Overshadowing as a Mechanism Underlying the Effect of Labels on Categorization

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Abstract

It has been suggested that labels facilitate categorization because children assume that labels refer to categories and hearing the same label associated with different entities directs attention to commonalities. However, it is also possible that labels facilitate categorization, not by directing attention to commonalities, but by overshadowing differences between compared entities. The current study tested this overshadowing hypothesis in 4-year-olds and adults. The results of the current study provide evidence suggesting that hearing the same label or hearing the same speech-like sound associated with two different entities decreased 4-year-olds' discriminabilty of these trained entities. Furthermore, accuracy was less likely to decrease when children were presented with stimuli that shared many of the same commonalities as the two trained stimuli. Experiment 3 demonstrated that these effects attenuated in adults. These findings provide a novel mechanism that may underlie how labels affect category formation.

Keywords: Cognitive Development, Attention, Categorization, Psychology; Human Experimentation.

Introduction

Language plays an important role in conceptual development. When two entities share a common label, children are more likely to perceive these entities as being more similar to each other (Sloutsky & Lo, 1999), more likely to group these entities together (Sloutsky & Fisher, 2004; Sloutsky, Lo, & Fisher, 2001), and more likely to make inferences from one entity to the other (Gelman & Markman, 1986; Sloutsky & Fisher, 2004; Welder & Graham, 2001). Although effects of labels are well documented, explanations of these effects differ considerably across theoretical positions.

According to the language-specific explanation, even young children understand that entities belong to categories, with labels highlighting categories (Gelman & Markman, 1986). Young children may also have broad assumptions about the importance of labels. According to Waxman and colleagues (e.g., Balaban & Waxman, 1997; Waxman & Booth, 2003, see also Waxman, 2003 for a review), children have broad assumptions that labels refer to categories, and hearing the same word associated with different objects directs infants' attention to commonalities among the to-be-categorized entities.

According to the general-auditory explanation, effects of labels may also stem in part from auditory input overshadowing (i.e., attenuating processing of) corresponding visual input (Napolitano & Sloutksy, 2004; Robinson & Sloutsky, 2004; Sloutsky & Napolitano, 2003). Although complete overshadowing should hinder object recognition and the formation of perceptual categories, partial overshadowing may facilitate category learning. More specifically, labels may facilitate category learning by overshadowing differences between compared entities.

Therefore, these approaches hypothesize different mechanisms underlying the effect of labels on categorization. According to the former approach, labels facilitate categorization by attracting attention to commonalities among the to-be-categorized entities. At the same time, according to the latter approach, labels facilitate categorization by overshadowing differences among the to-be-categorized entities. Because both mechanisms should result in successful categorization, a simple categorization task cannot differentiate between these mechanisms.

One way of distinguishing between these mechanisms is to compare discrimination within and outside the trained set. In particular, if labels overshadow differences between compared entities, then discrimination in the trained set may

decrease, whereas, untrained entities that share commonalties with the trained entities should not be affected. At the same time, if labels direct attention to commonalties, then trained entities as well as untrained entities that share commonalties with the trained entities should be affected by training.

The aim of the current study was to determine if hearing the same label associated with two different entities affects the perceived similarity of these entities by directing attention to commonalties or by overshadowing differences (Experiment 1), whether these effects are specific to count nouns produced by a person (Experiment 2), and how these effects change throughout development (Experiment 3). Given that previous studies showed that auditory input often overshadows visual stimuli, and that these effects are not specific to labels (Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004; Sloutsky & Napolitano, 2003), it was expected that both labels and speech-like sounds would decrease the discriminabilty of trained entities in young children by overshadowing the differences between these entities.

Experiment 1

Method

Participants Thirty-five four-year olds (22 girls and 13 boys, $M = 4.55$ years, $SD = .27$ years) participated in this experiment. Children were recruited through local day-care centers located in middle- and upper-middle-class suburbs of Columbus, Ohio. The majority of children were Caucasian.

Stimuli Children were presented with 3 visual stimuli (see Figure 1). Visual stimuli were constructed so that all three images shared many features (i.e., V1, V2, and V3 shared many commonalties), whereas, there was only one feature that distinguished V1 from V2 (e.g., mane) and a different feature that distinguished V1 from V3 (e.g., darkened spots). Each visual stimulus was presented at approximately 8 cm x 13 cm. The auditory stimulus consisted of a nonsense label (i.e., "This is a gatu."). Nonsense labels were presented by a female experimenter and lasted approximately 1500 ms.

Procedure The procedure consisted of two phases: a training phase and a testing phase. During training children were presented with two different images (V1 and V2). Each image was presented individually six times (1500 ms stimulus duration) for a total of 12 training trials, and the order of stimulus presentation was randomized. Prior to training, children were explicitly told they were going to see two different animals, and these animals were going to be very similar to each other so they had to pay close attention because they were going to be asked about them later. Approximately half of the children heard labels during training ($N = 19$). In particular, on each training trial, the experimenter labeled the visual images (both V1 and V2) by saying, "This is a gatu". The remaining children ($N = 16$)

were in the baseline condition, and they heard no labels during training. Images were presented on a Dell Inspiron laptop computer with Presentation software, and experimenters controlled the timing of the experiment by pressing the spacebar to start each trial.
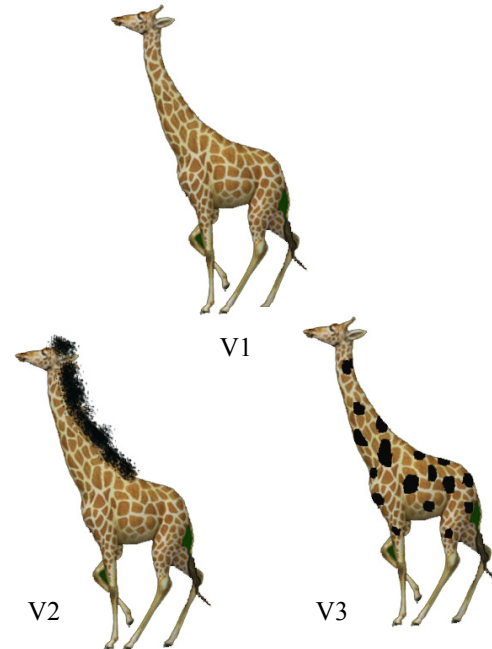

Figure 1. Example of Stimuli used in Experiments 1-3

After the training phase, children were presented with 24 test trials. The testing phase was identical for both the label and baseline conditions: No labels were provided at test. During testing, children had to determine if two simultaneously presented images were the same or different. The experimenter recorded children's responses by pressing 1 of 2 buttons on the computer. Stimulus pairs were presented until children made a response. Twelve of the testing trials were *same* trials in which children were presented with two identical stimuli (V1-V1 trials). The remaining 12 trials were *different* trials: Six of the different trials consisted of simultaneously presenting the two trained stimuli (i.e., V1-V2 trials), and the other six different trials consisted of pairing one of the trained images with an untrained image that shared many commonalties with the trained stimuli (i.e., V1-V3 trials). The order of test trials was randomized.

An additional six trials were randomly presented with the test trials to insure that children were paying attention. These catcher trials consisted of pairing V1 with a completely novel animal. One child was excluded because s/he missed more than two catcher trials.

Results and Discussion

Accuracy (i.e., hits – false alarms) was calculated for trained and untrained sets. In the current experiment and all following experiments, outliers above or below 2 *SD* of the mean were not included in the following analyses. Two children were excluded from the current experiment. Mean accuracy by condition and trial type are presented in Figure 2. As seen in Figure 2, accuracy was more likely to drop for the trained set than for the untrained set. A two-way (Condition by Trial Type) ANOVA confirmed a significant Condition x Trial Type interaction, $F(1, 33) = 6.84, p < .05$. Independent sample *t*-tests revealed that children were less accurate at discriminating trained items in the label condition than in the baseline condition, $t(33) = 3.25, p < .005$, whereas there was no significant decrease in accuracy on untrained items, $t(33) = 1.35, p = .19$.
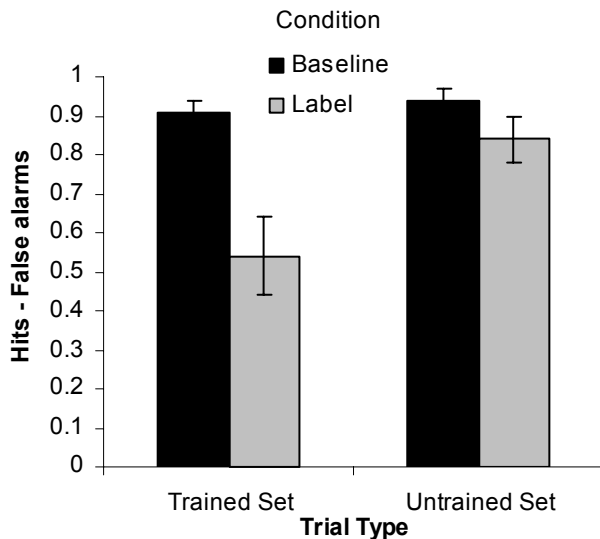
Note: Error bars represent Standard Errors.

Figure 2. Children's discrimination across Condition and Trial Type in Experiment 1

The findings of Experiment 1 demonstrate that hearing the same label associated with two discriminable objects (V1 and V2) influences the discriminabilty of these objects: Under testing conditions where labels were introduced, the ability of children to discriminate these objects dropped dramatically. At the same time, accuracy on untrained stimuli (V1-V3 trials) was less likely to decrease. This finding is important when considering possible mechanisms underlying effects of labels on categorization. Recall that labels can facilitate categorization by directing attention to commonalities or by overshadowing differences. If labels directed children's attention to the commonalities of trained items then accuracy on untrained items should have also dropped because V1, V2, and V3 all share many of the same commonalities. However, if labels overshadowed the

differences between the trained items (i.e., helped children overlook the mane on V2) then accuracy on untrained items should be less likely to drop because the feature that distinguished V1 from V2 was different from the feature that differentiated V1 from V3. The results of Experiment 1 support the latter explanation.

Experiment 2

The goal of Experiment 2 was to further investigate the overshadowing hypothesis by determining whether the findings of Experiment 1 are restricted to count nouns or if they can be generalized to other auditory stimuli. This time, auditory stimuli were strings of vowels that were shown to overshadow corresponding visual input (Napolitano & Sloutsky, 2004).

Method

Participants Eighteen four-year olds (8 girls and 10 boys, $M = 4.48$ years, $SD = .36$ years) participated in this experiment. Participant demographics were identical to Experiment 1. Three children were not included in the following analyses: Two children missed more than two catcher trials and one child's data was an outlier.

Stimuli and Procedure The procedure was similar to Experiment 1, except for two changes. First, the nonsense label in Experiment 1 (i.e., "This is a gatu") was replaced by a three-vowel sequence (e.g., "[ā] [ōō] [a]"). As in Experiment 1, the same auditory stimulus was associated with both V1 and V2 across training, and no auditory input was provided at test. Second, the vowel sequence was produced by the computer instead of the experimenter. The auditory stimulus was recorded as a high quality 44.1 kHz wav file and was presented for 1500 ms at approximately 65-68 dB.

Results and Discussion

Children's accuracy on trained and untrained sets in the current experiment were compared to baseline performance from Experiment 1. As can be seen in Figure 3, the vowel sequences had a larger effect on discriminating trained items ($d = 1.34$) than on discriminating untrained items ($d = .77$). A two-way (Condition by Trial Type) ANOVA confirmed the significant Condition x Trial Type interaction, $F(1, 32) = 6.42, p < .05$. Independent sample *t*-tests revealed that children were less accurate at discriminating the trained items in the vowel string condition than in the baseline condition, $t(32) = 5.21, p < .001$. In contrast to Experiment 1, children were also less accurate at discriminating the untrained items in the vowel string condition than in the baseline condition, $t(32) = 2.40, p < .05$.
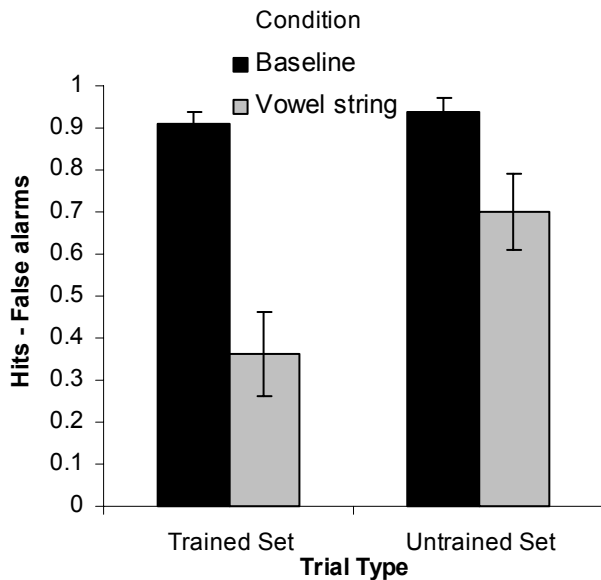
Note: Error bars represent Standard Errors.

Figure 3. Children's discrimination compared to the baseline condition from Experiment 1

The results of Experiments 1 and 2 demonstrate that when the same label or same vowel string is associated with different entities, discriminabilty of these entities decreases, even under testing conditions where no auditory input is provided. Furthermore, these effects were stronger for the trained stimuli (V1 and V2) than for stimuli that share many commonalities with the trained stimuli (i.e., V3). These findings support the general-auditory explanation, suggesting that effects of labels on categorization may stem from labels overshadowing differences between compared entities. In both experiments, when two entities were accompanied by the same auditory stimulus, discriminability of these entities decreased, whereas untrained entities that shared commonalities with the trained entities, were less likely to be affected by training.

Experiment 3

The goal of Experiment 3 was to investigate the developmental trajectory of these findings. While labels and other speech sounds influence similarity judgments in young children, there is little support for this finding in adults (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999). Therefore, it is expected that overshadowing effects would be attenuated in adults.

Method

Participants Twenty-two adults (11 women and 11 men, $M = 20.24$ years, $SD = 2.83$ years) participated in this experiment. The majority of adults were Caucasian. Two

adults were excluded because they missed more than two catcher trials.

Stimuli and Procedure With the exception of two changes, the procedure was similar to Experiment 1. First, the nonsense label (i.e., "This is a gatu") was produced by the computer rather than a female experimenter. The auditory stimulus was recorded as a high quality 44.1 kHz wav file and was presented for approximately 1500 ms at 65-68 dB. Second, adults recorded their own same-different response via computer. The stimuli used in the current experiment were identical to Experiments 1 and 2 (see Figure 1).

Results and Discussion

Accuracies on trained and untrained trials by condition are presented in Figure 4. As can be seen in the Figure, in contrast with Experiments 1-2, labeling the entities during training did not attenuate discrimination in adults, **independent sample *t*s < 1.**
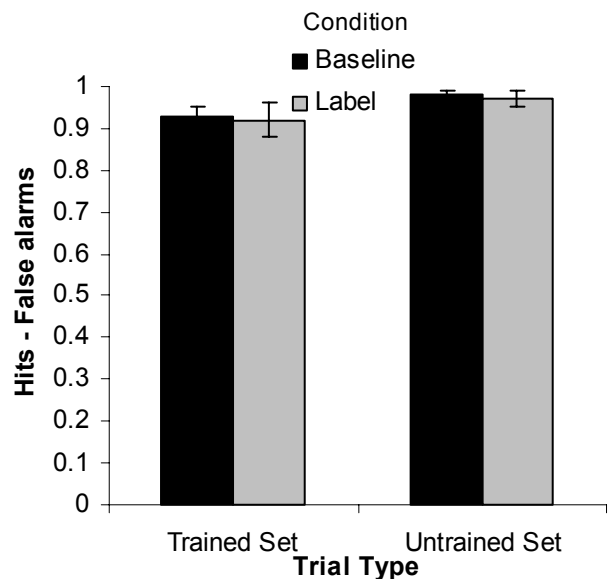
Note: Error bars represent Standard Errors.

Figure 4. Adults' discrimination across Condition and Trial Type in Experiment 3

General Discussion

The results of the current study point to several important findings. First, when the same label (introduced by experimenter) or the same speech-like sound (introduced by computer) was associated with two different entities, discriminabilty of these entities decreased in young children, even under testing conditions where no auditory input was provided. Second, stimuli that shared many of the same commonalities as the trained stimuli were less likely to be affected by this training. Finally, these effects of labels were not found in adults.

These findings have important implications for the understanding of possible mechanisms underlying the effects of labels on categorization and induction. In particular, many studies have demonstrated that very young children are more likely to group two objects together when they are associated with the same label (e.g., Balaban & Waxman, 1997). It has also been demonstrated that children are more likely to ignore appearance and rely on shared labels when inducing non-obvious properties (e.g., Welder & Graham, 2001). From one perspective, it has been argued that: (a) children have assumptions that words and categories are linked, and (b) hearing the same word associated with different objects directs attention to commonalties (e.g., Waxman, 2003). Or, more specifically, children understand that count nouns highlight category membership (Gelman & Coley, 1991).

The general-auditory explanation argues that the effects of labels found early in development may stem from auditory input overshadowing visual information (Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004; Sloutsky & Napolitano, 2003). Furthermore, these overshadowing effects are not driven by strategic considerations: When presented with auditory-visual compounds and told to pay attention to the visual information, young children often had difficulty inhibiting their attention to auditory information (Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004).

Results of current research support the latter explanation – labels accompanying visual stimuli attenuated discrimination of these stimuli, whereas untrained visual stimuli that shared many similarities were not affected. These results provided an important insight into mechanisms underlying effects of labels on categorization. These findings are novel, and the hypothesized mechanism can explain previous research findings. Furthermore, the general-auditory effects are not specifically tied to word-like stimuli, and the mechanism does not assume conceptual knowledge on the children's behalf.

However, it is important to note that future research will need to systematically manipulate the relative commonalities and differences between compared entities. For example, many entities in the environment differ from other category members by more than one feature, thus, potentially requiring more training to overshadow differences. At the same time, many entities also have fewer commonalities than the stimuli used in the current study. Understanding how different training regimes direct children's attention to commonalities and/or overshadow differences, and whether these shifts in attention are child-initiated, are necessary for fully understanding how labels affect category formation at different points in development.

Acknowledgments

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