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Linguistic labels: Conceptual markers or object features?

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ABSTRACT

Linguistic labels affect inductive generalization; however, the mechanism underlying these effects remains unclear. According to one similarity-based model, SINC (similarity, induction, naming, and categorization), early in development labels are features of objects contributing to the overall similarity of compared entities, with early induction being similarity based. If this is the case, then not only identical but also phonologically similar labels may contribute to the overall similarity and thus to induction. These predictions were tested in a series of experiments with 5-year-olds and adults. In Experiments 1–5 participants performed a label extension task, whereas in Experiment 6 they performed a feature induction task. Results indicate that phonological similarity contributes to early induction and support the notion that for young children labels are features of objects.

Introduction

Words play an important role in directing inductive generalization from known to novel. For example, when two appreciably different entities are referred to as "dogs" and one of the dogs is described as having a particular property (e.g., it has short bones), even young children are more likely to generalize this property to another dog than when the entities are referred to as "a dog" and "a cat" or when no words are introduced (Gelman & Markman, 1986; Sloutsky & Fisher, 2004; Sloutsky, Lo, & Fisher, 2001). However, the mechanism by which words guide young children's induction remains unclear.

Some researchers suggest that young children hold a number of *conceptual* assumptions about the world and language (see Gelman & Coley, 1991; Keil, Smith, Simons, & Levin, 1998; Murphy, 2002, for

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reviews of these assumptions), and words guide induction by invoking this conceptual knowledge. First, young children assume that (a) individuals belong to categories and (b) things belonging to the same category have much in common. Second, they assume that linguistic labels presented as count nouns are symbols denoting categories. Thus, on the basis of these assumptions, young children conclude that things having the same name are likely to have much in common.

Another theoretical position argues that there is no need to posit rich conceptual knowledge to understand effects of words on young children's induction. For example, a similarity-based model of generalization in children, SINC (similarity, induction, naming, and categorization (Sloutsky & Fisher, 2004), argues that (a) young children perform induction on the basis of the overall similarity among compared entities, (b) shared linguistic labels are features contributing to the overall similarity, and (c) the process of computing similarity over visual and auditory features is automatic rather than deliberate (see Sloutsky & Fisher, 2005 for a discussion). In the next section, we present SINC in greater detail.

SINC: Labels as features contributing to similarity

SINC considers labels as features contributing to the overall similarity of compared entities (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999; Sloutsky et al., 2001; see also Sloutsky & Fisher, 2005 for a discussion). There is evidence supporting this assumption of SINC; when entities share a label, young children tend to consider these entities as looking more alike than when the same entities are presented without labels (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999). According to the theory underlying SINC, these effects stem from attentional factors such as auditory information overshadowing (or attenuating processing of) corresponding visual information (Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004, 2007a, 2007b, 2008; Sloutsky & Napolitano, 2003).

Initial evidence for overshadowing was presented in the Sloutsky and Napolitano (2003) study in which 4-year-olds and adults were presented with an auditory–visual target item followed by a test item. Participants needed to respond "same" if the two compound stimuli had the same auditory and visual components and respond "different" if either the auditory or visual component differed between the target and test items. The auditory components consisted of unfamiliar nonlinguistic sounds, and the visual components consisted of unfamiliar images (e.g., abstract geometric shapes). If participants encode both auditory and visual stimuli, they should correctly accept target items as the same while correctly rejecting items that had either new visual or new auditory components as different. It was found that 4-year-olds failed to report that the visual components changed when visual input was accompanied by auditory input. At the same time, processing of visual stimuli was not difficult per se; in the absence of auditory input, young children ably encoded the visual input (Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004; Sloutsky & Napolitano, 2003). Similar effects were found in 8-, 12-, and 16-month-olds (Robinson & Sloutsky, 2004).

To introduce SINC more formally, we first consider its predictions for a class of frequently used induction tasks (Gelman & Markman, 1986; Sloutsky & Fisher, 2004). In these tasks, children are presented with a target item and two test items: A and B. After labels for the target and test items are introduced, children are taught that Test A has a particular quasi-biological property (e.g., has hollow bones) and Test B has a different quasi-biological property (e.g., has solid bones). The task is to decide whether the target has hollow bones like Test A or solid bones like Test B. SINC predicts that the probability of inducing a property from a test item (say Test B) to the target is a function of ratio of the overall similarity of Test A to the target and Test B to the target, which is a consequence of Luce's choice rule. More formally, this probability is presented in Eq. (1):

$$P(B) = \frac{\mathrm{Sim}(B,T)}{\mathrm{Sim}(B,T) + \mathrm{Sim}(A,T)} = \frac{1}{1 + \frac{\mathrm{Sim}(A,T)}{\mathrm{Sim}(B,T)}}, \tag{1}$$

where Sim(A,T) and Sim(B,T) are similarities of Test A and Test B to the target, respectively. Furthermore, according to SINC, the overall similarity between each of the test items and the target is a function of visual similarity and the weight of linguistic label:

$$\text{Sim}(B,T) = \lambda v^B, \tag{2}$$

where λ and v (these parameters vary between 0 and 1) denote values (weights) of a label and visual properties, respectively, whereas B denotes the number of featural mismatches between the appearance of Test B and the target. When there are no mismatches, $B = 0$ and $\lambda = v = 1$; thus, the similarity between Test B and the target was equal to unity.

Now substituting similarities in Eq. (1) with those in Eq. (2), we can express the probability of inducing a property from Test B to the target:

$$P(B) = \frac{1}{1 + \lambda \frac{v^A}{v^B}}, \tag{3}$$

where λ is the weight of label mismatch and $\frac{v^A}{v^B}$ is the ratio of appearance similarities of each of the test items to the target. Therefore, according to SINC, the probability of inducing a property from Test B to the target is a function of (1) the ratio of similarities of each of the test item's appearance to the target's appearance and (2) the weight of the label.

There are a number of reports supporting predictions of SINC. In particular, Sloutsky and Fisher (2004) demonstrated that SINC accurately predicts induction and categorization performance of young children with a variety of stimuli, including those that were previously used in research supporting the naive theory approach to induction (e.g., picture triads used by Gelman and Markman (1986)). In addition, as mentioned above, there is evidence supporting the basic assumption of SINC that early in development labels are features contributing to the overall similarity of compared entities. In particular, when two entities share a label, young children tend to consider these entities as looking more alike than when the same entities are presented without labels (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999).

However, previous research testing SINC (e.g., Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999; Sloutsky et al., 2001) used only triads in which items had either identical or different labels, with identical labels contributing to similarity and thus to induction. At the same time, if labels are features contributing to similarity, it is possible that labels are perceived as subjectively continuous variables, in which case not only the identity but also the phonological similarity of labels would contribute to the overall similarity and to induction (Eq. (4)):

$$\text{Sim}(B,T) = \lambda^{\beta} v^B, \tag{4}$$

where λ and v denote values (weights) of a label and visual property, respectively, and B and β denote the number of featural mismatches between the appearance and the label of Test B and the target, respectively. When there are no mismatches, $\beta = B = 0$ and $\lambda = v = 1$, the similarity between Test B and the target was equal to unity. Finally, substituting similarities in Eq. (4) with those in Eq. (1), we can express the probability of inducing a property from Test B to the target:

$$P(B) \frac{1}{1 + \frac{\lambda^{\alpha}}{\lambda^{\beta}} \frac{v^A}{v^B}} \tag{5}$$

where λ^{α} is the similarity of the label of Test A to the label of the target and λ^{β} is the similarity of the label of Test B to the label of the target. Therefore, the probability of inducing a property from Test B to the target is a function of two similarity ratios: (a) the ratio of appearance similarities of each of the test items to the target's appearance and (b) the ratio of label similarity of each of the test items to the target's label.

There is evidence supporting (albeit indirectly) the possibility of effects of phonological similarity on induction. In particular, Merriman and Schuster (1991) demonstrated that phonological similarity of words led to attenuated "mutual exclusivity" effects in 2- and 4-year-olds. Mutual exclusivity is a tendency of toddlers and young children to interpret novel words as referring to novel items rather than familiar items (Markman & Wachtel, 1988). For example, when presented with an apple and a novel object and asked to select a *dax*, participants pointed to the novel object. Merriman and Schuster (1991) found that the effect decreases markedly or disappears if the novel word is phonologically similar to a familiar word; children would not necessarily extend a novel word *japple* to a novel object but might instead extend it to an apple.

Although these findings might be indicative of the fact that phonological similarity of words is important for young children, there is another possible interpretation (and Merriman and Schuster (1991) explicitly pointed to this possibility). In particular, these findings may stem from young children's tendency to interpret phonologically similar words as variants of the target words. First, it is possible that young children interpret a phonologically similar variant of a familiar target word as a morphological derivation of the target word (i.e., *japple* is to *apple* is like *doggie* is to *dog*). Another possibility is that children interpret a phonologically similar word as an alternative pronunciation of the target word (similar to alternative pronunciations of words such as *route* and *data*) or as a different speech token of the target word.

However, there is evidence challenging these alternative interpretations of Merriman and Schuster's (1991) findings while supporting the possibility that phonological similarity is important for early generalization. According to a report by Dewhurst and Robinson (2004), even when phonologically similar words are known to be different words (e.g., *bag* vs. *bad*), phonological similarity affects the way words are represented in memory. These authors demonstrated that young children are more susceptible to phonological errors on the recall tasks than older participants. In particular, young children falsely reported that the word *bag* was presented when in fact the presented word was *bad*. At the same time, preadolescents and adults are more prone to semantic intrusions (i.e., they falsely reported that the word *good* was presented when in fact the presented word was *bad*). These effects could not stem from young children interpreting phonologically similar words as morphological variants or alternative pronunciations of the same word because all words were familiar to young children.

The Merriman and Schuster (1991) study, in conjunction with the Dewhurst and Robinson (2004) study, presents indirect evidence supporting the prediction of SINC that phonological similarity of labels may affect induction in young children. The goal of the current research was to test this prediction directly. The second goal was to test another prediction that follows directly from the idea that early in development phonological similarity of labels contributes to the overall similarity and thus to induction. This prediction concerns performance on a lexical extension task (i.e., "This is a *gatu*; show me a *zatu*"). Because label extension is a variant of an induction task, with participants generalizing a label rather than a property, performance on a label extension task should also be driven by the overall similarity, such that children should map phonologically similar labels to visually similar items. There is some evidence supporting this prediction; young children extend identical words (with identity being the maximal similarity) to similarly looking items (Gentner, 1978). However, effects of phonological similarity on label extension in young children have never been examined directly.

Both predictions (i.e., that phonological similarity contributes to the induction of properties and to label extension) are novel, and they follow from the central assumption of the model. The qualitative predictions of SINC pertaining to label extension (i.e., that phonologically similar labels get mapped onto similarly looking items) were tested in Experiments 1–5, whereas quantitative predictions of SINC pertaining to induction of properties (i.e., to what extent phonological similarity of labels contributes to induction) were tested in Experiment 6.

Experiment 1

The goal of Experiment 1 was to test the prediction of SINC that phonological similarity of labels directs young children's induction. Experiment 1 used a variant of an induction task in which young children extended the label of the target item to one of the test items. If phonological similarity guides early induction, then young children should extend phonologically similar labels to perceptually similar entities. At the same time, this might not be the case for adults, who may treat labels as proxies for category membership rather than object features (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999; Yamauchi & Markman, 2000).

Method

Participants

The participants were 18 preschool-age children (10 girls and 8 boys, mean age = 5.26 years, *SD* = 0.33) recruited from child-care centers located in middle-class neighborhoods of the Columbus, Ohio, area of the midwestern United States. In this and all other experiments reported here, participants were included in the sample on the basis of returned parental consent forms. There were also 15 adults (5 women and 10 men, mean age = 21.21 years, *SD* = 3.45) who participated in this experiment in exchange for a partial course credit.

Materials

Materials consisted of eight sets of color photographs and eight pairs of artificial labels calibrated for phonological similarity. Calibration was done in a separate experiment with 103 young children (see Appendix for details of the calibration experiment) in which participants needed to decide which of the two test words sounded more similar to the target. The calibration experiment yielded three levels of phonological similarity, with some test items being identical to the target (e.g., both were referred to as *gama*), some being similar to the target (e.g., one test item being referred to as *gatu* and the target being referred to as *zatu*), and some being different from the target (e.g., one test item being referred to as *satu* and the target being referred to as *kipa*). Special care was taken to insure that phonological similarity would not communicate morphological relatedness (see Appendix for details). Experiments 1–5 used either phonologically similar or phonologically different labels, whereas Experiment 6 used labels at all three levels of phonological similarity. The list of label pairs used in Experiments 1–5 is presented in Table 1.

Although these labels were phonologically similar, they were discriminable by young children. The discriminability of labels was established in a calibration experiment (see Experiment 5 for a detailed description) with a separate group of 20 children. These participants were asked to judge whether two successively presented labels were identical or not, with half of these label pairs being identical and half being phonologically similar. The results indicated that young children had little difficulty in discriminating phonologically similar labels ($d' = 3.41$, above 0, one-sample $t(19) = 9.76$, $p < .0001$). Therefore, phonological similarity effects (if found) cannot be attributed to children's inability to discriminate phonologically similar labels.

Each picture set consisted of colored photographs of a *target* (e.g., red grapes) and four *test* items; Test 1 was identical to the target (i.e., *identical*), Test 2 depicted a similar entity from the same basic level category as the target such as green grapes (i.e., *similar*), Test 3 depicted an entity coming from the same superordinate category as the target such as cherries (i.e., *less similar*), and Test 4 was perceptually and ontologically different from the target such as a purse (i.e., *dissimilar*). Examples of pictures sets are presented in Fig. 1.

Procedure

In this and all other experiments presented below, children were tested individually in their childcare centers and adults were tested individually in a laboratory on campus by hypothesis-blind female experimenters. Picture sets were presented on a computer screen. Participants were told that they would see pictures of things they might know and would learn what these things are called "in a far-away place." There were a total of eight trials. On each trial, a target was labeled with an artificial word and participants were asked to find a test item that would be labeled with a phonologically

Table 1
Label pairs used in Experiments 1–5.

Unfamiliar phonologically similar labels used in Experiments 1, 3, and 5[a]	Unfamiliar phonologically different labels used in Experiment 2	Familiar phonologically similar labels used in Experiment 4
Fika/pika	Ti-gi/zuma	Mouse/house
Sudu/su-gu	Ta-ni/sodu	Bone/boat
Tabi/da-bi	No-bi/sadu	Box/fox
Fima/fina	Sotu/ku-ma	Horse/horn
Zatu/gatu	Gitu/vu-ka	Dream/drum
Gama/guma	Fida/zo-tu	Bug/mug
Foka/fuka	Tabi/fo-ka	Bed/bell
Sanu/sadu	Satu/kipa	Flower/shower

Note: Hyphenation indicates a long vowel.
[a] The subset of label pairs used in Experiment 5 is underlined.

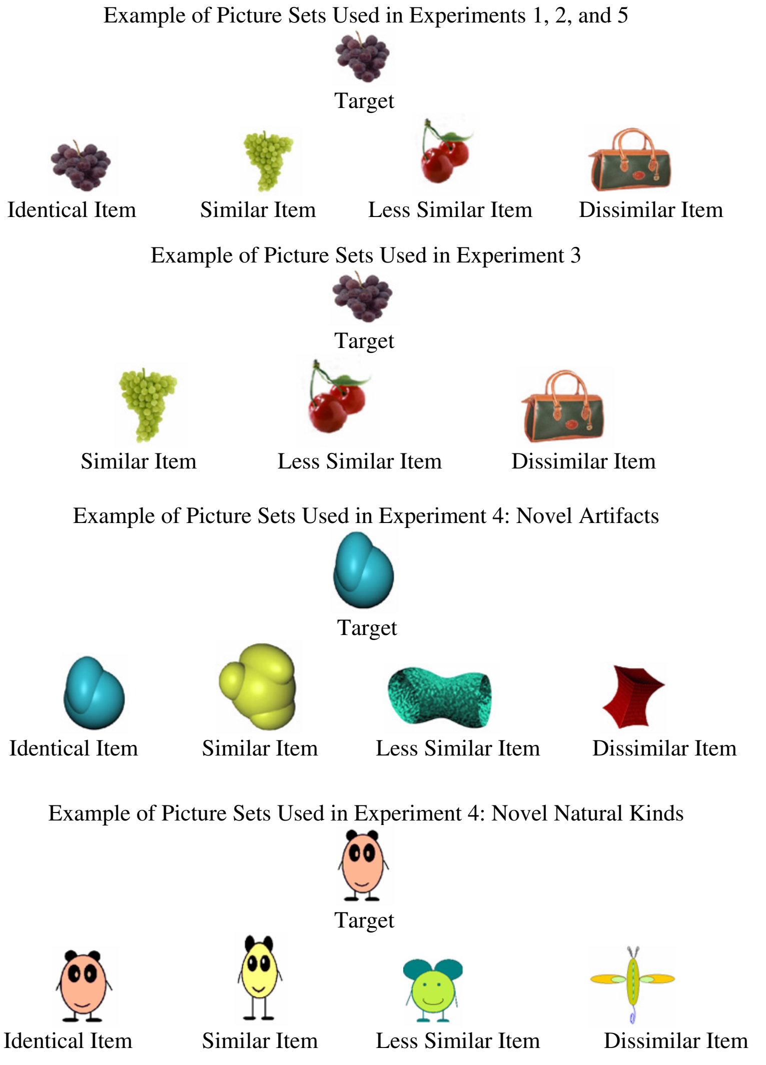

Fig. 1. Examples of picture sets used in Experiments 1–5.

similar word. For instance, participants could be told that the target is called a *gama* in a far-away place and asked to find a test item that is called a *guma* in the far-away place. The position of test items on the screen and the order of trials were randomized.

Results and discussion

Proportions of label extensions across the four levels of test–target similarity for children and adults are presented in Fig. 2 (these proportions for children across experiments are also presented in Table 2). Data in this figure indicate that young children overwhelmingly extended phonologically similar labels to identical items (i.e., 84%, above chance, one-sample $t(17) = 8.19$, Bonferroni-adjusted $p < .0001$), whereas they rarely selected the similar, less similar, and dissimilar items (i.e., 9%, 4%, and 3%, respectively). Furthermore, of 18 tested children, 16 demonstrated a dominant pattern of responding (i.e., selecting the same type of test item on at least 75% of the trials or at least six of the eight

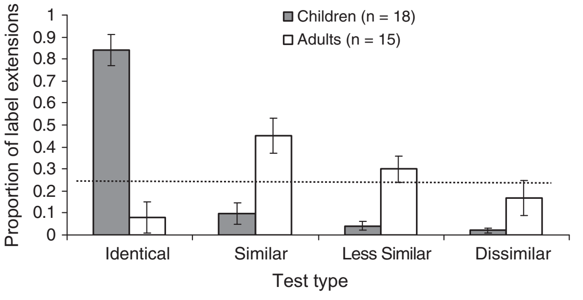

Fig. 2. Proportions of label extensions by test item type and age in Experiment 1. Error bars represent the standard error of the mean, and the dotted line represents chance level.

Table 2
Percentages of children's label extension by test item type in Experiments 1–4.

	Test item			
	Identical	Similar	Less similar	Dissimilar
Experiment 1 (unfamiliar similar labels)	84	9	4	3
Experiment 2 (unfamiliar dissimilar labels)	28	26	25	21
Experiment 3 (unfamiliar similar labels and "identical" item removed)	N/A	78	19	3
Experiment 4 (familiar similar labels)	65	10	12	13

Note: N/A, not applicable.

trials). In contrast, adults' responses were more diffused, with only 4 of 15 participants demonstrating a dominant pattern of responding (2 participants chose similar test items, 1 participant chose less similar items, and 1 participant chose dissimilar items consistently) and none of the choice options eliciting above-chance responding (all Bonferroni-adjusted *p*s > .12). The difference in the proportions of child and adult participants demonstrating a dominant pattern of responding was significant, $\chi^2(1, N = 33) = 13.27$, $p < .001$.

These results point to an important difference between label extension in young children and that in adults. Whereas young children overwhelmingly extend similar labels to identical items, adults exhibit no dominant pattern of responding, with their responses being diffused across the choice options. These results indicate that phonological similarity of labels contributes to young children's generalization (something that could be expected if labels are treated as continuous features), whereas it has no contribution to generalization of adults (something that could be expected if labels are treated as category markers).

It could be argued, however, that young children were merely matching pictures without attending to the phonological similarity of labels. According to this explanation, even when presented with different labels, children should continue to match pictures and extend different words to visually similar entities. This possibility was tested in Experiment 2, where children were presented with the same visual stimuli as in Experiment 1, except that this time phonologically different labels were used (see Table 1 for examples).

Experiment 2

Method

Participants

The participants were 14 preschool-age children (11 girls and 3 boys, mean age = 4.92 years, *SD* = 0.26) recruited from child-care centers located in middle-class neighborhoods of the Columbus area.

Materials and procedure

Materials and procedure were similar to those of Experiment 1 with one important difference: Phonologically different labels, such as *satu/kipa,* were used instead of similar labels (see Table 1 for the list of labels used in Experiment 2).

Results and discussion

Results of Experiment 2 differed markedly from those of Experiment 1 (see Table 2). In particular, when presented with phonologically different labels, young children were equally likely to extend these labels to each of the four types of test items (28%, 26%, 25%, and 21% of label extensions to identical, similar, less similar, and dissimilar test items, respectively, not different from chance, all $ps > .45$). Taken together with results of Experiment 1, the current findings indicate that children exhibit different patterns of responses when extending phonologically similar labels than when extending phonologically different labels. Therefore, it seems highly unlikely that children's responding in Experiment 1 was driven by their tendency to merely match pictures.

Note that in Experiment 1 children overwhelmingly extended similar labels to identical items, with identity representing the maximum level of similarity. Therefore, if children's induction is guided by similarity and is not limited to identity, removing identical items from the test set should encourage young children to extend phonologically similar labels to the next most similar to the target item in the set (i.e., the similar item). To test this prediction, we conducted Experiment 3, where we presented participants with the task and materials identical to those used in Experiment 1 with one important difference: Items identical to the target were removed from the sets of test items.

Experiment 3

Method

Participants, materials, and design

The participants were 15 preschool-age children (10 girls and 5 boys, mean age = 4.99 years, $SD = 0.35$) recruited from child-care centers located in middle-class neighborhoods of the Columbus area. The materials and procedure were similar to those of Experiment 1; however, the identical items were removed from the test sets.

Results and discussion

Results of this experiment are presented in Table 2. When identical items were removed from the test set, young children overwhelmingly extended phonologically similar labels to similar items (i.e., 78%, above chance, one-sample $t(14) = 10.52$, Bonferroni-adjusted $p < .0001$), whereas they rarely extended similar labels to either less similar or dissimilar test items (i.e., 19% and 3%, respectively). These findings replicate and further extend results of Experiment 1; young children extend phonologically similar labels not only to identical items (as in Experiment 1) but also to visually similar items.

However, it could be argued that children generalized phonologically similar labels along the lines of visual similarity in Experiments 1 and 3 because they considered similar labels to be variants of pronunciation of the same words, similar to different variants of pronunciation of words such as *route* and *data.* We consider this possibility as highly unlikely for three reasons. First, words with alternative pronunciations are highly infrequent. An extensive search that included two linguists generated just five such words in American English: *route*, *data*, *tomato*, *aunt*, and *vase*. Given such infrequency, the hypothesis that words can have alternative pronunciations should be highly counterintuitive for young children. In addition, there is no evidence indicating that young children know both pronunciations for these words. Finally, results of Experiment 1 provide little evidence that even adults generate such a counterintuitive hypothesis for phonologically similar words.

A more likely possibility is that children may consider the two phonologically similar words as different phonological tokens of the same word. This possibility is more likely because every word is pronounced differently by different speakers, yet even young infants have little difficulty in ignoring this surface variation and perceive the variants as phonological tokens of the same word (see Jusczyk, 1997, for a review; see also Swingley & Aslin, 2007).

We addressed this possibility in Experiment 4, where we presented participants with the same label extension task used in Experiments 1 and 3; however, instead of using familiar objects and novel label pairs, in Experiment 4 we presented participants with novel objects and familiar phonologically similar labels (i.e., *mouse* and *house*). There is little doubt that children do not treat phonologically similar familiar labels, such as *mouse* and *house*, as different tokens of the same word. Therefore, if we replicate the findings of Experiment 1 with phonologically similar familiar labels, it would render highly unlikely the possibility that these results stemmed from children interpreting phonologically similar words as tokens of the same word.

Experiment 4

Method

Participants

The participants were 22 preschool-age children (11 girls and 11 boys, mean age = 4.9 years, *SD* = 0.42) recruited from a child-care center located in a middle-class neighborhood of Pittsburgh, Pennsylvania.

Materials and design

Materials consisted of eight sets of color pictures of unfamiliar objects, half of which represented novel artifacts and half of which represented novel natural kind-like items (see Fig. 1 for examples), and eight label pairs consisting of familiar phonologically similar labels (see Table 1 for the list of label pairs used). A subset of children ($n = 11$) who participated in Experiment 4 were interviewed a week after the completion of the experiment proper to establish that labels used in Experiment 4 were indeed familiar to 5-year-olds. Participants were presented with 16 displays consisting of four pictures each and asked to identify objects corresponding to the labels used in Experiment 4. Children were more than 99% accurate in performing this task.

Results and discussion

Results of this experiment are presented in Table 2. The pattern of label extension obtained with familiar similar labels (which children are unlikely to interpret as variants of pronunciation of the same words) in Experiment 4 was similar to the pattern of results obtained with similar novel labels in Experiment 1. In particular, young children extended phonologically similar labels to identical items (i.e., 65%, above chance, one-sample $t(21) > 4.57$, Bonferroni-adjusted $p < .001$, $d = 1.33$), whereas they rarely extended similar labels to similar, less similar, and dissimilar objects (i.e., 10%, 12%, and 13%, respectively). The use of familiar labels undermines the possibility that young children interpreted phonologically similar words (e.g., *mouse* and *house*) as tokens of the same word. Given that familiar phonologically similar words used in the current experiment elicited a similar pattern of responses as novel phonologically similar (yet discriminable) words used in Experiments 1 and 3, it seems likely that label extension in Experiments 1 and 3 was driven by phonological similarity of labels rather than young children considering phonologically similar labels to be alternative pronunciations of the same word.

Overall, results of Experiments 1–4 (presented in Table 2) generate several important findings. First, label extension in young children is driven by similarity; young children extend phonologically similar labels (but not dissimilar labels) to visually similar items. Moreover, effects of phonological similarity on label extension are strong even when children are presented with novel objects and familiar similar labels. Given that the words used in this experiment were highly familiar (e.g., *mouse* and *house*, *flower* and *shower*), it is very unlikely that children considered the word pairs to be phonological tokens of the same word. Therefore, results of Experiment 4 strongly support the phonological similarity hypothesis while undermining alternative interpretations of results of Experiments 1 and 3.

In sum, results of Experiments 1–4 suggest that for young children phonological similarity of labels affects label extension, with similar sounding labels being extended to similar looking entities. If this is the case, then reducing phonological similarity of labels should also affect the pattern of label extension. The goal of Experiment 5 was to test this hypothesis, thereby providing converging evidence for findings of Experiments 1–4.

Experiment 5

In Experiment 5, young children were presented with a label extension task identical to that of Experiment 1; however, the experiment proper was preceded by discrimination training. Note that label pairs used in Experiments 1–3 were discriminable yet phonologically similar. At the same time, it was assumed that perceptual similarity is a function of discriminability, such that the higher the discriminability, the lower the perceived similarity. Therefore, a training procedure that increases discriminability should decrease similarity of phonologically similar labels. The goal of Experiment 5 was to provide such discrimination training and examine its effects on phonological similarity and on the pattern of label extension.

Discrimination training was followed by the label extension task used in Experiment 1. There were two training conditions: *experimental* and *control*. In the experimental condition, the trained label pairs were also used in the label extension task. In the control condition, participants were trained on one set of phonologically similar pairs, whereas a different set of phonologically similar pairs was used in the label extension task.

The experiment was based on the following logic. If young children's performance in Experiments 1 and 3 was driven by phonological similarity, then discrimination training (which should result in decreased phonological similarity of presented labels) should decrease the level of label extensions to identical items in the experimental condition but not in the control condition.

Note that training was focused strictly on discriminability (and thus on similarity) of labels, and care was taken to insure that young children would not consider training as a hint as to whether the phonologically similar words were token pronunciations of the same word or two different words. In particular, the discrimination task differed from the experiment proper and the words "same," "different," and "word" were never mentioned in the course of training. Furthermore, in terms of potential hints, the experimental and control conditions were identical. Therefore, any considerations prompted in young children by the experimental condition should also be prompted by the control condition.

Method

Participants

The participants were 38 preschool-age children (21 girls and 17 boys, mean age = 5.14 years, *SD* = 0.49), with 17 children participating in the experimental training condition and 21 participating in the control training condition.

Design, materials, and procedure

Experiment 5 consisted of two parts: discrimination training and the experiment proper. There were two discrimination training conditions, experimental and control, with both conditions having the same procedure but different training materials. In the experimental condition, training and the experiment proper used similar materials; labels used in the experimental condition were a subset of labels subsequently presented to participants in the experiment proper (these were labels used in Experiment 1). In particular, the following six label pairs were used in the course of training in the experimental condition[1]: *zatu–gatu*, *pika–fika*, *sudu–su-gu*, *gama–guma*, *tabi–da-bi*, and *fima–fina*. The control condition was similar to the experimental condition in length and task demands; however, the label pairs used in the control condition were unrelated to the label pairs used in the experiment proper (e.g., *tibi–tobi*, *tudi–tugi*, *zuma–zu-uma*).

Discrimination training. During discrimination training, participants were told that they would play a guessing game in which they would see animal cartoons presented on a computer screen. The cartoons could appear either on the left or on the right side of the computer screen. The experimenter then demonstrated how children could predict which cartoon would appear and where. For example, participants were told that when they heard the computer play [at this time *zatu* was played by the computer], a dog cartoon would appear on the left side of the screen, whereas when they heard the computer play [at this time *gatu* was played by the computer], a bird cartoon would play on the right side of the screen. Participants were then told that their task was to predict on which side of the screen the cartoon would appear by carefully listening to the computer. During discrimination training, participants received feedback; cartoons appeared only following correct predictions, whereas incorrect predictions were followed by an unrelated still picture appearing at the center of the screen. The discrimination task consisted of six training blocks (one block per label pair) with 10 trials per block for a total of 60 trials. The order of blocks was constant for all participants, and the order of trials within a block was randomized for each participant. At the conclusion of training in both the experimental and control conditions, participants were praised for their performance and presented with the experiment proper, which was identical to Experiment 1.

Effect of discrimination training on phonological similarity. The ability of training to attenuate phonological similarity by increasing discrimination was tested in a separate calibration experiment with 42 4- and 5-year-olds, none of whom participated in previous experiments or in Experiment 5. There were two between-participants conditions, with 20 children participating in a baseline discrimination condition and 22 participating in the training condition. In the baseline condition participants were presented with a discrimination task, whereas in the training condition the discrimination task was preceded by the training procedure described above. The discrimination task consisted of eight label pairs used in Experiment 2 and eight pairs of identical labels. Participants' goal was to determine whether each pair consisted of the same words or different words. Discrimination accuracy was calculated as the difference between the proportion of hits (correct detection that two presented labels were different) and false alarms (incorrect reporting that two identical labels were different). When there was no discrimination, hits equaled false alarms and discrimination accuracy equaled 0. Perfect discrimination resulted in accuracy of 1. Results of the calibration experiment indicated that participants reliably discriminated phonologically similar labels in the baseline condition (hits = .71, false alarms = .09, accuracy = .62, above 0, one-sample $t(19) = 12.37$, $p < .0001$). More important, training resulted in significantly improved discrimination of the phonologically similar labels (hits = .82, false alarms = .06, accuracy = .76, above the baseline, independent-sample $t(40) > 2.09$, $p < .05$). Given that training increases discrimination of phonologically similar labels, it was expected that in Experiment 5 training would somewhat attenuate phonological similarity of labels (by increasing their discriminability). The attenuation of phonological similarity of labels would in turn affect the pattern of label extension in the experimental condition, which used the same label pairs for training and testing, but not in the control condition, which used different label pairs for training and testing.

Results and discussion

During discrimination training, nine participants (four in the experimental condition and five in the control condition) responded accurately on less than 75% of trials, and their data were excluded from

[1] Using all eight label pairs from Experiment 1 for discrimination training would make the experiment prohibitively long for young children, so a random subset of six label pairs was used. Therefore, it is likely that effects of discrimination training observed in Experiment 5 are underestimated; greater effect of training could be observed if participants were given discrimination training on all eight label pairs used in Experiment 1.

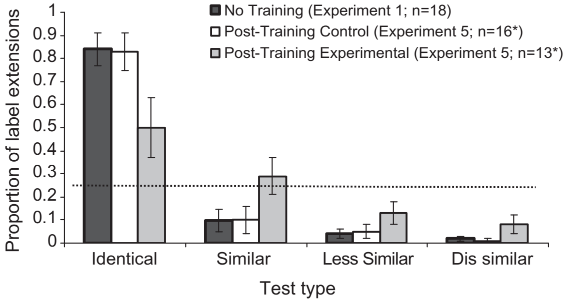

Fig. 3. Proportions of label extensions by test item type and training condition in Experiment 5. Proportions of label extensions in Experiment 1 are included for comparison. Error bars represent the standard error of the mean, and the dotted line represents chance level. *These *n*s include only those children who reached at lease 75% accuracy during training in Experiment 5.

further analysis. The rest of the participants averaged 86% of correct responses in the experimental condition and 87% of correct responses in the control condition (above chance, both one-sample ts > 17.69, $p < .0001$), and our analysis of the label extension data is limited to these participants.

Proportions of label extensions in the experimental and control conditions, as well as proportions of label extensions without training (Experiment 1), are presented in Fig. 3. As can be seen in this figure, discrimination training in the experimental condition changed the patterns of label extension. To analyze this change, proportions of label extensions to identical items in Experiments 1 and 5 were submitted to a one-way analysis of variance (ANOVA) with the training condition as a factor (no training in Experiment 1, experimental training condition in Experiment 5, or control training condition in Experiment 5). Results of the analysis revealed significant differences among these conditions, $F(2, 44) = 4.29$, $p < .05$, $\eta_p^2 = .16$, and a post hoc Tukey test revealed that the decrease in proportion of label extensions to identical items in the experimental condition of Experiment 5 (50%) was significant compared with Experiment 1 (84%, Cohen's $d = .87$) and the control condition of Experiment 5 (83%, Cohen's $d = .84$) (both ps < .05). At the same time, the proportions of extensions in the control condition of Experiment 5 (83%) and Experiment 1 (84%) were statistically equivalent ($p > .99$). These findings clearly indicate that effects observed in the experimental condition of Experiment 5 stemmed from discrimination training resulting in attenuated similarity of labels and not from extraneous factors.

The results of Experiment 5 demonstrate that increasing discriminability (and thus decreasing phonological similarity) of labels has a strong effect on children's performance on a label extension task. In particular, children were less likely to extend phonologically similar labels to identical items after being trained to discriminate pairs of labels used in a subsequent label extension task than after being trained to discriminate pairs of labels irrelevant to the subsequent task. These results provide converging evidence that phonological similarity of labels affects label extension in young children.

Taken together, results of Experiments 1–5 indicate that phonological similarity of labels affects generalization in young children. Furthermore, Experiments 4 and 5 undermine alternative interpretations of the phonological similarity effect, and we come back to this issue in the General Discussion. Whereas results of Experiments 1–5 support predictions of SINC pertaining to the label extension task, the goal of Experiment 6 was to test predictions of SINC pertaining to the property induction task.

Experiment 6

To examine effects of phonological similarity on induction of properties and to test predictions of SINC, Experiment 6 used a variant of the triad task, which includes a target and two test items, with one test item being more similar to the target and the other having a more similar label. Participants were told that Test A had a particular property (e.g., hollow bones), whereas Test B had another property (e.g., solid bones), and their task was to decide whether the target had the same property as Test A or Test B. To separate the contribution of phonological similarity from the contribution of visual similarity, we independently varied both the ratio of visual similarity of entities and the ratio of phonological similarity of labels.

Although the ratio of similarities is a continuous variable, an experiment can have only a finite number of trials and, particularly when participants are young children, this number must be rather small. Therefore, similarity ratios were broken down into two levels for the visual dimension (see Fig. 4) and three levels for the auditory dimension (see Fig. 5). As shown in Fig. 4, at Level 1 appearances were not predictive, with the target and both test items being identical, and the similarity ratio was equal to 1. At Level 2, appearances were fully predictive, with Test A being identical to the target and Test B being very dissimilar. In this case, the similarity ratio, Sim(*A*, target)/Sim(*B*, target), was equal to 9, with Test A, but not Test B, being similar to the target.

There were three levels of phonological similarity (see Fig. 5). At Level 1, labels were not predictive, with test and target labels being the same, and the similarity ratio was equal to 1. At Level 2, labels

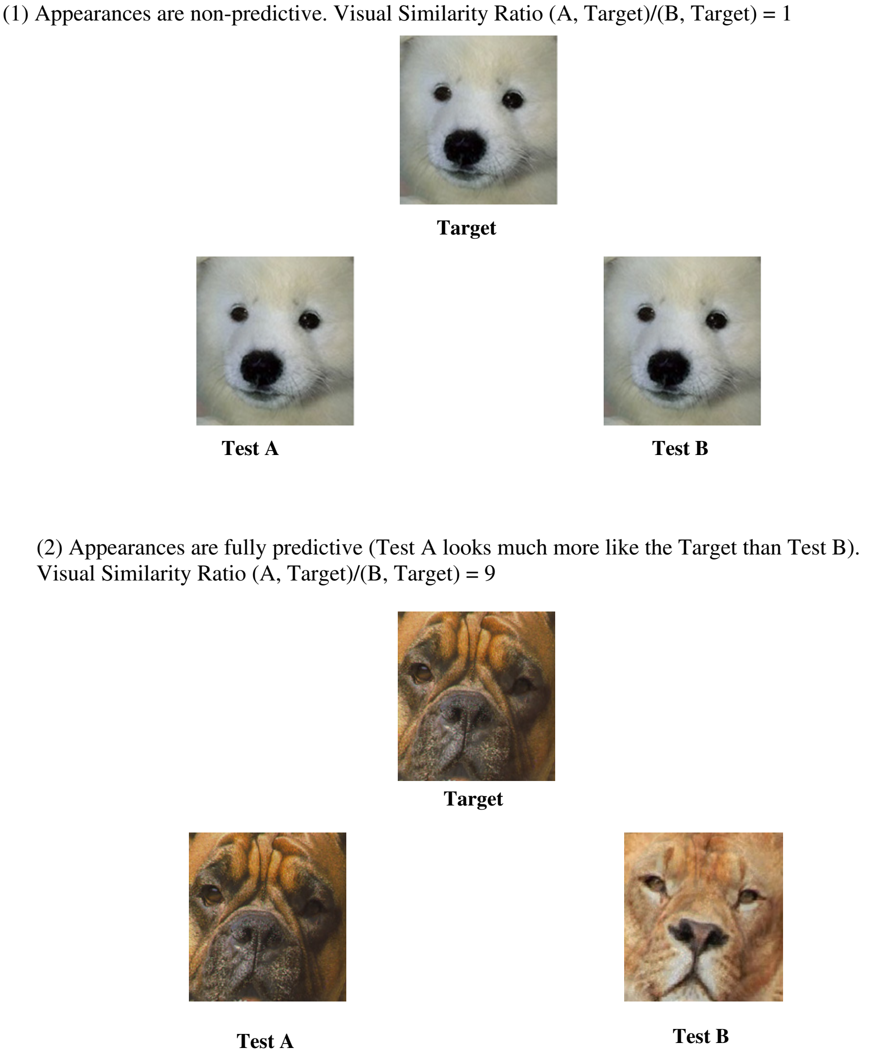

Fig. 4. Examples of visual stimuli used in Experiment 6.

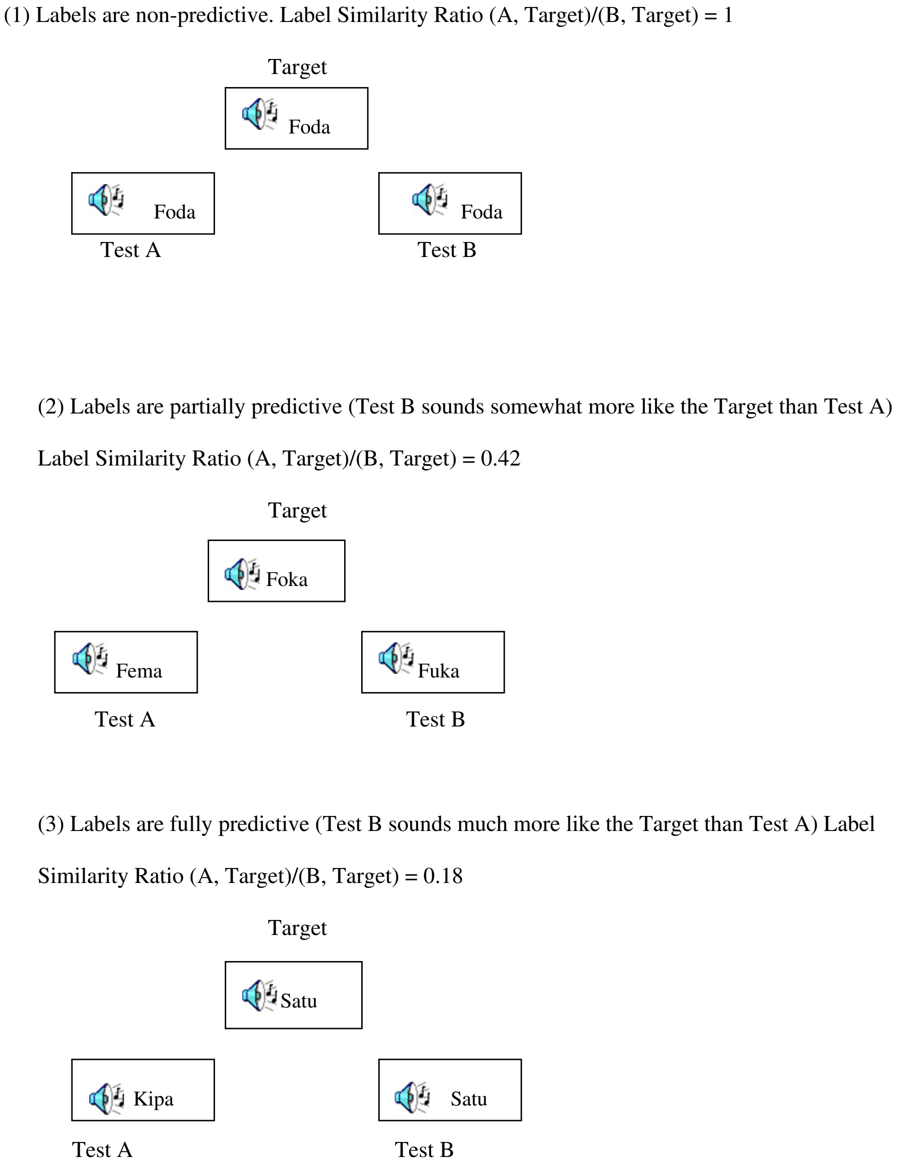

Fig. 5. Examples of labels used in Experiment 6.

were partially predictive, with the label of Test B being somewhat more similar to the target's label than the label of Test A. At Level 2, the label of Test B was more similar to the target label than the label of Test A. Therefore, the ratio was somewhat less than 1; Sim(*A*, target)/Sim(*B*, target) was equal to 0.42. Finally, at Level 3, labels were fully predictive, with the Test B label being identical to the target label and the Test A label being very dissimilar. In this case, the ratio was much less than 1; Sim(*A*, target)/Sim(*B*, target) was equal to 0.18.

To discern the contribution of labels and appearances, Test A always had the same or greater appearance similarity to the target than Test B (thus, the ratio of appearance similarities was equal to or greater than 1), whereas it had the same or smaller label similarity to the target than Test B (thus, the ratio of label similarities was equal to or less than 1). Proportions of Test B choices predicted by SINC (derived by plugging the respective similarity ratios into Eq. (5)) are presented in Fig. 6A. As shown in this figure, SINC predicts the main effect of visual similarity on induction; the probability of inducing a property from Test B to the target would decrease with a decrease in visual similarity of Test B to the target. This prediction was tested and confirmed previously (e.g., Sloutsky & Fisher, 2004). More important, SINC predicts the main effect of phonological similarity on induction; the probability of inducing a property from Test B to the target should increase with an increase of phonological similarity of Test B's label to the label of the target. In other words, the more similar the labels of Test B and the target (and thus the smaller the similarity ratio of labels) are, the more likely the induction of properties from Test B to the target. The goal of Experiment 6 was to test this prediction of SINC.

Method

Participants

The participants were 67 preschool-age children (31 girls and 36 boys, mean age = 4.90 years, *SD* = 0.34), with 20 participants in the phonological ratio = 1 condition, 22 in the phonological ratio = 0.42 condition, and 25 in the phonological ratio = 0.18 condition.

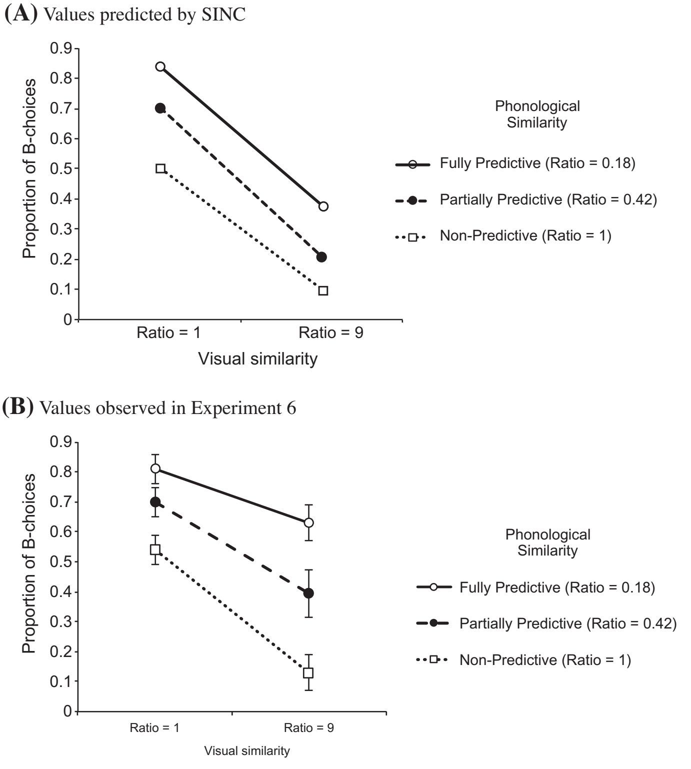

Fig. 6. Proportions of B-choices across the levels of visual and phonological similarity. (A) Values predicted by SINC. (B) Values observed in Experiment 6. Phonological similarity ratio = 0.18: Test B's label is markedly more similar to the target's label than Test A's label. Phonological similarity ratio = 0.42: Test B's label is somewhat more similar to the target's label than Test A's label. Phonological similarity ratio = 1: Test B's label is as similar to the target's label as Test A's label. Visual similarity ratio = 1: Test B is as similar to the target as Test A. Visual similarity ratio = 9: Test B is markedly less similar to the target than Test A.

Materials and design

Materials consisted of visual and auditory stimuli that were calibrated for similarity. Visual stimuli were eight triads of pictures of animals selected from the sequences of images in which one animal was "morphed" into another in a fixed number of steps in the manner described by Sloutsky and Fisher (2004). Visual similarity ratios were estimated in a separate calibration experiment (see Sloutsky & Fisher, 2004, for the details of calibration). During calibration, children were presented with calibration triads consisting of a target and two test items, Test A and Test B, such that Test A was either equally or more similar to the target compared with Test B. Participants were then asked whether the target looked more like Test A or Test B, and proportions of Test A and Test B selections were converted into similarity ratios (similarity ratio = proportion of Test A selections/proportion of Test B selections). When Test A and Test B were nondiscriminable, the visual similarity ratio was equal to 1, and as discriminability of test items increased, so did the visual similarity ratio. There were two levels of visual similarity with four triads per level: ratio = 1 (both test stimuli looked equally similar to the target) and ratio = 9 (Test A looked almost identical to the target, whereas Test B looked very different from the target).

Auditory stimuli were selected from 36 pronounceable two-syllable nonwords recorded by a male native English speaker, each ranging from 560 to 1120 ms in duration. These stimuli were calibrated in a separate experiment with 103 young children (see Appendix for details of the calibration). In the calibration experiment, the nonwords were organized into 84 triads, each consisting of a target (i.e., *foka*) and two test stimuli, such that Test B (i.e., *fuka*) always shared more phonetic features with the target than Test A (i.e., *fema*). Children were asked to determine which of the test stimuli sounded more like the target.

Proportions of stimuli selection were converted into phonological similarity ratios. A total of 24 triads were selected to represent three levels of phonological similarity (see Table 3 for the list of selected triads). There were eight triads at ratio = 1 (Tests A and B sounded equally similar to the

Table 3
Label triads used in Experiment 6.

Similarity ratio of labels	Label type		
	Target label	Test A label	Test B label
Ratio = 1 (identical labels)	Si-du	Si-du	Si-du
	Gama	Gama	Gama
	Foda	Foda	Foda
	Kipa	Kipa	Kipa
	Zitu	Zitu	Zitu
	Satu	Satu	Satu
	No-bi	No-bi	No-bi
	Zi-bi	Zi-bi	Zi-bi
Ratio = 0.42 (phonologically similar labels)	Tobi[a]	Sinu	Todi[a]
	Kuma[a]	Gu-ma	Ku-ma[a]
	Zatu[a]	Su-gu	Ga-tu[a]
	Gama[a]	Botu	Guma[a]
	Sanu[a]	Nabi	Sadu[a]
	Fika[a]	Fo-da	Pika[a]
	Sotu[a]	Fima	So-bu[a]
	Foka[a]	Fema	Fuka[a]
Ratio = 0.18 (phonologically different labels)	Ti-gi	Zuma	Ti-gi
	Ta-ni	Sodu	Ta-ni
	No-bi	Sadu	No-bi
	Sotu	Ku-ma	Sotu
	Gitu	Vu-ka	Gitu
	Fida	Zo-tu	Fida
	Tabi	Fo-ka	Tabi
	Satu	Kipa	Satu

Note: Hyphenation indicates a long vowel.
[a] Phonologically similar labels.

target), eight triads at ratio = 0.42 (Test A sounded somewhat less similar to the target than Test B), and eight triads at ratio = 0.18 (Test A sounded markedly less similar to the target than Test B). The set of triads with a similarity ratio of 1 consisted of three identical items and therefore was not calibrated. Note that unlike the visual triads, in which it was Test A that was equally or more similar to the target, in the auditory triads it was Test B that was equally or more similar to the target. As mentioned above, the nonidentical labels were discriminable by young children.

The experiment had a 2 (Visual Similarity: ratio = 1 or ratio = 9) by 3 (Phonological Similarity: ratio = 1, ratio = 0.42, or ratio = 0.18) mixed design, with visual similarity as a repeated measure. Participants were presented with eight induction trials and four filler trials, with the order of trials randomized for each participant. Half of the trials were at visual similarity ratio = 1, and the another half were at visual similarity ratio = 9. On each trial, participants performed an induction task in which each of the test items was described as having a particular quasi-biological property, such as long bones versus short bones, and participants were asked to decide whether the target item had long or short bones. Recall that in all trials, Test A had the same or greater appearance similarity to the target than Test B, whereas Test B had the same or greater label similarity to the target.

Procedure

Participants were interviewed individually in their child-care centers, with pictures presented on the screen of a portable computer and labels presented through Sony MDR-CD770 headphones. Participants were told that they would play a game in which they would be shown pictures of animals and the names of the animals would be played by the computer. The computer presentation of labels was intended to preserve the calibrated similarity ratios in label triads. Participants were then presented with the induction trials.

Results and discussion

Predicted and observed proportions of B choices (i.e., induction from Test B to the target) across the conditions are presented in Fig. 6A and B, respectively. These observed proportions were subjected to a two-way mixed ANOVA with phonological similarity as a between-participants factor and visual similarity as a repeated measure. There were two significant main effects with no significant interaction ($p > .10$). The main effect of visual similarity, $F(1, 64) = 46.51$, $p < .0001$, $\eta_p^2 = .42$, replicated previous findings; as similarity of Test B to the target decreased, participants were less likely to induce properties from Test B to the target. More important, there was a main effect of phonological similarity; as phonological similarity of Test B labels to the target labels increased, participants were more likely to induce properties from Test B to the target, $F(2, 64) = 19.72$, $p < .0001$, $\eta_p^2 = .38$. Post hoc Tukey tests revealed significant differences in performance among all three levels of phonological similarity (all $ps < .05$).

These results confirmed predictions of SINC, with both main effects being observed. Furthermore, a comparison of predicted and observed values indicates that SINC accounts for approximately 84% of the observed variance. Therefore, as predicted by SINC, phonological similarity of labels contributed to young children's induction.

Despite the overall accuracy, the model somewhat underpredicted the proportion of label-based responding in those conditions where the two sources of information are in conflict (i.e., the visual ratio = 9 and phonological ratio = 0.42 condition and the visual ratio = 9 and phonological ratio = 0.18 condition). This is because our intention was to capture only quantitative tendencies in the data, and we did not include any free parameters in the current version of the model. However, attentional weights of labels are higher than those of visual features (see Sloutsky & Fisher, 2004), and when these differences are taken into account, predictions of the model become substantially more accurate.

General discussion

Several important findings stem from the reported experiments. Experiment 1 indicated that young children, unlike adults, exhibit a phonological similarity effect; they extend phonologically similar labels to perceptually similar items. Results of the follow-up experiments with phonologically different novel labels (Experiment 2) and with phonologically similar familiar labels (Experiment 4) demonstrate that the obtained findings stem from the effects of phonological similarity of labels rather than from children's tendency to match pictures or treat similar labels as tokens of the same words. Differential effects of phonological similarity on lexical extension in children and adults (Experiment 1) support previous findings suggesting that whereas young children are likely to treat labels as features of entities, adults may treat labels as symbols denoting category membership (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999; Yamauchi & Markman, 2000). Overall, Experiments 1–4 generated novel findings indicating that phonological similarity of labels contributes to early (but not mature) generalization. These findings support the idea that different mechanisms may underlie early and mature induction, with early induction being similarity based and mature induction being category based (cf. Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004).

Experiment 5 demonstrated that increasing discriminability of labels attenuates young children's tendency to extend these labels to identical items. This finding provides converging evidence that young children's induction is driven by phonological similarity of labels while further undermining the possibility that it was driven by the tendency to interpret phonologically similar labels as tokens of the same word. Finally, Experiment 6 indicated that labels make a quantitative contribution rather than an all-or-none contribution to early induction. In particular, it was demonstrated that identical labels make a greater contribution to induction than phonologically similar labels; however, similar labels make a greater contribution than phonologically different labels. These results support predictions of SINC that phonological similarity of labels affects label extension and inductive generalization.

Phonological similarity effect: What is the mechanism?

Recall that according to SINC, words are features contributing to similarity, and it is possible that effects of words are continuous rather than categorical. One possibility is that early in development, under many conditions, auditory information (including speech sounds) overshadows (i.e., attenuates processing of) corresponding visual input (Napolitano & Sloutsky, 2004; Sloutsky & Napolitano, 2003). Specifically, when visual stimuli were accompanied by sounds, discrimination of visual stimuli (but not sounds) dropped compared with a unimodal baseline. As a result of auditory overshadowing, entities associated with the same label become more similar (Sloutsky & Fisher, 2004; Sloutsky & Lo, 1999), with similarity driving both categorization and induction. The labels-as-features notion of SINC can both predict and account for current results as well as for the overshadowing effects.

Could it be that the reported results stem from other factors? In particular, it is possible that young children consider phonologically similar words as phonological tokens of the same word. A related possibility is that the effects are driven by some top–down conceptual assumptions. For example, young children may assume that phonologically similar words refer to similar entities. Although neither possibility undermines the novelty of reported findings, each possibility has different theoretical implications. In what follows, we consider each of these possibilities in greater detail.

Recall that these alternative possibilities were tested directly in Experiments 4 and 5, and results suggested that these possibilities are unlikely. First, results of Experiment 4 indicate that the phonological similarity effect persisted even when highly familiar words were used (e.g., *house* and *mouse*); young children generalized phonologically similar words to visually similar items. This finding is particularly difficult to reconcile with the token interpretation given that even 24-month-olds ably detect even small variations in pronunciation, especially when the words are familiar (e.g., Bailey & Plunkett, 2002). Second, results of Experiment 5 indicate that discrimination training reduced phonological similarity of words and the phonological similarity effect in the experimental condition (where the trained words were used in a subsequent generalization task) but not in the control condition (where the trained words differed from those used in the generalization task). Finally, results of Experiment 1 indicate that adults, unlike young children, exhibit little evidence of the phonological similarity effect. Although the above-described mechanism underlying effects of labels and developmental changes in these effects predicts all of these findings, it is not clear how any of the alternatives could coherently account for these findings.

Overall, the reported research presents novel findings pertaining to effects of phonological similarity in a variety of induction tasks. These findings support the prediction of SINC, further indicating that for young children labels are features rather than category markers. As discussed below, these results affect our understanding of the mechanisms underlying early induction.

Labels, similarity, induction, and categorization

Recall that according to SINC, effects of words on similarity, and thus on induction, stem from low-level attentional mechanisms rather than an understanding of conceptual importance of labels (Sloutsky & Fisher, 2004, 2005). According to this view, at least early in development, words are features affecting processing of corresponding visual input, and these effects of words could be (at least partially) grounded in auditory overshadowing effects. Therefore, words could be affecting inductive generalization by overshadowing differences among entities sharing the same label, thereby making them appear to be more similar. The labels-as-features notion of SINC can both predict and account for current results as well as for the overshadowing effects.

Alternatively, it is possible that labels are category markers affecting categorization and induction by communicating category information, with children realizing that members of the same category share multiple commonalities (e.g., Gelman & Coley, 1991; Gelman & Markman, 1986; see also Gelman, 2003; Waxman, 2003, for reviews). According to this view, (a) labels affect inductive generalization in nontrivial ways that cannot be explained by low-level accounts and (b) these effects of labels manifest themselves even during infancy.

For example, in one study (Ferry, Hespos, & Waxman, 2010), 3- and 4-month-olds were presented with a categorization task, such that members of a to-be-learned category were accompanied either by a common label or by a common tone. Results indicated that participants were more likely to categorize in the former condition than in the latter condition. In another study, it was shown that lexical extension in 14- to 18-month-olds was more likely when words were presented as count nouns than when they were presented as adjectives (Booth & Waxman, 2009). Although these effects could be interpreted as evidence of labels being more than just features, we believe that these effects could also be explained by a low-level attentional mechanism. In particular, if familiar auditory stimuli are processed faster and more efficiently than novel stimuli, then (at least in infancy paradigms) more familiar auditory stimuli may have smaller interference effects than less familiar auditory input. As a result, less familiar tones may interfere with categorization to a greater degree than relatively more familiar speech sounds. Similarly, according to the lexical norms of the MacArthur–Bates Communicative Development Inventories (Dale & Fenson, 1996), among 384 words potentially comprehended by infants at 16 months of age, fewer than 10% are adjectives and more than 60% are nouns. Therefore, it seems likely that nouns represent a more familiar input than adjectives; consequently, adjectives may interfere with categorization to a greater degree than nouns. Although there is no supporting evidence for this possibility with regard to nouns and adjectives, it was shown that both words and unfamiliar sounds interfered with categorization (Robinson & Sloutsky, 2007a) and individuation (Robinson & Sloutsky, 2008) when compared with a silent condition and that for infants this interference was stronger for less familiar auditory input.

Another finding that may potentially undermine the idea of labels as features is that participants are more likely to rely on linguistic labels when inferring a biological property, such as the type of heart of an animal, than when inferring a physical property, such as the size of the animal (e.g., Gelman & Markman, 1986). However, there is recent evidence (Sloutsky & Fisher, 2008) that addresses this issue directly. A key idea is that many stimulus properties intercorrelate, such that some clusters of properties co-occur with particular outcomes and other clusters co-occur with different outcomes. In particular, count nouns are more likely to co-occur with stable properties than with highly variable properties. Learning of these correlations may result in differential allocation of attention to predictive and nonpredictive stimulus dimensions (cf. Kersten, Goldstone, & Schaffert, 1998; Kruschke, 1992; Nosofsky, 1986). Therefore, if labels correlate with stable properties and do not correlate with variable properties, then participants should learn to attend to labels in the former context but not in the latter context. Given that size is a variable property (it varies between individuals and, for living things, within individuals), and given that children have experience with this variability (i.e., a small puppy grows into a large dog), there is little surprise that children do not rely on labels in the context of size. Findings reported in Sloutsky and Fisher (2008) support these notions pointing to successful attentional learning in 4- and 5-year-olds, who learned to rely differentially on the same predictor across different contexts while exhibiting little or no awareness that learning had occurred.

The notion that early in development induction, categorization, and naming are similarity-based processes is able to account for a variety of other seemingly disjoint effects. For example, Markman and Hutchinson (1984) found that in the absence of a label, young children grouped things thematically (e.g., a police car and a policeman), whereas when a police car was named a *dax* and children were asked to select another *dax*, they selected a passenger car. There is also a set of findings that toddlers and young children tend to interpret novel words as referring to novel items (Markman & Wachtel, 1988). The effect, however, decreases markedly or disappears if the novel word is phonologically similar to a familiar word; children would extend a novel word *japple* to an apple rather than to a novel object (Merriman & Schuster, 1991).

These findings have been treated as stemming from different sources, with the first tendency being driven by the "taxonomic bias" (which reflects early understanding that words refer to categories), the second tendency being driven by the "mutual exclusivity" assumption in young children (see Markman, 1989, for a review of both the taxonomic bias and mutual exclusivity assumption), and the third tendency being driven by children's interpretation of phonologically similar words as variants of the same word.

Current results suggest that all three effects may stem from the same tendency to extend words in a similarity-based manner (cf. Gentner, 1978; Landau, Smith, & Jones, 1998). Although similarity-based induction and categorization give a straightforward explanation to Markman and Hutchinson's (1984) findings, the latter two effects require further consideration. Note that in the Markman and Wachtel (1988) studies, the novel label differed from that of the known entity, with the label dissimilarity possibly blocking the extension of this dissimilar label to the known entity (similar to results of Experiment 2 presented here). In the Merriman and Schuster (1991) studies, the introduced label was similar to that of the known entity, which may promote the extension of this new label to the known entity (similar to results of Experiments 1, 3, and 5 presented here). The following hypothetical scenarios could illustrate this reasoning. First, as in Markman and Wachtel (1988), children are presented with an apple-like object and a novel object and are asked to point to the *dax*. Second, as in Merriman and Schuster (1991), children are presented with an apple-like object and a novel object and are asked to point to the *japple*. Finally, in a thought experiment, children are presented with an apple-like object and a novel object and are asked to point to the *apple*. Based on Markman and Wachtel's (1988) findings, we can expect that few children would select the apple-like object in the *dax* condition, whereas based on Merriman and Schuster (1991), we should expect significantly more children to select the apple-like object in the *japple* condition. Assuming that in the *apple* condition children would overwhelmingly point to the apple-like object, the three scenarios would reveal the same trend as found in current research: Very similar labels support induction more strongly than somewhat similar labels, whereas somewhat similar labels support induction more strongly than different labels.

Conclusion

Overall, the reported results indicate that phonological similarity of words contributes to early induction, driving inductive generalization across a variety of induction tasks. These findings shed light on how words affect young children's induction; they indicate that children may consider words as features contributing to the overall similarity of compared entities.

Acknowledgments

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Appendix. Details of calibration of auditory stimuli

Auditory stimuli were calibrated in an experiment with 103 young children. In the calibration experiment, the nonwords were organized into 84 triads, each consisting of a target (i.e., *foka*) and two test stimuli, such that Test B (i.e., *fuka*) always shared more phonetic features with the target than Test A (i.e., *fema*). To reduce the possibility that Test B words would be interpreted as morphological or inflectional derivations of target words, differences between Test B and the target were made not to approximate such derivations in English. Unlike English, where derivations are realized by adding a morpheme to the word (e.g., *dog* → *doggie*, *car* → *cars*), Test B items were created by changing parts of the stems of target words. The triads were broken into blocks, with each triad presented three times within each block in random order, and participants were asked to determine which of the test stimuli sounded more like the target (see Table 3 for examples).

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