YOUNG CHILDREN’S COORDINATION OF LABEL EXTENSION ACROSS THE SENSES

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by

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This project would not have been possible without the assistance, guidance, and support of my advisor, Bill Merriman. I would also like to thank the preschools and children that agreed to participate in this project. Finally, I thank the members of my committee: Jill Folk, John Dunlosky, and Karin Coifman.
INTRODUCTION

At birth, infants have already developed a complex system for organizing their world. They are especially attuned to amodal information, or features of the world that are detectable across multiple senses (e.g., shape, texture, size) (Bahrick, 2004; Gibson, 1969). In several studies, infants have demonstrated greater sensitivity to amodal features than to other features such as color (Bahrick, 1983, 1987; Gibson, 1969; Hernandez-Reif & Bahrick, 2001). They have also shown a remarkable ability to integrate the different sensory manifestations of an amodal feature. That is, children increase attention to a feature in one modality if they also detect it in another modality (Gottfried, Rose, & Bridger, 1977; Meltzoff & Borton, 1979; Spelke, 1976). These reoccurring, stable features are also hypothesized to play an important role in learning about objects.

Shape is a particularly important amodal feature for learning to name and categorize objects (Landau, Smith, & Jones, 1988; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). Both children and adults tend to rely on shape similarity to determine whether an object belongs to a particular category. This shape bias begins developing around the second birthday and becomes stronger over early childhood (Smith et al., 2002). Shape is also one of the first object features that infants integrate cross-modally (Steri, 1987).
Scofield, Hernandez-Reif, and Keith (2009) reasoned that because shape is such a highly accessible amodal feature that dominates the interpretation of novel object labels, young children should have little difficulty extending a novel label trained for an object in one sensory modality to that same object in a different sensory modality. They considered this prediction to be consistent with the Gibsonian claim that information detected in one modality becomes available to the other senses automatically (Gibson, 1969; Bahrick, 2004). To test this prediction, Scofield et al. (2009) taught 2-to-5-year-olds a label for a novel object that was presented only tactually (Experiment 1) or only visually (Experiment 2). The children were then tested on whether they could extend the label to that object when it was presented in the other modality. For example, in Experiment 2, after being told that a visual object was a “zav”, the children were asked to reach into a box and examine two hidden objects, then decide which one was also a “zav”. All age groups, except 2-year-olds, tended to select the training object rather than the other novel object in the box.

Scofield et al. (2009) interpreted the youngest group’s failure as evidence that the cross-modal transfer of shape was not as automatic as Gibsonian theory suggests. They noted that the 2-year-olds explored and manipulated the objects less extensively than the other children, and suggested that the 2-year-olds’ failure to extend the trained label cross-modally was due to not having extracted enough information about the object’s shape in the tactile modality.
Another indication that cross-modal transfer of shape was not automatic was that even the 3- to 5-year-olds failed to avoid extending a second label to the training object when this object was presented in the other sense modality. For example, in Experiment 2, when taught that the visible object was a “zav”, and then asked to determine which of the two touched objects was a “tigg”, children chose the training object more often than the novel object. Although this selection tendency was not as strong as their tendency to choose the training object when tested on the trained name (i.e., “zav”), it differs from what is usually observed in children’s novel label extension. Children as young as 15 or 16 months old tend to select a novel object rather than an object that can already be named as the referent of a novel label (Halberda, 2003; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1994). This mapping tendency has been found to be quite robust in children 2½ years old or older (Evey & Merriman, 1998; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Markman & Wachtel, 1988). If the cross-modal transfer of shape information is a relatively automatic process, then why should children as old as 5 years fail to avoid extending two labels to the same object cross-modally?

The goal of the current investigation was to examine factors that may affect whether preschoolers decide to avoid mapping a novel label onto an object that had just been presented in a different modality and called by a different label. Two experiments were conducted using variations of the vision-to-touch procedure developed by Scofield et al. (2009). The experiments may not only advance our understanding of young children’s cross-modal integration processes, but also inform us about why they might
avoid mapping two labels to the same object in some circumstances, but allow this dual labeling, or even prefer it, in others. We limited our sample to 3- and 4-year-olds based on Scofield et al.’s evidence that multimodal word learning was not evident in children younger than 3-years-old, and that 5-year-olds’ performance was nearly identical to that of 4-year-olds.

Two of the leading explanations for children’s avoidance of label overlap are the Mutual Exclusivity principle (Markman & Wachtel, 1988; Merriman & Bowman, 1989) and the pragmatic account (Diesendruck & Markson, 2001; Clark, 1990; Gathercole, 1989). According to the first explanation, children possess a default assumption that labels do not have overlapping extensions. They reject this assumption for a particular pair of labels only if they receive evidence against it, such as being told, “A collie is a kind of dog.” According to the pragmatic account, children’s default assumption is that if someone wants to direct them to an object, and there is a mutually known way of making this reference, the person will use it. So, for example, if the child believes that a person wants him or her to look at the cup, the person is more likely to use the word “cup” than some unfamiliar word to refer to it.

Halberda (2003, 2006) has argued that both accounts assume that children make a kind of deductive inference known as a disjunctive syllogism. The object that can already be labeled is rejected to avoid contradicting a default assumption. According to the Mutual Exclusivity account, selecting this object would contradict the assumption that label extensions do not overlap. According to the pragmatic account, selecting it would
contradict the assumption that speakers use mutually known ways of referring to things.

In support of this argument, Halberda (2006) found that preschoolers and adults nearly always looked at the object with the known name immediately before selecting the novel object as the referent of a novel label.

In the current experiments, 3- and 4-year-olds completed several trials in which they first learned a label for a visual training object, then examined two hidden objects with their hands. One object was identical to the training object and the other was novel. On the critical trials, the children were asked to decide which object was the referent of a novel label. The experiments addressed the role of two processes: label retrieval – retrieving the trained label and applying it to the tactile version of the training object just before (or as) the child considers extending the novel label to this object; and match expression – allowing the child to communicate his or her discovery that one of the tactile objects matched the visual training object. The current experiments also examined whether children’s avoidance of label overlap was related to their ability to make reflective judgments about their knowledge of object names.

The role of label retrieval was addressed in several ways. The procedures used in both experiments differed from those employed by Scofield et al. (2009) in that children had to demonstrate that they could recall the label that had been trained for the visual object before proceeding to the cross-modal label extension tests. When considering whether an object is a referent of a novel label, children may only avoid selecting an object that can already be labeled if, at that moment, they retrieve the known label for
that object. If they do not retrieve it, they may fail to realize that extending a novel label onto that object would violate their default assumption about labels and/or speakers’ referring expressions. If in contrast to Scofield et al.’s (2009) results, our participants avoid mapping a novel label onto an object that had just served as the visual referent of a different label, this finding would support the proposed role of label retrieval in the avoidance of label overlap.

This proposed role is consistent with the observation that German preschoolers did not avoid mapping a novel label onto an object for which another label was known when their knowledge of the other label was receptive, but not productive (Grassmann, Schulze, & Tomasello, 2012). For example, they tended to select an as-yet-unnameable object over a nail file as the referent of a novel label only if they could recall the conventional name for nail file. They did not show this tendency if they could only pick out a nail file from a set of objects. In the latter case, they would not have been capable of retrieving this name when considering whether a novel label referred to the nail file.

The role of label retrieval was assessed more directly in Experiment 2. On every trial, after children had heard the label for the visual object and had examined the tactile objects, those in the labeled condition were asked to indicate the tactile object to which the trained label applied (i.e., the training object). Others, in the unlabeled condition, were asked to indicate the tactile object that was “the same as” the visual object (also the training object). In both conditions, the children were subsequently asked to indicate which tactile object was the referent of a novel label. If children showed a stronger
tendency to avoid selecting the training object in the labeled condition than in the unlabeled condition, this result would support the claim that their tendency to avoid mapping a second label onto an object that is encountered in a new sense modality depends on whether they represent the object at that moment as having the label that had been trained for it in the original modality.

The role of match expression was assessed by comparing the performance of children in the unlabeled condition of Experiment 2 to that of children in Experiment 1. The logic of this comparison will be presented in a later section.

Our final goal was to examine whether children’s reflective awareness of their knowledge of object names was related to how reliably they avoided label overlap across the senses. Those preschoolers who are better able to make this kind of reflective judgment also show a more robust tendency to avoid label overlap in standard tests (i.e., non-cross modal ones) (see Marazita & Merriman, 2004, for a review). Marazita and Merriman proposed two possible explanations for this relation. First, both judgment of name knowledge and avoidance of label overlap may be affected by some of the same processes. In particular, a child’s skill in object recognition and object name retrieval may affect how accurately the child judges whether a particular object has a known name (Lipowski & Merriman, 2011) and how reliably he or she executes the object encoding, name retrieval, and name comparison processes necessary for avoiding label overlap (Evey & Merriman, 1998). Secondly, reflective awareness of one’s name knowledge may play a direct, causal role in avoiding label overlap (Marazita & Merriman, 2004). The
child who realizes that an already-nameable object is one he or she knows, and that a novel object and a novel label are unknown, may be more likely to select the novel label because this selection effectively matches unknown to unknown.
INTRODUCTION - EXPERIMENT 1

On each of four trials, 3- and 4-year-olds learned a label for a visual training object, then examined two tactile objects. One of the latter was identical to the visual training object and the other was novel. On some trials (trained label trials), they were asked to choose the tactile object that was the referent of the label that had just been trained. The other trials (novel label trials) were the critical ones. On these, they were asked to choose the tactile object that was the referent of a novel label. Children were also administered a separate test of their ability to judge whether various visually-presented objects had known names.

Two versions of Experiment 1 were run, one after the other. Their results did not differ, and so the results were pooled to increase the statistical power of analyses. The versions differed in how the request to find the referent of a novel label was posed on the novel label trials. In the first version, children were not reminded of the trained label immediately before being asked to find the referent of the novel label. In the second version, they were.
METHOD

Participants

The no label reminder group consisted of 11 3-year-olds ($M = 43$ months, range = 36-47 months; five boys) and 13 4-year-olds ($M = 56$ months, range = 52-59 months; seven boys). The label reminder group consisted of 15 3-year-olds ($M = 43$ months, range = 38-47 months; seven boys) and 17 4-year-olds ($M = 54$ months, range = 48-58 months; nine boys). An additional seven children were excluded from data analysis due to failure to follow directions. All of the children were recruited from preschools in middle- to upper-class regions of Northeast Ohio. Nearly all were Caucasian and all spoke English as their first language. Each child received a sticker for his or her participation.

Materials and Procedure

After obtaining parental consent, the children participated in a brief 10-15 min session in a quiet room at their preschool. Each child completed a label extension task and an object nameability judgment task. Task order was counterbalanced.

A white wooden box measuring 16 in X 17 in X 8.5 in was used for the cross-modal label extension task. The inside of the box was empty, and one side of the box was open so that the experimenter could transfer objects in and out of the box. The opposite side of the box had two arm holes cut into it. These were 3 inches in diameter and had
cotton sleeves attached to them. The side with the arm holes faced the child so he or she could put his or her arms inside the box without seeing inside of it.

A unique set of three unfamiliar objects (two of which were identical to each other) was used on each of the four trials. These objects were small and easy to manipulate, and had names the children did not know (e.g., a plastic t-joint). Six nonsense words (e.g. zav, cobe, ferp, jeet, hust, and lide) were used as either a trained or novel label. None of these words was used on more than one trial, and the order of trial type and novel labels was counterbalanced across all children. Twelve additional objects were used for the object nameability judgment task. Six were common, familiar objects (i.e., flashlight, key, sock, toy car, fork, toothbrush) and the other six were uncommon objects that were likely to be unnameable for preschoolers (i.e., plate hanger, tube squeezer, egg slicer, spouncer, latch hook, gel heel cushion).

Label Extension. The experimenter and child sat opposite of each other at a small table. After the child was comfortable, the experimental box was introduced. As a warm up, the child was asked to close his or her eyes while the experimenter placed a soft, foam ball inside the box. The child was then asked to place his or her arms inside the arm holes, pick up the object, and answer three questions: “Is it hard or is it soft?”, “Is it big or is it small?”, and finally, “What is it?” While there was little agreement on the size of the object (51% said “big”), nearly every child agreed that the object was soft (91%) and was a ball (93%). Each child was provided feedback and shown the object afterward.
The children were then told that they were going to play a game. The experimenter explained that she was going to show them an object and tell them the name for it. The children were also instructed that they were not allowed to touch the object; they were only allowed to look at it. The experimenter then showed the child a novel object and labeled it three times (e.g. “This is a zav. It’s a zav. You’re looking at a zav.”). The child was prompted to repeat the name out loud. To ensure that the child had learned the label for the object well enough to retrieve it later, a distractor task that lasted approximately 5 sec followed. The object was removed from sight and the child was asked to state how many fingers the experimenter held up. The child did this for two finger displays. The experimenter then placed the object back on top of the box and asked the child what it was called. If the child did not recall the label correctly, the experimenter labeled it herself and then repeated the whole procedure (beginning with, for example, “This is a zav. It’s a zav. You’re looking at a zav”) until the child successfully recalled the label. If the child did not recall the label after three training and test cycles, the experimenter taught the name one more time and then moved on to the cross-modal label extension test. Each child was trained and tested on four labels.

Once the child demonstrated an ability to retrieve the trained label, the training object was placed on top of the box so that it remained visible to the child. The experimenter instructed the child to close his or her eyes while she placed two objects inside of the box. One was identical to the training object (i.e. another “zav”) while the other was a different object. The child was then instructed to place his or her hands
through the sleeves, hold the objects that the experimenter placed in each hand, and then indicate which one was the referent of a label.

In the no label reminder condition, the label request took the form: “Do you know what a ___ is? One of these is a ___. Which one is the ___?” On the two trained label test trials, the trained label filled the slots in the form. On the two novel label test trials, a novel label filled these slots. Children were never tested on both labels on a particular trial. The form of the label request was nearly identical in label reminder condition, except that on novel label test trials, the first slot was filled by the trained label to highlight the difference between it and the novel label (e.g., “Do you know what a zav is? One of these is a tigg. Which one is the tigg?”). In both conditions, the first and fourth trials involved trained label tests for half of the participants. For the other participants, the first and fourth trials involved novel label tests. Children indicated their response to the test questions either by picking up an object or verbally stating “this one” and handing it to the experimenter. Minimal feedback was provided (e.g., “Good”).

Object Nameability Judgment. The child was shown six familiar and six unfamiliar objects one at a time and was asked, “Do you know the name for this?” The child was instructed to only say “yes” or “no” and not name the object out loud. The experimenter first provided a short demonstration with one of the familiar (e.g., flashlight) and unfamiliar objects (e.g., plate hanger) in order to make sure the child understood the task. Once the child had responded “yes” or “no” on the test trials, the child was prompted to name any unfamiliar object that he or she had identified as having
a known name (i.e., said “yes” when asked to judge whether its name was known). If the children named the (so-called) unfamiliar object correctly, or produced a plausible overextension, that trial was dropped from the computation of the child’s accuracy in judging the nameability of as-yet-unnameable objects ($M$ trials dropped = 0.96, range = 0-3).
RESULTS

Trained Label – Visual Trials to Criterion

Children were considered to have learned the label that had been trained for a visual object if, after the brief retention interval, they correctly recalled the label when shown the object. Participants usually met this criterion on their first attempt (63% of the trials). However, only five 3-year-olds and nine 4-year-olds met the criterion for every trained label on the first recall test. The younger group tended to require more training trials to reach criterion ($M = 1.67, SD = .51$) than the older group ($M = 1.40, SD = .41$), $t(54) = 2.22, p < .05$, $\eta^2 = .08$.

Trained Label - Tactile Label Extension

After meeting criterion, the training object and a novel object were placed in the box (where the children had already placed their hands). On two of four trials, the children were asked to indicate which object was the exemplar of the trained label. Table 1 summarizes how often children chose correctly. Performance was excellent ($M$ correct = $1.77, SD = .54$), and did not vary by age, reminder, or age x reminder. None of the latter factors increased the fit of a log-linear model to the data, $ps > .10$. 
Table 1. Children classified by choices on tests of the trained label in Experiment 1.

<table>
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<th>AGE</th>
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<td>3 Years</td>
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**Novel Label -- Tactile Label Extension**

On the other two trials, the children were asked to indicate which object was the exemplar of a novel label. Table 2 summarizes how often children chose correctly. Performance was at chance ($M_{\text{correct}} = 1.02$, $SD = .78$), and did not vary by age, reminder, or age x reminder. None of the latter factors increased the fit of a log-linear model to the data, $ps > .10$.

**Object Nameability Judgment**

Children were more accurate at judging whether they knew the names for the familiar objects (i.e., said “yes”), ($M = .83$, $SD = .30$) compared to the unfamiliar objects (i.e., said “no”), ($M = .59$, $SD = .41$), $t (55) = 3.43$, $p < .01$. As in previous studies (Merriman & Marazita, 2004; Merriman & Lipko, 2008), overall accuracy of these judgments was positively correlated with age, $r (54) = .37$, $p < .01$.

As predicted, children who were more accurate at judging whether they knew various objects’ names also avoided label overlap more often on the novel label test trials, $r (54) = .28$, $p < .05$. This relation remained significant after age was partialled out, $r (53) = .28$, $p < .05$. To explore this relation, the children were split into three groups based on their average object nameability judgment score: low (range = .20-.575; $M = .46$; $N = 21$); intermediate (range = .60-.80; $M = .67$; $N = 14$); and high (range = .875-1.00; $M = .98$; $N = 21$). Their average frequency of avoiding label overlap (i.e., mapping novel labels onto novel objects) is depicted in Figure 1 (max = 2).
Table 2. Children classified by choices on the tests of the novel label in Experiment 1.

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Figure 1. For Experiment 1, novel object selections on novel label trials as a function of object nameability judgment accuracy. Error bars are +/- 1 standard error of each mean.
The high scorers avoided label overlap more often than not (M number of selections = 1.29; no preference = 1.00), although this tendency only exceeded chance by a one-tailed test, t (20) = 1.83, p = .04. In contrast, the exact opposite tendency was evident in the low scorers (M = 0.71), t (20) = 1.83. The intermediate scorers neither favored label overlap nor avoided it (M = 1.07, t (13) < 1).

The accuracy of object nameability judgment was also related to how often a child extended the trained label onto the tactile version of its training object, even though this mapping frequency was near ceiling, r (54) = .31, p < .05. Among those whose nameability judgment score was above the median, 26 extended the trained label correctly on both tactile test trials and two extended it correctly on one test trial. Among those whose nameability judgment score was below the median, 20 extended the trained label correctly on both tactile test trials, five extended it correctly on one test trial, and three extended it correctly on neither test trial.
DISCUSSION

The children integrated lexical information about objects across sense modalities. After learning a label for a visual training object, 3- and 4-year olds consistently extended that label to a tactile version of the training object rather than to a novel object. This result replicates Scofield et al. (2009).

When asked to find the tactile referent of a novel label, the children showed no preference for either object. In contrast, Scofield et al. (2009) observed their participants to prefer the training object over the novel object on such tests. This inconsistency may be due to the current experiment’s extra training of the label for the visual object and/or its requirement that children be able to produce this label for the visual object before proceeding to the cross-modal label extension tests. These factors may have increased the likelihood that when given the tactile test of the novel label, a child spontaneously retrieved the label that they had learned for the training object and noted that this label mismatched the novel label. This realization may have worked against a preference to select the training object as the referent of the novel label.

Individual differences in the tendency to spontaneously retrieve the label for the training object may account for the correlation found between the accuracy of children’s object nameability judgments and how often they avoided label overlap. Children who
judge object nameability more accurately than their peers also tend to retrieve names for familiar objects more rapidly (Lipowski & Merriman, 2011). However, the correlation between nameability judgment and novel label extension could also reflect the tendency of those who are more aware of their name knowledge to extend the novel label to the novel object because this solution represents mapping unknown onto unknown.

The children who judged object nameability the most accurately showed only a weak tendency to avoid label overlap, however. This result is surprising because all of the children could recall the label for the visual training object and selected the tactile version of this object when tested on the trained label. In one condition, they were even reminded of the trained label immediately before being tested on the novel label. All of these factors should have promoted avoidance of label overlap. Some other factor(s) must have opposed this solution to the novel label extension problem.

One such factor may be match expression. When the children first examined the tactile choice objects, their discovery that one of these objects matched the visual training object may have led them to expect the experimenter to ask about it and/or led them to want to tell the experimenter about it. The expectation/desire to refer to the matching object may have led them to select this object rather than the novel object when asked to choose the referent of the novel label. A related possibility is that children only discovered the match between the visual and tactile training object when attempting to determine the referent of the novel label, and their surprise at discovering this match disrupted their execution of the encoding, retrieval, comparison, and inference processes.
that, according to Halberda (2003) and Marazita and Merriman (2004), promote avoiding label overlap.

Experiment 2 was designed to eliminate match expression as a factor in children’s response to the novel label test. All participants were given the opportunity to express their realization that one of the tactile objects matched the training object before being tested on a novel label. It was hypothesized that allowing children to satisfy any desire or expectation to refer to this object would increase their likelihood of subsequently rejecting the tactile training object when asked to determine the referent of the novel label.

Experiment 2 also manipulated whether the trained label was used in the instructions that allowed the children to satisfy match expression. In the labeled condition, every tactile test trial began with the request to select the object that was the referent of the trained label. After making this selection and receiving two distractor questions, children were asked to select the tactile object that was the referent of the novel label. In the unlabeled condition, every tactile test trial began with the request to select the object that was the same as the visual training object (which was still in view in both conditions). Children then received the distractor questions and the request to select the referent of the novel label. Children’s likelihood of noting that the tactile training object’s label mismatched the novel label was expected to be lower in the unlabeled than in the labeled condition. Thus, their tendency to avoid extending the novel label to the training object was expected to be weaker in the unlabeled condition.
METHOD - EXPERIMENT 2

Participants

The labeled condition consisted of 16 3-year-olds ($M = 42$ months, range = 36-47 months) and 16 4-year-olds ($M = 54$ months, range = 49-59 months). The unlabeled condition also consisted of 16 3-year-olds ($M = 43$ months, range = 36-47 months) and 16 4-year-olds ($M = 53$ months, range = 48-59 months). Every age x condition group had equal numbers of boys and girls. The children were recruited from the same types of preschools as were sampled in Experiment 1. An additional four children were excluded from analyses for failure to follow directions (3) or because they required more than 2.5 training trials on average to recall a trained label (1). All of the children spoke English as their first language and nearly all were Caucasian. Each child received a sticker for participating.

Materials and Procedure

The materials and procedure were the same as in Experiment 1 except for changes to the tactile tests of the trained and novel labels. After successfully recalling the visual object’s trained label, the child placed his or her hands in the box and picked up both the training object and a novel object. The experimenter then asked the child to indicate which one was the training object. The wording of this request varied according to
condition. In the labeled condition, the trained label was used, for example, “Do you
know what a zav is? One of these is a zav. Which one is the zav?” In the unlabeled
condition, the experimenter asked instead, “Which one [looking in the direction of the
tactile objects] is the same as that one [gazing at the visual version of the training object
which had been placed on top of the box]?” In both conditions, the experimenter then
asked two distractor questions about the tactile objects, and then requested that the child
select the tactile object that was the referent of a novel label (e.g., “Do you know what a
tigg is? One of these is a tigg. Which one is the tigg?”) In both conditions, every child
completed four such trials.

The distractor questions were intended to convey that either tactile object could be
the correct referent of an experimenter’s request. Some distractor questions had correct
answers (“Which one is smaller?”), while others did not (“Which one do you like
better?”) Two distractor questions were asked immediately before the novel label test to
eliminate any expectation regarding the particular object the experimenter might ask
about. The order of the pairs of distractor questions was counterbalanced over
participants.

Children selected the tactile training object as the referent of one distractor
question and the novel object as the referent of the other distractor question on a greater
proportion of trials ($M = .59$) compared to selecting the training object twice ($M = .09$) or
selecting the novel object twice ($M = .31$). Although the children rarely chose the tactile
training object as the referent of both distractor questions, 3-year-olds were more likely to
show this pattern compared to 4-year-olds ($M = .16, SD = .26$ and $M = .03, SD = .08$, respectively), $t(37.41) = 2.59, p < .05$. Only one 3-year-old and one 4-year-old restricted their selections to one type of object (i.e., the training object or the novel object) in response to the distractor questions on all four trials.
RESULTS

Warm Up Trials

Similar to Experiment 1, children’s performance on the warm up trials was excellent. Although they disagreed about whether the object was big or small, 94% agreed that it was soft and that it was a ball.

Trained Label – Visual Trials to Criterion

On the majority of trials (73%), children recalled the trained label after only one attempt. On all four trials, ten 3-year-olds and 17 4-year-olds recalled the trained label on the first recall test. As in Experiment 1, 3-year-olds required more trials than 4-year-olds to learn to produce the label ($M = 1.52, SD = .53$, and $M = 1.28, SD = .40$, respectively), $t(57.08) = 1.99$, one-tailed $p < .05$.

Training Object – Tactile Identification

On each of four trials, the children were first asked to identify the tactile version of the training object. Table 3 summarizes how often children chose correctly. Overall, performance was excellent ($M = 3.58, SD = .77$). Because of a non-normal distribution of responses, a 2 (age) X 2 (condition) X 2 (number correct: 4 vs. fewer) log-linear analysis was conducted. Performance did not vary by age, condition, or age x condition.
Table 3. Children classified by choices on tests of the trained label in Experiment 2.

<table>
<thead>
<tr>
<th>AGE</th>
<th># CORRECT</th>
<th>Labeled Match</th>
<th>Unlabeled Match</th>
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<tbody>
<tr>
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Novel Label – Tactile Label Extension

At the end of each trial, the children were asked to find the tactile referent of a novel label. Table 4 summarizes how often children responded by choosing the novel object. An age x condition analysis of variance of these responses could not be conducted because of heterogeneity of variance; main effects were examined with t tests. Most 4-year-olds chose the novel object on every trial ($M = 3.50, SD = .88, \text{max} = 4$), whereas 3-year-olds showed only a weak tendency to select this object rather than the training object ($M = 2.47, SD = 1.32$), $t(54.02, \text{equal variances not assumed}) = 3.68, p < .01$. The younger group’s frequency of selecting the novel object exceeded chance by a one-tailed test, $t(31) = 2.01, p < .05$. Children in the labeled condition selected the novel object ($M = 3.25, SD = 0.98$) more often than those in the unlabeled condition ($M = 2.72, SD = 1.40$), $t(55.68) = 1.76$, one-tailed $p < .05$. Selection of the novel object exceeded chance in both conditions, $t_s > 2.71, p < .01$.

Although a two-way analysis of variance could not be performed, the mean difference between the labeled and unlabeled condition was somewhat larger in the 4-year-olds (3.81 vs. 3.19) than in the 3-year-olds (2.69 vs. 2.25). Also, the difference was significant in the older group, $t(18.90) = 2.12, p < .05$, but not the younger group, $t < 1$. Although this last result does not support the claim that condition affected the selections of the younger group, 3-year-olds’ frequency of selecting the novel object did exceed
Table 4. Children classified by choices on tests of the novel label in Experiment 2.

<table>
<thead>
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<th>INSTRUCTION</th>
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<tr>
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chance in the labeled condition, $t (15) = 2.55, p < .05$, but not the unlabeled condition, $t (15) < 1$.

**Object Nameability Judgment**

Children were more accurate at judging whether they knew the names for familiar objects ($M = .89, SD = .21$) compared to unfamiliar objects ($M = .56, SD = .41$), $t (63) = 5.44, p < .01$. The overall accuracy of these judgments increased with age, $r (62) = .41, p < .01$, replicating Experiment 1. Also as in Experiment 1, judgment accuracy was positively associated with how often a child extended novel labels to novel objects, $r (62) = .31, p < .05$. When this relation was examined within condition, however, it was significant in the unlabeled condition, $r (30) = .42, p < .05$, but not the labeled condition, $r (30) = .19, p > .10$.

To further examine the relation in the unlabeled condition, children were split into three groups based on their object nameability judgment score: low (range = .37-.50; $M = .49; N= 12$); intermediate (range = .60-.83; $M = .71; N = 8$); and high (range = .88-1.00; $M = .96; N = 12$). The low scorers extended the novel label onto the novel object with a frequency no different from chance ($M = 1.92, SD = 1.56$, chance = 2), $t < 1$, whereas the high scorers showed a strong preference for this mapping ($M = 3.42, SD = 1.00$), $t (11) = 4.93, p < .001$. The intermediate scorers showed a moderate preference for it ($M = 2.88, SD = 1.13$), $t (7) = 2.20$, one-tailed $p < .05$. When the accuracy of object nameability judgment was partialled out, the correlation between age and frequency of extending novel labels onto novel objects in this condition was no longer significant, $r (29) = .15, p$
>.05. Thus, the greater frequency with which older children avoided label overlap in the unlabeled condition was accounted for by their greater ability to make reflective judgments of their object name knowledge.

Figure 2 depicts novel label extension performance as a function of object nameability judgment accuracy in both the unlabeled and labeled conditions. Condition only affected the novel label extension of the children who showed no ability to judge whether objects had known names (i.e., low scorers). In the unlabeled condition, these children did not consistently map novel labels onto novel objects ($M = 1.92$), but in the labeled condition, they did ($M = 3.07, SD = 0.92$), $t (17.17) = 2.25, p < .05$. In contrast, those children who showed at least some ability to judge object nameability (i.e., intermediate and high scorers) mapped novel names onto novel objects with comparable frequency in the unlabeled and labeled conditions (3.20 and 3.39, respectively), $t (36) < 1$. 
Figure 2. For Experiment 2, novel object selections on novel label trials as a function of condition and object nameability judgment accuracy. Error bars are +/- 1 standard error of each mean.
DISCUSSION

In contrast to Experiment 1, most of the children avoided label overlap. The most likely reason for this contrast is that only the procedures of Experiment 2 eliminated the influence of match expression. By beginning every tactile test trial with a request to select the object that matched the visual training object, the children were given an opportunity to communicate their discovery that one of the tactile objects matched the training object. This procedure satisfied any desire or expectation they might have had to refer to the matching object, and allowed them to fully comprehend the subsequent request to select a referent of the novel label.

Match expression was stronger in the 4-year-olds than in the 3-year-olds. Even in the unlabeled condition, in which instructions did not use the trained label to refer to the tactile training object, 4-year-olds avoided label overlap on the majority of the test trials ($M = .80$). This selection rate exceeded the chance-level rate (.55) shown by the 4-year-olds in Experiment 1 (in which procedures did not allow children to satisfy match expression), $t(44) = 2.19, p < .05$. In contrast to the older children, 3-year-olds avoided label overlap in the unlabeled condition at a rate (.56) that did not differ from chance or from the rate shown by 3-year-olds in Experiment 1 (.48), $t(40) < 1$. 
Although 4-year-olds’ tendency to avoid label overlap was strong in the unlabeled condition, it was nearly absolute in the labeled condition (see Table 4). Thus, in a few instances, allowing 4-year-olds to satisfy match expression was not sufficient to insure their avoidance of label overlap. The benefit they received from being directed to the match by the experimenter’s use of the trained label is evidence that their occasional double-labeling of the training object in the unlabeled condition is due to an occasional failure to represent this object by the trained label rather than to some decision to override the default assumptions of Mutual Exclusivity and/or speaker cooperation.

Three-year-olds’ tendency to avoid label overlap was significant in the labeled condition, but not in the unlabeled condition. However, even in the labeled condition, the tendency was weak. Therefore, some “help” other than being allowed to express the visual-tactile match or being directed to this match by the trained label may be needed to induce 3-year-olds to show a strong tendency to avoid label overlap across the senses.

The correlations between children’s object nameability judgment scores and their novel label extension preferences may provide some clues as to what is holding the 3-year-olds back. This correlation accounted for the age difference in novel label extension performance in the unlabeled condition. After identifying the visual-tactile match, many 3-year-olds may have failed to reliably select the other tactile object as the referent of the novel label for the same reason(s) that they often reported knowing the name for a novel kind of object. Both errors may derive from failure to try to retrieve a label for an object. In novel label extension, failure to retrieve the trained label for the tactile training object
would have left a child with little reason to reject extending the novel label onto this object. In object nameability judgment, failure to attempt to retrieve a name for a novel kind of object would have left a child with little reason to decide that he or she did not know its name.

Failure to spontaneously retrieve the trained label for the tactile training object during the novel label test cannot be 3-year-olds’ only stumbling block, however. If it were, then they would have shown a much stronger tendency to avoid label overlap in the labeled condition. In this condition, the trained label for the tactile training object should have been fresh in their mind when they considered whether this object or the novel object was the referent of the novel label. Other factors that may have reduced 3-year-olds’ tendency to avoid label overlap will be addressed in the next section.
GENERAL DISCUSSION

Just as in Scofield et al. (2009), 3- and 4-year-olds had little difficulty extending a label that had been trained for a visual object to a tactile version of this object. However, their decision regarding whether to map a second, novel label onto this object varied across experiments and individuals.

Our position is that much of this variation can be explained by label retrieval and match expression. Regarding label retrieval, our specific claim is that the greater the likelihood that a child represents the tactile training object by the trained label when he or she considers mapping a novel label onto it, the greater the likelihood that he or she will reject the novel label for it. Although Mutual Exclusivity (Markman & Wachtel, 1988; Merriman & Bowman, 1989) and pragmatic accounts (Clark, 1989; Diesendruck & Markson, 2001; Gathercole, 1989) of avoidance of label overlap differ in several respects, both require that the child note the mismatch between the label being considered for an object and a label that the child knows for the object (Halberda, 2003). It is not enough that the child have previously accepted the known label for the object (or objects of its kind); rather, the child must represent the object by that label when he or she considers accepting a second label for it. That is, the child will only reject the second label if he or she realizes that it mismatches the label that he or she already knows for it.
This proposal would explain Grassmann et al.’s (2012) finding that preschoolers avoided extending a novel label onto an object if they could produce another label for it, but not if they had only receptive knowledge of the object’s name.

Several findings from the current investigation are consistent with the label retrieval hypothesis. First, where preschoolers in Scofield et al.’s (2009) experiments tended to extend the novel label onto the tactile training object rather than the novel tactile object, those in Experiment 1 showed no mapping preference. More training of the label for the visual object was provided in Experiment 1 than in Scofield et al.’s experiments, and only in Experiment 1 were children required to show that they could produce this label for the visual object before proceeding to the cross-modal label extension tests. For these reasons, the likelihood that children represented the tactile version of the training object by the trained label when they considered mapping the novel label onto it may have been greater in Experiment 1 than in Scofield et al.’s experiments, although not great enough to reverse the novel label extension preference shown by Scofield et al.’s participants.

Secondly, the label retrieval hypothesis could account for the positive correlation found between how often children avoided label overlap and how accurately they judged their knowledge of object names in both Experiment 1 and the unlabeled condition of Experiment 2. The primary error made by inaccurate judges of object name knowledge is to report knowing the name for an object that they cannot actually name (Marazita & Merriman, 2004). Their tendency to make this error may stem from slower name retrieval
processes and/or a weaker tendency to try to retrieve labels for objects. Poorer judges of object name knowledge have been found to name familiar kinds of objects less rapidly than other children (Lipowski & Merriman, 2011). If preschoolers’ object nameability judgments are a marker for the strength of name retrieval processes, and the label retrieval hypothesis is valid, then it makes sense that the accuracy of these judgments would correlate with avoidance of label overlap in Experiment 1 and the unlabeled condition of Experiment 2, but not the labeled condition of Experiment 2. Only in the latter condition were children asked to verify that the trained label applied to the tactile training object rather than the novel tactile object shortly before deciding which object was the referent of a novel label. Because children nearly always succeeded in verifying this mapping, even those with weak name retrieval processes should have tended to represent the tactile training object by the trained label when they considered whether to extend the novel label onto it.

Thirdly, the finding that 4-year-olds avoided label overlap more frequently in the labeled than unlabeled condition of Experiment 2 provides further support for the label retrieval hypothesis, at least for this age group. Although children in the unlabeled condition verified that the tactile training object match the visual training object, they were not asked to verify that the label they had learned for the visual object extended to its tactile counterpart. Thus, the 4-year-olds in this condition should have been less likely to represent the tactile object by the trained label when tested on the novel label, compared to the 4-year-olds in the labeled condition.
Regarding match expression, our claim is that when examining the tactile choice objects, children discovered that one of these objects matched the visual training object, which led them to expect the experimenter to ask about it and/or made them want to tell the experimenter about it. This expectation/desire may have been stronger than the expectation(s) that usually promote avoiding label overlap (i.e., the expectation that labels will have mutually exclusive extensions and/or that a speaker will use a mutually known label to refer to a familiar object). Alternatively, the expectation/desire to refer to the cross-modal-match may have interfered with executing the processes that would have promoted avoiding label overlap (e.g., with realizing that the novel label in the experimenter’s test question did not match the known label for the training object).

Four-year-olds gave clearer evidence than 3-year-olds of having been influenced by match expression. The older age group showed a stronger tendency to avoid label overlap in both conditions of Experiment 2, but showed no tendency in Experiment 1; only the procedures of Experiment 2 allowed them to satisfy an expectation/desire to refer to the cross-modal match before they were asked to select the referent of a novel label.

We could find no research demonstrating that young children desire to tell another person about a discovery or expect someone to ask about a discovery that is relevant to shared discourse. Akhtar, Carpenter and Tomasello (1996) did find that 2-year-olds interpreted a speaker’s novel label as referring to an object that was new to discourse. This object was the only one that had been presented to the children after the speaker had
momentarily stepped out of the room, and so was the only one that was new to the speaker when she returned and uttered the label. The authors proposed that 2-year-olds are sensitive to the knowledge states of others, and expect a person to comment on things that are new to the person, but not necessarily new to the child listener. (See Samuelson and Smith (1998) for an alternative mechanistic explanation, and Diesendruck, Markson, Akhtar, and Reudor (2004) for a rebuttal.)

Even if the pragmatic explanation advanced by Akhtar et al. (1996) is valid, it does not clearly imply that the children in the current experiments would expect the speaker to comment on the tactile object that matches the visual training object rather than the novel object. One could even argue that it implies the opposite because only the novel object is new to discourse from the child’s perspective. Of course, the way in which the child experience each object (i.e., via touch without vision) is new to discourse.

A pragmatically sophisticated child might reason that because the match between the tactile training object and the visual training object is not obvious, the interlocutor would not know whether the child had discovered the match unless the child expressed this fact to the interlocutor. Therefore, to satisfy the desire/expectation to express this fact, the child might select the tactile training object when asked to select the referent of the novel label. Note that such a child would not make a similar type of selection in the standard (non-cross-modal) novel label extension paradigm. In the standard paradigm, the child is likely to judge that the match between the visual training object and this very same object in the test set is so obvious that there is no need to inform the speaker of
having detected it. Therefore, to avoid violating a default assumption about label extensions and/or speaker’s choice of referring expressions (see Halberda, 2006), the child would tend to select the novel object in the test set as the referent of the novel label.

Our results imply that the expectation/desire to inform the speaker of the cross-modal match is stronger in 4-year-olds than in 3-year-olds. So the pragmatic concepts and reasoning abilities that underlie this expectation/desire are most likely related to those that tend to develop around the fourth birthday.

The fourth birthday tends to be the age at which most children being to reliably pass tests of whether they understand false belief and Level II perspective taking (Wellman, Cross, & Watson, 2001; Doherty, 2009). These tests require a child to represent the representation that a person forms based on the perceptual or verbal information that is available about a situation. Moreover, the child must understand that the person’s decisions about the situation will be based on this representation, not necessarily on the true nature of the situation. In the cross-modal test of novel label extension, only children who tend to represent the beliefs of another person and expect the person to be guided by these beliefs may form the desire or expectation to communicate their discovery of the cross-modal match to the experimenter.

Children’s understanding of teaching may be particularly relevant to match expression. In order for teaching to occur, one must be aware of a knowledge gap between a teacher and learner (Olson & Bruner, 1998). Between the ages of 3- and 5-year-old, children begin to reason about others’ beliefs when determining whether
teaching will occur. For example, they come to recognize that it is not a learner’s actual knowledge state, but a teacher’s belief about it that determines whether the teacher will attempt to teach the learner (Ziv & Frye, 2004). Children also come to understand that teacher’s sometimes ask for information that they themselves already possess in order to determine whether the learner possesses it (Ziv, Solomon, & Frye, 2008). When teaching a peer how to play a game, older preschoolers are more likely than younger ones to “check in” on the learner’s understanding (David-Unger & Carlson, 2008) and adjust their teaching strategy to fit the learner’s current knowledge state (Strauss, Ziv, & Stein, 2002).

In the current studies, because of their more advanced understanding of teaching, 4-year-olds may have been more likely than the 3-year-olds to speculate about the experimenter’s belief about the child’s knowledge, which led them to form a desire/expectation to communicate their discovery of the cross-modal match. For example, upon discovering that one of the tactile objects matched the visual training object, the 4-year-olds may have assumed that the experimenter did not know that they had discovered this match. The 4-year-olds may have chosen the tactile training object in order to inform (or “teach”) the experimenter of their discovery. Alternatively, they may have expected that the experimenter was going to ask about the matching object to assess whether the child had discovered the match.

Even though there was no evidence that a desire/expectation for match expression affected the 3-year-olds’ mapping of a novel label, they still showed a weaker tendency
than the 4-year-olds to extend the novel label to the novel rather than training object. This age difference was even evident in the labeled condition where the demands on label retrieval ability were minimized.

Perhaps 3-year-olds just have fewer working memory resources available to carry out processes (besides label retrieval) that are necessary for avoiding label overlap. Another possibility is that the 3-year-olds were affected more negatively by the introduction of distractor questions in Experiment 2. While these questions were designed to demonstrate that the experimenter was equally likely to ask about either object, they may have caused children to attend to properties that were not salient in the visual modality. For example, one of the distractor questions asked, “Which one is heavier?” While weight may be a salient object feature in the tactile modality, it is unlikely that the children encoded information about the training object’s weight in the visual modality. So even though the 3-year-olds selected the tactile training object when tested first on the trained label, the subsequent distractor questions may have shifted their attention to salient tactile features of the choice objects, which reduced their tendency to represent the tactile training object by the label that had been trained for its visual counterpart.

According to Bushnell and Baxt (1999), the varying salience of some properties across modalities can explain why young children’s cross-modal matching is sometimes less accurate than their within-modality matching. Future research will need to address the extent to which these factors account for 3-year-olds’ performance.
Overall, the findings from the current experiments have implications for both the cross-modal and word-learning literatures. First, children will only avoid extending a novel label onto an object if they can retrieve a different label for it. Moreover, once they retrieve a label for the object, children must represent that object by that label at the moment they are considering it as a referent of a different label. If both of these steps occur, children are likely to note the mismatch between the two labels and avoid label overlap.

Second, in the cross-modal context, opposing pragmatic principles may affect the novel word mapping of 4-year-olds. On the one hand, they may expect a speaker to refer to an object that is novel to discourse (Akhtar, Carpenter, & Tomasello, 1996) and to refer to novel rather than familiar kinds of objects when using novel referring expressions (Clark, 1989; Diesendruck & Markson, 2001; Gathercole, 1989). On the other hand, they may expect or desire to make reference to a discovery, in this case, the discovery that the tactile “familiar” object matches the visual object for which a label was just trained. A goal for future research will be to determine whether such a conflict is unique to cross-modal contexts or whether it is evident whenever a child believes that a listener would want to know about a discovery that the child has made.
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