can continue.” and left the room. While A was absent, E said to infants “Oh, look!”, while touching the top of the cup that contained the object, and alternated gaze between the door and infants. E then took the toy out of the cup where it was hidden, said “Look! I'm putting it here.” and put it under the cup at the opposite end (referred to as the currently baited cup). Before putting down the cup on the toy, E alternated gaze between the door and the infants, showed the toy again, and placed the cup back on it. Then A came back to the room.

The TB condition followed the same procedure as the FB condition except for the following changes. A witnessed the change of the location before going out of the room. E did not alternate gaze between the door and infants while changing the location of the toy. Instead, before E took the toy out of the initially baited cup, he looked at A and said, “Look, “[A's name]”. He then took the toy out of its location, said “Look, “[A's name], I'm putting it here.” and put the toy under the cup at the opposite end (i.e., the currently baited cup). Before putting down the cup on the toy, E showed the toy to both A and the infant again and placed the cup back on it. Then A said “Aha, OK.” to demonstrate that she witnessed the location-change of the toy and then she left as before. To have the two conditions of equal time-length, A spent less time outside the room before coming back.

Spontaneous-pointing phase Following Knudsen and Liszkowski (2012b), the spontaneous-pointing phase lasted a pre-determined and timed sequence (approx. 30 secs. in total) starting from when A came back to the room. After A came back to the room in both conditions, E waved at both A and the infant in a friendly manner and said “Bye, [A's name]!”. Then he left the scene (went behind a curtain on the other side of the room so that he was out of sight for the rest of the trial). After entering the room, A first walked in parallel to the table at about 2 meters distance without revealing which cup she would approach, stopped briefly in the middle, looked at the infant, and said "Good. Shall we continue playing?" (i.e., the first spot; waiting for approx. 15 secs.). Then she approached the midline of the table for a meter, stopped again, and said “Okay, let's go on” (i.e., the second spot; waiting for approx. 10 secs.). The spontaneous-pointing phase ended as soon as she sat down and before she reached for one of the cups. If the infant pointed in any part of the spontaneous-pointing phase, A said "Yes!" and continued her pre-determined sequence, as follows. Both FB and TB trials ended with A, reaching for the current location of the object if the infant pointed to the current location. If the infant did not point at any of the cups, A reached for the initial location of the object in the FB condition, and she reached for the current location of the object in the TB condition. If the infant pointed to the initial location of the object or the cup in the middle in either of the conditions, A reached for the pointed cup, and given that she did not find the object, the direct-question phase began.

Direct-question phase In the direct-question phase, after reaching for the pointed cup in cases in which the toy was not there, A showed the empty cup to the infant and said “Huh? How is this possible? It is empty!” (Direct question 1). If infants did not point to the current location of the object, the A continued “Where is the toy? “[Infant's name], do you know where the toy is? (Direct question 2). If infants did not point to the current location of the object after any of the search questions, or after they pointed to the current location, A found the toy in its location and activated it for roughly 10 seconds. The participants were not given the toys to play with until the end of the last test trial.

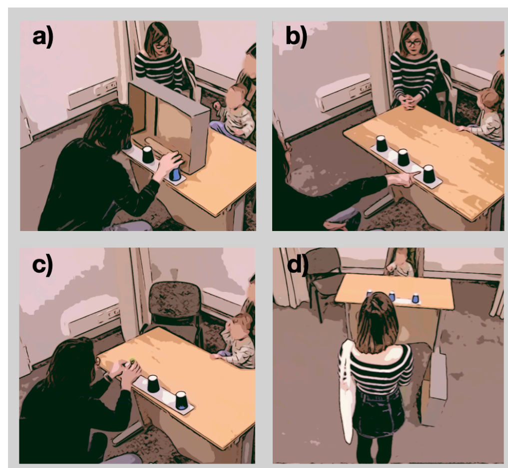

Figure 1: Schematic depiction of the experimental design. a) Hiding phase: The experimenter (E) hid the toy into one of the cups. b) Belief-induction phase: E pointed and verbally informed both A and infants about the location of the object. c) Switch phase: E changed the location of the object (unbeknown to A in the FB condition) d) Spontaneous-pointing phase: A re-entered the room and walked in a predefined L-shaped path, then waited in two spots before sitting at the chair across the infant.

Coding and Analysis

Index-finger pointing to any of the cups and E's hiding location were coded from the video recordings if it occurred during the spontaneous-pointing or the direct-question phase. Pointing was defined as a half or fully-extended arm with an open palm down or the index finger extended. The arm extension had to have a clear onset and end with a clear trajectory toward one of the cups. Dependent variables were

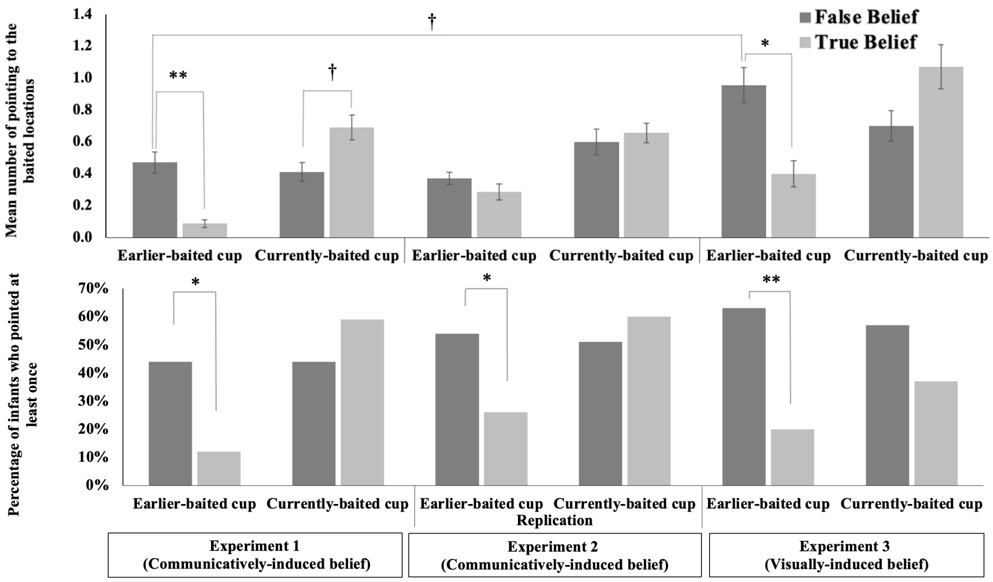

Figure 2: Mean number of pointing per trial (upper panel) and percentage of infants who pointed at least once (lower panel) to the currently baited and initially baited locations as a function of experimental conditions (FB and TB) across Experiments 1-3. Error bars represent standard error. $^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$.

mean number of pointing (1) and pointing at least once (2) to the initially and currently baited cups following Knudsen and Liszkowski, 2012b. Because the data were not normally distributed (*p*s < .01, Shapiro–Wilk tests), mean comparison analyses were conducted with non-parametric tests in all experiments (i.e., Wilcoxon signed-rank test for the within-subject analyses and Mann-Whitney U test for the between-subject analyses). All *p*-values were two-tailed. To evaluate the strength of evidence for the alternative hypotheses ($H_{1:}$ a difference between the mean number of pointing to the initial and current locations of the object across the TB and FB conditions) over the null hypotheses ($H_{0:}$ no difference across the mean number of pointing to the initially and currently baited location across the conditions) with the default Cauchy prior width (.707), Bayesian Wilcoxon signed-rank tests were conducted. The data for all three experiments can be found at https://osf.io/5daqt/

Results and Discussion

The Wilcoxon signed-rank test revealed that infants' mean number of pointing to the currently baited location differed marginally across the FB (M = .412, SD = .668) and TB (M = .691, SD = .913) conditions, z = –1.755, p = .072, with more pointing in the TB condition, in contrast to the result we predicted and in contrast to the findings by Knudsen & Liszkowski, 2012b). Interestingly, however, a Wilcoxon signed-rank test revealed an unexpected effect, specifically infants' mean number of pointing to the initially baited location was higher in the FB (M = .471, SD = .778) compared to the TB condition (M = .088, SD = .288), z = 2.580, p = .009. A between-subject comparison between the very first trials of the FB (M = .667, SD = .907) and TB (M = .063, SD = .250) condition yielded the same pattern, U = 200.500, p = .012, *Mann-Whitney U* test. A Bayesian Wilcoxon signed-rank test suggested moderate evidence in favor of the alternative hypothesis over the null for pointing to the initial location (BF_{10} = 6.58), but not for pointing to the current location (BF_{10} = 0.83).

Furthermore, more infants pointed to the initially baited cup at least once in the FB condition (15/34) than in the TB condition (4/34), McNemar, p =.010, but a similar number of infants pointed to the currently baited location at least once in the TB condition (20/34) and FB condition (15/34), McNemar, p = .267 (see Figure 2).

Next, we asked whether infants could remember where the object was. One-sample Wilcoxon signed-rank test revealed that the average proportion of trials with pointing to the current location of the object at least once (spontaneous-pointing & direct-question phases combined; M = .867, SD = .320) was above the chance level (.50), p < .001, r = .786.

While we expected to find evidence for i) tracking the agent's false belief via ii) modulating their own communicative pointing to correct this false belief (point more to the current location in FB), we found evidence for i), tracking other's beliefs, as manifested by an unexpected altercentric effect (i.e., the agent's false belief that the object is in the empty location attracted infants' pointing).

Experiment 2

Altercentric effects can be defined as a strong or unexpected influence of others' perspectives on human behavior (see also Kampis & Southgate, 2020; Southgate, 2020). In the current study, the influence of the agent's perspective was reflected via pointing to the initially baited location of the object, where the agent falsely believed it to be. Considering infants' pointing to the current location of the object in the direct question phase, infants do remember the object's location. However, in the spontaneous-response phase, infants pointed presumably to the empty location *influenced by* the agent's *false belief* about the object's location (note that a more adaptive communicative act would have been to point to the current location of the object, to inform about the change). Given that we found an unexpected altercentric effect via pointing to the initially baited FB location, in Experiment 2, a replication of Experiment 1 was conducted with a single change in the counterbalancing order. In Experiment 1, the initial hiding location of the object alternated across the four trials (left or right, 1212), as well as the conditions alternated (starting either with TB or FB). In this way, while the final location of the object alternated as there was a switch always (2121), however, the agent (A) always believed (truly or falsely) the object to be on the same side on each trial (i.e., 1111). Although this likely did not influence our results as the same pattern was found in the very first trial in Experiment 1, we used a different counterbalancing in Experiment 2 (see #125224|AsPredicted: https://aspredicted.org/3VN_DJ6).

Participants

Thirty-five 18-month-old infants participated from German-speaking households (mean age = 18; 15; range = 18;01 – 19;00; 17 females) in Experiment 2. Nineteen additional infants were tested but excluded from the analyses due to fussiness (N = 10), lack of interest (i.e., no pointing at all in the spontaneous-pointing/the direct-question phases; N = 9).

Materials, Design, and Procedure

Materials and procedure were the same as in Experiment 1. The design was the same as in Experiment 1 except for the counterbalancing order. The initial hiding location (left or right) of the object changed in every two trials (1122) such that the agent (A)'s belief about the object's location alternated in every trial (e.g., 1212 – for infants starting with a FB or TB trial).

Results and Discussion

A Wilcoxon signed-rank test showed that infants' mean number of pointing to the currently baited location did not differ across the FB (M = .600, SD = .946) and TB (M = .657, SD = .715) conditions, z = –0.556, p = .583. Additionally, infants' mean number of pointing to the initially baited location also did not differ across the FB (M = .371, SD = .459) and TB (M = .286, SD = .598) conditions, z = 0.938, p = .338, (see Figure 2). However, a between-subject comparison between the very first trials of the FB (M = .444, SD = .616) and TB (M = .059, SD = .243) trials yielded the same pattern as in Experiment 1, U = 204.000, p = .022, *Mann-Whitney U* test. A Bayesian Wilcoxon signed-rank test suggested no evidence in favor of the alternative hypothesis over the null in pointing to the initial location (BF_{10} = 0.34), or the current location (BF_{10} = 0.21).

Nevertheless, as in Experiment 1, more infants pointed to the initially baited cup at least once in the FB condition (19/35) than the TB condition (9/35) McNemar, p =.033, but a similar number of infants pointed to the currently baited cup at least once in the TB (21/35) and FB (18/35) conditions, McNemar, p = .579 (see Figure 2).

One-sample Wilcoxon signed-rank test revealed that the average proportion of trials with pointing to the current location of the object at least once (spontaneous-pointing & direct-question phases combined; M = .750, SD = .381) was above the chance level (50%), p = .002, r = .615.

Experiment 2 revealed a partial replication of the novel altercentric effect in Experiment 1 (i.e., pointing to the initial location of the object at least once more in the FB condition; categorical measure). The null results in the continuous measure could be due to the counterbalancing/order effects, given that we replicated the difference on the very first trials (i.e., changing the hiding location once in every two trials might lead to some preservation bias).

Experiment 3

In Experiment 3, infants were presented with a scenario where beliefs induced via visual information. Thus, we aimed to explore how the type of belief induction (i.e., beliefs induced via communicated vs. visual information) influences infants' pointing, and whether the visual belief induction would induce stronger or weaker altercentric effects (see #136897|AsPredicted: https://aspredicted.org/Z2L_1Z1).

Participants

Thirty-five 18-month-old infants participated from German-speaking households (mean age = 18; 14; range = 17;30 – 19;14; 15 females) in Experiment 3. 9 additional infants were tested but excluded from the analyses due to fussiness (N = 6), or lack of interest (i.e., no response in the spontaneous-pointing/the direct question phases; N = 3).

Materials, Design, and Procedure

Materials and design were the same with Experiment 1 except that no occluder and no extra communicative signals were used in the belief induction. The procedure was the same as in Experiment 1 and 2 except that both infants and A could see the initial hiding location of the object. Accordingly, no communicative pointing nor the affirmative sentence ("The toy is here") was present in the belief induction phase, however, the hiding was performed in an ostensive manner.

Results and Discussion

A Wilcoxon signed-rank test showed that infants' mean number of pointing to the currently baited location did not differ across the FB (M = .700, SD = 1.145) and TB (M = 1.071, SD = 1.646) conditions, z = –1.566, p = .118. However, infants' mean number of pointing to the initially baited location differed across the FB (M = .957, SD = 1.291) and TB (M = .400, SD = .976) conditions, z = 2.243, p = .025, supporting an altercentric effect in this experiment as well. A between-subject comparison between the very first trials of the FB (M = 1.111, SD = 1.491) and TB (M = .059, SD = .243) trials yielded the same pattern, U = 223.000, p = .004, *Mann-Whitney U* test. A Bayesian Wilcoxon signed-rank test suggested moderate evidence in favor of the alternative hypothesis over the null in pointing to the initial location

(BF_{10} = 3.92), but this was not the case in pointing to the current location (BF_{10} = 0.63).

Furthermore, more infants pointed to the initially baited cup at least once in the FB condition (22/35) than in the TB condition (7/35), McNemar, p = .001, but the number of infants pointing to the currently baited cup at least once in the TB (20/35) and FB (13/35) conditions did not differ, McNemar, p = .146 (see Figure 2).

One-sample Wilcoxon signed-rank test revealed that the average proportion of trials with pointing to the current location of the object at least once (spontaneous-pointing & direct-question phases combined; M = .797, SD = .333) was above the chance level (50%), p < .001, r = .760.

Comparison of communication and visually-induced belief attribution (Experiment 1 and 3) experiments

Infants' pointing to the initial location differed marginally across Experiment 1 (M = .471, SD = .778) and Experiment 3 (M = .957, SD = 1.291), *Mann-Whitney U* = 449.500, p = .064, in the FB condition. The number of infants who pointed to the initially baited cup at least once in the FB conditions of Experiment 1 (15/34) and Experiment 3 (22/35), showed a similar pattern, but was not significantly different, χ^2 (1, N = 69) = 2.44, p = .119.

Infants' pointing to the initial location did not differ across Experiment 1 (M = .088, SD = .288) and Experiment 3 (M = .400, SD = .976), *Mann-Whitney U* = 536.500, p = .275, in the TB condition. The number of infants who pointed to the initially baited cup at least once in the TB conditions of Experiment 1 (4/34) and Experiment 3 (7/35), did not differ, χ^2 (1, N = 69) = .873, p = .350 (see Figure 2)

Experiment 3 replicated the previous findings on infants' pointing across the FB and TB conditions (i.e., the altercentric effect), however, a trend for a difference between the belief induction types (i.e., belief induction based on communicated vs. visual information) was observed in the mean number of pointing analyses for the false belief condition, with more pointing in the visually induced version.

General Discussion

We aimed to investigate whether infants can track others' beliefs when beliefs are induced via communication, as all earlier studies that we are aware of were based on belief induction via visual information. The current results revealed that infants did take others' beliefs into account even when beliefs were induced via communication, as reflected by the novel altercentric effect on their pointing behavior in the FB condition. Indeed, other studies in early childhood suggest that trust in communication and testimony have a crucial role in the transmission of cultural knowledge, including counter-intuitive beliefs in science and religion (Harris & Koenig, 2006; see also Harris et al., 2018 for a review). The current results suggest that young infants not only readily endorse communicated information in their first-person reasoning, but they also accept communicated information as a valid source for belief formation for other people as well, which may then result in true or false beliefs.

The current findings provided counter-evidence against three-way association or registration-based low-level accounts between an agent, an object and a location (Apperly & Butterfill, 2009; Perner & Ruffman, 2005). In Experiment 1 and 2, infants were not able to *see* the initial hiding location of the object but *communicated* to them. Therefore, infants' belief tracking, influencing their communicative pointing, could not be based on simple agent-object relations.

Our second goal was to investigate whether belief induction type influences the strength of infants' belief encoding, as reflected by their pointing behavior. We cannot conclude that the way beliefs were induced had a strong impact on infants' pointing, however, we observed a trend in favor of the visual condition, with more pointing in the FB condition of Experiment 3 compared to Experiment 1 (see the Results and Discussion in Experiment 3). The fact that this comparison did not reach significance could be due to a lack of power and it is possible that a significant difference across the belief induction types could be detected with a larger sample. Furthermore, analogously to how trust in the communicated information may get stronger throughout infancy in first-person reasoning (e.g., 24-months-olds showed stronger trust than younger infants; Mascaro & Kovacs, 2022), one may wonder whether the direction of the strength may shift during later ontogeny in third-person reasoning as well (i.e., stronger response to belief induction via communicated vs. visual information).

The altercentric effect we observed in the FB conditions of the three experiments (spontaneously pointing to where the agent falsely believed the object to be) seems to suggest that infants' communicative pointing is influenced by others' beliefs and they may point to the earlier location of the toy to *inform* the agent about the changes (that the toy is *not* there anymore), relevant to her future behavior (i.e., an atypical proto-declarative pointing). However, infants' pointing to the empty location where the other agent believes the toy to be could be interpreted in different ways. According to a strong altercentric proposal, infants may lack competing self-perspective until sometime in the second year of life that creates a bias for focusing on others' perspectives (see Yeung et al., 2022). In the case of false belief tasks, the altercentric bias strengthens the memory for the object's location from the "other-perspective" (which prevails over the "self-perspective" of infants; Southgate, 2020). If such a strong case of altercentricism is correct, infants might have not encoded the actual location of the toy in the current task. The findings from the direct-question phase, however, indicate that most of the participants correctly remembered the current location of the toy across Experiment 1-3. Thus, such results do not seem to support a strong altercentricism, instead they seem to suggest that infants may have access to both the other's (false) belief and their own reality representation.

Future research might explore more directly infants' first-person representation of the events, as well as whether pointing to the location where the other believes the object to be serves to re-establish common ground in a communicative interaction with that specific agent.

Acknowledgments

We are grateful to the families who participated in this research. We thank Dorottya Mészégető, Christina Regorosa and Ágnes Volein for research assistance.

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