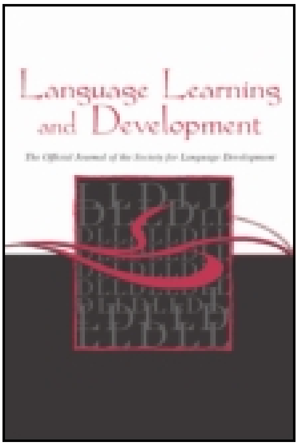

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Sumarga H. Suanda [a] , Katherine M. Walton [a] , Tanya Broesch [a] , Laira Kolkin [a] & Laura L. Namy [a]
[a] Department of Psychology, Emory University
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Why Two-Year-Olds Fail to Learn Gestures as Object Labels: Evidence from Looking Time and Forced-Choice Measures

Sumarga H. Suanda, Katherine M. Walton, Tanya Broesch, Laira Kolkin, and Laura L. Namy
Department of Psychology, Emory University

The range of symbols that children treat as object names narrows over the course of development as children accrue more experience with and exposure to language. By two years of age, children no longer treat gestures as object labels. Here we investigate the source of this new-found failure and ask whether it stems primarily from a failure to form associations between gestures and their referents, as opposed to a failure to interpret these associations as referential. To explore these possibilities, we tested word versus gesture learning in a paradigm consisting of both a preferential looking task (designed to detect implicit associations) and a forced-choice task (designed to index explicit symbol-to-referent mapping). Our findings reveal that unlike two-year-olds in the word condition, two-year-olds in the gesture condition failed to demonstrate associations between gestures and objects in either task, suggesting that they did not form associative links between gestures and their intended referent. Importantly, those who did exhibit associations during preferential looking were also more likely to demonstrate successful learning of gestures in the forced-choice task. In contrast, 18-month-olds readily formed associations between gestures and objects. We conclude that the decline in receptivity to gestural labels during the second year is due to a failure to form reliable associations between gestures and their referents.

Recent research has demonstrated that a variety of basic word-learning phenomena generalize to other domains such as facts (Diesendruck & Markson, 2001; Markson & Bloom, 1997) and nonverbal symbols (Graham & Kilbreth, 2007; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). These findings have led to challenges to traditional domain specific views of lexical acquisition (e.g., Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989; for discussion, see Diesendruck, 2007). Of particular interest for the purposes of this paper is the finding that word learning and nonverbal symbol learning show similar patterns early in development but diverge with age. For example, the range of symbols that children interpret as object names appears to narrow over the course of development, as children accrue more experience with and exposure to language.

Correspondence should be addressed to Sumarga H. Suanda, Department of Psychology, Emory University, 36 Eagle Row, Atlanta, GA, 30322. E-mail: ssuanda@emory.edu

Namy and Waxman (1998) compared 18- and 26-month-olds' willingness to accept novel words versus symbolic gestures as object names. They labeled familiar object categories (e.g., fruits, vehicles) with either a novel word (e.g., "blicket") or a novel gesture (e.g., a dropping motion) and examined mapping and extension patterns of the different symbol types. Eighteen-month-old infants interpreted words and gestures as object names with equal facility (see also Namy, 2001). However, 26-month-olds demonstrated a different pattern of behavior. Although they successfully interpreted words as object names, these infants failed to exhibit the spontaneous receptivity toward gestural labels that 18-month-olds displayed. Only through extensive training in the gestural modality did 26-month-olds learn to interpret symbolic gestures as category names. Namy and Waxman interpreted this developmental trend as evidence of a general symbolic capacity that becomes specified as hearing infants gain extensive exposure to spoken language (Namy & Waxman, 1998).

This developmental pattern has been replicated with different symbolic forms (Woodward & Hoyne, 1999) and using inference tasks as well as word extension tasks (Graham & Kilbreath, 2007). Additionally, the developmental trajectory has been substantiated neurophysiologically (Sheehan, Namy, & Mills, 2007). Using event-related potentials to investigate semantic processing of both words and symbolic gestures, Sheehan et al. (2007) reported similar semantic congruity (N400) effects for matching versus mismatching word-object and gesture-object pairings at 18 months but not at 26 months. Although this developmental decline in receptivity to nonverbal symbols as object names is well established, why this decline occurs is not well understood. There are at least three possible explanations for 26-month-olds' resistance to interpreting nonverbal symbols as object names. The first is that infants at this age simply fail to attend to or encode gestures and other nonverbal symbols during the naming event. However, analysis of the spontaneous production of experimentally introduced novel gestures (Namy & Waxman, 2002) reveals that 26-month-olds frequently imitated the symbolic gestures used in the study. In fact, Namy and Waxman (2002) observed an increase in the frequency of symbolic gesture imitation in 26-month-olds compared to 18-month-olds.

A second possible explanation for 26-month-olds' failure to spontaneously interpret gestural symbols is that although they successfully attend to the gestures, they fail to form a reliable association between the gesture and the target object. Such a hypothesis would suggest that infants attend to gestures but, perhaps given the relative infrequency of this type of symbolic input and the necessity of dividing visual attention between gestures and objects, fail to form a link between the gesture and object. A third possible explanation for the decline in mapping of gestural labels to their referents is that 26-month-olds attend to the gestures and associate them with the target objects but decline to interpret these associations as referential. This possibility would imply that infants perform an additional step, gauging the plausibility of the signal-to-object association as a referential act, and that the breakdown in the symbol learning process occurs during this step.

The goal of the current experiment is to shed light on the possible reasons for 26-month-old's failure to learn symbolic gestures as object labels by disambiguating between these latter two hypotheses. Specifically, we examine the extent to which the failure to learn gestures as object names is due to failed associations between gestures and their referents or to a failure to interpret the association as a candidate label. To address this question, we employ a paradigm that includes both a preferential looking task (Hirsh-Pasek & Golinkoff, 1991; Hirsh-Pasek, Golinkoff, & Hollich, 2000) and a forced-choice gesture-mapping task (Namy, 2001; Namy, Campbell, & Tomasello, 2004; Namy & Waxman, 1998). Our logic is that the preferential looking paradigm may reveal implicit associations between gestures and their referents that may have gone undetected in the forced choice tasks used in previous studies of symbolic gesture learning (e.g., Namy & Waxman, 1998). This logic is supported by previous research. For example, Clements and Perner (1994) have suggested that the reduced task demands of looking time measures, which simply require infants to represent information, demonstrate implicit knowledge that may be masked when infants have to make an explicit judgment. Consistent with this claim, a handful of studies (Bannard & Tomasello, 2009; Chan, Meints, Lieven, & Tomasello, 2010; Gurteen, Horne, & Erjavec, 2011; Nilsen, Graham, Smith, & Chambers, 2008) have revealed that measures of implicit awareness, such as response latency and eye gaze duration, demonstrate sensitivity to children's language processing not apparent in their explicit play or choice behaviors. Further, recent research has revealed that even different measures of looking may be sensitive to different levels of language competence (e.g., Fernald, Zangl, Portillo, & Marchman, 2008; Yoshida, Fennell, Swingley, & Werker, 2009).

Motivated by this previous work, we employ a combination of a preferential looking task and a forced choice task to investigate whether the reduced demands of the preferential looking task will reveal associations not captured by the forced choice task. We propose that if 26-month-olds' failure to learn gestural symbols occurs as a result of failure to acquire gesture-object associations, the failed link will be evident in both looking time and choice measures. Alternatively, if the failure to learn gestures is due to children's rejection of this form as referentially plausible, as Namy and colleagues (e.g., Namy, 2009) have argued, then we may find dissociation between looking time and choice measures. Specifically, infants may display that they have learned the associations between gestures and objects as measured by looking time patterns, but fail to map the gesture to its referent as indexed by their choice patterns. In contrast to infants' gesture-learning performance, we anticipate that infants at this age will readily exhibit learning of novel *words* as measured by both the looking time and choice tasks.

EXPERIMENT 1

Methods

Participants

Thirty-six 26-month-olds ($M = 26.5$, $Range = 25.2–27.4$) including 22 boys and 14 girls from predominantly White or Black middle-class families in the Atlanta area participated. An equal number of boys and girls were randomly assigned to the word and gesture conditions. Across the two conditions, there was no difference in infants' age or their productive vocabularies (as indicated by parent-report on the short-form version of the MacArthur Communicative Developmental Inventory, Fenson et al., 2000). An additional 11 infants were excluded from analysis due to fussiness (5), technical difficulties with the eye-tracking system (5), or failure to make enough clear choices (1).

Stimuli

Six familiar objects (shoe, car, horse, spoon, apple, and hammer) were used as stimuli. Dynamic videos as well as still photos of these objects were used as stimuli in the preferential looking portion of the study and the objects themselves were used in the forced choice phase.

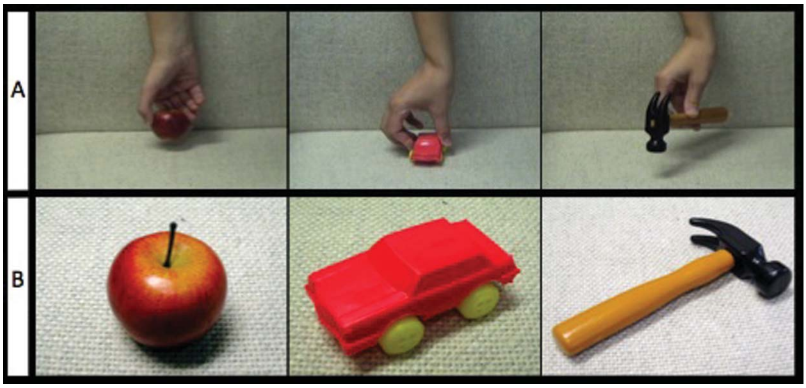

FIGURE 1 Video still frames of the three familiar objects used in the introduction phase (A). Images of objects used in the preferential looking task (B) (color figure available online).

Each video depicted a hand manipulating the object slowly from above (see Figure 1A). At a viewing distance of 60 cm, the 23 x 16.5 cm video stimuli subtended 21.7° x 15.7° visual angle. Still photos (14.6 x 11.4 cm, 13.9° x 10.8° visual angle) were shot from a canonical view, slightly above and to the side of each object as it rested on a solid surface (see Figure 1B). Objects were paired based on salience matching determined during pilot testing. These pairs (shoe-apple, car-horse, spoon-hammer) were fixed across participants. However within the pair, which object was designated as the target object varied across participants.

Three novel labels were used to label the target objects in each condition. In the word condition, labels were three novel words: "blicket," "daxen," and "riffle." In the gesture condition, labels were three novel gestures: a side-to-side sweeping motion with an open hand extended as if to shake hands; a closed fist repeatedly extending the index and middle fingers simultaneously; and a closed fist opening downward in a dropping motion. Which novel label was paired with which target object was assigned randomly for each infant.

Apparatus

A Tobii 1750 Eye Tracker was used to collect data on gaze direction and duration during the preferential looking task. The eye tracker was integrated into a 43 cm flat panel monitor, and stimuli were presented on this monitor through a computer running Tobii's Clearview software. No head mounted apparatus was necessary. Each infant underwent a five-point calibration procedure prior to the onset of the experimental procedure. The calibration procedure included presenting an infant-friendly animated character at five locations on the screen (i.e., every corner and the center) accompanied by an engaging auditory stimulus. The experimenter focused infants' attention toward the calibration display (e.g., by pointing toward the clip and saying, "wow, look at that!"), ensuring that infants attended to the relevant portion of the screen. A second experimenter controlled the calibration stimulus' movement from one location to the next. The calibration procedure was repeated if poor calibration (as indicated by the Clearview software) was obtained for both eyes in more than one location.

Procedure

The experimental procedure consisted of three phases: an Introduction Phase, the Preferential Looking Task (PLT), and the Forced Choice Task (FCT). Each infant completed these three phases for one pair of objects and then repeated the three phases with the other two pairs. The procedure was identical in the word and gesture conditions with the exception of the type of label employed.

Introduction Phase

Each infant was seated on a booster seat or on a parent's lap 60 cm from the eye-tracking monitor. Following calibration, the infant was introduced to two 20 s dynamic video clips of a hand manipulating each object in a pair. One video clip depicted the target object, and one depicted the distracter object. Videos were presented in succession with a brief (5 s) pause in between. Order of presentation of the two videos was randomized for each participant.

During the presentation of each video, the experimenter knelt next to the infant and engaged in a period of joint attention with the infant, directing the infant's gaze toward the object on the screen. The experimenter drew attention to each object six times using phrases such as, "Look at that!" and "Do you see that?" During presentation of the target video, the experimenter labeled the object following each attentional phrase with a verbal or gestural label depending on condition (e.g., "Look at that! Blicket!" or "Do you see that? [gesture]"). Labels were introduced in syntactic isolation for two reasons. First, we wanted to avoid inserting the gesture into a spoken sentence which infants at this age may find unnatural and distracting. Second, we wanted to avoid providing any syntactic cueing that might inflate infants' mapping of the words and gestures to the objects.

Preferential Looking Task

At the conclusion of the Introduction Phase, the experimenter repositioned herself behind the eye-tracking monitor with her head and upper body visible to the infant above the display.

For each trial, a still image of the two objects appeared side-by-side 5 cm (4.8° visual angle) apart. Prior to a trial, the experimenter prompted the infant to orient to the screen with the phrase, "What do you see?" On target trials, but not on control trials, the experimenter also produced the label (either word or gesture). These labels were produced in isolation immediately following the orienting phrase. The images appeared on the screen immediately following the word "see" on control trials and following the object label on target trials. The images remained on the screen for five seconds. After the images appeared, the experimenter added, "Do you see? [label]" on target trials and "Do you see?" on control trials. Two target and two control trials were administered with a brief delay between trials. Trials were blocked by type but order of presentation of trial types was randomly determined for each infant.

Forced Choice Task

Following the PLT, the experimenter repositioned the infant's chair to the infant's right. The experimenter then rolled a small table over to the infant, where the forced choice task (FCT) was administered. During the FCT, the experimenter sat directly across the table from the infant. The FCT began with the experimenter handing the infant the two objects that had been depicted in the videos and PLT. The infant played freely with the two objects for approximately 10 s. The experimenter drew attention to each object. The experimenter did not re-label the target object during this period.

The experimenter then removed the two objects from the infant's reach and re-presented both objects on the table one at each side out of the infant's reach. She administered four forced-choice test trials including two target and two control trials. On target trials, the experimenter elicited a choice by producing the label (either novel word or gesture), saying, "Which one can you get? [label] Can you get it? [label]." On control trials, the experimenter elicited a choice by saying, "Which one can you get? Can you get one?" In each trial type following these phrases, the experimenter slid the objects simultaneously towards the infant, one on each side of the infant's midline, equidistant from the infant. While eliciting the choice, the experimenter placed her hand, palm up, at the infant's midline and directed gaze at either the infant's face or at her hand. The experimenter provided neutral feedback (i.e., "Thank you") in response to infants' choices regardless of which object was selected. As in the PLT, trials were blocked by type but order of the two trial types was randomly determined for each infant.

After completing the calibration, introduction, PLT and FCT with the first pair of objects, the procedure was repeated with the second and third pairs of objects, yielding a total of six target trials and six control trials per infant for each test phase (PLT and FCT). Infants were excluded from further analysis if (a) they failed to complete the three phases for at least two of the three sets of objects or (b) they failed to make clear choices on at least eight of the 12 FCT trials (including at least four of the six trials for each trial type).

Coding

Infant's gaze direction during PLT was recorded and analyzed using Tobii's Clearview analysis software. A file containing information on timestamp and duration of fixations to specific Areas of Interest (i.e., the regions defined by the outlines of target and control objects) was exported at 50 Hz from the Clearview program. We excluded short fixations lasting less than 100 ms, as such short fixations were likely caused by eye-tracking errors (see also Yu & Smith, 2011). No further data reduction or smoothing procedures were employed to the fixation data. Fixations to target and control pictures were then summed to calculate amount of looking time to each picture. Time spent looking off screen or on screen outside of the pre-defined regions of interest (i.e., the objects) was not included in the calculations.

Infant's choice patterns in FCT were videotaped and coded by a primary coder blind to which object was the target object. Infants' choices were classified as (a) choosing the target object, (b) choosing the distracter object, or (c) no clear choice. The object the infant touched first was considered the infant's choice. If the infant touched both objects simultaneously but then handed one of the objects to the experimenter, the object given to the experimenter was considered the infant's choice. If however, the infant touched both objects simultaneously and failed to hand one to the experimenter, the response was coded as no clear choice. A second coder analyzed a randomly selected 50% of the sessions. Inter-rater reliability calculated across individual trials was 97.2%.

Results

Preferential Looking Task

For each individual PLT trial, the proportion looking to target object was obtained by calculating the amount of looking time to target object divided by the total amount looking to target plus control object. We compared the average proportion of time infants looked to the target object during target trials compared to control trials in each condition (see Figure 2). We employed proportions rather than raw values to control for individual differences in overall looking times and for potential differences in overall looking to the two objects as a function of the trial type and condition (e.g., production of the label in target trials might have resulted in greater overall visual attention to the depicted objects; Baldwin & Markman, 1989; Balaban & Waxman, 1997; and use of a gestural label may have divided visual attention in a manner that reduced overall amount of looking to the screen relative to the word condition). To normalize the distributions, all proportions were arc-sine transformed prior to analyses. For ease of interpretation, the mean and standard deviation values we present are of the untransformed values. Success on this task was operationalized as greater proportion looking to the target object on target trials relative to control trials and greater proportion looking towards the target object during target trials than would be predicted by chance (.50).

A condition (Word vs. Gesture) x trial type (Target vs. Control) analysis of variance (ANOVA) on proportion looking to target object revealed a marginally significant main effect of trial type, $F(1,34) = 3.09$, $p = .088$, $\eta^2{}_p = .08$, qualified by a marginally significant condition-by-trial type interaction $F(1,34) = 3.63$, $p = .065$, $\eta^2{}_p = .10$.

Although the overall interaction was marginal, planned comparisons reveal distinct patterns in the word and gesture conditions. Infants in the word condition looked at the target object for a greater proportion of time during target trials ($M = 0.58$, $SD = .10$) than control trials ($M = .49$, $SD = .13$), $t(17) = 2.63$, $p < .05$. In contrast, infants in the gesture condition did not differ reliably

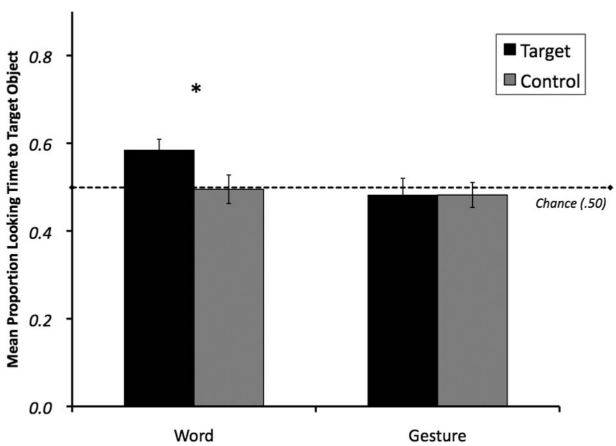

FIGURE 2 Mean proportion looking time to target object by trial type and condition in the Preferential Looking Task of Experiment 1. *$p < .05$.

in their proportion looking to the target object between the target ($M = .48$, $SD = .16$) and control trials ($M = .48$, $SD = .12$), $p > .10$. Further, proportion looking to target object on target trials was significantly higher in the word condition than the gesture condition, $t(34) = 2.21$, $p < .05$. Proportion looking to target object on control trials did not differ across conditions.

Comparisons to chance responding (.50) yielded patterns consistent with the observed condition effects. In the word condition, proportion looking to target object during target trials was significantly higher than predicted by chance, $t(17) = 3.30$, $p < .01$. Proportion looking to target object during control trials, however, did not differ from chance, $p > .10$. In the gesture condition, proportion looking to the target object did not differ from chance in either target or control trials, $ps > .10$.

Forced Choice Task

We performed similar comparisons for infants' performance in FCT. That is, we calculated the proportion of trials on which each infant chose the target object during target and control trials (see Figure 3). In FCT, success was operationalized as selecting the target object on target trials reliably more often than on control trials and reliably more often than predicted by chance.

A Condition (Word vs. Gesture) x Trial type (Target vs. Control) ANOVA on proportion target object selection revealed a significant main effect of trial type, $F(1,34) = 25.66$, $p < .001$, $\eta^2_p = .43$, qualified by a significant interaction between trial type and condition $F(1,34) = 8.18$, $p < .01$, $\eta^2_p = .19$, indicating that infants in the word condition selected the target object more often in the target trials than the control trials, but infants in the gesture condition did not.

Planned comparisons confirmed that infants in the word condition chose the target object significantly more often in target trials ($M = .71$, $SD = .16$) compared to control trials ($M = .47$, $SD = .15$), $t(17) = 5.01$, $p < .001$. In contrast, infants in the gesture condition chose the target object marginally more often on target trials ($M = .53$, $SD = .18$) relative to control trials ($M = .47$, $SD = .20$), $t(17) = 1.80$, $p = .09$. Infants in the word condition selected the target object on

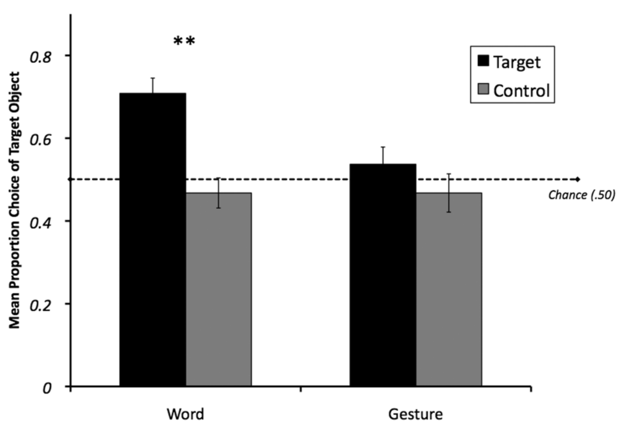

FIGURE 3 Mean proportion choice of target object by trial type and condition in the Forced Choice Task of Experiment 1. **$p < .01$.

target trials significantly more often than infants in the gesture condition, $t(36) = 2.78$, $p < .01$. Proportion choosing target object on control trials did not differ across conditions.

Comparisons to chance underscored the performance differences between conditions. Infants in the word condition, selected the target object on target trials significantly more often than predicted by chance performance (.50), $t(17) = 5.05$, $p < .001$. Performance on control trials did not differ from chance, $p > .10$. In the gesture condition, proportion choosing of target object did not differ reliably from chance in either target or control trials, $ps > .10$.

Cross-Task Contingencies

We next examined the relation between PLT and FCT performance. Specifically, we investigated whether infants' ability to map a novel gesture onto an object as measured by FCT performance was contingent on their successful association between gesture and object as indexed by PLT performance. To this end we categorized infants in terms of their performance on PLT. Infants were classified as *associaters* if their proportion looking to target object was greater than .50 on target trials and greater in target trials compared to control trials. Infants who did not meet these criteria were classified as *non-associaters*. This classification yielded 8 associaters and 10 non-associaters in the gesture condition. Associaters did not differ reliably from non-associaters in either age or productive-vocabulary.

We examined whether gesture-object associaters were more likely to demonstrate successful mapping in FCT trials compared with nonassociaters as indexed by the criteria used above: higher proportion choice of target object on target trials relative to control trials. We found a clear relationship between being an associater and mapping in the gesture condition. As demonstrated by Figure 4, associaters chose the target object more often on target trials than on control trials in the FCT, $t(7) = 2.43$, $p < .05$, whereas non-associaters did not, $t(9) = .56$, $p > .10$. These findings suggest that successfully associating gestures with target objects during PLT determined

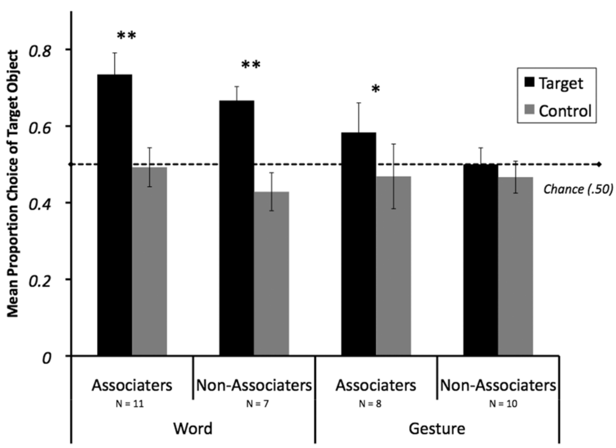

FIGURE 4 Mean proportion choice of target object in the Forced Choice Task as a function of successful performance in the Preferential Looking Task in Experiment 1. *$p < .05$, **$p < .01$.

whether infants displayed learning of the association during FCT, consistent with the notion that the breakdown in gesture learning at this age is a function of failure to reliably associate gestures with their referents.

Interestingly, performance on the FCT did not appear to be contingent on associations formed during the PLT in the word condition. In the PLT task, there were 11 associaters and seven nonassociaters in the word condition; however, both associaters and nonassociaters chose the target object more often on target trials than control trials (associaters: $t(10) = 3.53$, $p < .01$; non-Associaters: $t(6) = 3.77$, $p < .01$). That is, those in the word condition displayed robust learning in the FCT regardless of their looking behavior during PLT. This difference may simply reflect the lack of variability due to ceiling effects in FCT performance among children in the word condition. We discuss this outcome in greater detail in the discussion below.

DISCUSSION

Consistent with previous findings (e.g., Namy & Waxman, 1998; Namy et al., 2004), the results of this experiment revealed that 26-month-olds readily mapped a novel word but not a novel gesture onto its correct referent. Further, the current experiment extends previous investigations by demonstrating similar patterns of learning, or lack thereof, across both a preferential looking and forced choice tasks. That is, overall, infants in the gesture condition failed to demonstrate learning in both looking time and forced choice measures. In contrast, infants in the word condition demonstrated learning in both tasks.

In the current experiment, we employed a combination of preferential looking and forced choice tasks as a window into why 26-month-olds fail to learn symbolic gestures. We hypothesized that if infants reliably associated gestures with objects but rejected these associations as referential, we would see dissociation between the more sensitive looking time measure and the more explicit forced choice measure. Results from Experiment 1 do not support this hypothesis, suggesting instead that the infants in the gesture condition generally failed to form an association between the gesture and object.

Although we found a lack of association between gesture and referent overall, there were some infants who displayed this association in the gesture condition. These infants were also significantly more likely to display learning in the forced-choice task. The finding that looking behavior patterned after forced choice performance both across and within infants provides further support for the interpretation that the obstacle to gesture learning at 26 months is one of failing to associate, rather than failing to interpret the association as referential. Interestingly, although there was an association between PLT and FCT performance in the gesture condition, this relationship was not observed in the word condition. That is, although infants in the word condition as a group demonstrated learning in both preferential looking and forced-choice tasks, success on the forced choice task did not appear contingent on success in the looking time task within individuals. One likely explanation for this finding is that there was little variability in 26-month-olds' forced choice performance in the word condition. That is, nearly all 2-year-olds successfully mapped the word onto the referent in the forced choice task.

We argue that the lack of dissociation between tasks in the gesture condition is inconsistent with the notion that 2-year-olds successfully associate gestures with their referents but fail to interpret the associations as referential. It is conceivable, however, that a methodological feature of the current looking time paradigm may have underestimated infant's gesture-to-referent associations, and thus masked potential task dissociations. That is, given that in the looking time task both the gesture and the object were presented visually, infants were required to split their visual attention between the experimenter's gestures and the computer screen, rendering the opportunity to form an association particularly difficult. Although previous studies of symbolic gesture learning (e.g., Namy & Waxman, 1998) also placed similar visual attention demands on the infants, the experimenter in these studies typically produced the gestures adjacent to the three dimensional objects to which the gestures referred while the experimenter or infant was manipulating them. Thus the physical proximity of the gestures to their referents in those studies may have reduced the need for division of visual attention between the gesture and its referent.

In Experiment 2, we rule out the possibility that lack of gesture learning was due to the nature of the task, validating the use of the PLT as a measure of gesture learning. To this end, we replicated the gesture condition's PLT procedure, including a younger population of 18-month-olds who have been shown to be receptive to symbolic gesture learning based on explicit choice measures (e.g., Namy, 2001). If 26-month-olds' failure to reliably associate gestures with objects is an artifact of the procedure's demands, then we would expect both 18- and 26-month-olds to display a lack of gesture-object association. If, however, the younger 18-month-olds, who are inherently more limited information processors, display evidence of associating gestures with their referents in the PLT, we may rule out visual attention demands as a basis for the 26-month-olds' failure to form gesture-referent associations.

EXPERIMENT 2

In Experiment 2, we compared gesture-object association learning in 26-month-olds to 18-month-olds in a preferential looking task to ascertain whether 26-month-olds' failure to associate gestures with objects was an artifact of the procedure. The paradigm was identical to the gesture condition from Experiment 1 with the exception that we administered only the preferential looking task, excluding the forced-choice task, to better accommodate the more limited attention spans of 18-month-olds and more directly assess the impact of the structure of the introduction phase on gesture-object associations. We expected to replicate Namy and colleagues' previous work (Namy et al., 2004; Namy & Waxman, 1998) that 18- but not 26-month-olds would reliably associate symbolic gestures with their referent objects.

Methods

Participants

Twenty 18-month-olds (M = 18.5, *Range* = 17.6–20.4, 12 girls) and 20 26-month-olds (M = 26.3, *Range* = 24.9–27.9, 12 girls) from predominantly White or Black middle-class families in the Atlanta area participated. An additional 7 18-month-old infants were excluded from analysis due to fussiness (2), technical difficulties with the eye-tracking system (4), or parental interference (1). No 26-month-olds were excluded.

Stimuli, Apparatus, Procedure, and Coding

Stimuli, apparatus, procedure and coding were identical to those in the gesture condition of Experiment 1 with one exception. In Experiment 2, the experimental procedure did not include a FCT. Thus, after completing the Introduction phase and PLT for the first set of objects, the experimenter repeated the Introduction phase and PLT for the second and third pairs of objects. This procedure yielded a total of six target trials and six control PLT trials per infant. As in Experiment 1, infants were excluded from further analysis if they failed to complete both phases for at least two of the three sets of objects.

Results and Discussion

For each age group, we examined the average proportion of time infants looked to the target object during target trials compared to control trials in each condition (see Figure 5). An age (18-month-olds vs. 26-month-olds) x trial type (Target vs. Control) ANOVA on proportion looking to target object revealed a significant main effect of trial type. $F(1,38) = 7.33$, $p < .05$, $\eta^2{}_p = .16$, qualified by a marginally significant age-by-trial type interaction $F(1,38) = 3.01$, $p = .09$, $\eta^2{}_p = .07$.

Planned comparisons indicated that 18-month-olds looked at the target object for a greater proportion of time during target trials ($M = 0.608$, $SD = .13$) than control trials ($M = .495$, $SD = .10$), $t(19) = 3.19$, $p < .01$. In contrast, 26-month-olds' proportion looking to target object did not differ between target ($M = .482$, $SD = .14$) and control trials ($M = .458$, $SD = .14$), $p > .10$. Eighteen-month-olds' proportion looking to target object on target trials was greater than 26-month-olds', $t(38) = 2.86$, $p < .01$. The two age groups did not differ in their proportion looking to target object on control trials.

Comparisons to chance responding (.50) yielded patterns consistent with the observed age difference. Eighteen-month-olds' proportion looking to the target during target trials was significantly higher than predicted by chance, $t(19) = 3.42$, $p < .01$. Eighteen-month-olds' proportion

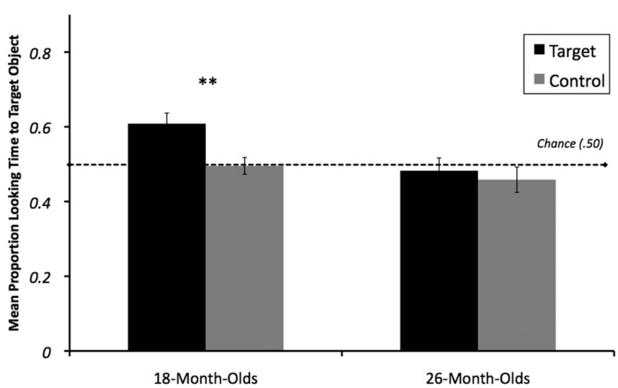

FIGURE 5 Mean proportion looking time to target object by trial type and age in Experiment 2. $^{**}p < .01$.

looking to target object during control trials, however, did not differ from chance, $p > .10$. In contrast, 26-month-olds' proportion looking to the target object did not differ from chance in either target or control trials, ps $> .10$. The observed age differences in patterns of looking were not due to differences in overall attentiveness to the stimuli during the task. Eighteen-month-olds ($M =$ 1759 ms, $SD = 722$ ms) and 26-month-olds ($M = 1781$, $SD = 604$) attended to the stimuli for a similar amount of time, $p > .10$, but, as our analyses indicate, distributed their looks to the two pictures differently.

These results replicate previous findings employing forced choice procedures demonstrating that 18-, but not 26-, month-olds readily learn gestures as object labels (Namy, 2001; Namy et al., 2004; Namy & Waxman, 1998). Most important for the context of the current paper is that this outcome rules out difficulty associated with the experimental procedure and design as a basis for the 26-month-olds' failure to associate symbolic gestures with objects in the PLT of Experiment 1, because infants eight months younger readily associated the gestures with their referents in this paradigm.

GENERAL DISCUSSION

Previous research employing observational (e.g., Acredolo & Goodwyn, 1988), behavioral (e.g., Namy & Waxman, 1998) and more recently, neurophysiological techniques (Sheehan et al., 2007) has revealed striking similarities between infants' interpretations of words and symbolic gestures. Many of these same studies demonstrate, however, that these parallels are short lived developmentally. In the present study, we asked why older infants (at 26 months of age) fail to spontaneously learn symbolic gestures as labels for objects, a task at which their 18-month-old counterparts easily succeed. Specifically, we employed a combination of preferential looking and forced choice tasks to examine whether 26-month-olds' failure to learn gestural labels can be explained by a failure to associate symbolic gestures with their referents; or whether infants successfully associate gestures and object but inhibit interpreting these associations as referential.

Contrary to our expectations (Namy, 2009), our findings appear most consistent with the first explanation. That is, 2-year-olds' failure to learn symbolic gestures appears due to the lack of reliable associations formed between gestures and their intended referents. Three aspects of our results lead us to this conclusion. First, we found similar behaviors across both preferential looking and forced choice tasks. Thus, the more automatic measure of looking did not reveal implicit associations between gestures and their referents that were not apparent using an overt choice measure.

Second, although 26-month-olds failed to display evidence of gesture learning overall, performance in the two tasks was correlated. That is, those who associated symbolic gestures and their referents, as measured by the preferential looking task, also performed successfully in the forced choice task. This confirms that 26-month-old infants *can* learn symbolic gestures as object names although they do so less readily (see also Namy & Waxman, 1998, Experiment 3). This finding also supports the conclusion that the barrier to gesture learning at two years of age lies in the lack of associative links between gesture and referent.

Third, we ruled out an alternative explanation for 26-month-olds' failure to form gesture-object associations, that dividing attention visually between experimenter and screen prevented infants from forming a ready association in the PLT. By demonstrating that 18- but not 26-month-olds formed these associations, we can conclude that it is the nature of the symbolic medium and not the nature of the task that resulted in an inhibition of association at 26 months. This finding also replicates, using a novel paradigm, the developmental decline in receptivity to symbolic gestures that had previously been shown in forced-choice symbol-extension (Namy & Waxman, 1998; Namy et al., 2004) and inductive inference (Graham & Kilbreath, 2007) tasks.

That 26-month-olds exhibited word learning in both measures but gesture learning in neither is consistent with the argument that words and gestures are processed differently at this point in development (Namy & Waxman, 1998; Sheehan et al., 2007). We suggest that one possible interpretation of this finding is that by two years of age, word learning and gesture learning are supported by different cognitive processes. That is, in making word-to-referent mappings, 26-month-olds appear to recruit a host of additional processes such as an interpretation of communicative context and intent of the speaker (Akhtar, Carpenter, & Tomasello, 1996; Baldwin et al., 1996; Diessendruck, Markson, Akhtar, & Reudor, 2004), which may help explain the fact that we found no relation between simple word-object associations and mappings in our study (see also Bannard & Tomasello, 2009). In contrast, nonverbal symbol-to-referent mappings at 26 months of age may recruit a more basic mechanism that relies primarily on creating associations (Samuelson & Smith, 1998).

Although we argue for a qualitative difference in cognitive processing of the two symbolic forms, we acknowledge that other explanations, which are not necessarily mutually exclusive from the current account, also exist. First, it is possible that what distinguishes the two symbolic forms has less to do with the underlying learning process and more to do with the class of referents 26-month-olds readily link with gestures. Marentette and Nicoladis (2011) have recently provided evidence suggesting that preschool children between the ages of 40 to 60 months interpret gestures as action associates instead of object labels. Although differences in task and age of child render a *direct* comparison between their study and the current work difficult, the work highlights an important direction for future work: would two-year-olds more readily learn gestures if they were linked with actions as opposed to objects?

A second alternative explanation of the difference between two-year-olds' processing of words and symbolic gestures is that the difference is more quantitative than qualitative in nature. Perhaps, for example, the amount of fixation time or number of exposures to the pairings required to establish a link between symbol and object may be greater for gestures than it is for words at 26 months. Certainly, in Namy and Waxman's (1998) original paper, 26-month-olds who ultimately succeeded at mapping gestures to objects (in Experiment 3) did so after many more repetitions, more reinforcement, and opportunities to produce the gestures that were not inherent in the current design. In future research, it will be important to disentangle which elements of Namy and Waxman's training regimen were most important for enabling infants to generate gesture-to-object mappings at this age, as well as what might have distinguished gesture associaters from nonassociaters in the present task.

To conclude, we replicated the previous finding that 26-month-old infants overall spontaneously learn words but not symbolic gestures as object names in a forced choice task. Further, we extend the finding of developmental decline from 18 to 26 months in symbolic gesture receptivity to a more automatic and implicit measure of learning (i.e., preferential looking). The parallel results across both looking time and forced choice measures suggest that 26-month-olds' failure to spontaneously learn symbolic gestures is attributable to a failure to create reliable associations between gestures and their intended referents. In conjunction with previous work, the current findings support the notion that words and gestures begin to play different roles in children's communicative repertoires as they develop.

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