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Novel labels support 10-month-olds' attention to novel objects

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ABSTRACT

What is the source of the *mutual exclusivity* bias whereby infants map novel labels onto novel objects? In an intermodal preferential looking task, we found that novel labels support 10-month-olds' attention to a novel object over a familiar object. In contrast, familiar labels and a neutral phrase gradually reduced attention to a novel object. Markman (1989, 1990) argued that infants must recall the name of a familiar object to exclude it as the referent of a novel label. We argue that 10-month-olds' attention is guided by the *novelty* of objects and labels rather than knowledge of the names for familiar objects. Mutual exclusivity, as a language-specific bias, might emerge from a more general constraint on attention and learning.

Introduction

Infants can use their existing vocabulary to form new word mappings. This ability is commonly known as the *mutual exclusivity* response; infants will map a novel label onto a novel object rather than a familiar object. We use the term mutual exclusivity in a neutral manner to refer to the *behavior* of mapping a novel label to a novel object. One prominent explanation of mutual exclusivity is that infants reject second labels for objects that already have names (Markman, 1989, 1990). Another account is that infants are directly biased to map novel labels onto nameless objects, that is, the *novel name–nameless category principle* (Mervis & Bertrand, 1994). Relatedly, the *principle of contrast* (Clark, 1987)—that a difference in form within a language signals a difference in meaning—may also lead an infant to exclude a name-known object as the referent of a novel label. Diesendruck and Markson (2001) argued that mutual exclusivity is an outcome of social pragmatic reasoning. Under this account, a toddler expects the speaker to refer to a familiar object with a known word. Hence, if the

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speaker uses a new word, it must refer to a novel object. All of these explanations require the infant to recognize or retrieve the names for familiar objects. A different account is that the infant is guided by the *novelty* of an object rather than prior lexical knowledge (Merriman, Marazita, & Jarvis, 1995). Hence, even without knowing the name for the familiar object, the infant is expected to map the novel label onto the novel object.

The age at which infants apply the mutual exclusivity assumption has varied across studies. Earlier investigations found that toddlers do not use mutual exclusivity until 2 years of age at the earliest (e.g., Merriman & Bowman, 1989; Merriman & Schuster, 1991) or until there has been substantial vocabulary development (Mervis & Bertrand, 1994). Subsequent investigation has pushed back the age at which infants apply mutual exclusivity to their word learning. Markman, Wasow, and Hansen (2003) found evidence for mutual exclusivity in an object search task with 15- to 17-month-olds. Similarly, Halberda (2003) found evidence for mutual exclusivity at 17 months of age in an intermodal preferential looking task.

The computations involved in mutual exclusivity have yet to be identified. How does the infant judge the novelty of a label? Does the infant need to retrieve or know the name for the familiar object? One response to these questions is to investigate how stimulus properties determine the use of mutual exclusivity. For example, Merriman and Bowman (1989) varied both the lexical status of an object (i.e., whether the name for an object was known or unknown) and the novelty of an object (through preexposure) in one experiment and found that object novelty was more important than lexical status in guiding 2-year-olds' mapping of a novel label (see also Merriman & Schuster, 1991).

An alternative approach to understanding the cognitive processes underlying mutual exclusivity is to study the development of the word-learning strategy. Halberda (2003) found evidence of mutual exclusivity in an intermodal preferential looking task at 17 months of age. Infants were presented with one familiar object and one novel object, and they heard a novel label. Whereas 17-month-olds increased attention to the novel object on hearing the novel label, 16-month-olds did not. In contrast, 14-month-olds increased attention to the familiar object. Based on these developmental changes, Halberda suggested that mutual exclusivity is implemented as the logical argument "Not *A*, therefore *B*" (the disjunctive syllogism). The 14-month-olds' attention to the familiar object in response to the novel label might represent the first step in ruling out the familiar object as the referent; however, they apparently struggled to complete this step.

If infants respond systematically to novel labels from as young as 14 months of age, we might be able to observe other precursors to mutual exclusivity at even younger ages. One enduring question is whether mutual exclusivity, as a linguistic constraint, might emerge from simpler learning mechanisms. Theories of associative learning (e.g., Mackintosh, 1975; Pearce & Hall, 1980) predict the *selective* formation of new associations. For example, preexposure to a stimulus reduces the associability of the stimulus, a phenomenon known as *latent inhibition* (see Lubow, 1973, 1989). A basic learning mechanism of this kind could guide the infant toward selectively associating a novel label with a novel object without needing to retrieve the names of familiar objects to exclude them as potential referents.

Some studies demonstrate that object novelty can facilitate or disrupt the mutual exclusivity response depending on whether the name-known or name-unknown category exemplar is the more novel one (Merriman & Bowman, 1989; Merriman & Schuster, 1991). It is also well known that from birth infants typically prefer novel stimuli over habituated stimuli (e.g., Slater, Morison, & Rose, 1982, 1983). Thus, even very young infants might respond systematically to familiar and novel objects on hearing a novel label. If evidence for the use or development of the mutual exclusivity response can be found for infants prior to any substantial vocabulary development, this would suggest that the mutual exclusivity assumption starts out as a general constraint on learning.

We report an intermodal preferential looking experiment with 10-month-olds to investigate their attention to familiar and novel objects on hearing different kinds of labels and phrases. On each trial, infants were presented with one familiar object and one novel object. Infants heard either a familiar label, a novel label, or a "neutral" directive phrase. We predicted that 10-month-olds would attend more to a novel object on hearing a novel label compared with hearing either a familiar label or a neutral phrase. Infants' responses on familiar label trials and parental vocabulary report can be used to check whether the infants know the familiar object names, facilitating analysis and interpretation of their behavior.

Experiment 1

Method

Participants

Participants were 42 full-term 10-month-olds (mean age = 10.1 months, range = 9.7–10.5, 24 boys and 18 girls). An additional four infants were excluded due to fussiness (1), parental interference (1), refusal to look (1), or side bias (1). All infants had healthy hearing and vision, were recruited via the local maternity ward, and came from homes where only English was spoken.

Stimuli

Speech stimuli were recorded from a native female speaker of English in an infant-directed manner. Stimuli were six familiar labels (*ball*, *car*, *cup*, *shoe*, *sock*, and *spoon*) and two novel labels (*meb* and *wug*), each uttered in the frame "Look! ... Look at the [label]! ... Look! [Label]!" and the control phrase "Look! ... Look at that! ... Oooh! ... Look there!" The phrase "Look!" was used as an attention stimulus. Visual stimuli were color images of six typical object exemplars corresponding to the six familiar labels and six novel objects that the infants were unlikely to have encountered (e.g., accordion, hair curler). The familiar objects were selected as commonplace items that the infants were likely to have frequently encountered in their home environment or elsewhere. Examples are provided in Fig. 1. A red cross was used as an attention stimulus.

Design

The experiment consisted of 12 trials, each presenting a familiar object and a novel object. Each trial lasted 10 s and was accompanied by one of three types of auditory stimulus—*familiar label* trials, *novel label* trials, or *control* trials—presenting the phrase "Look! ... Look at that! ... Oooh! ... Look there!" Label onsets were at 4633 and 7133 ms during the trials (onsets were for "that" and "there" during control trials). Allowing for a 367-ms processing latency (Swingley & Aslin, 2000), trials were split into four 2.5-s phases: two prenaming and two postnaming phases (see Fig. 2).

The 12 trials were split into two halves of 6 trials. A different set of objects and labels was presented in each half. Each half was divided into two blocks of 3 trials. The first block in each half presented one example of each trial type (see Fig. 1). The second block in each half presented the same sequence of trials as the first block, counterbalancing for side of presentation. Therefore, every trial had both an original presentation and a repeat presentation. For a given infant, each pair of objects

Fig. 1. Example of a trial block.

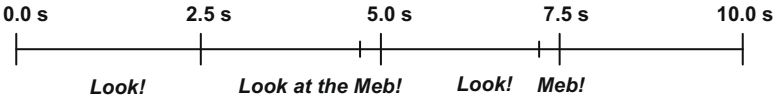

Fig. 2. Trial timeline.

served under only one of the three conditions. Across the experiment, infants heard two novel labels, two familiar labels, and the control phrase. The order of trials within a block was randomized for each infant.

To create the pairs of object images, two sets of six familiar and novel object pairs were randomly constructed, with the constraint that no pair was repeated across sets. Approximately half of the infants were tested on one set, and the remaining infants were tested on the other set. Across infants, each pair of objects served under each of the three trial types. Each novel label was rotated across six object pairs. Within each half of the experiment, familiar and novel objects appeared equally to the left- and right-hand sides of the display. Side of presentation was counterbalanced for every object pair across blocks.

Procedure

Prior to participation, parents completed a British adaptation of the MacArthur–Bates Communicative Development Inventory (CDI) (Hamilton, Plunkett, & Schafer, 2000). Infants sat on their caregivers' laps facing a wide-screen display (1.1 × 0.4 m) with their eyes at a distance of approximately 0.8 m, level with the vertical midpoint of the images and at an equal horizontal distance from both images. Images were positioned at a distance of 62 cm center to center, each with a display size of 32 × 24 cm. Two cameras mounted directly above the horizontal midpoints of each image recorded infants' eye movements. Synchronized camera signals were routed via a digital splitter to produce two time-locked images. Auditory stimuli were delivered via two loudspeakers centrally positioned side by side above the display. Caregivers were asked to keep their eyes closed, to wear headphones playing music, and to not point at the screen. A trial was launched by the experimenter when an infant looked toward the screen. If the infant looked away between trials, the attention stimuli were presented to return the infant's gaze to center.

Scoring

Digital videos were coded offline on a frame-by-frame basis (every 40 ms) by a skilled blind coder. Every fixation was coded as either left looking, right looking, or other looking. Coding reliability was assessed by a second blind coder for a random sample of 15% of infants (n = 7). The mean intraclass correlation coefficient was r = .984 (range = .957–.997).

Results

Main analysis

A proportion of familiar object fixation measure (total duration of fixations to the familiar object divided by total duration of fixations to both objects) was calculated for each of the four 2.5-s trial phases (see Fig. 2) to observe how infants' looking behavior unfolded during a trial. This trial phase factor was entered into a preliminary repeated-measures analysis of variance (ANOVA) with the factors of experiment half, trial repetition, and trial type. There were no significant interactions or main effects for experiment half or trial repetition (all $ps > .20$)[1]; further analyses are collapsed across these factors.

Fig. 3 illustrates how attention to the familiar object unfolded as a function of trial type. During the first three trial phases, there was little difference between trial types. However, during the final trial

[1] In total, 18 infants contributed data to all 48 cells of the Experimental Half × Trial Repetition × Trial Type × Trial Phase design. Further analysis collapsed across the experiment half factor, in which 39 of 42 infants contributed data, also did not reveal any interactions or main effects for trial repetition (all $ps > .40$).

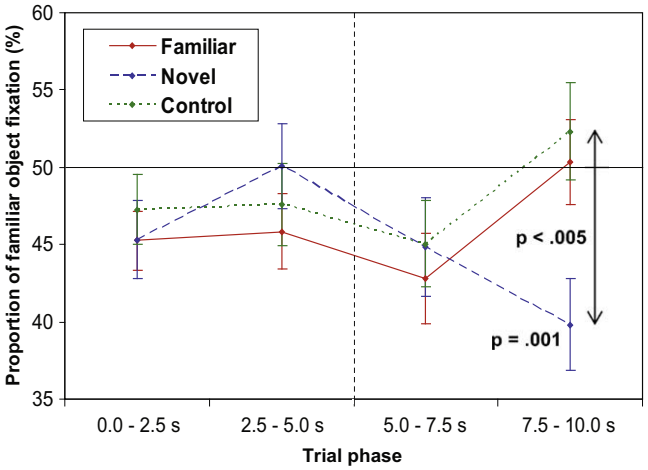

Fig. 3. Proportions of familiar object fixation as a function of trial type. Error bars are ±1 standard error.

phase, attention to the familiar object was lower during novel label trials than during either familiar label or control trials. In a repeated-measures ANOVA, there was a significant interaction between trial type and trial phase, $F(4.6, 185.4) = 2.36$, $\eta_p^2 = .06$, $p < .05$ (Greenhouse–Geisser corrected). There were no main effects (all $ps > .15$). An analysis of simple main effects for each trial phase did not reveal significant differences between conditions for the first three trial phases (all $ps > .50$), but it revealed a significant effect of condition for the fourth trial phase, $F(2, 80) = 4.35$, $\eta_p^2 = .10$, $p = .016$.

During the fourth trial phase, the proportion of familiar object fixation in the novel label condition was significantly different from both the control condition, $t(41) = 3.02$, $d = .47$, $p < .005$, and the familiar label condition, $t(40) = 2.41$, $d = .38$, $p < .025$. The familiar label and control conditions were not significantly different from each other, $t(40) = 0.43$, *ns.* The proportion of attention to the familiar object in the novel label condition at 39.8% ($SD = 19.3$) was significantly below chance, $t(41) = -3.41$, $d = .53$, $p = .001$, and indicates a preference to fixate the novel object. The proportion of attention to the familiar object in both the familiar label condition ($M = 50.4\%$, $SD = 17.4$) and the control condition ($M = 52.4\%$, $SD = 20.3$) was not significantly different from chance for the fourth trial phase (all $ps > .40$).[2]

We conducted a more detailed post hoc analysis to understand how infants' looking behavior changed between the third and fourth trial phases to produce the divergence between conditions evident during the final trial phase. Fig. 3 shows that there is an increase in looking to the familiar object across the last two trial phases during familiar label and control trials. Paired-sample *t* tests confirm that these increases in attention to the familiar object were significant for both familiar label trials, $t(40) = 2.18$, $d = .34$, $p < .05$, and control trials, $t(41) = 2.31$, $d = .37$, $p < .05$. Conversely, Fig. 3 illustrates an increase in looking to the novel object between the last two trial phases, although this trend was not significant, $t(41) = 1.40$, *ns.*

Finally, it is worth noting that even though there were no significant differences between conditions during the two prenaming phases (0.0–2.5 and 2.5–5.0 s), there was a preference across all conditions to fixate the novel object more than the familiar object. Averaging across conditions and the first two trial phases, preference for the familiar object ($M = 47.0\%$, $SD = 7.0$) was significantly below chance, $t(41) = -2.77$, $d = .43$, $p = .008$. The relation between this "baseline" preference for the novel object and the subsequent effect of hearing different labels is discussed below.

[2] One infant did not contribute to the Trial Type × Trial Phase analysis due to missing data for the fourth trial phase of the familiar label condition. However, the exclusion of this infant resulted in a highly similar pattern of findings for the fourth trial phase: novel label versus control condition, $p = .007$, and novel label versus chance, $p = .003$.

CDI analysis

Parental reports indicated that the mean number of words understood by the infants was 25 words (range = 0–102) and the mean number of words produced was 1 word (range = 0–6). Parents reported low levels of comprehension for the six familiar object labels used in the study: *ball* (29%), *car* (19%), *cup* (5%), *shoe* (7%), *sock* (10%), and *spoon* (12%). The inclusion of a median split on infants' comprehension vocabulary as a factor in the main analysis did not reveal any significant interactions with the other experimental variables. There was a main effect of vocabulary, where high-vocabulary infants had a lower preference for the familiar object (i.e., greater preference for the novel object) than low-vocabulary infants (43.0 versus 50.0%), $F(1, 39) = 12.4$, $\eta_p^2 = .24$, $p = .001$. Finally, the exclusion of trials where infants were reported to comprehend the name of the familiar object resulted in a similar pattern of findings to those reported in the main analysis.

Discussion

During the experiment, infants' responses to familiar and novel objects did not initially differ according to the type of labeling event. Yet toward the end of the trials, interest in the novel object was significantly greater after hearing a novel label than after hearing a familiar label or neutral phrase. Therefore, novel labels enhance 10-month-olds' interest in novel objects. The current findings are evidence for the mutual exclusivity response at a considerably younger age than has been demonstrated previously (see Halberda, 2003; Markman et al., 2003).

It is notable that there was no difference in looking behavior across conditions following the first presentation of a label. However, interest in the novel object differed across conditions following the second presentation of a label. It is not certain whether the second presentation of the label was necessary to produce this difference; the difference between conditions might have slowly unfolded in response to the first label (see Mather & Plunkett, 2009, for the role of label repetition in mutual exclusivity). In either case, it was specifically a novel label that sustained interest in the novel object during the 7.5- to 10.0-s phase of the trial.

In a previous intermodal preferential looking study of mutual exclusivity, 19-month-olds displayed a prenaming preference for the familiar object (White & Morgan, 2008). Therefore, mutual exclusivity has been indexed as a decrease in attention to the familiar object (i.e., an increase in attention to the novel object) between the pre- and postnaming phases of novel label trials (Halberda, 2003; White & Morgan, 2008). In contrast, we found a prenaming preference for the novel object. Thus, for the 10-month-olds, the novel label did not serve to shift attention away from the familiar object. However, attention to the novel object persisted during novel label trials but not during familiar label or control trials. Thus, attention to the novel object was congruous with hearing a novel label, but not with hearing either a familiar label or even a neutral phrase. In fact, attention to the novel object increased across the postnaming phases of the novel label trials, although this was not a significant trend.

We had predicted that 10-month-olds would produce the mutual exclusivity response because either a linguistic constraint or a general learning mechanism could cause this behavior. The young age of the infants and their limited vocabulary resources lend support to the latter explanation. However, it is important to examine the experimental evidence for whether or not infants knew the names for the familiar objects. If the infants were able to draw on their knowledge of the names for the familiar objects, their behavior during the experiment would be consistent with the use of a language-specific principle.

During familiar label trials, the infants did not look at the familiar object on hearing it named. One explanation is that the infants did not comprehend the familiar object names. Parental vocabulary reports support this interpretation, with very low levels of reported comprehension for all six familiar object names. However, a study by Houston-Price, Mather, and Sakkalou (2007) found that British parents appear to underestimate comprehension vocabulary for infants between 15 and 21 months of age. It is currently unknown whether parents underreport vocabulary for younger infants. A related possibility is that the infants had weak representations of the familiar word mappings but could not inhibit attention to the novel objects. If the infants had difficulty in recognizing the familiar word mappings, *recall* of the familiar object names during novel label trials would have proven to be difficult. Attention to the familiar object did increase significantly across the postnaming phases of

familiar label trials. However, the infants did not look significantly longer at the named familiar object than the novel object during the final trial phase. Furthermore, the similar pattern of behavior during control trials suggests that the infants' behavior during familiar label trials is not necessarily driven by comprehension of specific word mappings.

In summary, both the parental reports and the experimental data suggest that the 10-month-olds did not know the familiar word mappings. Nonetheless, we wished to understand whether 10-month-olds might evidence comprehension of the familiar words under different conditions. In Experiment 1, infants' interest in novel objects might have disrupted attention to the named familiar objects. Hence, we ran a further experiment to assess 10-month-olds' knowledge of the familiar label mappings in the absence of novel objects. In Experiment 2, we paired familiar objects together, labeling each object across trials. The trials otherwise had the same timing of visual and auditory stimuli as in Experiment 1.

Experiment 2

Method

Participants

Participants were 24 full-term 10-month-olds (mean age = 10.1 months, range = 9.8–10.4, 11 boys and 13 girls). An additional six infants were excluded due to fussiness (4), difficulty in coding (1), or equipment failure (1). All infants had healthy hearing and vision, were recruited via the local maternity ward, and came from homes where only English was spoken.

Stimuli

The visual and auditory stimuli were the six familiar objects and labels used in the familiar label condition of Experiment 1, with the exception of the auditory attention stimulus, which was a chiming sound.

Design

The experiment consisted of 12 trials, each presenting two familiar objects and the name for one of the two objects. Each trial lasted 10 s, and label onsets were at 4633 and 7133 ms during the trial. Infants were tested on one of two sets of familiar object pairs. Each set was created by randomly pairing the six objects into three object pairs, with the constraint that there were different pairings in each set (*ball–spoon*, *car–sock*, *cup–shoe* or *ball–cup*, *spoon–sock*, *car–shoe*). Each object pair was presented four times during the experiment, and each object was named on two trials: once on the left and once on the right of the screen. The order of trials was randomized for each infant.

Procedure

The procedure was identical to that of Experiment 1. Infants sat on their parents' laps facing a wide-screen display (0.7 × 0.4 m) with their eyes at a distance of approximately 0.65 m and at an equal horizontal distance from both images. Images were positioned at a distance of 50 cm center to center, each with a display size of 20 × 15 cm.

Scoring

Digital videos were coded offline on a frame-by-frame basis (every 40 ms) by a skilled blind coder. Every fixation was coded as either left looking, right looking, or other looking.

Results and discussion

Parental reports of vocabulary were similar to those for Experiment 1. The mean comprehension vocabulary was 25 words (range = 1–159), and the mean production vocabulary was 1 word (range = 0–4). Parents reported low levels of comprehension for the six familiar object labels used in the study: *ball* (21%), *car* (25%), *cup* (0%), *shoe* (8%), *sock* (13%), and *spoon* (8%).

A proportion of target looking measure was calculated by dividing the total duration of fixations to the target (i.e., named) object by the total duration of fixations to both objects. This measure was calculated for each of the four 2.5-s trial phases. Fig. 4 shows how the mean proportion of target looking changed across the pre- and postnaming trial phases. There was a peak in looking to the named object during the first postnaming phase (5.0–7.5 s), although a mixed-model ANOVA with the factors of trial phase and a median split on comprehension vocabulary did not reveal any significant main effects or interactions. (Even with the exclusion of the comprehension vocabulary factor, there was no significant effect of trial phase.) We further compared the proportion of target looking with chance for the two postnaming phases. There was a significant preference for the target object during the 5.0- to 7.5-s trial phase (M = 53.3%, SD = 7.5), $t(23) = 2.14$, $d = .44$, $p = .043$ ($p_{critical} = .05$, one-tailed).

The preferential looking data suggested greater comprehension of the six familiar object names than parental vocabulary reports. To understand this discrepancy, we examined whether there were differences in looking behavior across the six familiar labels. A repeated-measures ANOVA with the factors of trial phase and object label revealed a significant main effect of object label, $F(5, 115) = 2.96$, $\eta_p^2 = .11$, $p < .025$. No other main effects or interactions were significant. One-sample tests revealed spurious effects for *ball* and *cup* trials, but these were the outcome of a simple preference to look at the ball over the paired object. There was an effect of naming only when *car* was labeled. A repeated-measures ANOVA for *car* trials revealed a significant effect of trial phase, $F(3, 69) = 4.20$, $\eta_p^2 = .15$, $p < .01$. One-sample tests revealed a significant preference for the target object (car) only during the 5.0- to 7.5-s trial phase (M = 63.6%, SD = 22.2), $t(23) = 2.99$, $d = .61$, $p < .01$.

These analyses suggested that the overall effect of naming is driven mostly by *car* trials. Hence, these infants appeared to understand the label *car* but not the other object–label mappings. This raises the possibility that knowledge of the object–label mapping for *car* might be responsible for mutual exclusivity effects in Experiment 1. We examined the effect of including *car* as a familiar object in Experiment 1 through exclusion of all trials in which the car served as the familiar object (one sixth of all trials). Aside from reduced statistical power, the data retained a pattern similar to that in the original analysis. Critically, mean preference during the last trial phase was not significantly different from chance for the familiar label and control trials but was significantly below chance during novel label trials (M = 41.6%, SD = 22.8), $t(41) = -2.38$, $d = .37$, $p < .025$. Although Experiment 1 involved a different group of infants from that of Experiment 2, we may conclude that knowledge of the *car* map-

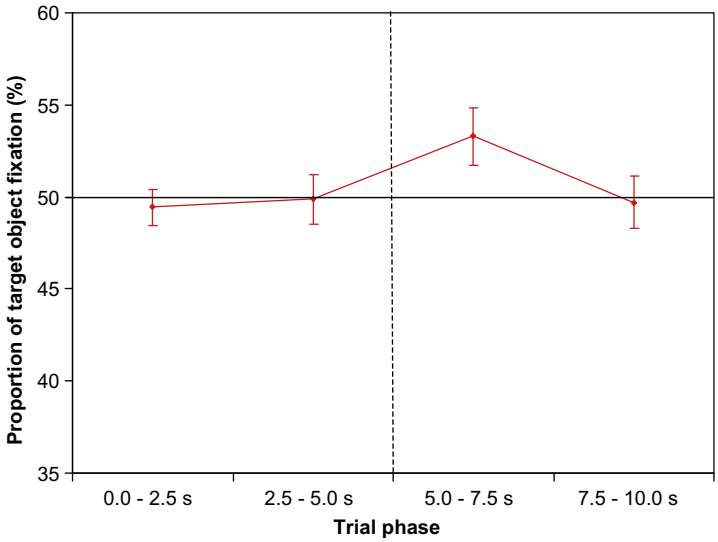

Fig. 4. Proportions of target object fixation. Error bars are ±1 standard error.

ping was not driving their novelty preference in novel label trials. It is worth noting that the CDI reports in Experiment 1 rated *ball* as more likely to be comprehended by the infants than *car* (the reverse pattern was obtained in Experiment 2). However, excluding *ball* trials from the analyses of Experiment 1 also failed to produce any change in the overall pattern of results.

General discussion

In Experiment 1, we investigated 10-month-olds' attention to familiar and novel objects according to whether they heard a novel label, a familiar label, or a neutral phrase. If novel labels cause greater attention to a novel object than either familiar labels or neutral phrases, this would provide evidence for the mutual exclusivity response at 10 months of age. The results of the experiment provided clear evidence that novel labels sustain a preference for novel objects, whereas familiar labels or neutral phrases do not. We chose to investigate infants at an age prior to any substantial vocabulary development to determine whether the mutual exclusivity response might originate as a general constraint on learning rather than a language-specific mechanism. To identify the type of mechanism underlying the mutual exclusivity response at 10 months of age, we examined whether infants knew the names of the six familiar objects used in Experiment 1. Parental vocabulary reports and infants' looking behavior during Experiment 1 suggested that the infants did not know the names for the familiar objects. Experiment 2 also failed to provide any clear evidence that 10-month-olds knew the names for the familiar objects.

Therefore, the evidence favors an explanation of novel label trials where infants do not need to know the name of the familiar object. Accounts of mutual exclusivity based on word-learning principles or pragmatic reasoning require the infant to know the name for the familiar object. An exception is the *feeling-of-novelty* principle (Merriman et al., 1995), that is, the expectation that "new names will map onto physical entities that feel new" (p. 155). This principle does not require the retrieval of familiar object names and could account for the current findings. However, the feeling-of-novelty principle is nonetheless a lexical principle couched in terms of mappings between names and objects. The limited vocabularies of the 10-month-olds suggest the operation of a general cognitive process rather than a later-emerging linguistic constraint.

Latent inhibition (Lubow, 1973, 1989) is an example of a general learning phenomenon where a novel stimulus is more likely to enter into an association compared with a familiar stimulus. However, it should be noted that some aspects of latent inhibition, such as its context and stimulus specificity (e.g., Lubow, 1973), are incompatible with the current findings. The infants would not have been exposed to the specific familiar object stimuli prior to participation—a condition assumed to be a prerequisite for latent inhibition. However, a mechanism based on stimulus novelty may ultimately provide a more compelling explanation of the 10-month-olds' behavior than a mechanism based on retrieval of lexical knowledge. Likewise, Merriman and colleagues (1995) cited evidence that it is easier to learn associations between similar attributes than between different attributes (see Rescorla, 1980); hence, they argued that infants may prefer to associate "novelty with novelty."

A possible caveat is that we cannot entirely rule out the possibility that 10-month-olds have a conceptual understanding of how labels map onto objects. For example, Xu, Cote, and Baker (2005) and Dewar and Xu (2007) showed that 9- to 12-month-olds can use different labels to differentiate objects within an object individuation task. Although their experiments were not word-learning tasks, they support the idea that novel labels can impact infants' processing of novel objects prior to any substantial vocabulary development.

Although the infants showed no evidence of comprehending the familiar word mappings, the infants in Experiment 1 clearly discriminated the familiar words from the novel words, as evidenced by the difference in looking behavior between the familiar label and novel label conditions. Under all theoretical accounts of mutual exclusivity, the ability to judge the novelty of a label is a central process. Our results demonstrate that 10-month-olds can match a label to stored phonological forms to judge the novelty of a label. The search for matching forms might be restricted to those activated by the familiar object such as a weak representation of the familiar object name. Alternatively, discrimination of the familiar and novel labels might be due to recognizing that the novel labels do not match

any stored phonological forms. Many studies have shown that young infants can discriminate words familiarized in the laboratory from novel words (e.g., Jusczyk & Aslin, 1995; see Jusczyk, 1999, for a review). The current results further demonstrate that novel words are discriminated from stored phonological forms, some of which might not have been heard for some time prior to participation in the study.

Further research is necessary to understand whether a general associative learning mechanism underlies an early mutual exclusivity response, such as experimentally manipulating the familiarity of objects and labels. Nonetheless, an explanation of the 10-month-olds' behavior based on object novelty could account for the apparent discrepancy with Halberda (2003), who found that 14-month-olds increased their attention to a *familiar* object on hearing a novel label. Hence, the 10-month-olds in the current study appear to be more adept than the 14-month-olds in Halberda's (2003) study at attending to a novel object in response to a novel label. One possibility is that differences between these studies in the salience or familiarity of the stimuli are responsible for the discrepancy in the response to novel labels. Alternatively, the mechanism underlying the observed effects could differ between these two ages. Whereas a general learning mechanism might operate at 10 months, 14-month-olds might be developing a language-specific constraint to guide the mutual exclusivity response. Thus, 14-month-olds could be working through a more complex sequence of computations than 10-month-olds.

Why do 10-month-olds not have larger vocabularies if a novel label enhances their attention to a novel object? Some researchers (e.g., Carey & Bartlett, 1978; Mervis & Bertrand, 1994) have argued that the ability to map novel labels to novel objects is a mechanism for *fast-mapping*, that is, the rapid acquisition of novel word meanings. One consideration is that a mechanism favoring attention to a novel object on hearing a novel label leads only to the formation of fragile associations in 10-month-olds. Nevertheless, this bias is a potential precursor to the development of a language-specific principle, allowing mutual exclusivity to emerge from the interaction of a basic learning mechanism with the linguistic environment. A later-developing principle, specifically geared to the task of learning language, would produce more robust word mappings. However, our results indicate that the selective attention to novelty required for the operation of mutual exclusivity might be in place even at the earliest stages of vocabulary development.

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