

# Linking object names and object categories: Words (but not tones) facilitate object categorization in 6- and 12-month-olds

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## 1. Introduction

The infant's environment is filled with objects. If each were treated as unique, this complexity would quickly become overwhelming. Therefore, the task for the young infant is to construct categories that capture similarities among objects and to learn words that express these categories. And the task for developmental researchers is to figure out how infants do just that.

Recent work has revealed that categorization and word learning are not isolated abilities that develop independently, but are linked early in life. In particular, providing the same name (e.g., "dog") for a series of distinct objects (e.g., Golden Retriever, Collie, Poodle) helps infants to identify commonalities among those objects and promotes the formation of object categories (Balaban & Waxman, 1997, Fulkerson & Haaf, 2003, Waxman & Markow, 1995). This phenomenon was first documented in a study with 12- to 13-month-old infants (Waxman & Markow, 1995). In that study, infants were familiarized to four different objects from the same category (e.g., animals) with either a labeling phrase (e.g., "See the fauna?", "See the faunish one?") or a non-labeling phrase (e.g., "See here?"). Following familiarization, infants' detection of the category was assessed with a novelty-preference test in which a new object from the familiarized category (e.g., a new animal) was presented with an object from a different category (e.g., vehicle). Infants hearing novel words successfully formed categories, as evidenced by their preference for the out-of-category test object. Infants in the no word control condition did not form these categories. Other studies reveal that object naming also supports the acquisition of completely novel categories (Booth & Waxman, 2002; Fulkerson & Haaf, 1998, in press) and directs infants' attention beyond similarities that can readily be perceived, focusing them on deeper, nonobvious commonalities (Graham, Kilbreath, & Welder, 2004; Welder & Graham, 2001).

Findings such as these point to an early and powerful link between object naming and object categorization. But what is the origin of this link and when does it become specific to language? The weight of the currently available evidence indicates that words and object categories may be linked from the onset of lexical acquisition. Several studies have demonstrated that infants start out with a general expectation that words (independent of their grammatical form class) highlight a broad range of commonalities among objects, including category- and property-based commonalities. This broad expectation has several distinct developmental advantages: It guides infants' earliest efforts to map words to their meanings and promotes the acquisition of object categories. Moreover, with exposure to the language under acquisition, this initially broad expectation becomes increasingly fine-tuned, permitting infants to discover the grammatical forms marked in their language (e.g., noun, verb, adjective) and map them to distinct types of meaning (e.g., object categories, object properties, event categories) (Waxman, 1998; Waxman & Lidz, in press).

Moreover, current evidence suggests that this link may be specific to language. For example, for infants as young as 9 months of age, words facilitate object categorization, but nonlinguistic sounds (tones) do not (Balaban & Waxman, 1997; Fulkerson & Haaf, 2003). In one study, 9-month-olds were visually familiarized to line-drawn objects from a single category (e.g., rabbits); these were presented either in conjunction with a word (e.g., "rabbit") or a pure tone. Results of a novelty-preference test indicated that infants hearing the word detected the category, while those hearing the tone did not (Balaban & Waxman, 1997). The same pattern of results emerged in a different task, using a face-to-face object-examining procedure and more complex sounds: 9-month-olds successfully formed categories when objects were named, but not when they were presented with a melody or mouth sounds (Fulkerson & Haaf, 2003). In sum, the facilitative effect of novel words on categorization is robust in infants as young as 9 to 12 months of age. And although there are circumstances in which non-linguistic stimuli (e.g., tones, beeps, gestures) do promote object categorization, a careful review of the evidence reveals that this is the case only when interpersonal, social, and contextual cues are sufficiently strong to convey to the infant that the non-linguistic stimulus is being offered as a name (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

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In the present study, we pursued the evolution of the noun-object category link by comparing the influence of novel words vs. novel tones on object categorization in a novelty-preference task. We considered infants at two strategically-selected developmental points. To capture the very commencement of word learning, we included infants at 6 months, when infants first begin to a) comprehend highly familiar words such as “mommy” and “daddy” (Tincoff & Jusczyk, 1999) and b) reveal a preference for lexical (open-class) over grammatical (closed-class) words (Shi & Werker, 2001). For comparison, we included 12-month-olds, who have typically begun to produce their first words and who have previously demonstrated their sensitivity to a link between words and object categories (Fulkerson & Haaf, 1998, in press; Waxman & Braun, 2005; Waxman & Markow, 1995). Half of the infants at each age were randomly assigned to either a Word or Tone condition. This design permitted us to ask a) whether words promote categorization in infants at both ages, and b) whether this effect is specific to words.

For the 12-month-olds, our predictions were clear: We expected that novel words – but not tones – would facilitate the formation of object categories (Balaban & Waxman, 1997; Waxman & Markow, 1995; Fulkerson & Haaf, 1998, 2003, in press). For the 6-month-olds, we reasoned as follows. If novel words have conceptual consequences just as soon as infants begin to parse them from the speech stream, then words should facilitate the formation of object categories at 6 months. If this is a general effect, then tones (like words) should promote object categorization. However, if words play a unique conceptual role from the start, then tones should not promote object categorization.

## **2. Method**

### **2.1. Participants**

The final sample included a total of 64 six- and twelve-month-old infants. There were 19 male and 13 female 6-month-olds ( $M = 184.3$  days,  $range = 167$  to  $199$  days), and 12 male and 20 female 12-month-olds ( $M = 366.7$  days,  $range = 356$  to  $377$  days). All infants were full-term, healthy, learning English as their first language, and free from any known vision or hearing problems. Infants were identified from county birth records in the greater Toledo, Ohio area, and were predominantly from white middle-class families: 84.3% White Non-Hispanic, 8.3% Multi-Racial, 3.2% Black Non-Hispanic, 3.2% Hispanic, and 1% unknown race/ethnicity; 95.8% of mothers and 86.5% of fathers had at least some college education; 58.3% of mothers and 93.8% of fathers were employed. Parents of infants were first sent a letter, and then contacted by phone. A parent or legal guardian of each participating infant gave both verbal and written informed consent. One additional 6-month-old was tested but not included in the final sample due to fussiness.

### **2.2. Stimuli**

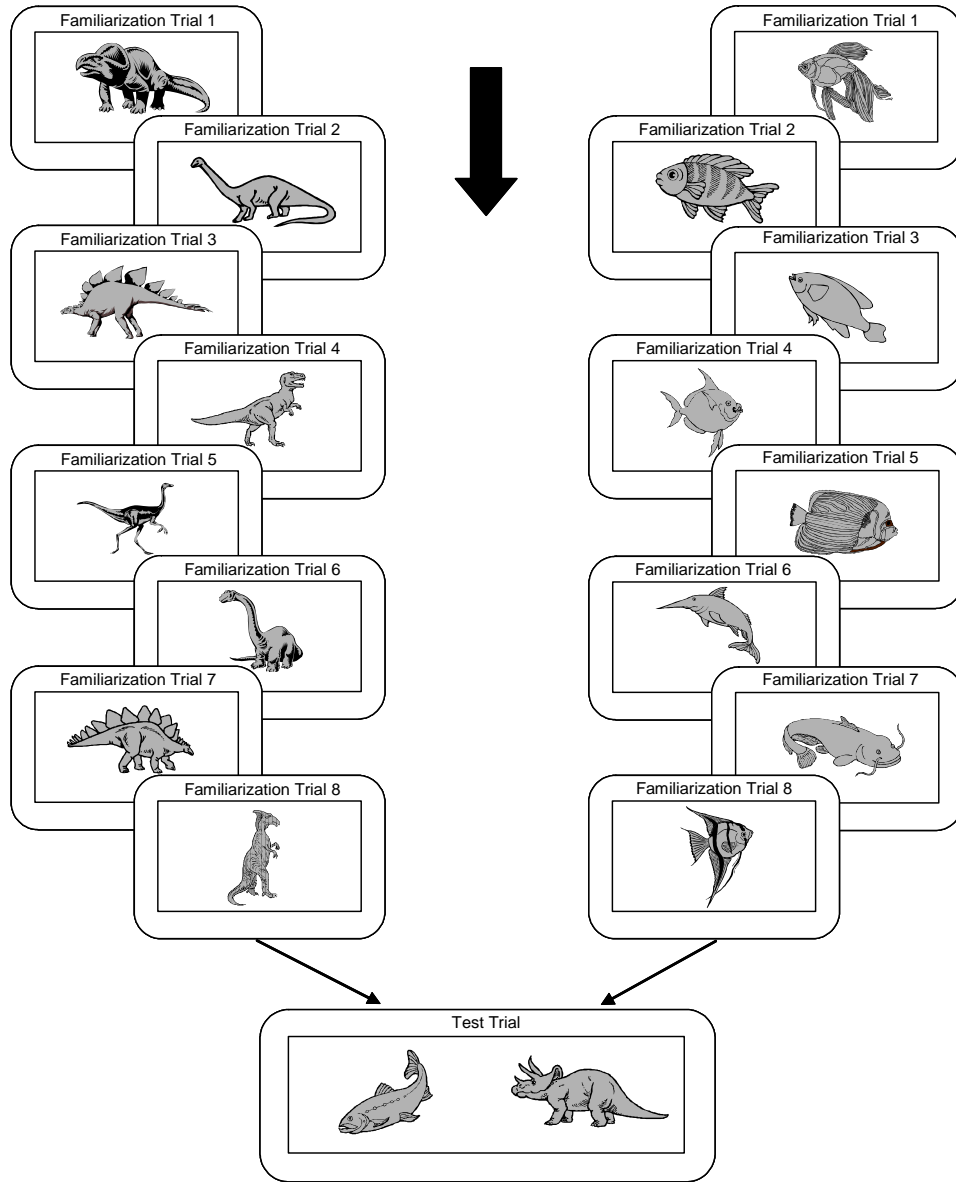
#### **2.2.1. Visual Stimuli**

Visual stimuli included 20 slides of line-drawn dinosaurs and fish, shown in Figure 1. All stimuli were outlined in black, filled with a solid color, and presented on a white background. There were two familiarization sets of eight stimuli each and two test sets of two stimuli each. Stimuli within a familiarization set varied in color; stimuli within a test set were identical in color. Although the exact sizes varied, stimuli averaged 14.5 cm in width ( $SD = 2.3$  cm) and 9.7 cm in height ( $SD = 2.0$  cm). The average angular size was 13.3 by 9.0 degrees.

#### **2.2.2. Auditory Stimuli**

The auditory stimuli consisted of two sets of labeling phrases (“Oh look, it’s a toma! Do you see the toma?” and “Oh look, it’s a modi! Do you see the modi?”) and two sequences of pure tones (400 Hz, 800 Hz). The labeling phrases were spoken by a female using characteristics of infant-directed speech (high pitch, exaggerated pitch contours; Fernald & Thomas, 1984). The tone sequences were created using Adobe Audition 1.0 and were matched to the labeling phrases in total length (3.4 s) as well as the duration of each syllable and pause. All auditory stimuli were recorded onto audiotape and played at a volume of approximately 92 dB.

**Figure 1. Representation of familiarization and test stimuli.**



### **2.3. Apparatus**

Infants were seated on a parent's lap in a three-sided observation chamber, with its interior walls and ceiling covered in a medium-gray material. The rear wall of the observation chamber contained two 18 by 18 cm (16.4 by 16.4 degrees visual angle) projection screens positioned 61 cm from infants' eye level. The lateral separation between screens was 30 cm (26.2 degrees). A video camera located behind the rear wall of the observation chamber recorded infants through a 6 cm hole centered 11 cm below the projection screens. Visual stimuli were presented by slide projector; auditory stimuli were played on a tape player and presented through a hidden speaker centered 58 cm below the two screens. A computer equipped with an input/output buffer system timed trial durations, recorded fixation times, operated the slide projectors, and controlled the output of sound to the speakers.

## 2.4. Procedure

Infants were tested using a visual familiarization/novelty-preference procedure. During the familiarization phase, infants were shown eight different exemplars from a given category (e.g., dinosaurs), one at a time, in random order, for a fixed duration of 20 s each. On each familiarization trial, a single stimulus exemplar was displayed on one of the two projection screens. The lateral position of the familiarization stimulus was determined randomly on the first trial and alternated on each subsequent trial. Infants were assigned to one of two different between-participant sound conditions. In the Word condition, each familiarization exemplar was presented with a labeling phrase (e.g., “Oh look, it’s a toma! Do you see the toma?”); in the Tone condition familiarization exemplars were presented with a sequence of pure tones. The auditory stimulus was presented during the initial 4 s of each familiarization trial ( $M = 3.0$  s) and once again approximately 3 s later. Timing of the onset of auditory stimuli varied slightly ( $SD = .65$  s) due to variations in the relay control of the cassette player and the time it took the computer to advance the slide projectors. The same auditory stimulus was presented on all eight familiarization trials. Familiarization stimulus set (i.e., dinosaurs, fish) and auditory stimulus were counterbalanced.

The test phase immediately followed the familiarization phase and included one 10 s trial. To ensure that infants looked at the test stimuli, timing of the trial did not commence until the onset of infants’ first visual fixation. During the test trial, infants were presented with one of two different pairs of novel stimuli, side-by-side, in the absence of any added sound. One test stimulus in the pair was from the familiarized category (e.g., a new dinosaur) and one was from the contrasting category (e.g., a fish). The test stimulus pair to which infants were assigned and the lateral position of the stimuli were completely counterbalanced in the design. Parents were not told the hypotheses of the experiment and were instructed not to talk or to influence their infant’s attention in any way during either phase of the procedure.

Infants’ visual fixations were coded from videotape by one of 15 trained observers who were blind to the hypotheses of the experiment as well as to the specific visual stimuli presented. Observers recorded the total amount of time that infants spent looking at a stimulus on a given trial. Eight different observers re-rated 25% of the infants in each age and sound condition. Reliability between observers during the test phase was  $r = .99$ .

## 3. Results

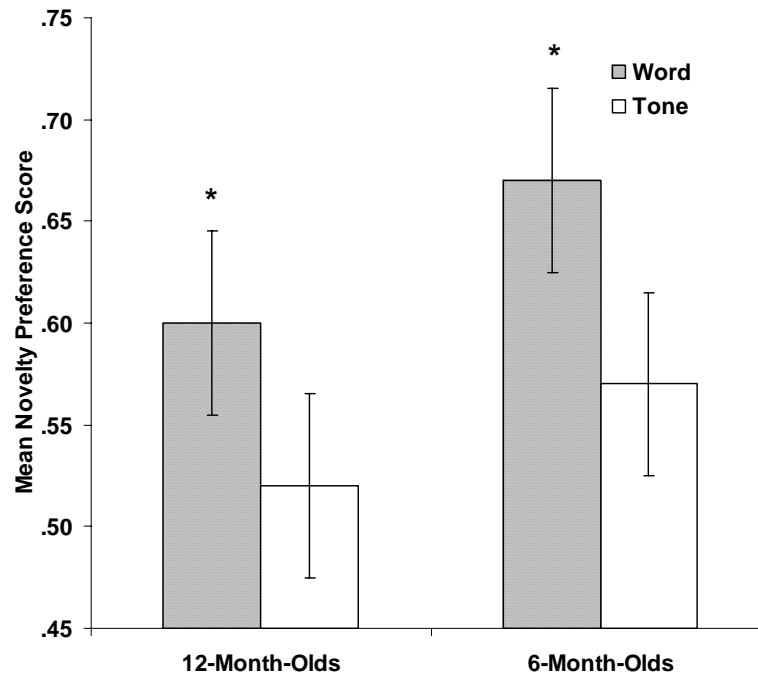
We calculated a novelty preference score for each infant by dividing total looking to the out-of-category exemplar by total looking to the out-of-category and within-category exemplars combined. If infants detect the categorical relation among the stimuli, then they should look longer at the out-of-category test stimulus than the within-category one, resulting in a novelty preference score greater than a chance value of .50.

Our predictions for the test trial were as follows. If words and tones both promote object categorization, then infants should reveal a novelty preference in both the Word and Tone conditions. If words are specifically linked to object categories, then infants should exhibit a novelty preference in the Word condition but not in the Tone condition.

Based on the existing evidence with 9-month-olds (Balaban & Waxman, 1997), we expected 12-month-olds to demonstrate categorization in the Word condition but not in the Tone condition. For 6-month-olds, our predictions were less firm. If words and object categories are not yet specifically linked, infants should categorize successfully in the Word and Tone conditions. However, if the link is already tied specifically to names, then infants should categorize successfully in the Word—but not the Tone—condition.

Novelty preference scores for each age and condition are depicted in Figure 2. As predicted, 12-month-olds demonstrated reliable novelty preferences in the Word condition ( $M = .60$ ,  $SD = .16$ ;  $t(15) 2.29$ ,  $p = .02$ ), but performed at chance in the Tone condition ( $M = .52$ ,  $SD = .15$ ,  $t(15) = .40$ ,  $p = .35$ ). This constitutes a strong replication and extension of previously published work (Balaban & Waxman, 1997; Fulkerson & Haaf, 2003, in press; Waxman & Braun, 2005; Waxman & Markow, 1995).

**Figure. 2. Mean novelty preference scores ( $\pm SE$ ) during the test trial for each age and condition.**



Strikingly, an identical pattern of results emerged for 6-month-olds. Six-month-olds in the Word condition demonstrated a reliable novelty preference ( $M = .67$ ,  $SD = .22$ ,  $t(15) = 3.11$ ,  $p = .004$ ), while 6-month-olds in the Tone condition performed at chance ( $M = .57$ ,  $SD = .20$ ;  $t(15) = 1.37$ ,  $p = .10$ ).

An analysis of individual infants' performance was consistent with the group data. We compared the number of infants in each age and condition who exhibited a novelty preference with the number that would be expected by chance. Twelve 12-month-olds exhibited a novelty preference in the Word condition ( $p = .04$ ), but only 8 did so in the Tone condition ( $p = .50$ ). Likewise, fourteen 6-month-olds revealed a novelty preference in the Word condition ( $p = .002$ ), but only eleven 6-month-olds did so in the Tone condition ( $p = .11$ ).

#### 4. Discussion

The current experiment offers two insights into the evolution of the link between object naming and categorization. First, the results reveal that this link between naming and categorization is in place as early as 6 months of age. This is the first demonstration of its kind at this young age. Coupled with previous evidence from 9- and 12-month-old infants (Balaban & Waxman, 1997; Fulkerson & Haaf, 1998, 2003, in press; Waxman & Braun, 2005; Waxman & Markow, 1995), this finding calls into serious question the claim that infants enter the process of word-learning without any *a priori* linkages between word meanings and conceptual organization (Roberts, 1997; Smith, 1999). Instead, the results suggest that words and object categories are linked even as infants first cross the threshold into word comprehension—6 months (Tincoff & Jusczyk, 1999).

Second, the results suggest that there is some degree of specificity to this linkage by 6 months of age: 6-month-olds hearing words formed object categories while those hearing tone sequences did not. This finding suggests that 6-month-olds have made some differentiation in how they link linguistic and non-linguistic stimuli to object categories. However, additional research will be necessary to identify more precisely the scope of this early link. For example, in previous work with infants 9 months of age and older, a wide range of non-linguistic sounds have failed to promote object categorization, suggesting that by 9 months, the link may be specific to linguistic stimuli (Balaban & Waxman, 1997; Fulkerson & Haaf, 2003). In the present study, the non-linguistic stimuli were pure tone sequences. It will be necessary to test 6-month-olds with a wider range of non-linguistic sounds before we can ascertain how specific this link is in 6-month-olds. Additional research is also needed to determine whether this link between words and object categories is specifically tied to object names. We know that by 12 months this is

indeed the case—phrases containing object names facilitate categorization (e.g., “Look at the dax”), but general orienting phrases (e.g., “Look at what’s here”) do not (Fulkerson & Haaf, 1998, in press; Waxman & Braun, 2005; Waxman & Markow, 1995). Whether this is also the case for 6-month-olds remains an open question, and one that we are currently pursuing in our labs.

Whatever its initial scope, we propose that the link between object naming and categorization supports both word-learning and conceptual organization, and is an important building block in early language acquisition. From the very onset of lexical acquisition, words and object categories are powerfully linked. This link serves three fundamental functions (Waxman, 1998). First, it helps to guide infants’ attention to just those aspects of the environment that they should be attending to for the rapid acquisition of words—object categories. Second, it promotes conceptual development through the efficient organization of information about objects into cognitively-manageable categories. Third, it lays the foundation for the acquisition of more fine-tuned linkages between particular types of words (e.g., count nouns, adjectives) and particular types of conceptual relations among objects (object categories, object properties).

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