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Pointing as Epistemic Request: 12-month-olds Point to Receive New Information

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Abstract

Infants start pointing systematically to objects or events around their first birthday. It has been proposed that infants point to an event in order to share their appreciation of it with others. In the current study, we tested another hypothesis, according to which infants' pointing could also serve as an epistemic request directed to the adult. Thus, infants' motivation for pointing could include the expectation that adults would provide new information about the referent. In two experiments, an adult reacted to 12-month-olds' pointing gestures by exhibiting 'informing' or 'sharing' behavior. In response, infants pointed more frequently across trials in the informing than in the sharing condition. This suggests that the feedback that contained new information matched infants' expectations more than mere attention sharing. Such a result is consistent with the idea that not just the comprehension but also the production of early communicative signals is tuned to assist infants' learning from others.

Pointing as a referential communicative act seems to be unique to human behavior (Tomasello, 2009). The questions of when and why young children start using pointing for communication are important not only for understanding infants' preparedness to successfully initiate communicative interactions, but they also offer a route to study infants' early abilities in grasping social agents' intentional and referential states.

Human infants start to point to objects and events for adults shortly before their first birthday (Carpenter et al., 1998). Traditionally, these gestures are classified as (proto-)imperative or (proto-)declarative in nature (Bates et al., 1975), depending on the communicative content they attempt to convey (e.g., "Give that to me" vs. "I like that"). Liszkowski and colleagues provided ample evidence that the primary function of early pointing is not imperative but declarative, and infants are guided by two kinds of social motives in pointing to objects or events (Liszkowski et al., 2004; Liszkowski et al., 2006; Liszkowski et al., 2007a, 2007b; Tomasello et al., 2007). Infants may point (1) to provide information for adults who appear to be ignorant of some relevant episodic fact ('helping'), or (2) to share their interest and excitement about an object or an event ('sharing'), for instance to share an experience with the parent, as it was also suggested by Baldwin & Moses (1996).

In the present study, we address the question whether a further motive, requesting information about the referent, could also explain infants' pointing to objects and events, as has been proposed on theoretical grounds earlier (Csibra & Gergely, 2006; Southgate et al., 2007). Whether or not infants sometimes point purely to express their interest for an adult, plenty of evidence suggests that they are also motivated to learn from adult informants, both by mere observation and by referential communication (e.g., Gergely et al 2002; Király et al., 2013; Vaish et al., 2011). However, young infants might not only be good 'consumers' of information, as it was argued in earlier proposals (Baldwin & Moses, 1996), but they might also be active seekers of information (Vaish et al., 2011), and pointing could serve such a function. If infants can themselves assign referents by pointing (Liszkowski et al., 2007a), this gesture could also serve as a question to initiate referential communication from an adult, which may provide an opportunity to infants to learn from the response. Such a (proto-)interrogative use of pointing (e.g., "What is that?") may also express infants' interest in the referent, but the underlying motive of this expression would be epistemic gain rather than mental state sharing. In a recent analysis on infants' capacity to understand nonverbal and verbal information exchange Harris & Lane (2013) has also distinguished interrogative pointing from imperative and declarative pointing.

In an earlier study, Liszkowski et al. (2004) tested whether pointing at 12 months of age is guided by a strong motivation to share intentional states (attention and interest) with an adult. They compared a sharing ('joint attention') situation, in which the adult responded to infant pointing with sharing attention and interest in the referent (alternating gaze between the child and the event while positively emoting), with other situations in which the adult ignored the pointing gesture, did not look at the referent, or did not look at the child. They found that infants were subsequently more likely to point to new events when the addressee had responded with attention sharing than in the other situations. However, in the sharing condition the adult not only shared infants' attention to the referent, but also provided information about the target object, saying "Oh wow What's that? Are you showing Grover to me? Yes he is blue" (p. 299). Further studies from the same group employed other kinds of information, for example valence ("Oh, That's nice") in the response to infants' pointing gestures (Liszkowski et al., 2007a). However, such responses seem to go beyond what is required for establishing joint attention with an infant, as they involve an additional commentary with a specific content predicated about the referent. Liszkowski et al. (2007a) argue that the commentary also serves the function of sharing, not just sharing attention to the referent, but also sharing the infant's subjective attitude (likely a positive one) towards the referent. Given, however, that the infants' referential pointing is often produced without any clear expression (verbal, emotive, or gestural) specifying the *content* of their specific attitude towards the referent, the proposal that the content expressed by the adult matches the infant's (often non-expressed) intentional attitude remains inferential. In fact, this leaves open the alternative possibility that the adult's commentary functions to convey some *informative* content about the referent that is *new* to the infant, and does not mirror or match the infant's intentional attitude towards the referent. Whether or not this alternative is embraced, it at least makes uncertain whether infants' pointing was facilitated because the adult had shared attention (and maybe referential attitude) with them, or because the adult provided new information about the target (its name or its valence).

We developed modified versions of the Liszkowski et al. (2004) paradigm in order to investigate whether infants' pointing is driven by the expectation to learn new information. In two experiments, we measured infants' satisfaction with adults' response to their pointing in a 'Sharing' and an 'Informing' condition. In both conditions, the adult established joint attention to an object with the infant (which may be a necessary condition for successful communication), but only in the Informing condition was this accompanied by novel referential information. If infants' only goal of pointing were attention (and attitude) sharing with the adult, we should see no increase of pointing when new information is provided in response. However, if pointing serves epistemic purposes as well, then infants should be more satisfied with the adult's response in the Informing condition.

Experiment 1

In Experiment 1 we provided different types of responses to two groups of infants after they had pointed to an object. In the Sharing condition, the experimenter shared attention and interest in the event with the infant, while in the Informing condition the adult also provided positive or negative valence information about the target. We compared how often infants pointed across the trials in the two conditions. According to the account that infants point to share their interest and positive attitude (Liszkowski et al., 2004; Tomasello et al., 2007), they should point the same amount in the two conditions, because joint attention is established in both. Moreover, they might even point less often in the Informing condition, in which they also receive responses involving negative emotional expressions elicited by the expression of their own positive attitude. In contrast, if infants' pointing is rooted in a motivation to request information about the referent from an adult, they should point more in the Informing condition than in the Sharing condition, because the feedback they receive would meet better their expectation.

Method

Participants—Thirty-two healthy full-term monolingual 12-month-olds (range 12 months 5 days to 12 months 29 days, 15 females), randomly assigned to one of two conditions, completed the study. Four additional infants did not finish the experiment due to fussiness, 3 infants were excluded due to parental interference, and further 8 infants did not point at all during any of the trials, and thus were excluded from the analyses (the number of excluded infants was similar in the two conditions).

Apparatus and materials—Infants were tested using a procedure similar to Liszkowski et al. (2004). They were seated on the caretaker's lap at a table facing Experimenter 1. A toy with multiple parts that could be manipulated in several ways was on the table throughout the study. Behind Experimenter 1, a grey curtain hung, which had an opening where puppets emerged during the study. Experimenter 2 was hidden behind the curtain and operated the puppets (Figure 1). We used 8 different puppets (a teddy bear, a crow, a cat, a dog, a cow, a fox, a lion and a rooster) of approximately the same size. The behavior of infants and experimenters were recorded by two video cameras and were coded offline. Caretakers were instructed to hold their infants and avoid interacting with them during the study.

Procedure—Infants were randomly assigned to one of the two experimental conditions (Sharing or Informing), and were exposed to 8 trials. Before each trial, the experimenter played with the child for 30-40 seconds using the toy on the table. Then Experimenter 1 signaled to Experimenter 2 to display the puppet from behind the curtain by embedding the word “now” in various sentences across trials. At the same time, the toy on the table was retracted, and Experimenter 1 leaned back, refraining from interaction with the infant in order to avoid distraction. The puppet was displayed in the visual field of the child right behind the experimenter and bounced rhythmically for 25 s, during which period the child could point to it. We made sure that infants noticed the toy in all trials. Infants who failed to notice the toy due to looking to the mother or fussing out, were considered fussy and excluded from the analysis. Thus, all participants who were included in the analysis contributed data in all the 8 trials.

Experimenter 1 ignored the puppet until the infant pointed to it. If the child pointed¹, Experimenter 1 reacted for 5 s in a 'sharing' or 'informing' manner depending on the condition. In the Sharing condition, Experimenter 1 smiled, nodded and said ‘Ühüm’ in Hungarian (corresponding to ‘Yeah’ or ‘Uh-huh’), acknowledging that she had noticed the puppet by looking back and forth between the child and the puppet and simultaneously expressing (sharing) a positive interest. In the Informing condition, Experimenter 1 looked back and forth between the child and the puppet, while simultaneously expressing one of four referential attitudes towards it as if she was transmitting valence information about the object. The attitudes were conveyed by facial expressions and by an appropriate interjection. The attitudes were (1) surprise, expressed by ‘H ha’ (‘Wow’), (2) delight, expressed by ‘Áááá’ (‘Aah’), (3) disgust, expressed by ‘Pfuj’ (‘Yuck’), and (4) fright, expressed by ‘Juj’ (‘Yikes’). Each of the 4 attitudes was presented in 2 of the 8 trials in pseudorandom order (different for each infant).

In both conditions, if the child pointed again while the puppet was displayed², or if 5s elapsed from Experimenter 1’s reaction, Experimenter 1 repeated the same response for another 5 s. Then the puppet disappeared, the trial ended and Experimenter 1 engaged the child in playing with the toy on the table.

Results

First, we calculated the proportion of trials in which infants had pointed at least once towards the puppet. Pointing proportion was higher in the Informing condition ($M = .83$, $SD = .23$) than in the Sharing condition ($M = .64$, $SD = .24$; Mann-Whitney test ($z = 2.5$, $p = .01$). We also analyzed how infants’ inclination to point developed across trials (Figure 2A) by averaging pairs of consecutive trials in four mini-blocks (Block 1 = trials 1-2; Block 2 = trials 3-4; Block 3 = trials 5-6; Block 4 = trials 7-8). A multinomial logistic regression with the factors Condition (Sharing vs. Informing) and Block (1 to 4) yielded a main effect of Condition ($Chi Square = 15.5$, $p = .01$) and a Condition X Block interaction ($Chi Square =$

¹We defined pointing following the criteria of Liszkowski et al. (2004), that is, the infant extending the arm and index finger or open hand, palm down, in the direction of the stimulus.

²In case the infants pointed while the puppet was not displayed, Experimenter 1 did not follow their point and briefly commented on the behavior (e.g., ‘Aha, that was a nice point’, following Liszkowski et al., 2004), and drew the child’s attention back to the toy on the table.

17.45, $p = .04$). Infants in the two conditions pointed similarly often during the first two trials (Mann-Whitney $z = 0.19$, $p = .84$), while more infants pointed on the last two trials of the Informing condition compared to the Sharing condition (Mann-Whitney $z = 2.86$, $p = .004$). This suggests that infants in the two groups were equally likely to point initially, and that the feedback they received had a differential effect on their subsequent pointing behavior in the two conditions.

To investigate whether the valence of the experimenter's response had an effect on infants' pointing, we calculated the proportion of trials with pointing for trials *following* a positive (delight, surprise) or negative (disgust, fright) response. Trials that were not preceded by feedback in the previous trial, i.e., (1) the first trial of each participant and (2) those that followed trials in which infants did not point, were excluded from this analysis. Thus, excluding the first trials, the total number of trials that could follow a feedback (negative or positive) was maximum 7 per infant. The exclusion of trials that followed a no point (and thus no feedback) resulted in a mean average number of coded trials of 2.93 following a positive trial, and a mean average number of coded trials of 2.75 following a negative trial (Wilcoxon $z = .53$ $p = .59$). Note that when a child pointed after a positive or negative feedback on the following trial, the child could not yet know whether this pointing would elicit positive or negative feedback on that specific trial, as pointing preceded feedback. We found that infants produced more pointing gestures after negative trials ($M = .95$, $SD = .14$) than after positive ones ($M = .81$, $SD = .26$), though this difference did not reach statistical significance (Mann-Whitney $z = 1.62$, $p = .10$). This result suggests that both negative and positive referential attitudes provided valuable feedback for the infants, and opens the possibility that negative attitudes could be evaluated by infants as constituting a potentially more valuable or informative feedback. This would be in line with the predictions of the interrogative account of infant pointing, but not with the predictions of the sharing account.

Experiment 2

In Experiment 2, we intended to establish the contrast between 'sharing' and 'informing' responses to infant pointing in a different way. One reason for this was to control for some aspects of the manipulation we used in Experiment 1, which were not relevant for the question of interest. In particular, the experimenter's feedback to the infant in the Informing condition was richer and more variable across trials than it was in the Sharing condition (the same way as the 'Joint attention' condition provided more variable feedback than the other conditions in the study by Liszkowski et al., 2004). In addition, we wanted to test another difference between declarative and interrogative accounts of infant pointing: Sharing experience and mental states between communicative partners is more likely to be established on the basis of common semantic knowledge, while informing implies asymmetric distribution of knowledge. We established this contrast by presenting infants with objects that were atypical members of a known kind (e.g., a cat in boots, or a race car), and in response to their pointing we labeled the object with a familiar word ('a kitty') in the Sharing condition, or a novel one ('a dax') in the Informing condition. This procedure equated the variability of feedback across trials in the two conditions, and allowed us to test whether infants preferred the adult's response that came from shared semantic knowledge or

the one that provided new information about the referent. If pointing serves an epistemic request, infants should be more satisfied with the latter type of response.

Method

Participants—Thirty-two healthy full-term monolingual 12-month-olds (age range from 12 months 5 days to 12 months 29 days, 14 females), randomly assigned to one of two conditions, completed the study. An additional 5 infants did not complete the experiment due to fussiness, 2 infants were excluded due to experimental error, and further 9 did not point at all during any of the trials and thus were excluded (the number of excluded infants was similar in the two conditions).

Apparatus and materials—Infants were tested with the same apparatus as in Experiment 1. We used 8 different toys for both conditions: a teddy bear with a hat, a ball with spines, a cat in boots, a racing car, a doll puppet with a hat, a bunch of plastic keys, a dog puppet, and a green telephone.

Procedure—The procedure was identical to Experiment 1 with the following exceptions. In the Sharing condition, the experimenter looked at the target object (e.g., a cat) while labeling it with a word familiar to infants of this age ('kitty'). In the Informing condition, the experimenter looked at the target object while labeling it with a pseudo-word ('dax'). The familiar words were taken from the database gathered from parents of 12-month-old Hungarian infants, reporting which words their infant understood. While parental reports do not seem to be fully reliable at this age, as recent studies found that infants' performance does not correlate with parental reports on vocabulary (Bergelson & Swingley, 2012, 2013), we made sure to select words that were most frequent in this database. The words were: maci (teddy), labda (ball), cica (kitty), autó (car), baba (doll), kulcs (key), kutya (dog), and telefon (phone). Recent EEG studies showed that younger, 9-month-old Hungarian infants can match these very same words to their referents (Parise & Csibra, 2012). The pseudo-words were composed from the same phonemes as the familiar words and were: tacok, malaba, bukuci, lad, cefó, nala, bitey, and csuta. We ensured that the stimuli had similar syllable structures between conditions and that the non-words were phonotactically legal in Hungarian. Each puppet was named twice during a trial in both conditions: ("Wow a kitty This is a kitty" or "Wow a dax This is a dax"). The labels in the two conditions contained similar phonemes and were embedded in the same carrier sentences, while the tone and valence of the utterance was kept constant.

Results

As in Experiment 1, we compared the proportion of trials in which infants pointed at least once during Experiment 2 between the two conditions. We found that infants more likely pointed in the Informing condition ($M = .86$, $SD = .14$) than in the Sharing condition ($M = .67$, $SD = .23$; Mann-Whitney test ($z = 2.49$, $p = .01$)). We analyzed how infants' pointing behavior developed across the trials the same way as we did in Experiment 1 (Figure 2B). A multinomial logistic regression with the factors Condition (Sharing vs. Informing) and Block (1 to 4) yielded a main effect of Condition ($Chi Square = 13.8$, $p = .003$) and no other effects. Furthermore, infants pointed similarly often on the first two trials of the two

conditions (Mann-Whitney $z = .58, p = .56$), while they pointed more on the last two trials of the Informing condition compared to the Sharing condition (Mann-Whitney $z = 2.3, p = .02$). This suggests that infants in the two groups were equally likely to point initially, and that the feedback they received had an effect on their pointing behavior.

Additionally, we analyzed infants' behavior on the trials where no pointing was produced. We coded the behavior of the infants on these trials with respect to the referential looks to the experimenter from the target object, and with respect to vocalizations. In the trials where no pointing occurred infants provided 1.26 referential looks (looking from the target toy to the experimenter) towards the experimenter on average in the Sharing condition, and 1.49 in the Informing condition (Mann-Whitney $z = .99, p = .32$). Regarding the vocalizations produced towards the target or the experimenter in the period while the target was displayed but no pointing occurred, infants had 1.4 vocalizations on average in the Sharing condition and 1.1 in the Informing condition (Mann-Whitney $z = .67, p = .50$).

Discussion

Results from two experiments suggest that a feedback that provided new information (a referential attitude or a new label) about an object led to more frequent subsequent pointing behavior than a feedback whereby the experimenter simply shared attention and interest with the infant. While in Experiment 1 in the experimenter provided a more variable feedback in the Informing condition than in the Sharing condition, in Experiment 2, the feedback had the same variability in both conditions. This was achieved by using a different label on each trial. The finding that infants pointed more in the Informing condition does not seem to be in line with the predictions of the account according to which infants point to novel objects or events solely to share attention and interest with an adult (Liszkowski et al., 2004; Tomasello et al., 2007). However, the results fit very well with the epistemic request hypothesis, according to which infants expect to learn something from the response they receive to their pointing gesture (Southgate et al., 2007).

This interpretation of our results is compatible with other recent findings. Infants in the second year of life point more for adults than for peers (Franco, Perucchini, & March, 2009), and 16-month-old infants are more likely to point for adults who have been seen competent in labeling objects than for ignorant ones (Begus & Southgate, 2012). In the study of Begus and Southgate (2012), the mislabeling adult used words that infants knew to refer to a different kind of object (calling the cat 'a ball'), and this gave infants evidence about the unreliability of her responses. In contrast, in Experiment 2 of the present study familiar labels were contrasted with novel labels. This allowed infants to interpret the label as a novel word for an object, which might have equally been an atypical member of a familiar kind or an exemplar of a novel kind, thus both containing new information. While either interpretation would support the interrogative role of pointing, earlier studies on the phenomenon of mutual exclusivity in word learning suggest that infants could have preferred the latter option. Indeed, it is regularly found that infants generally avoid accepting alternative labels for kinds they already have a label for (Markman et al., 2003).

It is also noteworthy that, in agreement with the informing account, it is primarily novel objects and unexpected events, rather than familiar scenes, that elicit pointing, although at a later age infants can also selectively point to pictures they have previously shared with an adult (Liebal et al., 2009). One could raise the question whether infants' pointing in our study was triggered by novel events. However, while novelty is indeed a necessary criterion for acquiring new information, the events (appearance of puppets) that triggered the pointing in our study were the same in the Sharing and the Informing conditions. Thus, given that the new information could come only *after* the infant pointed, a more appropriate description of our finding would be that infants pointed in order to trigger novel responses, rather than novelty triggering infants' pointing.

It has been shown that adults tend to respond to infant pointing by verbal communication, whether or not the infant has been vocalizing during the gesture, suggesting that the natural interpretation of infant pointing is interrogative (Kishimoto et al., 2007). We have also found that a negative referential attitude presented by the adult was not in conflict with infants' expectation, and did not disrupt or inhibit their subsequent pointing. This result is also incompatible with the idea that what infants intend to achieve with the pointing gesture is that the adult's mental and emotional state be adjusted to their own attitude (e.g., "the adult not just attend to a referent but also align with their attitude about it" Tomasello et al., 2007, p. 713). Earlier findings indicated that infants pointed more when the adult expressed a positive attitude ("Oh, that's nice You are showing something neat to me.") compared to a more negative attitude ("Hmm? Well, that's not really exciting", Liszkowski et al., 2007a). However, such pattern could have been due to the fact that while in the positive attitude case the experimenter expressed valence information about the object, the negative case could have been perceived by the infant as expressing disinterest or refusal to communicate about the referent, rather than a negative attitude about the referent. In contrast, the present study involved equivalent amount of positive and negative referencing and our account predicted that expressing a negative referential attitude or negative valence towards a target can be as important, or even more important from an evolutionary point of view, as expressing positive valence.

While our results are better explained by the 'epistemic request' account than the 'sharing' account of infants' pointing, we do not propose that purely declarative motives never drive infants' gesturing. Just like imitation, which may serve both cognitive (epistemic) and social (collaborative) functions (Užgiris, 1981; Over & Carpenter, 2013), productive communication in infancy may also be rooted in both epistemic and affiliative motives. Nevertheless, the relation between an infant and an adult is inherently asymmetric, and so infants should try aligning their mental states (including their knowledge) to others rather than attempting to do the reverse. If infants use the pointing gesture as an epistemic request, they can take an active part in the process of information gathering by designating the referent about which they wish to learn.

How much of this behavior is originating from infants' intrinsic motivation to learn or from the social situation that may itself indicate the possibility of learning, is difficult to answer. It is possible that it was the experimenter's ostensive-communicative behavior that made infants think that it was a 'pedagogical' situation where they could acquire new knowledge

(Csibra & Gergely, 2009; Gergely & Csibra, 2006). However, the Sharing and Informing conditions did not differ in the amount of ostensive or deictic-referential signals that infants received, so they could not explain the contrast between conditions. Also, if infants' motivation to point is triggered only by the answer they received, they would point less initially and would increase this response only after they have received feedback. However, our results (Figure 2) did not confirm this prediction, especially in Experiment 1. Perhaps the most cautious explanation to our findings is that infant's motivation to point to novel events is explained by the interaction between the social context of a responsive adult and their drive to acquire knowledge.

One could also raise the possibility that infants might be motivated to point in ways that are consistent with, and conducive to learning, however without being motivated to learn. Since motivation cannot be measured directly, it can only be inferred from what function the behavior in question could serve. While one can imagine a framework where pointing behavior emerges for an unrelated reason and serves learning as a by-product, until such a reason is specified we are inclined to favor the alternative hypothesis derived from the theory that infants' communicative pointing may have an interrogative motive.

What kind of information may infants expect to receive when they point? Our study identified novelty as an important factor characterizing infants' expectation, and excluded positive valence as preferred content in the adult's response. While the current results do not allow us to specify infants' expectations further, in agreement with the theory of natural pedagogy (Csibra & Gergely, 2009), we speculate that the motivation of learning drives not just the interpretation of *infant-directed* communication but *infant-initiated* communication as well. In particular, infants may expect to acquire generalizable information about the referent, such as its kind (identified by its label), its function (if it is an artifact), or its kind-generalizable properties (such as its valence). Whether infants do indeed generalize the information elicited from others by pointing remains a question for further research.

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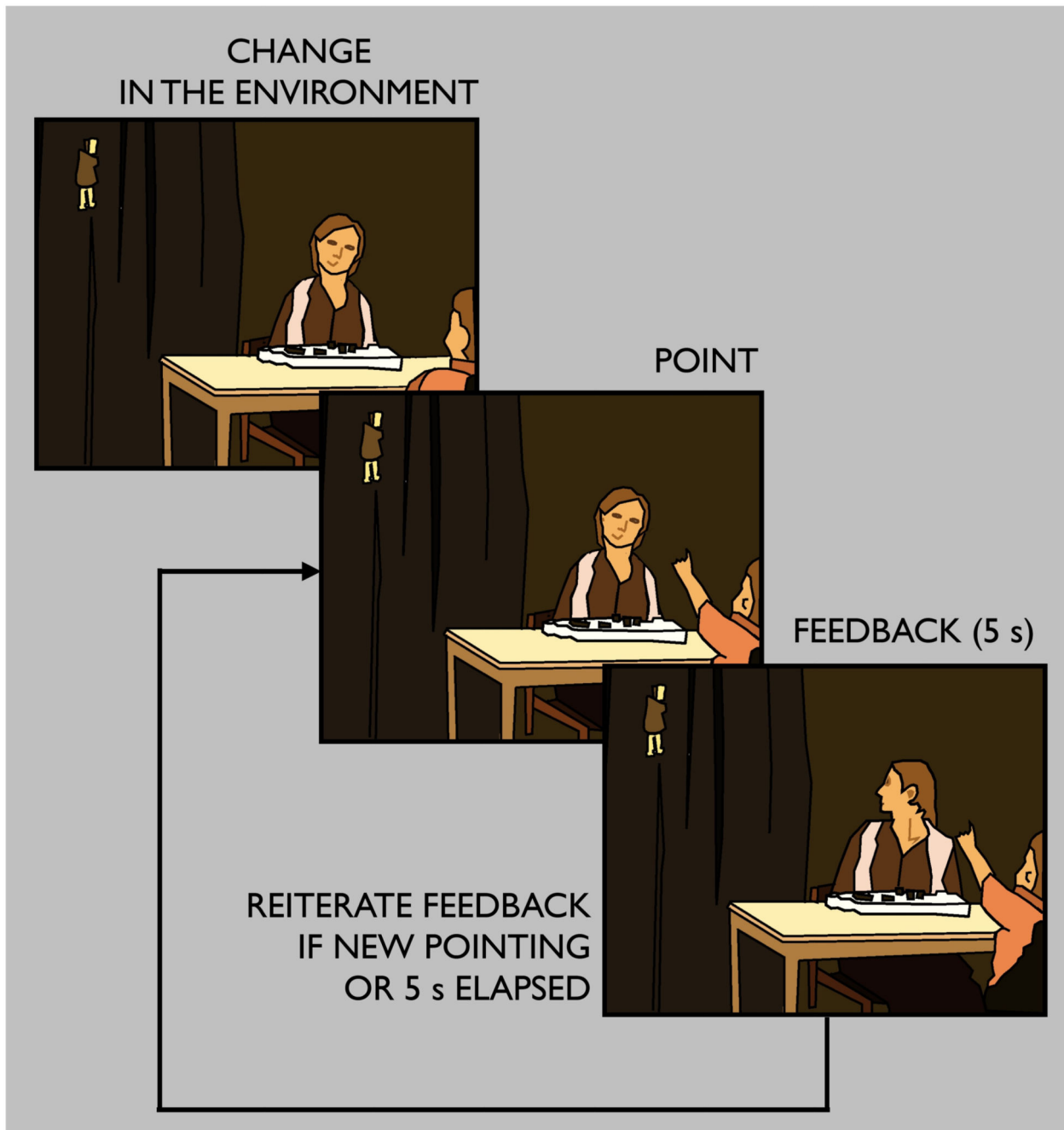


Figure 1.
Schematic illustration of the setting in Experiment 1 and 2

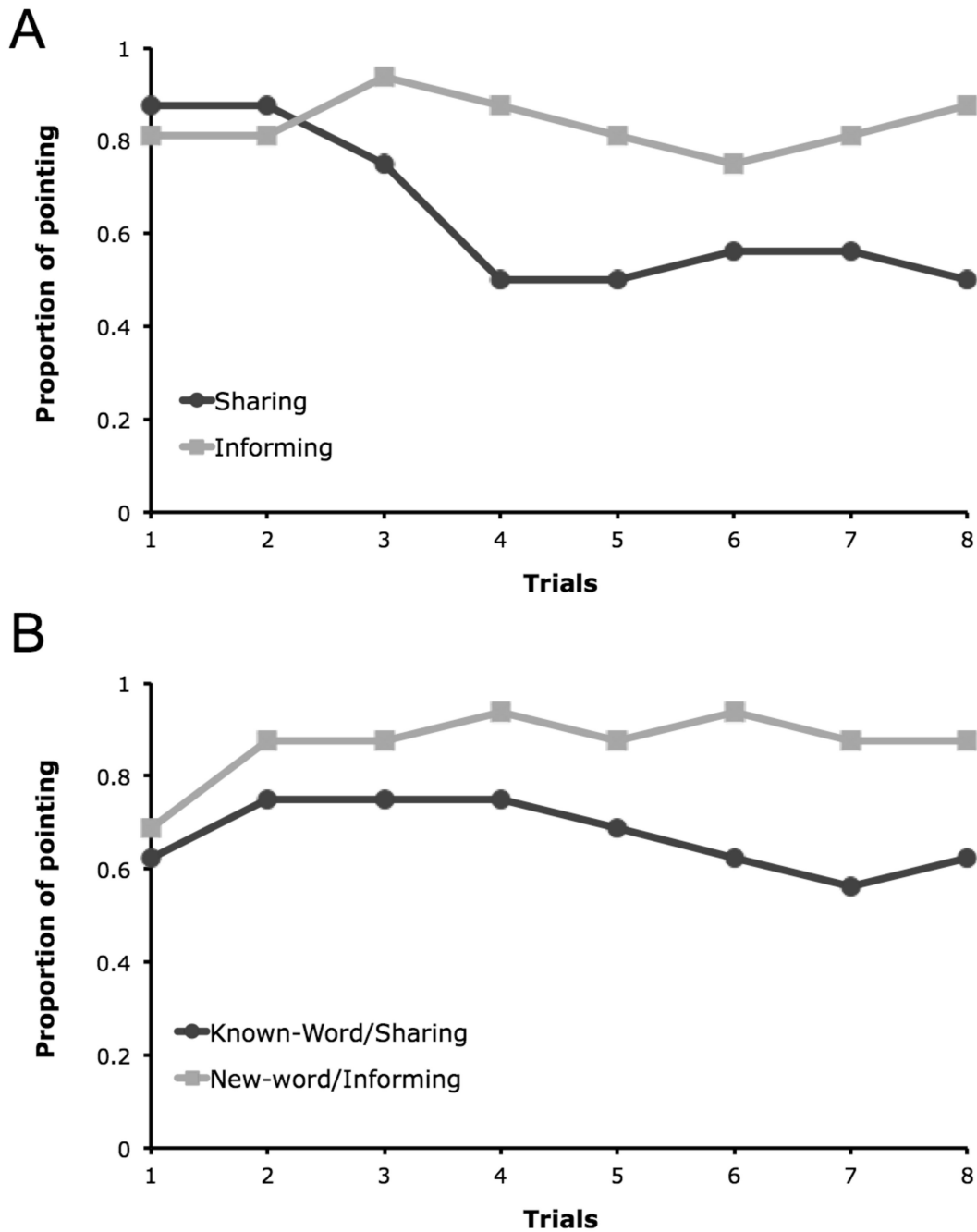


Figure 2.
Proportion of infants pointing in each trial as a function of condition in Experiment 1 (A)
and Experiment 2 (B)