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Original Articles

The social-cognitive basis of infants' reference to absent entities

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ABSTRACT

Recent evidence suggests that infants as young as 12 month of age use pointing to communicate about absent entities. The tacit assumption underlying these studies is that infants do so based on tracking what their interlocutor experienced in a previous shared interaction. The present study addresses this assumption empirically. In three experiments, 12-month-old infants could request additional desired objects by pointing to the location in which these objects were previously located. We systematically varied whether the adult from whom infants were requesting had previously experienced the former content of the location with the infant. Infants systematically adjusted their pointing to the now empty location to what they experienced with the adult previously. These results suggest that infants' ability to communicate about absent referents is based on an incipient form of common ground.

1. Introduction

Language is inherently ambiguous. When interpreting others' utterances, it is not sufficient to focus on what is said, but one also needs to consider the context in which something is said. A crucial aspect of context is the common ground shared between speaker and listener (Bohn & Köymen, 2017; Clark, 1996; Sperber & Wilson, 2001; Tomasello, 2008). Part of the common ground between two individuals is what they mutually know about a certain state of affairs. As an example for how common ground can be used to disambiguate utterances consider the following: A speaker may communicate to a listener that she desires another piece of cake by pointing to an empty plate if it is part of common ground that this plate previously contained pieces of cake. For a person not sharing this common ground, the point to the empty plate would fail to denote the absent cake. To use common ground, speakers and listeners therefore have to keep track of what they experience with whom. Utterances produced *and* interpreted in light of common ground quickly lose their ambiguity.

Common ground is not only vital for adult communication, but arguably even more so for young children in the process of learning language. This is for at least two reasons: On the one hand, children's earliest forms of intentional communication (e.g. pointing gestures or one-word utterances) are considerably more ambiguous compared to fully formed adult speech. Successful communication based on these signals heavily relies on common ground. By considering whether something is part of common ground, children can actively help their partner figure out what they mean. On the other hand, when on the receiving end, children are faced with more ambiguity compared to an adult listener because oftentimes they do not know the conventional meaning of words. Again, considering common ground when interpreting utterances greatly facilitates disambiguation and learning. For example, when engaged with someone in naming things by their color, the novel word "zeleny" most likely refers to yet another object's color instead of e.g. its name. In this spirit, a number of theoretical accounts have emphasized the importance of common ground for early communication and language acquisition (Bohn & Köymen, 2017; Bruner, 1974; Clark, 2015; Tomasello, 2008; Tomasello, Carpenter, & Liszkowski, 2007).

From a psychological perspective, common ground is traditionally conceptualized as involving recursive mindreading on both ends: Speaker and listener reason about each other's mental states to determine what is part of common ground and what not. If recursive mindreading was a pre-requisite for using common ground, it would be unlikely that infants are able to do so because these abilities do not emerge until around six years of age (Miller, 2009). Recently, Bohn and Köymen (2017) proposed a developmental perspective on common

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ground, arguing that recursive mindreading might be an outcome of communication based on common ground rather than a prerequisite. The developmental primitive of common ground is the expectation that others act rationally in light of shared experience. While preserving the idea of ambiguity reduction, this view does not put recursive mindreading at the core of common ground. When reviewing the literature and discussing our results, we do so in light of this perspective.

There is a solid body of empirical evidence supporting the claim that even very young children (below age 2) rely on common ground when interpreting ambiguous utterances. Tomasello and Haberl (2003) showed that 12- and 18-month-old children consider what is new to a speaker (i.e. what is not part of common ground) when interpreting ambiguous requests (see also Moll, Carpenter, & Tomasello, 2007; Moll & Tomasello, 2007). In a study by Ganea and Saylor (2007), 15- and 18-month-olds interpreted an ambiguous request ("Can you get it for me?") as referring to an object that was part of a previous interaction (see also Saylor & Ganea, 2007; Saylor, Ganea, & Vázquez, 2011). Liebal, Behne, Carpenter, and Tomasello (2009) had infants play different games with two experimenters. Later, 18-month-olds (and to some extend also 14-month-olds) interpreted and ambiguous point to an object by one of the experimenters as referring to the game they previously played with that particular individual.

There is considerably less evidence that young children adjust their own communicative acts to common ground. In a study by Liebal, Carpenter, and Tomasello (2010), participants played with different toys with two different experimenters. When later confronted with a photograph of these toys, 18-month-old infants pointed more often to the toy they previously shared with the experimenter that was now with them. In this study, 14-month-olds did not show a consistent pattern of pointing. More recently, a number of studies claimed that already 12-month-olds rely on common ground when communicating about absent entities (Bohn, Call, & Tomasello, 2015; Liszkowski, Schäfer, Carpenter, & Tomasello, 2009).

Studies looking at children's comprehension of words referring to absent entities find first signs of comprehension at around 12 months of age (Ganea & Saylor, 2013; Osina, Saylor, & Ganea, 2013, 2014; Saylor, 2004) and fairly solid comprehension abilities in place around 16 months (Osina, Saylor, & Ganea, 2017). On the other hand, children do not produce their first words referring to absent entities until around 18 months (Veneziano & Sinclair, 1995). The studies reporting early use of common ground therefore looked at children's pointing behavior. When pointing, reference to the absent entity is not grounded in the conventional semantics of words but in shared experience. In the corresponding studies, children pointed to the previous location of an object in order to request another one of that kind (Bohn et al., 2015; Liszkowski et al., 2009; see also Liszkowski, Carpenter, & Tomasello, 2007). Presumably, infants did so in appreciation of the shared interaction with their interlocutor around this location while it still contained objects. However, this assumption and with it the role of common ground was not addressed empirically.

The present study aimed at filling this gap by investigating whether 12-month-old infants adjust their communicative acts to previous interactions with an interlocutor. In particular, we focused on whether they take into account what their interlocutor experienced in an earlier interaction. To this end, we adopted the methodology developed by Bohn et al. (2015). Participants played a game in which they requested visible objects, placed on two plates, from an experimenter in order to throw them into a container. Following Bohn et al. (2015), we manipulated the content of the two plates. The plates either contained objects of the same quality (both high or both low quality) or of a different quality (one high quality and the other low quality). Importantly, the low quality objects were nevertheless desirable to infants when presented on their own. During the warm-up phase, whenever one option was depleted, the experimenter (E1) left the room and brought new objects of that kind. In the test phase, after the participant had again requested all objects from one of the plates, E1 left the room again. In this situation, one plate was empty and the other still contained visible objects. Bohn et al. (2015) argued and presented evidence that a desirable and visible alternative is necessary to interpret infants' requests as intended to obtain a specific object. Furthermore, without a desirable alternative option, participants might simply point to the empty plate because no other way to continue the game in general is available. This would make it difficult to investigate whether infants take into account previous interactions with the respective experimenter. However, presenting a valuable alternative option decreases the number of points to the empty plate in the test phase. The focus of the study was therefore not whether infants at 12 month of age request absent objects more often than visible objects but how requests for absent objects were distributed across conditions.

We then manipulated who would return to the test room. In the case that E1 returned to the test room, E1 had previously seen the former content of the plate. If E2 returned to the test room, she had not seen it. During the test phase, we coded whether infants would point to the empty plate to request additional objects. For E1, who previously saw the former content of the plate, we expected infants to point to the empty plate only if its previous content was of a higher quality compared to the visible option (specific requests). For E2, who never saw the former content of the empty plate, we expected infants to ignore the previous content of the empty plate. In a second experiment, we specified which aspects of the previous interaction drives infants' pointing. A third experiment replicated experiment 2.

2. Experiment 1

2.1. Participants

We tested 64 twelve-month-old infants (M = 382.9 days, SD = 7.0 days, 32 girls). Participants came from mixed socioeconomic backgrounds, lived in a middle-sized German city and were recruited from a database of children whose parents volunteered for studies on child development. Parents were asked prior to the study whether their child already pointed and only infants who pointed were included in the study. Additional infants were invited but had to be excluded because they completed only one experimental session (12) lost interest or became uncomfortable in the first experimental session (nine), their parents interfered (one) or the experimenter made a mistake (one).

2.2. Setup

Infants were tested in a separate room within a child laboratory. They were seated on their parents lap facing the experimenter's chair (distance: 140 cm), flanked by two platforms (55 × 28 × 69 cm; distance between platforms 50 cm) with a ceramic plate (Ø 20 cm) on top. In front of the infant stood a cylindrical container (Ø 24 cm, height 47 cm) with a funnel on top (see Fig. 1). The container was close enough to the infant to insert objects into the funnel. Inserting an object produced a rattling sound and made the object disappear. The two platforms were located closer to the experimenter so that she could easily reach for the objects placed on the plates while the objects were out of reach for the infant. The objects used throughout the study were colorful balls (red and blue, Ø 5 cm) as well as wooden cubes (side length 2.5 cm). Pilot testing showed that infants generally preferred the balls to the blocks, although the blocks were nevertheless desirable when presented on their own. Additional objects were stored outside the test room and were never visible to the infant.

2.3. Procedure

For a schematic overview of the procedure see Fig. 1. Infants and their parents arrived in a playroom within the laboratory where they met the experimenters E1 and E2. Together they played until the infant was comfortable with the situation. Within the test room, the

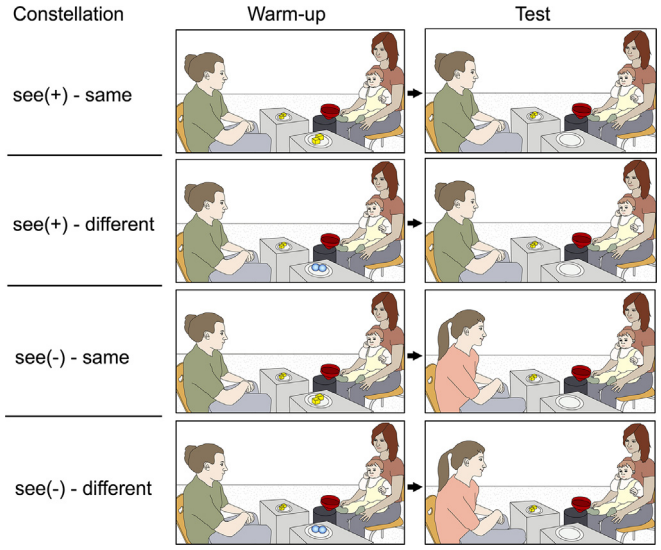

Fig. 1. Schematic overview of the setup and procedure in experiment 1. Constellations varied depending on whether the experimenter who was present during test, previously saw the content of the empty plate [see (+/−)]. They further varied depending on the previous content of the empty plate at test (same or different from the visible alternative). In a second variation of the same condition (not depicted here), there were balls on both plates.

interaction between the infant and the experimenter was structured as a game in which the experimenter would hand over requested objects to the infant who could insert them into the container. Infants requested objects placed on the plates one by one by pointing to them. In the beginning of each session, both plates were covered by a grey cardboard box. Throughout the experiment, the experimenter never labeled the objects. Each session had a warm-up and a test phase.

2.3.1. Warm-up

E1 led the infant together with the parent to the test room. After sitting down, E1 removed the cardboard boxes from the plates simultaneously. Each plate contained two objects of the same kind (either two balls or two blocks). Depending on the condition of the factor content the two plates contained either the same kind of objects (same condition, both plates balls or both plates blocks) or different objects (different condition, one plate balls the other blocks). In the beginning, E1 took one object from the right plate, showed it to the infant and threw it into the container. E1 then repeated the same procedure with an object from the left plate. Next, E1 took an object from the right plate, handed it over to the infant and encouraged him or her to throw it into the container. Again the same procedure was repeated with an object from the left plate. As soon as the infant had thrown the last object into the container, E1 stood up, left the room and returned with four additional objects. E1 placed them on the plates so that each plate contained the same kind of object as it did before. After re-baiting, E1 waited for the infant to request further objects by pointing. As soon as the infant had requested all objects from one plate, E1 stood up, left the room and re-baited the two plates in the same way as before. Then, E1 waited for the infant to request more objects. As soon as the infant had requested all objects from one of the plates for the second time, E1 again stood up and left the room. Next, one of the experimenters entered the room and the test phase began. However, this time the experimenter who entered the room did not re-bait the empty plate. Therefore, one plate still contained objects while the other one was empty. The warm-up phase served three purposes: (a) to familiarize infants with the general structure of the game, (b) to show that more objects are available, and (c) that E1 is willing and able to get them.

2.3.2. Test

The test phase followed immediately after the end of the warm-up phase. Depending on the condition of the factor see either E1 or E2 entered the room. In the see(+) condition, E1 entered the room. In this case, E1 had seen the former content of the now empty plate. In the see (-) condition, E2 entered the room. In this case, E2 had not seen the former content of the now empty plate. After entering the test room, the experimenter sat down and waited for the infant to request additional objects. If the infant pointed to the empty plate, the experimenter left the room and brought another object of the kind that was previously on the empty plate. Then the test session ended. If the infant pointed the container, the experimenter ignored the point. If the infant pointed to the visible object, the experimenter handed over one of the objects and a second test trial began. The test session ended as soon as both plates were empty. The maximum number of test trials per participant and session was therefore two. For each test trial, if infants did not point spontaneously, the experimenter issued a reminder every 15 s in which she alternated lifting the plates while calling the infant's name. If the infant did not point for 60 s, the test session ended. During test trials, the experimenter openly looked at the participant and specifically avoided looking at the plates when waiting for a request. Parents were unaware of the details of the study. They were told that the objective of the study was to investigate infants' reactions to the interruption of a communicative interaction. Furthermore, they were instructed to remain passive and refrain from pointing or labeling the objects. Debriefing after the study showed that parents did not regard pointing to empty plates as the focus of the study.

Crossing of the two factors content and see resulted in a two by two design with four different constellations (see Fig. 1). In the see(+) – different constellation, the two plates contained different objects and E1 was present during the test phase. The empty plate therefore previously contained the infant's preferred kind of object and E1 knew about this. In the see(+) – same constellation, the two plates contained the same objects and E1 was present during the test phase. The empty plate therefore previously contained the same kind of object that was also visible on the other plate. Furthermore, E1 knew about this. In the see(-) – different constellation, the two plates contained different objects and E2 was present during the test phase. The empty plate therefore previously contained the infant's preferred kind of object. However, E2 did not know about this. In the see(-) – same constellation, the two plates contained the same objects and E2 was present during the test phase. The empty plate therefore previously contained the same kind of object that was also visible on the other plate. Furthermore, E2 did not know about this.

In order to have a complete within-subject design, each participant would have had to complete four test sessions. However, this would have resulted in a procedure that would have been too long for 12-month-old infants. Therefore, we resorted to a partial within-subject design and tested each infant in only two test sessions. In doing so, we varied both factors at the same time between test sessions for each infant. For example, infants who started with the see(+) – different constellation in the first session received the see(-) – same constellation in the second session. Infants starting with see(-) – different continued with see(+) – same and so on. This resulted in four different combinations of conditions. Infants were randomly assigned to one of these combinations with the same number of boys and girls in each combination.

2.4. Coding and analysis

We coded whether infants pointed or not and whether they pointed to the empty plate. We defined pointing in the following way: the participant extended at least one arm (either fully or partially), with either the index finger or the whole hand stretched out, and briefly stayed in this position. We did not code as pointing if the participant pointed to two different locations simultaneously or pointed while E

was away. The first author coded all sessions from video. A second coder, blind to the purpose of the study, coded 25% of all test sessions randomly selected for experiment 1 and 2 combined. There was a very high agreement of 98.6% between the two coders (κ = .97).

To analyse whether pointing to the empty plate was influenced by content and see we used generalized linear mixed models (GLMM) with a binomial error structure. We included content, see and their interaction as fixed within-subject factors and participant id as a random effect. Furthermore, we assessed whether age (in days) or sex had an effect. We used likelihood ratio tests (LRT) to obtain p-values by comparing the model fit of different models. Significant interactions were followed up with post-hoc general linear models (GLMs) within each see condition. All models were fitted in R (R Core Team, 2017) using the functions glmer and glm of the R-package lme4 (Bates, Mächler, Bolker, & Walker, 2015). The data and r-code associated with this article can be found in the supplementary material.

2.5. Results

All infants (100%) pointed during the warm-up phase and all but five infants (92.2%) pointed at least once during the test phase. In the test phase, we observed a total number of 181 points. The majority of points were directed at the visible alternative (160) and only a smaller proportion at the empty plate (21). This distribution was expected and corresponds to that of earlier studies using the same general setup (Bohn et al., 2015). The focus of this study was whether infants' pointing for absent entities would follow a systematic pattern. In what follows, we therefore only analyzed the points that were directed at empty plates. Fig. 2 shows how the points to empty plates were distributed across the four constellations.

A GLMM with content, see and their interaction as fixed effects fitted the data better compared to a model lacking them (LRT: $\chi^2(3) = 8.73$, $p = .033$). The inclusion of sex and age did not further improve the model fit and were therefore omitted for subsequent analysis (LRT: $\chi^2(2) = 4.22$, $p = .12$). In the final model, we found a significant interaction between content and see (LRT: $\chi^2(1) = 4.47$, $p = .034$; β = -3.36, 95% CI = [-9.16: -0.26]). The follow-up analysis within each see condition showed that infants pointed to the empty plate more often in the different than in the same condition in the see (+) condition (β = -2.33, $p = .007$; 95% CI = [-5.27: -0.57], d = -0.44) but not in the see(-) condition (β = 0.31, $p = .626$; 95% CI = [-0.92: 1.61], d = 0.11).

2.6. Discussion

In this experiment, infants were faced with the choice of either requesting a visible object or requesting an absent object by pointing to its previous location. In the factor content, we varied whether the two locations contained the same or a different object. Pointing to the empty location only when it previously contained an object that is different from the visible object indicated a specific request. In the factor see, we further varied whether the person from whom infants were requesting had seen the former content of the now empty plate. The significant interaction between content and see indicated that infants treated the content of the plates differently depending on what the experimenter knew about them. The follow-up analysis showed that infants pointed more often to the empty plate in the different compared to the same condition (i.e. they made specific requests) only for E1 but not for E2. This shows that infants requested specific absent entities only from an experimenter who saw them in the same location in an earlier episode.

Pointing to empty plates cannot be explained by low-level associative cues or simple heuristics. Infants had not been rewarded for pointing to the empty plate prior to the test trial and if pointing would have reflected simply repeating the same behavior as before, no difference between the conditions should have been found (see also Bohn et al., 2015, p. 70).

There are, however, two major objections to be raised: First, the interaction between content and see was driven by the low rate of pointing in the see(+) – same constellation instead of a high rate of pointing in the see(+) – different constellation (see Fig. 2). We expected that infants would treat the see(+) – same constellation similar to the two see(-) constellations and show a considerable higher rate of pointing only in the see(+) – different constellation. A potential explanation for this pattern is that infants' overall rate of pointing to the empty plate was lower in the two see(+) constellations compared to the see(-) constellations. Why? During the warm-up, E1 left the room twice and returned with new objects. Prior to the test phase E1 also left

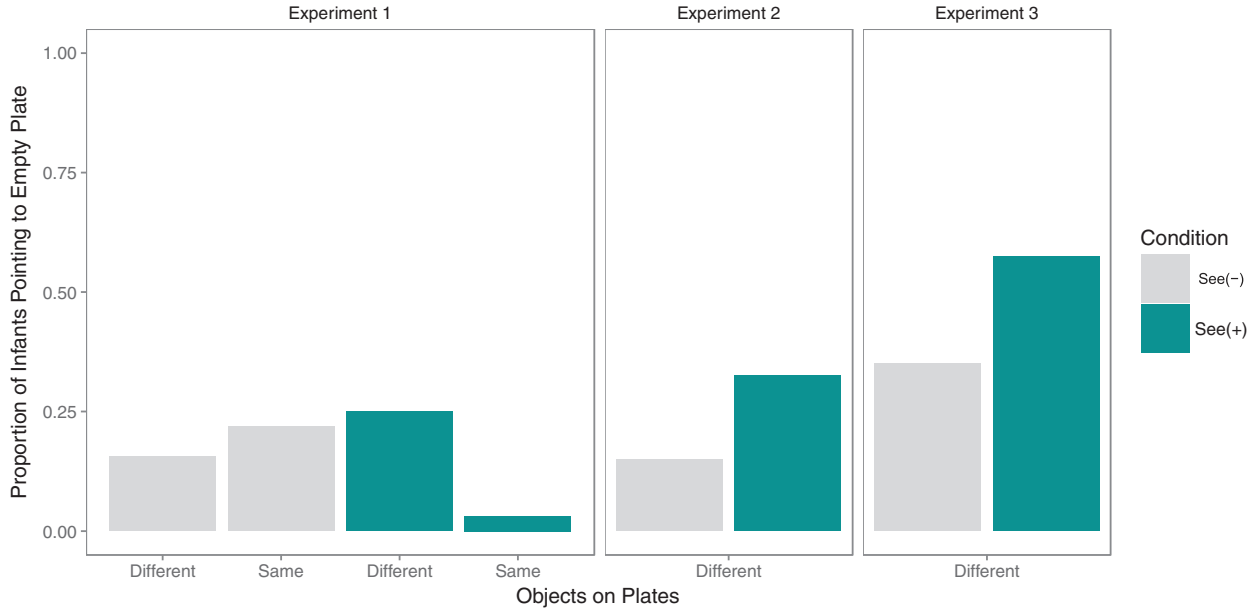

Fig. 2. Proportion of infants pointing to the empty plate in each experiment. During test trials, one plate was empty. Objects on plates refers to the previous content of the plates, which was either of the same or of a different quality. See (+/-) denotes whether the experimenter present in the test trial had previously seen the content of the empty plate.

the room, but this time she returned empty-handed. This might have lowered infants' expectation that additional objects are available and therefore lowered their requests of absent entities in general while still conserving the difference between the two content conditions. E2 on the other hand had never brought objects before and E2's empty-handed appearance bore no direct relation to the availability of additional objects. Second, it is unclear which aspect of the previous interaction affected pointing. E1 and E2 not only differed in what they saw in the previous interaction but also differed in what they demonstrated about their ability to provide additional objects. That is, it is unclear whether infants did not request specific objects from E2 because E2 never saw the former content of the plate or because E2 never brought additional objects. Common ground in communication as outlined in the introduction requires tracking of shared experience. For the purpose of the current study it would therefore be important to show that infants take into account what their interlocutor saw during the earlier episode, not just what she is able to do. To address these concerns, we conducted a second experiment.

3. Experiment 2

In the second experiment, we changed the setup so that the place where E1 retrieved additional objects was different from the place where E1 disappeared (and re-appeared from) in the test phase. We separated a small portion of the test room with a large cupboard (see Fig. 3). Furthermore, we changed the procedure, so that the experimenter from whom infants requested in the test phase had always provided them with additional objects before. This allowed us to vary the experimenter's knowledge independently from her ability. Infants initially played the game in a separate warm-up session with E1. During this warm-up session, E1 repeatedly left the room to get additional objects. In the following test session, infants initially played the same game either with E1 or E2. This time, as soon as one plate was empty, the experimenter – either E1 or E2 – did not refill the plate but disappeared behind the cupboard. Shortly afterwards, always E1 returned from behind the cupboard. If E1 was also the one who disappeared behind the cupboard, E1 had seen what was on the plate. If E2 was initially present, E1 had not seen the previous content of the plate. The central question was whether infants would point to the empty plate more often if E1 knew about its previous content.

To shorten and streamline the procedure for each participant we dropped the partial within-subject design and tested each infant only in a single test session with a single test trial. In experiment 1 as well as in a previous study (Bohn et al., 2015), only a single point to an empty plate occurred in the second test trial. Furthermore, because we expected E1's knowledge to affect infants' pointing only in the different condition, we dropped the same condition.

3.1. Participants

We tested a new group of 80 twelve-month-old infants (M = 382.5 days, SD = 7.2 days, 40 girls). Again, only infants who pointed were included in the study. For the second experiment, 13 additional infants were invited but had to be excluded because they lost interest or became uncomfortable (nine), their parents interfered (two) or the experimenter made a mistake (two).

3.2. Setup

The setup and the materials were identical to experiment 1 except for the following changes: A small portion of the test room to the left of the experimenter's chair was separated from the rest of the room by two large cupboards that completely occluded a person standing behind them from any other position within the room (Fig. 3). Furthermore, the two plates always contained different objects. The location of the balls (left or right) was counterbalanced across participants.

3.3. Procedure

For a schematic overview of the procedure see Fig. 3. Infants and their parents arrived in a playroom within the laboratory where they met the experimenters E1 and E2. Infants were randomly assigned to one of the two experimental conditions with the same number of boys and girls in each condition. The experiment was split into two sessions, warm-up and test. The two sessions were separated by a short time in the playroom. The general structure of the game was the same as in experiment 1.

3.3.1. Warm-up

The warm-up session was the same as the warm-up phase in experiment 1. However, as soon as the infant requested all objects from one plate for the second time, the experimenter put the cardboard boxes back on the plates and the session ended. E1 then led the infant together with the parent back to the playroom. Again, this warm-up session served three purposes: (a) to familiarize infants with the general structure of the game, (b) to show that more objects are available, and (c) that E1 is able to get them.

3.3.2. Test

There were two different test conditions. In the see(+) condition,

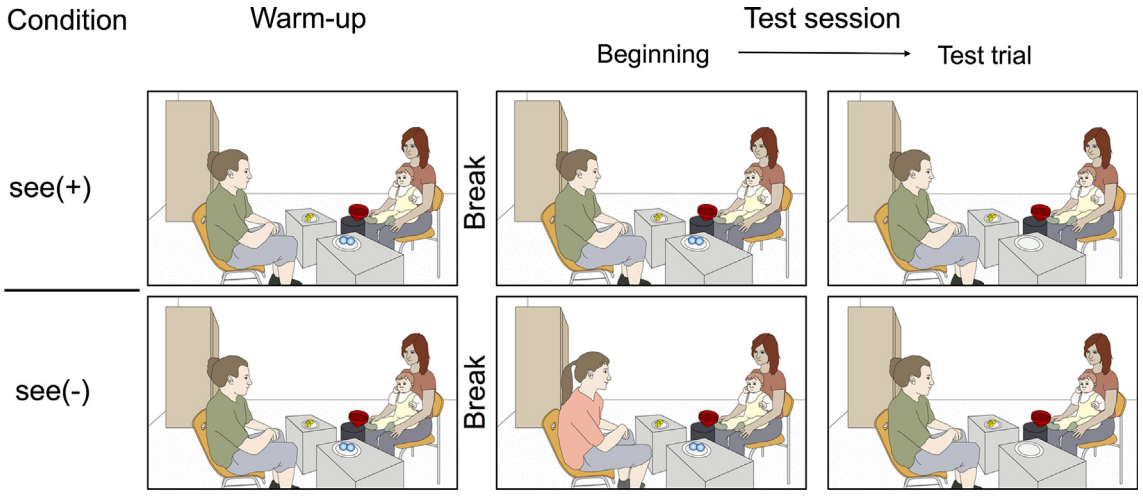

Fig. 3. Schematic overview of the setup and the procedure in experiment 2. Instead of leaving the room the experimenters dis- and reappeared from behind the cupboard depicted on the left of the experimenter. The factor see (+/−) varied depending on which experimenter was present in the beginning of the test session.

E1 led the infant and the parent back to the test room. Like in the warm-up session, one of the plates contained balls and the other contained blocks. E1 uncovered the plates and the infant was allowed to request his or her preferred objects. As soon as the infant emptied one of the plates, E1 stood up and disappeared behind the cupboards. After five seconds, E1 re-appeared from behind the cupboards and sat down on the experimenter's chair. This marked the beginning of the single test trial. In the test trial, E1 had seen the content of the now empty plate.

In the see(-) condition, E1 left the playroom earlier (during the play period between the warm-up and test session) and silently hid behind the cupboard in the test room. E2 led the infant and the parent back to the test room, sat down on the experimenter's chair and uncovered the plates. The plates were baited in the same way as in the see(+) condition. Infants could request their preferred objects. As soon as the infant emptied one of the plates, E2 stood up and disappeared behind the cupboards. After five seconds, E1 re-appeared from behind the cupboards and sat down on the experimenter's chair. In the test trial, E1 had therefore not seen the content of the now empty plate. During the test trial, the experimenter behaved in the same way as in experiment 1. Parents were again asked to remain passive and were not fully debriefed until after the study. Pointing to empty plates was not regarded as the focus of the study.

3.4. Coding and analysis

The general coding was the same as in experiment 1. For reliability see Section 2.4. To analyse whether infants pointed differently in the two experimental conditions we used generalized linear models (GLM). The response variable was binary (point to absent or not); therefore we used a binomial error structure to fit the data. The models included see as fixed between-subject effect. Furthermore, we assessed the effect of age and sex as fixed between-subject factors.

3.5. Results

All infants (100%) pointed during the warm-up sessions and the majority of infants (82.5%) also pointed during the single test trial. Nineteen infants pointed to the empty plate. Fig. 2 shows the proportion of infants pointing to the empty plate in each condition. We found that a GLM with see as predictor tended to fit the data better compared to the null model lacking this predictor (LRT: $\chi^2(1) = 3.45$, $p = .063$). Infants tended to point more often to the empty plate in the see(+) condition compared to the see(-) condition ($\beta = 1.00$, $p = .063$; 95% CI = [-0.05: 2.16]; $d = 0.41$). The additional predictors sex and age did not improve the fit to the data and were therefore omitted (LRT: $\chi^2(2) = 1.84$, $p = .399$).

3.6. Discussion

In experiment 2, we addressed several concerns that had been raised in the discussion of experiment 1. Like in experiment 1, we varied whether or not E had seen the former content of the empty plate. Importantly we did this while keeping E's ability to provide additional objects constant. We found that infants tended to point to the empty plate more often when E1 had previously seen its former content.

The design of experiment 2 rules out several additional alternative explanations. First of all, perceptual differences during test trials cannot explain the difference between the conditions. The test situation was identical in both conditions: infants were faced with two plates of which one contained a less preferred visible alternative while the other plate previously contained a preferred object. Furthermore, the experimenter from whom infants were requesting was identical. Second, forming an association between pointing to an empty plate in the presence of E1 and receiving an object was not possible because the single test trial was the first instance in which infants had the chance to point to an empty plate. Third, it is unlikely that infants pointed less often to the empty plate in the see(-) condition because they were distracted or surprised by the appearance of a different person from behind the cupboard. This is unlikely because the person appearing (E1) was already familiar to them from the warm-up period (for infants ability to recognize individuals see Haan, Johnson, Maurer, & Perrett, 2001; Turati, Bulf, & Simion, 2008). Fourth, infants did not simply associate "pointing in the presence of E1" with "more desirable objects". An association like this should not have led to differential outcomes between the conditions as infants requested desirable objects from E1 in the same way in the warm-up session.

Even though experiment 2 provides suggestive evidence that infants tracked their shared experiences with the experimenter, this interpretation is compromised by the fact that the effect was small and only a trend from a statistical perspective. Presumably, a stronger effect was masked by the overall low rate of pointing to the empty plate. To test the robustness of the effect found in experiment 2, we conducted a third experiment.

4. Experiment 3

The low rate of pointing to the empty plate in experiment 2 might have been due to the relatively attractive alternative option and the fact that participants only received a single trial. Liszkowski et al. (2009) used an unattractive alternative option and administered two trials, yielding a substantially higher rate of pointing to the empty plate. To increase the rate of pointing in experiment 3, we replaced the desirable alternative option with an undesirable one and also administered a second trial. In contrast to experiment 1, in which additional test trials happened within the same session, in experiment 3, the two test trials were administered in two separate sessions.

We also addressed another procedural shortcoming of experiment 2. During warm-up and the beginning of the test trial, infants received two more objects from E1 in the see(+) condition because E2 was present in the beginning of the test trials of the see(-) condition. Differential pointing might therefore have been due to a stronger association between E1 and the desirable object in the see(+) condition. To alleviate this concern, in experiment 3, E1 handed the child two additional objects during the warm-up in the see(-) condition.

4.1. Participants

We tested a novel group of 80 twelve-month-old infants (M = 381.0 days, SD = 8.0 days, 40 girls). Like in previous experiments, only infants who pointed were included in the study. For the third experiment, 15 additional infants were invited but had to be excluded because they lost interest or became uncomfortable (12), their parents interfered (2) or the experimenter made a mistake (1).

4.2. Setup

The setup was the same as in experiment 2 with a single change. Instead of small wooden blocks, we presented a small piece of cloth as alternative option (as in Liszkowski et al., 2009). For the warm-up in the playroom we used a second container that was similar to the one in the test room.

4.3. Procedure

The general procedure was the same as in experiment 2 with the following changes: Instead of having a warm-up in the test room, E1 introduced the child to the balls and the game in the playroom. E1 repeatedly left the room to collect additional balls to demonstrate that she knew where to get more. In the see(+) condition, she left the room twice, retrieving a total of four balls, whereas she left three times (six balls) in the see(-) condition.

The two test trials were separated by a short period in the playroom

during which E1 introduced novel balls (different in color) and repeated the warm-up procedure. Infants received two test trials of the same condition to which they were randomly assigned. The location of the balls (left or right) was counterbalanced across children and alternated from trial 1 to trial 2.

4.4. Coding and analysis

For each infant we coded, whether or not he or she pointed to the empty plate during one of the two test trials, yielding a binary code per participant analogous to experiment 2. Otherwise, coding and analysis were identical to Experiment 2. Reliability coding for experiment 3 yielded a very high agreement between coders of 94.9% ($\kappa = .87$).

4.5. Results

The majority of infants (85.0%) pointed during one of the test trials. Thirty-seven infants pointed to the empty plate. Fig. 2 shows the proportion of infants pointing to the empty plate per condition. The statistical analysis yielded very similar results as for experiment 2. Including see as a predictor improved the model fit (LRT: $\chi^2(1) = 4.11$, $p = .043$). Infants pointed more often to the empty plate in the see(+) compared to see(-) condition ($\beta = 0.92$, $p = .043$; 95% CI = [0.03: 1.84]; $d = 0.45$). Sex and age did not improve the model fit (LRT: $\chi^2(2) = 0.08$, $p = .960$).

4.6. Discussion

Reducing the quality of the alternative option and adding a second trial succeeded in generating more points to the empty plate (see Fig. 2), but it failed in augmenting the difference between the two conditions. The effect sizes found in the two experiments were very similar ($d = 0.41$ vs. 0.45) suggesting an overall small to medium effect. Nevertheless, experiment 3 replicates experiment 2, suggesting that the difference between conditions is reliable. Furthermore, in this experiment, children received the same number of balls from E1 in the two conditions. This rules out that receiving two additional balls from E1 in the see(+) condition in experiment 2 led infants to point more often to the empty plate in that condition. In contrast to the previous two experiments, the alternative option was undesirable to children. As outlined in the introduction, we assumed that this would cancel the difference between the two conditions. As it turns out, this assumption was not warranted.

5. General discussion

The three experiments reported here explored the social-cognitive basis of infants' communication about absent entities. In experiment 1, we replicated an earlier finding showing that 12-month-old infants request specific absent entities (Bohn et al., 2015). We extended previous findings by demonstrating that infants only do so if they experienced these objects together with the person they were requesting from. In experiment 2 and 3 we provided further evidence that infants base their requests for absent entities on what the experimenter had seen during an earlier episode. Taken together, these findings suggest that infants use pointing to communicate about absent entities by making reference to an aspect of an earlier episode they experienced with their interlocutor. Earlier studies (Bohn et al., 2015; Liszkowski et al., 2009) assumed that this was case but did not demonstrate it empirically.

The observed effect size appears to be reliable but small. On the one hand, this could mean that an appreciation of when to expect others to act based on what one takes to be common ground is just emerging with some infants still assuming an "omniscient adult". After all, the manipulation in experiment 2 and 3 was fairly subtle in that children were familiar with E1 and had also previously played a similar game with her. The only thing that was missing in the see(-) condition was the brief shared episode preceding the test trial. Infants might differentiate between the conditions more thoroughly if the returning person was completely unfamiliar. However, this manipulation could have resulted in unwanted consequences (infants might be frightened if suddenly a completely unfamiliar person appears) and, as discussed after experiment 1, it would make the interpretation that children track shared episodes difficult. This is why we avoided it here. On the other hand, the small effect size could be due to some aspects of our procedure. Trying to tease these two interpretations apart could be a valuable avenue for future research. Whether direct social interaction is a necessary prerequisite for infants to assume that the experimenter is familiar with the previous content of the plate is unclear based on our study alone. However, research by Moll and Tomasello (2007) suggests infants do not assume that an adult is familiar with an object if she was merely looking at it from a distance while the infant is engaged with it.

Subsequent studies could also investigate the importance of timing and location. Ganea and Saylor (2007) showed that 15-month-olds used shared linguistic experience to interpret an ambiguous request only when the request was uttered immediately following the shared episode. Eighteen-month-olds were successful also after a 2.5 min delay. Saylor and Ganea (2007) reported that 17-month-olds interpreted a request for an absent object in line with a shared experience only if the requested object remained in the same location. These studies suggest that infants' ability to produce and understand communicative signals in line with the common ground they share with their interlocutor might be mediated by more domain general cognitive processes. Nevertheless, given the right kind of scaffolding, our study suggests that infants as young as 12 month already consider common ground when actively communicating.

Based on the results, we can speculate about what at least some infants ascribed to E1 based on their interaction. Experiment 1 showed that infants intended to request another preferred object (e.g. a ball) when they pointed to the empty plate. An alternative, relational interpretation could be that infants did not intended to obtain a specific object but an object that was better than the alternative. While this is certainly plausible, studies on object individuation in infancy suggest that from 12 months onward, infants represent absent objects in a fairly concrete, instead of relational, way (Van de Walle, Carey, & Prevor, 2000; Xu & Carey, 1996). Experiment 2 and 3 further showed that infants were more likely to point to the empty plate in a situation in which the experimenter previously saw objects of the kind they intended to obtain in the location they pointed to. In contrast to earlier studies (Liebal et al., 2010; Liszkowski, Carpenter, & Tomasello, 2008), the pointed to object at test (the plate) was different from the object pointed to during the warm-up (the ball). Pointing therefore reflects an act of reference not to an object in its current state but to its state in a previously shared episode. What infants attributed to E1 based on her experience could therefore be construed as entertaining a certain psychological relation (e.g. knowing) about a specific aspect of an earlier episode.

Finally, in conjunction with recent comparative work (Bohn, Call, & Tomasello, 2016; Bohn et al., 2015), the present research shows that language or other conventional communication systems are not a prerequisite for communication about absent entities. As such, it challenges theoretical accounts positing that displacement crucially depends on language. These theories assume that only a symbolic device such as a word can bridge the gap between the current perceptual experience and an absent entity or episode (Bickerton, 2009; Cuccio & Carapezza, 2015; Deacon, 1998). Our study suggests, that infants, who are not yet using language for this type of communication (Veneziano & Sinclair, 1995), recruit some form of common ground to make reference to absent entities using non-symbolic gestures.

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Appendix A. Supplementary material

Supplementary data and analysis scripts associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2018.03.024.

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