Flexible Attention to Labels and Appearances in Early Induction

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Abstract

Young children have been demonstrated to rely on both labeling and appearance information when performing induction. According to some accounts, labels are more conceptually important than appearances. According to others, reliance on labels and appearances stems from a low-level attentional mechanism. The latter, but not the former, predicts flexible attentional shifts in reliance on labels or appearances. Results of the two reported experiments indicate that attention to labels and appearances can be flexibly modified through associative training, thus supporting the latter, but not the former account.

Introduction

The ability to perform inductive generalizations is crucial for acquiring new knowledge. For instance, upon learning that a particular poodle uses enzymes to digest food, one could generalize this knowledge to other poodles, other canines, and possibly other mammals. It is well-documented that the ability to perform simple generalizations develops early in life (Gelman & Markman, 1986; Sloutsky & Fisher, 2004a, 2004b; Welder & Graham, 2001), however specific mechanisms underlying early induction remain unclear.

It has been demonstrated that when performing induction, young children rely on various sources of information, such as perceptual similarity and linguistic labels (Gelman & Markman, 1986; Sloutsky, Lo, & Fisher, 2001). Some have argued that even young children assume that these sources form a conceptual hierarchy, with some object properties being more important, or *central*, than others for determining category membership and generalizing properties of natural kind objects (Keil, et al, 1998; Gelman & Coley, 1991). For example, category labels are said to be proxies of category essences (e.g., Gelman & Coley, 1991), and as such their contribution to induction should be greater than that of *peripheral properties*, such as appearances.

Others have argued that reliance on labels during induction may stem from a low-level attentional mechanism. In particular, under many conditions auditory input (including labels) overshadows (or attenuates processing of) corresponding visual input (Sloutsky & Napolitano, 2003; Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004). As a result of overshadowing, entities that share the same label are perceived as more similar than the same entities presented without a label (Sloutsky & Lo, 1999; Sloutsky & Fisher, 2004), with induction being a function of the overall similarity of presented entities.

In short, whereas both positions predict the importance of labels, they posit vastly different mechanisms. According to the former, the importance of labels stems from top-down conceptual influences, whereas according to the latter it stems from a low-level attentional mechanism.

One way of distinguishing between the two positions is to examine the flexibility of reliance on different sources of information. If labels are more theoretically central than appearances, then it should be difficult if not impossible to change the reliance on labels in the course of associative learning. Conversely, if reliance on labels and appearances stems from attention being automatically allocated to these predictors, then changing attentional weights of labels or appearances should affect the reliance on these predictors in a subsequent induction task.

Preliminary evidence that early in development attentional weights of various attributes are flexible comes from the research by Smith, Jones, and Landau (1996). In this study 2- and 3- year-old children were presented with a task in which they had to generalize a novel label to other objects. Children generalized labels based on shape and texture attributes if presented objects had eyes (presence of eyes is highly correlated with animacy), whereas participants relied solely on shape if the same objects were presented without eyes. Similarly, young children generalize names of solid substances along the lines of shape similarity, whereas names for non-solid substances were generalized along the lines of texture similarity (Samuelson & Smith, 1999). Furthermore, there is evidence that these attentional biases are shaped by experience, since they affect learning only after children have acquired many names for solid and non-solid substances (Samuelson & Smith, 1999).

One way of changing an attentional weight of a predictor is by manipulating its predictive value. There is ample body of evidence in the animal learning literature indicating that if a cue is non-predictive in an associative learning task, reliance on this cue attenuates in a subsequent task (see Hall, 1991, for a review). Sloutsky & Spino (2004) demonstrated that the same is the case with 5-year-olds, with effects of associative learning sustaining for over two months.

In sum, when performing induction, young children rely on both, appearance and label information. Some have argued that reliance on labels stems from top-down conceptual knowledge, whereas others argued that it stems from low-level attentional mechanisms. One way of distinguishing between these positions is by systematically manipulating attentional weights of labels and appearances in the course of associative learning. While the former position predicts that values of appearance and labeling predictors should be relatively fixed, the latter position predicts a high degree of flexibility of all perceptual predictors.

Experiment 1

The goal of Experiment 1 was to increase attentional weights of either labels or appearances in the course of associative training. Young children were first presented with a training task, such that in one condition only labels (but not appearances), whereas in the other condition only appearances (but not labels) were predictive. After training participants were presented with an induction task using a novel set of stimuli, and the effectiveness of associative training was assessed against a Baseline training that did not manipulate attentional weights of either labels or appearances.

Method

Participants Participants were 53 4- to 5-year-olds (25 girls and 28 boys; M = 5.24 years, SD = .35 years). Nine more children were tested and omitted from the sample because they did not meet the learning criterion (see Procedure).

Materials Materials consisted of 16 training and 12 testing triads of pictures, with each triad including a Target and two Test stimuli. Materials also included a set of 28 artificial label triads, with labels presented as count nouns (e.g., a *Gula*, a *Zizi*, etc.).

Training Triads. Training triads consisted of pictures of hedgehogs and guinea pigs. A calibration experiment with a separate group of 25 five- year-olds established that children were unfamiliar with and could not correctly label these animals, but could reliably group them based on appearances. Only pictures that were reliably grouped with at least 85% accuracy by all participants were used in Experiment 1. In all 16 training triads appearance information was pitted against labeling information, such that the Target looked similar to Test 1, but shared the same label with Test 2. The screen position of each Test item (to the left or to the right of the Target) was randomized for each participant. Example of a training triad is presented in Figure 1.

Testing Triads. Testing triads consisted of pictures of animal faces used in previous research (Sloutsky & Fisher, 2004). The testing triads were calibrated to represent three levels of appearance similarity: at Level 1, both test items looked equally similar to the Target; at Level 2, Test 1 looked somewhat more like the Target than Test 2; at Level 3, Test 1 looked almost identical to the Target, while Test 2 was very different. For details of the calibration procedures see Sloutsky and Fisher (2004). Similar to the training triads, appearance information was pitted against labeling information, such that Test 2, which looked either equally or less similar to the Target than Test 1, always shared a label with the Target. Position of the Test items on the screen was randomized for each participant. Examples of testing triads are presented in Figure 2.

Procedure Participants were tested individually in the child care centers by hypothesis-blind experimenters. Participants were randomly assigned to one of the three between-subject training conditions: Label Training, Appearance Training, or Baseline Training conditions.

Label Training. In the Label Training condition participants were informed of a particular pseudo-biological property of the Target (e.g., *This is a zizi. This zizi has thick blood inside its body*) and were asked which of the Test items was likely to share this property with the Target (e.g., *Do you think that this bala or this zizi also has thick blood inside?*). Participants were provided with positive feedback if they generalized the property to the Test item that shared the label with the Target, and with negative feedback if they generalized the property to the Test item that looked more similar to the Target. Positive feedback consisted of engaging short movies, and negative feedback was given in a form of a still picture. No explanations were provided as part of feedback. Four participants failed to reach the learning criterion (75% of correct responses, or 12 correct responses on 16 trials) and were excluded from the sample.

Figure 1: Example of a training triad.

Appearance Training. Procedure in the Appearance Training condition was similar to that in the Label Training condition with one important difference: unlike the Label Training condition, participants were provided with positive feedback if they generalized the property to the Test item that looked similar to the Target, and with negative feedback if they generalized the property to the Test item that shared the label with the Target. Feedback was provided in a manner identical to that in the Label Training condition. Five participants who failed to reach the learning criterion (75% of correct responses) were excluded from the sample.

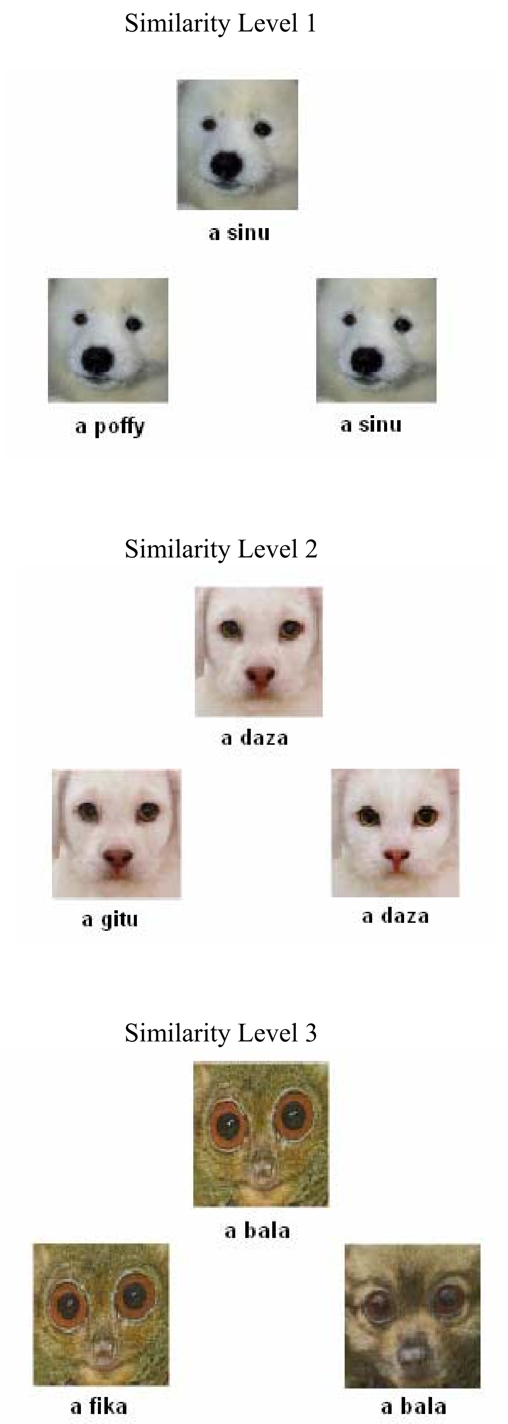

Figure 2: Examples of testing triads.

Baseline Training. This condition was intended to provide participants with experience with training triads and feedback movies similar to that of participants in the Label and Appearance training conditions, without affecting attentional weights of labeling and appearance attributes. In the Baseline Training condition participants were asked to decide whether the Target liked to play more with Test 1 or Test 2, and provided with positive feedback on the 75% of the trials, regardless of their responses. Feedback was provided in a manner identical to that in the Label and Appearance Training conditions.

Testing. Following training participants in all training conditions were presented with testing trials. Participants' task was to generalize a novel pseudo-biological property from the Target to one of the Test items. No feedback was given during testing and no children were omitted from the sample based on their performance during testing.

Results

Training Accuracy. In the training phase of the experiment participants demonstrated equivalent accuracy in the Label and Appearance training conditions, averaging 92% of correct responses, above chance, both one-sample *t*s > 20.69, *p*s < .0001.

Testing. Proportions of label-based generalizations in the Baseline, Appearance, and Label Training conditions are presented in Figure 3. As shown in the figure, increasing attentional weights of either labels or appearances through associative training dramatically changed the pattern of responses compared to the Baseline. In particular, in the Label Training condition participants relied solely on matching labels to perform induction (89%, 94%, and 88% of label-based responses, at the Similarity Levels 1, 2, and 3 respectively); in the Appearance Training condition children relied solely on appearances to perform induction: when appearances were non-predictive participants did not rely on matching labels, but rather exhibited a chance-level performance (57% of label-based responses at the Similarity Levels 1 and 2), and as predictiveness of appearances increased, proportion of label-based responses dropped below chance (32% of label-based responses at the Similarity Level 3). A mixed ANOVA with the trained predictor (Labels vs. Appearance) as a between-subject factor and similarity level as a within-subject factor confirmed a main effect of both, training condition and similarity, *F*s > 6.15, *p*s < .005, with the interaction of these two factors being non-significant, *p* > .2.

Results of Experiment 1 clearly demonstrate that attentional weights of appearance and label predictors can be flexibly adjusted through associative learning. However, it could be argued that effects observed in Experiment 1 are purely task-specific since the same task was used during training and testing. We addressed this possibility in Experiment 2, in which training and testing phases used different tasks: children were trained using a similarity judgment task and tested using an induction task. Observing similar effects of training under these conditions would indicate that reliance on appearance and labeling information during induction can be flexibly adjusted by changing perceived similarity of presented entities.

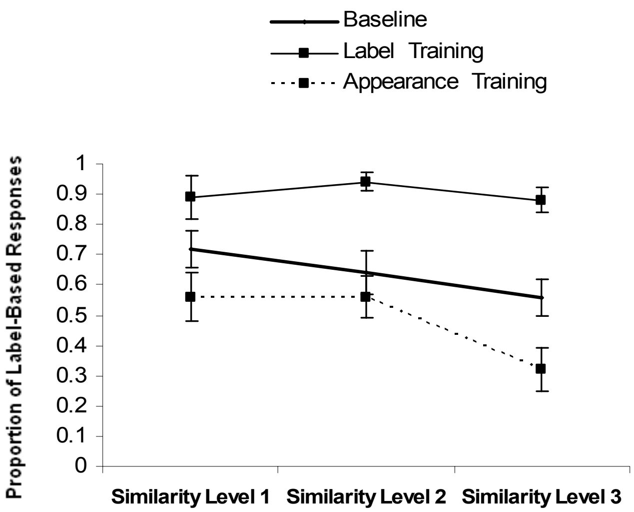

Figure 3: Proportion of label-based responses by similarity level and training condition in Experiment 1.

Experiment 2

It has been argued that for young children (1) labels are attributes of objects, contributing to perceived similarity of presented entities, and (2) generalization is a function of perceptual similarity computed over appearance and labeling attributes (Sloutsky & Fisher, 2004). Experiment 2 is based on this argument: if inductive generalization is a function of similarity (with both labels and appearances contributing to similarity), then, changing perceived similarity of presented entities should affect induction performance. To test this hypothesis we increased attentional weights of appearances or labels in a similarity judgment task, and then tested children using an induction task. It was expected that effects of training should be similar to those observed in Experiment 1, such that reliance of labels should increase in the Label Training condition, and reliance on appearances should increase in the Appearance Training condition.

Method

Participants Participants were 36 4- to 5-year-olds (12 girls and 24 boys; $M = 5.06$ years, $SD = .24$ years). Three more children were tested and omitted from the sample because they did not meet the learning criterion (see Experiment 1).

Materials and Procedure Materials and procedure were similar to those of Experiment 1, with one important difference: a similarity judgment task was used instead of an induction task during training. Participants were presented with the same training triads used in Experiment 1, and asked whether the Target looked more like Test 1 or Test 2. In the Appearance Training condition participants were told that it was important to pay attention to how animals look, and were provided with positive feedback for making appearance-based choices. In the Label Training condition participants were told that it was important to pay attention to animals' names, and were provided with positive feedback for making label-based choices. Three participants failed to reach the learning criterion (75% of correct responses) and were excluded from the sample. Following training participants were presented with the same testing trials used in Experiment 1. No feedback was given during testing and no children were omitted from the sample based on their performance during testing.

Results

Training Accuracy. In the training phase of the experiment participants demonstrated equivalent accuracy in the Label and Appearance training conditions, averaging 95% and 94% of correct responses respectively, above chance, both one-sample ts > 26.24, ps < .0001.

Testing. Proportions of label-based generalizations in Experiment 2 are presented in Figure 4. As can be seen in the Figure, similarity judgment training in Experiment 2 produced a pattern of results very close to that of induction training in Experiment 1: in both Label training and Appearance training conditions patterns of induction changed compared to the Baseline. This change appears pronounced at the Similarity Level 3 for both training conditions, however at the Similarity Levels 1 and 2 training effects seem to be limited to the label Training condition alone. Potential causes of this asymmetry are addressed in the General Discussion.

Proportions of labels-based responses in the Label and Appearance Training conditions in Experiment 2 and Baseline Training condition in Experiment 1 were submitted to a mixed ANOVA, with the similarity level used a within-subject factor, and trained predictor as a between-subject factors. The analysis indicated significant main effects of both similarity level and training condition (both Fs > 9.37, ps < .0001), qualified by the training condition by similarity level interaction, $F(4, 104) = 3.00$, $p < .022$. To compare this pattern of results with the one observed in Experiment 1, proportions of label-based responses in the Label and Appearance training conditions were submitted to a mixed ANOVA, with the similarity level used a within-subject factor, and trained predictor (Label vs. Appearance) and training task (Induction vs. Similarity Judgment) used as between-subject factors. The analysis confirmed that induction and similarity judgment training tasks produced similar effects on induction performance: the effect of task was not significant, $F < 1$.

Results of Experiment 2 indicate that effects of associative training observed in Experiment 1 are not purely task-specific: adjusting attentional weights of labels and appearances in the course of a similarity judgment task affected participants' willingness to rely on labels and appearances in the course of a subsequent induction task.

However, it could be counter argued that effects of training observed in Experiments 1 and 2 are not due to the adjustment in attentional weights; instead, participants could have discovered "the rule of the game" during training. According to this explanation, change in reliance on labels and appearances in the course if testing stems from participants deliberately focusing their attention on a particular attribute rather than attentional weights being adjusted in a non-deliberate manner.

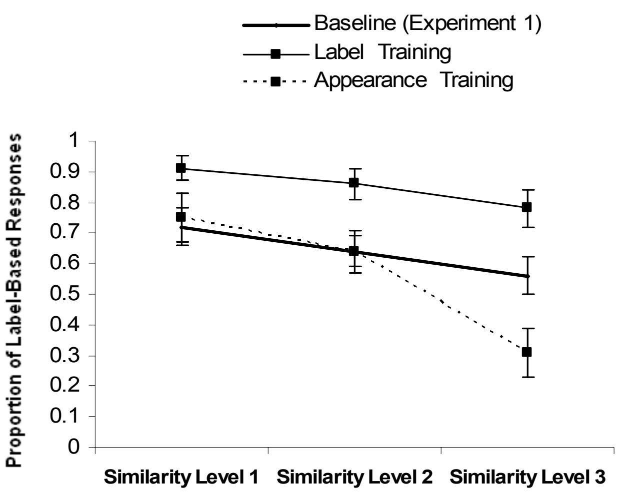

Figure 4: Proportion of label-based responses by similarity level and training condition in Experiment 2.

This possibility was addressed in a separate control experiment with 53 4- to 5-year-old children. In the control experiment, participants were presented with either a similarity judgment or an induction triad task similar to the ones used in Experiments 1-2 in one of the two between-subjects conditions: Baseline or Ignore Labels. In the Baseline condition participants were not provided with any additional instruction about performing the task. In the Ignore Labels condition participants were asked (on every trial) to focus on appearances, while ignoring labels. At the end of the experiment, participants' memory for the instructions was tested. If decreased (compared to the Baseline) reliance on labels during induction in the Appearance Training condition in Experiments 1 and 2 stemmed from participants discovering 'the rule", then we should observe a similar pattern of results in the control experiment, in which the "rule" does not need to be discovered, but rather is provided by experimenters. However, if attention to perceptual attributes is deployed automatically, then young children might experience difficulty in following instructions to focus on one attribute while ignoring the other. The results of this control experiment indicated that the proportion of the label-based responses in the Ignore Labels condition did not decrease compared to a no-instruction Baseline, $p > .3$. These results render it unlikely that results of Experiments 1 and 2 stemmed from participants discovering "the rule of the game" rather than from associative training: even when told the "rule" on every trial, participants had difficulty following the rule.

General Discussion

Results of the reported experiments indicate that attentional weights of both labeling and appearance attributes change flexibly in the course of associative training: when either attribute became consistently non-predictive during training, reliance on this attribute decreased markedly during testing. Moreover, these effects were not entirely task specific, as decreasing attentional weights of attributes in a similarity judgment task generalized over to an induction task (Experiment 2).

These results indicate that attentional weights of labels and appearances are rather flexible and they can change in the course of associative training. The reported findings offer new evidence about processes underlying young children's induction. The results do not support the essentialist claim of feature centrality: young children flexibly shifted attention away from predictors that are claimed to be theoretically central (i.e., linguistic labels) to those that are claimed to be theoretically peripheral (i.e., appearances). At the same time, these findings support the notion that reliance on labels and appearance in the course of induction stems from automatic attention and not from the top-down conceptual influences.

However, several important issues remain to be addressed. First, it must be noted that Experiments 1 and 2 manipulated attentional weights of both labels and appearances, whereas in the control experiment participants were only asked to ignore labels. It remains unclear whether young children would also find it difficult to ignore pictures, but our preliminary data strongly indicate this to be the case.

Another important consideration with regards to the data reported above concerns the asymmetry of the associative training effects: it appears that effects were stronger in the Label Training condition than in the Appearance Training condition, particularly for the triads representing Similarity Level 2. This asymmetry may stem from the fact the labels have greater attentional weight for younger children, with weights of labels decreasing with development (Sloutsky & Lo, 1999; Robinson & Sloutsky, 2004). Therefore, it is likely that stronger effects of appearance training can be obtained with increasing duration of associative training.

Another interesting issue that would require further research is independence or interdependence of attentional weights. First, it is possible that attentional weights are independent, such that increasing the weight of one attribute does not affect the weights of other attributes. Alternatively, it is possible that (due to limited attention capacity) weights are interdependent, such that increasing the weight of one attribute decreases the weights of other attributes.

While these important issues remain to be addressed in future research, experiments presented here indicate that (1) attention to labels and appearance is allocated in a non-deliberate manner and (2) attentional weights of labels and appearances can be flexibly change as a result of associative training. These findings suggest that reliance on labels in the course of induction may be driven by attention allocated automatically to labels and appearances.

Acknowledgments

This research has been supported by grants from the National Science Foundation (REC # 0208103 and BCS # 0078945) to Vladimir M. Sloutsky.

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