# The Effect of Labels on Children's Category Learning

**Catherine A. Best (best.140@osu.edu)**
Department of Psychology and the Center for Cognitive Science, The Ohio State University
208G Ohio Stadium East, 1961 Tuttle Park Place, Columbus, OH 43210, USA

**Christopher W. Robinson (robinson.777@osu.edu)**
Department of Psychology, The Ohio State University
208F Ohio Stadium East, 1961 Tuttle Park Place, Columbus, OH 43210, USA

**Vladimir M. Sloutsky (sloutsky.1@osu.edu)**
Department of Psychology and the Center for Cognitive Science, The Ohio State University
208D Ohio Stadium East, 1961 Tuttle Park Place, Columbus, OH 43210, USA

**Abstract**

The effect of language on perception of the visual world is an ongoing debate among researchers. According to one account, labels facilitate categorization by highlighting commonalities among labeled objects. Yet according to another account, early in development labels attenuate categorization by interfering with visual processing. In the current study, 4-year-old children were trained on two contrasting categories that were either labeled or presented in silence. Children were trained to discriminate the categories by associating them with a target object (Experiment 1) or with a target label (Experiment 2). Results demonstrated that children were more likely to learn the visual categories when images were presented in silence than when labeled. Furthermore, there was no evidence that children in the label condition reliably learned the categories, casting doubt on the idea that labels facilitate category learning in children.

**Keywords:** Category Learning; Language; Children

## Introduction

Previous research suggests that labels play a useful role in perceptual and conceptual discrimination of visual information early in development. For example, researchers have shown that infants ranging from 3 to 12 months are often better at learning visual categories when objects are associated with labels than when the same visual stimuli are associated with nonlinguistic sounds (Balaban & Waxman, 1997; Fulkerson & Waxman, 2007; Robinson & Sloutsky, 2007; Ferry, Hespos, & Waxman, 2010). And by 18 months, familiar labels have been shown to facilitate learning of more abstract categories like spatial relations (*e.g.*, Casasola, Bhagwat, & Burke, 2009). In addition, there is neurophysiological evidence suggesting that labels may directly influence how the brain processes visual information. Using EEG recordings, researchers have yielded evidence that 12-month-old infants displayed greater cortical responses (*e.g.*, gamma-band activity) when presented with labeled versus unlabeled objects (Gliga, Vloein, & Csibra, 2010). Finally, labels also influence the category structure that infants learn. For example, while looking at an identical set of visual images, 10-month-old infants hearing only one label associated with all exemplars learned one category; whereas, infants hearing two labels learned two categories (Plunkett, Hu, & Cohen, 2008).

Conversely, alternate research with 8- and 12-month-olds suggests that labels can attenuate infants' learning of visual categories when performance was compared to learning of objects presented in silence (Robinson & Sloutsky, 2007). For pre-linguistic infants, labels (and sounds) have been shown to interfere with the categorization of visual input.

What underlying mechanisms can account for the differential effects of labels on early categorization, and do these contradictory effects of labels exist later in development for category learning in childhood? One mechanism that has been proposed to account for effects of labels on category learning is that words facilitate categorization by highlighting the commonalities among labeled entities (Fulkerson & Waxman, 2007; Waxman, 2003). As a result, labeling helps children attend to category-relevant information (Waxman, 2004). An alternative idea is that infants and children have difficulty processing multimodal information, with labels and sounds often attenuating visual processing (Robinson & Sloutsky, 2004; Sloutsky & Napolitano, 2003). Therefore by this account, labels should have no facilitative effect above a silent condition and may even overshadow visual processing (Sloutsky & Robinson, 2008). Still, perhaps with development, labels have more influence on category learning as children become more efficient than infants at processing cross-modal information (Robinson & Sloutsky, 2004) and as they become more familiar with the notion that items belong in categories and labels denote these categories (Gelman & Coley, 1991; Gelman & Markman, 1986). In fact, research on the effect of labels on preschool children's category learning demonstrates that labels invite children to compare commonalities among category members while assessing both commonalities and differences between item pairs (Namy & Gentner, 2002).

To investigate the effect of labels on children's category learning, the current study presented 4-year-olds with two contrasting categories. In Experiment 1, half of the children were trained on category members with labels and half were trained on category members presented in silence.

Critically, half of the features of each category member were shared among the category members (*i.e*., category-relevant information); whereas, half of the features were not predictive of category membership (*i.e*., category-irrelevant information). Additionally, unlike previous research designs that teach infants and children word-category relations and test them afterward, the current study used multiple blocks of training and testing trials to examine the rate of category learning in children.

## Current Predictions

If exposure to linguistic input facilitates early category learning, then effects should be particularly evident when children learn novel categories with a distinct set of features common among category members. Specifically, if effects of linguistic labels on categorization stem from labels directing children's attention to category-relevant information (*i.e.*, through inviting comparison of perceptual commonalities), then participants who hear labels should learn the categories faster than participants who do not hear labels. However, if labels continue to disrupt visual processing throughout childhood, then participants who hear labels should be slower to learn the categories than participants who do not hear labels.

# Experiment 1

## Method

**Participants** Twenty preschool children (13 boys, 7 girls; $M$ = 56 months, $SD$ = 3.5 months) were tested, with 10 children per condition. Four-year-old children were recruited from middle-class, suburban preschools and childcare centers in the Columbus, Ohio area.

**Stimuli** Visual stimuli included two contrasting categories of cartoon flowers with 24 items per category. Each category member consisted of a four-petal line drawn flower with colorful shapes inside each petal (see Figure 1). Two petals contained consistent colored shapes across category members (*i.e.*, category-relevant features), while two petals contained colored shapes that were equally likely in either category (*i.e*., category-irrelevant features). Flowers were constructed to be a familiar concept to children; however, the featural information (*i.e*., petals) was artificially manipulated to provide every child with novel exemplars to learn. Although the cartoon flowers did not resemble real flowers, it was explained to children in the context of a story that these flowers grow on a far away planet. Each flower stimulus was approximately 7.5cm in width and 13.5cm in height.

Auditory stimuli included novel object labels (*e.g.*, zibblers or blickets) recorded by a female speaker within the context of a carrier phrase (*e.g.*, "Both of these flowers are called zibblers"). Speech was recorded at 44.10 kHz, 16 Bit, in stereo and paired with corresponding bitmap images. In the label condition, the audio-visual presentation lasted for a total duration of 5000ms, with the audio beginning with the onset of the image and lasted 2400ms in duration, and the remaining 2600ms consisting of silence. In the silent condition flowers were not labeled (i.e., the speech was removed entirely), and visual presentations lasted for a total duration of 5000ms.

**Design** The experiment had a between-subjects design, with participants randomly assigned to one of two experimental conditions (*i.e.*, label or silent). The visual input was the same for all conditions and was presented in a random sequence. Only the auditory input differed between conditions.

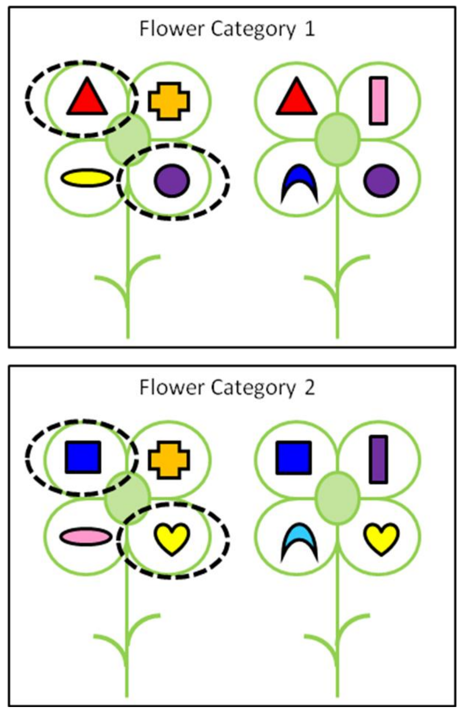


Figure 1. Example stimulus pairs from two contrasting categories. *Note.* Category-relevant features are circled with dashed lines on the left exemplar for the reader.

**Procedure** A female experimenter tested children with a laptop computer in a quiet room at their preschool or childcare center. The experiment was presented as a game in which children fed flowers to different alien creatures with the aim that they would learn two visual categories by associating each kind of flower with a different creature. Participants were first trained on which flower categories the creatures liked to eat. The cover story preceding training trials was as follows:

> *The creatures that live on Planet XX eat flowers. In this game, I need your help feeding the creatures some flowers. It is very important that we make sure to feed the creatures the right kind of flower. If they eat the wrong kind of flower,*

*they will get a tummy ache. Pay attention to what the flowers look like. The two kinds of flowers might look the same, but if you look closely, you will see that they are different. Are you ready to see what flowers the creatures like to eat?*

Training trials each had a two-sequence presentation. First the creature was shown and children were prompted with a pre-trial phrase, “Let’s see what flower the yellow (or purple) creature likes to eat.” Then a pair of flowers eaten by that creature was shown during the actual training trial. Only children in the label condition heard different labels for the two categories during training trials (see Figure 2). Children in the silent condition heard silence when the flower pairs were shown. The goal for all children was to learn to distinguish the two flower categories by mapping the two different creatures to each category.

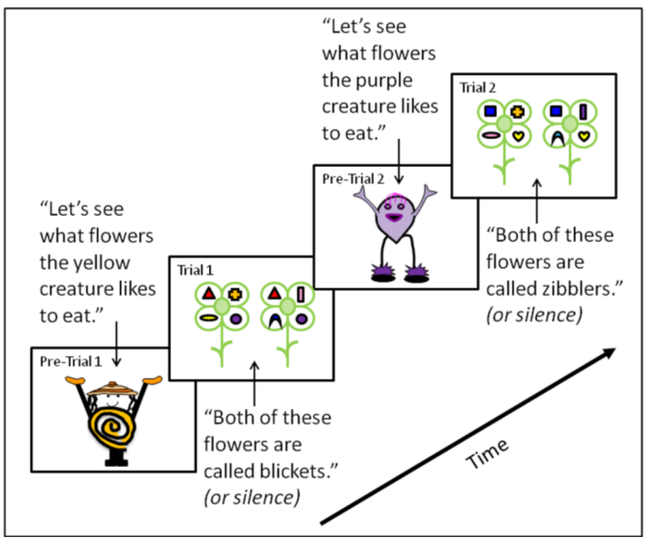


Figure 2. Example training sequence illustrating two of the four training trials per block.

At test, children were asked to feed the flowers to one of two creatures so as not to give the creature a tummy ache. The goal was for children to feed the correct kind of flower to the creatures (*i.e.*, the yellow creature eats flower category 1 and the purple creature eats flower category 2). Test stimuli were novel exemplars from the studied categories and were the same size as training stimuli. Each test trial remained visible until children made a verbal response. All participants completed four blocks, each with four training trials and six test trials, for a total of 40 trials. In each block, children were given feedback on the first two test trials, but not on the remaining four test trials. Examples of auditory feedback included “Yummy! Thank you” or “Bleck! I feel sick.” All stimuli were randomly selected from two contrasting categories. The experimenter recorded children’s responses on the computer using Presentation software version 14.4.

## Results and Discussion

Primary analyses focused on children’s learning rates between conditions as indicated by accuracy at test. To determine if labels facilitated children’s category learning over time, we compared mean accuracy for the first half of the experiment to the second half of the experiment. Therefore children’s accuracy in blocks 1 and 2 (*i.e*, test trials 1 to 12) were compared to children’s accuracy in blocks 3 and 4 (*i.e.*, test trials 13 to 24) between the label condition and the silent condition (see Figure 3). Children in the silent condition significantly improved their response accuracy from the first half ($M$ = .48, $SE$ = .21) to second half ($M$ = .63, $SE$ = .26) of the experiment, $t(9) = 1.83$, $p <$ .05, one tail, indicating they could learn the categories with exposure to more exemplars. In contrast, a similar increase in learning between experimental halves was not demonstrated by children in the label condition. Furthermore, children’s accuracy in the label condition never differed from chance performance throughout the experiment; however, children’s accuracy in the silent condition was marginally above chance by the second half of the experiment, $t(9) = 1.65$, $p = .06$ (one-tail).

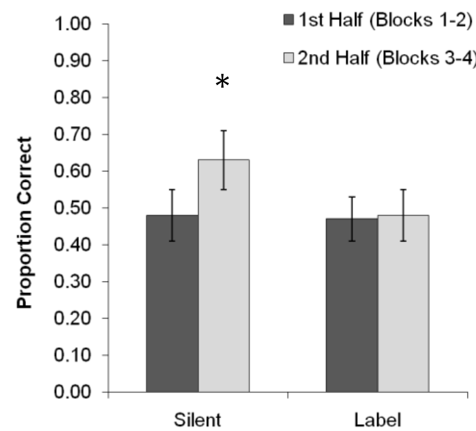


Figure 3. Mean accuracy between conditions by first half (blocks 1-2) and second half (blocks 3-4) of experiment. *Note.* The * indicates a reliable difference between experimental halves, $p < .05$.

**Summary** Experiment 1 found no effect of labels facilitating category learning compared to silence. Children presented with labeled category members did not learn faster than children presented with unlabeled category members. Furthermore, children in the label condition demonstrated no learning; whereas, children in the silent condition demonstrated learning over time. These results support the idea that labels do not facilitate category learning and may hinder performance. Still, it is possible that labels did facilitate learning of the categories; however, children associated the visual categories with the labels and not the creatures. To examine this possibility, we conducted

Experiment 2 in which the game was changed to assess children's ability to map two novel labels to two visual categories without associating categories to creatures.

## Experiment 2

### Method

**Participants** Fifteen preschool children (9 boys, 6 girls; *M* = 53 months, *SD* = 3.8 months) were tested in the control condition. Four-year-old children were recruited from middle-class, suburban preschools and childcare centers in the Columbus, Ohio area, but did not participate in Experiment 1.

**Stimuli** The cartoon flower category stimuli were identical to Experiment 1; however, to reduce task demands, children no longer needed to match the alien creatures with the flowers as part of the game. The current task required children to produce the correct category label at test. Auditory stimuli were identical to that of Experiment 1.

**Procedure** A female experimenter tested children with a laptop computer in a quiet room at their preschool or childcare center. The experiment was presented as a game in which children had to learn the names of two different flower categories. Participants were first trained by hearing the flower names paired with flower images. The cover story preceding training trials was as follows:

> *The creatures that live on Planet XX eat flowers. The flowers they eat have funny names. I'm going to show you two different kinds of flowers that they like to eat so you can learn the names of the flowers. Pay attention to what the flowers look like. The two kinds of flowers might look the same, but if you look closely, you will see that they are different. Now it is time to learn the names of the two different kinds of tasty flowers. Are you ready to see some flowers?*

Then children were tested by asking them to recall only the flower name when presented with a visual stimulus (*i.e.*, as opposed to recalling the corresponding alien creature as in Experiment 1). All participants completed four blocks, each with four training trials and six test trials, for a total of 40 trials. In each block, children were given feedback on the first two test trials, but not on the remaining four test trials. Examples of auditory feedback included "Good job! That was a blicket" or "Oops! That wasn't a zibbler." Each test trial remained visible until children made a verbal response. The experimenter recorded children's responses on the computer using Presentation software version 14.4.

### Results and Discussion

Primary analyses focused on children's learning rate as indicated by accuracy at test. Although the current task demands were lessened from Experiment 1, there was no evidence that children learned the visual categories since accuracy in the control condition never differed from chance performance. Children in the control condition of Experiment 2 were not faster to learn the categories than children in the silent condition of Experiment 1, with their performance at chance in both experimental halves (see Figure 4). In addition, children in the control condition of Experiment 2, like children in the label condition of Experiment 1, never differed from chance performance.

**Summary** Experiment 2 found comparable results as Experiment 1 with regard to the lack of a facilitative effect of category labels on children's learning. Children in the control condition never learned the category labels, and performed no better than the children in the label condition of Experiment 1. In fact performance by children provided with category labels never exceeded performance by children presented with category members in silence for the second half of the experiment. Taken together, these results suggest that labels do not facilitate category learning, and may actually hinder performance.

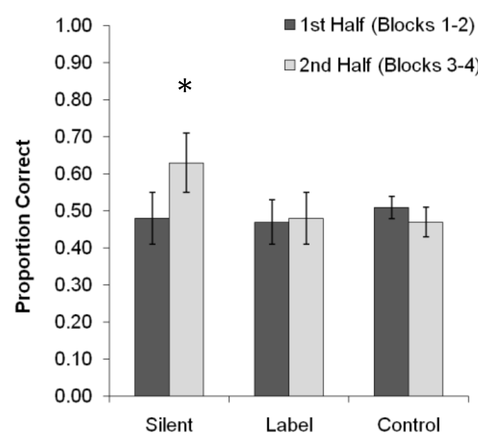


Figure 4. Mean accuracy between experiments by first half (blocks 1-2) and second half (blocks 3-4). *Note.* Means for silent and label condition as reported from Experiment 1 and the * indicates a reliable difference between experimental halves, $p < .05$.

## General Discussion

The current findings provide important evidence regarding effects of labels on early category learning. Despite that children are more experienced word-learners than infants, labeling category members during training did not help 4-year-old children to learn the categories faster than children in the silent condition. Experiment 1 demonstrated that children can discriminate categories by learning to associate visual categories with a visual target object, but only when category members were presented in silence. In fact, providing novel auditory labels for category members appeared to prevent learning of the visual categories altogether. Experiment 2 demonstrated that when task demands were lessened, children still could not learn two categories by associating visual categories with a novel label (rather than a target object as in Experiment 1).

Because the current study was particularly difficult, it is possible that children could not learn two related categories simultaneously. However, given this possibility, then the children in the silent condition should have been equally as poor at learning as the children in either the label or control conditions. It is also possible that the poor performance was due to children having to monitor multiple dimensions since the flower categories involved the conjunction of two features to identify each category, namely shape and color. However, even if children attended to one of the two correlated features, they still would have been able to discriminate the categories. Additionally, previous research examining category learning of structurally dense categories (i.e., where multiple features and values predict category membership), shows that redundancy and correlated information actually aids learning (Kloos & Slousky, 2008).

Although the current findings do not support previous evidence of facilitative effects of labels on categorization (Balaban & Waxman, 1997; Fulkerson & Waxman, 2007), these findings do support previous evidence of attenuated visual processing due to auditory input (e.g., Robinson & Sloutsky, 2007). Studies have shown that labels interfere with visual processing in pre-linguistic infants (Robinson & Sloutsky, 2007; Sloutsky & Robinson, 2008); however, the current study found similar interference results with 4-year-old children. Previous research by Sloutsky and Napolitano (2003) has demonstrated that 4-year-old children's attention to auditory information dominates over their attention to visual information when both types of input are presented simultaneously. Auditory dominance, a weakened encoding of visual input in the presence of audio input, may account for the results in the label condition as well as in the control condition if in fact children encoded the auditory stimuli, but not the visual stimuli. Perhaps children who heard labels never processed the visual information or they processed the visual information to some extent, but not sufficiently enough to accurately learn the categories at the expense of their preference to first process the auditory labels. Future research is currently underway to tease apart differences in the level of processing audio and visual input based on attentional measures during learning by recording eye movements during category learning to examine attention patterns during learning.

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