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Contingent Labeling after Infants' Pointing Helps Infants Learn Words

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Abstract

Previous studies provide suggestive evidence that infants' pointing gesture is associated with language development, but cannot verify a causal role of pointing in word learning. The present study thus experimentally manipulated infants' production of pointing, and responses to pointing, to investigate the role of pointing in infants' performance of forming novel word-object associations. Sixteen-month-olds were introduced to pairs of novel objects, and then heard the labels after they had pointed to an object, or when they were just looking at it, or at a predetermined time schedule. Results showed that children learned the labels the best when the labels were provided contingently after their pointing gesture. These results suggest that offering information in response to infants' pointing gestures may lead to better word learning.

Keywords: pointing gesture; word learning; infants

Introduction

The pointing gesture usually emerges in human infants at about 12 months of age (e.g., Carpenter, Nagell, & Tomasello, 1998; Leung & Rheingold, 1981). Observation studies found correlations between infants' pointing skill and subsequent vocabulary growth (Blake, Vitale, Osborne, & Olshansky, 2005; Brooks & Meltzoff, 2008; Butterworth & Morissette, 1996; Desrochers, Morissette, & Ricard, 1995; Rowe & Goldin-Meadow, 2009a, b; Rowe, Özçalışkan, & Goldin-Meadow, 2008), but it is unclear whether pointing influences children's language learning in real time contexts. The present study thus aimed to study the on-line effect of pointing on word learning.

By 20 months of age, children communicate mainly through gestures (Iverson, Capirci, & Caselli, 1994). Gestures also play an important role during the transition from prelinguistic communication to linguistic communication (Gullberg, de Bot, & Volterra, 2008). Infants' frequency of gestures at 14 months related to their vocabulary size measured by the Peabody Picture Vocabulary Test at 42 months (Rowe et al., 2008). Notably, children from high SES families gesture more than children from low SES families, and these differences in early gesture predict the disparities in vocabulary that children bring with them to school at 52 months (Rowe & Goldin-Meadow, 2009a). In addition, the age when children produce supplementary gesture-plus-word combinations, in

which gesture and speech express different semantic meanings through one single communicative act, predicts the onset of two-word combinations (Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2005). Rowe and Goldin-Meadow (2009b) further showed that the number of different meanings conveyed in gesture at 18 months predicted vocabulary size at 42 months, while the number of supplementary gesture-word combinations at 18 months predicted sentence complexity at 42 months, thus gesture selectively predicts vocabulary and syntactic skills.

Among gestures, *pointing* has been attributed a special role in the development of language (e.g., Liszkowski, 2008; Tomasello, Carpenter, & Liszkowski, 2007). The conventional pointing gesture, defined as the simultaneous extension of the arm and index finger towards a target, usually appears in human development around 12 months of age (Carpenter et al., 1998; Leung & Rheingold, 1981). In classic developmental theories, pointing has a special status with respect to other preverbal forms of communication. For example, pointing is considered particularly relevant for language acquisition, whether as a precursor of labeling (Werner & Kaplan, 1964) or as a symbolic instrument (Vygotsky, 1986). Clark (1978) further claimed that the evolution of a naming relation between object and word is formed on top of the link made through pointing. In a theoretical framework supporting continuity between non-verbal and verbal communication, pointing is described as particularly important in the transition to language (e.g. Bates, Camaioni & Volterra, 1975). This argument is further elaborated by the social pragmatic theory (Tomasello et al., 2007), which considers infants' pointing as a referential communicative tool that enables children to initiatively *direct* adults' interests and attention to external events and objects (Liszkowski, 2008; Liszkowski et al., 2004; Liszkowski et al., 2007). Moreover, other researchers argue that pointing is a powerful cultural learning tool by which infants can obtain information from knowledgeable adults (Southgate, van Maanen, & Csibra, 2007). Infants who interacted with a knowledgeable experimenter pointed significantly more to novel objects than infants who interacted with an ignorant experimenter (Begus & Southgate, 2012), and they replicated the actions on novel objects that they pointed to better than those they did not point to (Begus, Gliga, & Southgate, 2014). In sum,

pointing gestures produced by infants before the onset of full-fledged speech are hypothesized to be infants' "royal road to language" (Butterworth, 2003).

Many studies support the importance of pointing for language development. For example, children were found to produce more object-labeling words with pointing than with other gestures (Masur, 1982), and pointing also elicits more labeling responses from adults compared to other behaviors, such as reaching, vocalizing or object extension (Kishimoto et al., 2007; Masur, 1982; Olson & Masur, 2011; Wu & Gros-Louis, 2014). Both the onset and the frequency of pointing have been shown to be positively correlated to expressive and receptive language (Blake, Vitale, Osborne, & Olshansky, 2005; Brooks & Meltzoff, 2008; Butterworth & Morissette, 1996; Desrochers, Morissette, & Ricard, 1995). By contrast, infants' reach-request and protest gestures (e.g., pushing things away) at 15 months were negatively related to language at 3 years (Blake et al., 2005).

These correlational studies are suggestive that pointing is associated with language development, but cannot verify a causal role of pointing in word learning. To explore this question, we need to experimentally manipulate infants' production of pointing and responses to pointing. A prior study suggests that experimental manipulation of pointing is possible and impacts vocabulary: increasing children's pointing led to an increase in their overall gesture production, which correlated to their speech production during follow-up interactions with their parents (LeBarton, Goldin-Meadow, & Raudenbush, in press). In this study, fifteen 17-month-old children received training at home once a week for 6 weeks. Children were randomly assigned to one of the three training conditions: (1) in the child and experimenter gesture (C & EG) condition, the experimenter pointed to a target picture, labeled it, and asked the child to point to it (e.g., the experimenter pointed to a dress in a picture book and said, "look at the dress! Can you do it? That's a dress!"); (2) in the experimenter gesture condition, the experimenter pointed at and labeled the target picture, but did not ask the child to do so; (3) in the no gesture condition, the experimenter just labeled the target picture, but did not point to it or ask the child to point to it. In addition, children were observed in free-play caregiver-child interactions at home before each training session and 2 weeks after the training session to assess children's gesture production in naturalistic interactions as a function of training. Results showed that in the C & EG condition in which children were trained to point, the number of distinct gesture meanings that they produced (gesturing at different things, e.g., a point at a dog is assumed to mean dog and is thus counted as one gesture meaning, while a point to a bird is counted as another gesture meaning) increased significantly both during training and in follow-up interactions with caregivers. Furthermore, gestures correlated to larger spoken vocabulary in follow-up interactions in the group whose gestures were experimentally increased. However, this study did not control responses to infants' gesture, and did not investigate

whether pointing influences word learning in real-time contexts.

The present study aimed to directly test whether infants' pointing gestures could help them learn the association between words and objects in a short time period. Specifically, we asked whether 16-month-old infants would show superior learning when they received labels about referents to which they pointed. We compared their learning when they heard an object label contingent on their pointing, looking without a point, or at a predetermined time during the trial (details in Procedure below).

Methods

Participants

Thirty-six 16-month-olds (18 females, range 15.0 – 18.5 months) participated in the study. An additional 5 infants were tested but excluded from analysis due to fussiness (4) and absence of pointing (1).

Materials

The experimental set-up is illustrated in Figure 1. A curtain with two window openings stood blocking the back of the testing room. An assistant experimenter (AE) protruded objects through the openings, one for each opening (toys popping out unexpectedly is successful in eliciting infants' pointing behaviors, e.g., Liszkowski et al., 2004). Infants sat on a high chair at a table (or on the caregiver's lap if preferred) facing the curtain. The main experimenter (E) sat across the table from the infant and in front of the curtain. One camera recorded infants from the middle line of the curtain (above the head of E), and one camera recorded E and the stimuli from the side; both cameras were fed into a quad-splitter. The Macarthur Communicative Development Inventory (MCDI) and a demographic questionnaire were filled out by caregivers. This was to examine whether infants' performance in the experiment relates to general vocabulary acquisition. Caregivers were asked not to interfere during the study.

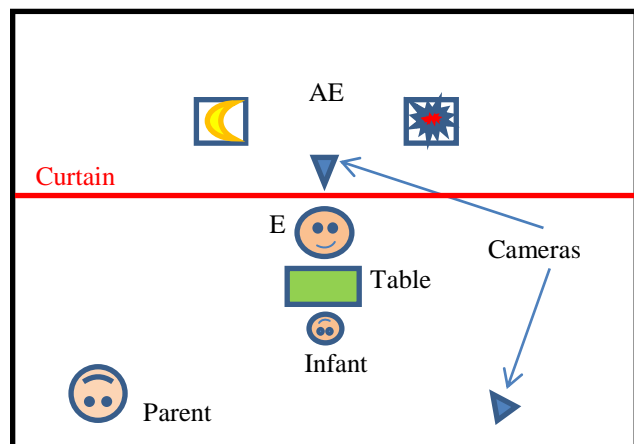


Figure 1: Schematic of experimental set-up



Figure 2: Photographs of 4 novel objects

Four novel objects (Figure 2) and four familiar objects were used as stimuli. The familiar objects were a shoe, a dog, a book and a cup. A set of familiar substitute objects (a banana, a cat, a duck, a hat, and a car) was also on hand in case a child did not know the name of one of the familiar objects.

Procedure

Each infant was randomly assigned to one of the three experimental conditions. In the *point contingent* (PC) condition and the *look contingent* (LC) condition, they heard object labels right after pointing or looking. In order to control for the potential effect of general communicative ability on word learning, infants were assigned to the *yoked control* (YC) condition if their language scores (measured by the MCDI) matched scores of infants in the PC condition. These infants heard labels at a time predetermined by when infants pointed in the PC condition (more details below). The procedure was divided into warm-up, novel word learning and testing phase.

Warm-up Phase. Infants played with four familiar objects one by one for up to 60 s. E then passed those objects underneath the curtain to AE, who protruded two familiar objects simultaneously out of the window openings for 30 s. E looked at the protruded object and labeled it with its name (e.g., “that’s a dog”) 1) immediately after the infant pointed to it (the point contingent condition, PC); or 2) at a schedule predetermined by when a vocabulary-matched infant in the pointing condition heard a label, i.e., when they pointed in the trials (the yoked control condition, YC). In the YC condition, therefore, infants heard labels after being exposed to the stimuli for the same amount of time in the trial as the matched infant in the PC condition, but the label was unrelated to their own behavior. Experimenter 1 was prompted over headphones for the timing of these labels. In the look contingent (LC) condition, E labeled an object while holding two objects at a distance near the window openings after infants oriented their first look to an object and maintained looking at it. Having E holding objects near the window openings is to further differentiate the PC and

LC condition, because a pilot study found that infants usually pointed very quickly after seeing objects popping out of the openings on the curtain, making the LC condition the same as PC; instead, infants rarely pointed if E held objects because it was unnecessary to point when the partner already knew the existence of target objects (Liszkowski, Schäfer, Carpenter, & Tomasello, 2009). In this way, we can thus test infants’ word learning when they were just looking without pointing. It should be noted, however, because of this, in the look contingent condition, infants and experiments both saw the objects and were not ‘surprised’ by their presentation.

After labeling one object in the first pair four times, the procedure was repeated with a second pair of objects. Note that only one object within each pair (the first object they pointed to or looked at) was labeled. If infants pointed to the other object within a pair of objects, E followed infants’ attention and said “I see”, but did not label it. After providing the 2 names, one name for each pair, AE then passed all four objects under the curtain to E, who gave them one by one to infants to examine up to 60 s again. After that, infants were presented with a *word comprehension test*. E presented two familiar objects simultaneously, side by side, on a white tray divided into 2 equal sections. She set the tray on the table and silently counted for 3 sec. This period gave the child an opportunity to look at the objects. E then looked at the child and asked, “Can you get the XX (name of one familiar object, e.g., dog)? Where is the XX?” and slid the tray forward. Infants were prompted up to four additional times on each trial. They were praised heavily for correct responses and corrected if necessary. Only when infants correctly identified objects out of 4 trials then the novel word learning and testing phase occurs. These warm-up stimuli were also used as familiar objects during the novel word testing phase.

Novel Word Learning and Testing Phase. The novel word learning and testing phase immediately followed the warm-up trials and proceeded in the same way except that 1) infants saw two pairs of novel objects, 2) infants thus heard two novel names (“stad” and “jick”) after they pointed, when they were just looking, or at a predetermined time schedule; 3) they were not praised or corrected on the word comprehension test. Instead, E simply said “OK” or “thank you”; 4) There were two kinds of word comprehension tests: On an easy testing trial, only one novel object had been labeled previously during word learning; on a hard testing trial, both novel objects had been labeled. In order to maintain infants’ interest and decrease fussiness, we presented the easy testing trials before the hard testing trials. Each novel word testing trial was repeated, resulting in 8 novel word testing trials. Moreover, after every two novel word testing trials, there was one familiar word comprehension trial, in which infants were shown familiar objects seen in the warm-up session. These known object trials were included as a control to check that the child stayed on task. Therefore, there were 4 familiar word testing trials, resulting in 12 testing trials in total.

Coding

A naïve coder coded infants' selections from video recordings of each session. A random selection of 33% of the sessions was coded by a second naïve coder. Inter coder agreement was 97%.

Results

Infants' mean comprehension vocabulary is 137.19 ($SD = 88.36$, range = 33-336), and production vocabulary is 27.39 ($SD = 36.10$, range = 0-159). Preliminary data analyses showed no significant differences in infants' age and vocabulary scores across the three conditions, $ps > .10$. The proportion of infants' final choice was used as the dependent variable. Proportions in all analyses were submitted to the arcsin transformation ($X' = \arcsin\sqrt{X}$).

Chi-square tests showed that the number of infants who pointed during the test was different across the conditions, $\chi^2(2) = 6.74$, $p = .03$. Specifically, fewer infants pointed in the look contingent condition (7 out of 12) than the point contingent condition (12 out of 12), $\chi^2(1) = 6.31$, $p = .01$. Comparisons between the other two pairs (look contingent and yoked control condition, point contingent and yoked control condition) showed no significant differences, $ps > .10$; however, the proportion of pointing gestures to the target objects (arcsin transformed) overall did not differ significantly across the three conditions, $F(2, 25) = 2.30$, $p = .12$, partial $\eta^2 = .16$. An independent-Samples Kruskal-Wallis Test showed similar results, test statistic = 3.78, $p = .15$. Thus, the proportion of pointing toward the target objects was the same across three conditions, yet infants in the point contingent condition heard labels immediately after they pointed to the target objects. By contrast, though some infants in the look contingent condition and the yoked control condition pointed, the naming events rarely occurred contingently on their pointing.

Infants' object choice on the familiar label trials were quite high, suggesting that they stayed on task ($M_{PC} = 81.65\%$, $SD_{PC} = 22.55\%$; $M_{LC} = 84.03\%$, $SD_{LC} = 18.99\%$; $M_{YC} = 80\%$, $SD_{YC} = 16.67\%$); furthermore, their performance on the familiar label trials did not differ across conditions, $p > .10$.

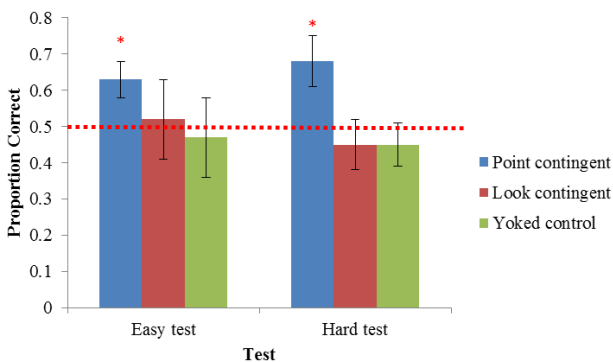


Figure 3: The proportion of infants' correct object choice on novel word testing trials

The proportion of infants' final choice was used as the dependent variable. Infants' word learning performance on novel label trials is shown in Figure 3. One-sample t-test showed that, infants chose the correct object significantly above the chance level only in the point contingent condition, for the easy test, $t(11) = 2.57$, $p = .03$, $d = 0.74$; for the hard test, $t(11) = 2.76$, $p = .02$, $d = 0.78$. Their object choice did not differ significantly from chance level in the other two conditions, $ps > .10$.

Moreover, a 2 (within-subject factor, test: easy vs. hard) \times 3 (between-subject factor, condition: PC, LC, YC) mixed-design analysis showed that there was a significant effect of condition, $F(2, 33) = 4.39$, $p = .02$, partial $\eta^2 = .21$. Post-hoc analyses showed that the word learning performance was significantly better in the PC condition than that in the LC condition, $p = .048$, and better than the YC condition, $p = .042$, but no difference was found between LC and YC, $p = 1.00$. The main effect of test [$F(1, 33) = .01$, $p = .92$, partial $\eta^2 = .00$] and the interactive effect of test and condition [$F(2, 33) = .23$, $p = .80$, partial $\eta^2 = .01$] were not significant.

Discussion

Previous studies have shown a positive relationship between the onset and frequency of infants' pointing gestures, and vocabulary growth in infancy (for a review, see Colonesi, Stams, Koster, & Noom, 2010). However, it was not clear whether the pointing gesture influences language learning in the moment. In the present study, we found that 16-month-old infants formed the correct object-word associations significantly more often when the word was provided contingently after pointing, than after looking or at predetermined time schedule. These experimental findings supplement previous natural observations that mothers frequently translated children's gestures into words; furthermore, these translations were related to later word- and sentence-production (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). Therefore, the current study provides the first direct experimental evidence that words offered in response to infants' pointing gestures were more likely to be learned.

Previous studies have shown that infants' pointing gestures can elicit linguistic input from the environment (Masur, 1982; Olson & Masur, 2011, 2013; Wu & Gros-Louis, 2014). Our study suggests that, in addition to eliciting information, the pointing gestures might have created an effective state that is conducive for word learning. Given the same linguistic input, the labels provided in response to pointing were better learned than the labels provided when infants were just looking. It thus suggests that the gestures may support infants for learning word-object associations.

One caveat to be noted is that further assessment of the labeling events are necessary to guarantee that the experimenter delivered the label with the same temporal contingency on looking and pointing. Maybe infants receive a label more immediately after looking than after pointing if

looking is easier to identify than pointing. But, if it is the contingency that matters, and this potentially differed between conditions, why did infants in the look contingent condition learn words worse than infants in the point contingent condition? One possible explanation is that the probability of contingency was higher in the point contingent condition than that in the look contingent condition, because it is impossible to label toys every time the child shifts gaze direction.

What remain to be determined are the mechanisms underlying the positive effect of pointing on word learning. One possibility is that pointing may increase infants' arousal or attention to an object, in a manner similar to the self-stimulating function of vocalizations, which help infants process object properties and learn word-object associations (Goldstein, Schwade, Briesch, & Syal, 2010). Goldstein and colleagues (2010) found that the more infants vocalized to an object, the more likely they would learn the shape of that object, as well as the word associated with it. They interpreted these results as vocalizations focusing infants' attention on the target object and the accompanying label. It might also be that in the look condition objects were in view for both infants and experimenters, rather than appearing by surprise through the curtain openings as they did in the point condition. Therefore, it is possible that seeing stimuli presented by surprise enhances learning in the point contingent condition due to arousal or excitement; however, some suggestion for the fact that the pointing gesture itself enhances attention comes from Campos et al. (2000) who posit that children's action experiences can impact their cognitive development due to changes in the focus of their attention associated with the accomplishment of those

actions. Although not speaking specifically about vocabulary development, Campos and colleagues (2000) propose that infants' actions may focus their attention to new events and entities. From this viewpoint, infants' pointing gesture may focus their attention to the targets and perhaps the labels accompanying them. This attention may facilitate learning labels for objects.

In addition, a second possibility is that caregiver's contingent label responses after pointing might be exactly the words that the child is ready to hear (Goldin-Meadow, 2003, 2007). Young children often use gestures to express their interests and attention that are too complicated for them to convey via speech. Therefore, the words they expressed via gesture may be exactly what the infants are ready to learn.

Thirdly, the pointing gesture may show what infants want to learn. They solicit information by pointing (Kovács, Tauzin, Téglás, Gergely, & Csibra, 2014), thus responding to infants' solicitation may result in superior learning (Begus et al., 2014). Future studies are required to test these possibilities.

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