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When Looks Are Everything: Appearance Similarity versus Kind Information in Early Induction

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ABSTRACT

The goal of this research is to examine mechanisms underlying early induction, specifically the relationship between induction and categorization. Some argue that even early in development induction is based on common category information, whereas others argue that early induction is based primarily on similarity. Children between 4 and 5 years of age participated in two types of tasks: categorization and induction. Both tasks were performed with artificial animal-like categories in which appearance was pitted against the category membership. Although participants readily acquired category membership information and subsequently used this information in categorization tasks, they ignored category membership during the induction task, relying instead on the appearance of items. These results support the idea that early in development induction is similarity-based.

When Looks Are Everything: Appearance Similarity versus Kind Information in Early Induction

Inductive generalization is a critical aspect of human cognition because it enables people to generate new knowledge. For example, upon learning that a cat has a particular biological property, one can generalize this property to another cat. It is well established that induction appears early in development (Gelman & Markman, 1986; Mandler & McDonough, 1996; Welder & Graham, 2001; Sloutsky & Fisher, 2004a), however, mechanisms of early induction remain unclear. In an attempt to understand early induction, two theoretical proposals have been formulated, the knowledge-based approach and the similarity-based approach.

Knowledge-Based Approach

According to the *knowledge-based* approach (often referred to as the “naïve-theory” position), when the task is to generalize properties of some natural kind categories (such as animal kinds), induction is driven by conceptual knowledge. This knowledge is implemented as a set of conceptual assumptions that do not stem from parental input (Gelman et al., 1998; see also Gelman, 2004; Murphy, 2002, for reviews). First, young children are said to believe that individuals belong to more general categories, with members of the same natural kind category sharing many important properties (i.e., category assumption). Second, young children are said to believe that count nouns denote categories (i.e., linguistic assumption). Although it is not claimed that the category and linguistic assumptions are a part of children’s explicit knowledge, it is generally argued that early induction is based on these assumptions. Specifically, when performing inductive generalizations, people, including young children, first identify the category of an entity and then generalize properties of the entity to other members of the category. Therefore, even early in development induction is said to be based on prior categorization of presented entities, and is thus category-based.

The main support for the category and the linguistic assumptions comes from the innovative research by Gelman and Markman (1986). In a series of experiments, they presented young children with a triad task, in which stimuli consisted of one target and two test items. The triad task was designed to pit appearance similarity against category membership: One test item belonged to the same category as the target but looked dissimilar from the target, whereas the other test item looked similar to the target, while belonging to a different category. Participants were presented with a triad and were informed that one test item had a particular hidden property (e.g., “hollow bones”), while the other test item had a different hidden property (e.g., “solid bones”). The task was to generalize a hidden property to the target. Category membership was communicated by using the same label for the target and the dissimilar test item. In general, children were more likely to generalize the property of the test item that shared the target’s label than the property of the test item that shared the target’s appearance (but see Sloutsky & Fisher, 2004a, Experiment 4, for diverging evidence and counterarguments). This finding was interpreted as evidence that children’s induction is based on common category information.

Similarity-Based Approach

According to the *similarity-based* approach, conceptual knowledge (e.g., knowledge that members of the same category share important properties) is a product rather than a precondition of learning. Therefore, early in development cognitive processes do not depend on top-down conceptual knowledge. Instead they are grounded in powerful learning mechanisms, such as statistical and attentional learning (Smith, 1989; Smith, Jones, & Landau, 1996; French, Mareschal, Mermillod, & Quinn, 2004; Mareschal, Quinn, & French, 2002; McClelland &

Rogers, 2003; Sloutsky & Fisher, 2004a). Within this approach, Sloutsky and colleagues have recently proposed a similarity-based model of early generalization – SINC, abbreviated for Similarity-Induction-Naming-Categorization (Sloutsky, Lo, & Fisher, 2001; Sloutsky & Fisher, 2004a).

SINC argues that early in development, both induction and categorization are based on the overall similarity of compared entities, with labels being features of objects that contribute to the overall similarity among items, rather than symbols denoting category membership. Support for this claim comes from findings that young children, but not adults, perceive identically labeled entities as looking more alike than differently labeled entities (Sloutsky & Fisher, 2004a; Sloutsky & Lo, 1999). Furthermore, this contribution of labels to similarity seems to stem from auditory input overshadowing (i.e., attenuating processing of) corresponding visual input early in development (Sloutsky & Napolitano, 2003; Napolitano & Sloutsky, 2004; Robinson & Sloutsky, 2004).

Induction: Category-Based or Similarity-Based?

The proponents of both positions expect labels to affect induction, however the mechanisms driving these effects differ radically across the positions. According to the knowledge-based approach, labels affect induction because they denote category membership, with category information driving induction. According to the similarity-based approach, labels affect induction because they contribute to the perceived similarity of items, with similarity driving induction. Therefore, the reliance on category label in a triad induction task is insufficient for distinguishing between the two positions.

One way to distinguish between these positions is to give participants direct access to category information by teaching them a new natural-kind category that has a clear category-identification rule. Once participants learn the category, they could be presented with an induction task, in which category membership is pitted against appearance.

If, for natural kinds, category-based induction is a default, then young children (who successfully learn the category) should assume that members of the same kind have much in common. As a result, when performing induction, they should rely on category membership and ignore appearance information. Conversely, if similarity-based induction is a default, then young children (even when they successfully learn the category) should rely on appearance information, while disregarding category membership information.

The experiments presented here had the following overall structure. Participants were first presented with a category learning task during which they learned that artificial animal-like creatures belong to two natural kinds: some are nice friendly pets and some are wild dangerous animals. The membership in a category could be detected by a rule, whereas appearances were not predictive of category membership. Children were then given a categorization task with items that differed from those used during training. Participants readily acquired these categories and accurately sorted the items according to their kind information. Then participants were presented with a triad induction task. Each triad consisted of a target and two test items, with one test item sharing the target's category membership but not its appearance, and the other test item sharing the target's appearance but not its category membership. Participants were familiarized with a quasi-biological property of the target, and asked to generalize this property to one of the test items. Finally, participants were given a final (i.e., post-induction) categorization task using the same items as the induction task.

Predictions of both theoretical approaches are straightforward: If children perform category-based induction they should overlook conflicting appearances and generalize properties from an item that they know belongs to the same kind as the target. Conversely, if children perform similarity-based induction, they should generalize properties on the basis of common appearances, despite their knowledge of category membership.

EXPERIMENT 1

Method

Participants

Sixteen 4- and 5-year-olds (*M* = 61.2 months, *SD* = 2.9 months, 9 girls and 7 boys) participated in the experiment. Four additional children were excluded from the sample because they failed to learn the category (see Procedure).

Materials

Materials were colorful drawings of bug-like entities, created by combining the following six attributes: a body, a tail, antennas, wings, buttons, and fingers (see Figure 1). Each of the six attributes varied on two dimensions (i.e., size and color, color and shape, or shape and size), with each dimension having three “levels” (e.g., for the size of the wing: 1 = short, 2 = medium, and 3 = long). The resulting 12 attributes represented the ‘appearance’ of an entity. Attributes were conjoined to create two types of stimuli, those with appearance A_1 and those with appearance A_2. For A_1 stimuli, 88% of dimensions belonged to level 1, whereas for A_2 stimuli, 88% of dimensions belonged to level 3. The rest of the dimensions for both A_1 and A_2 stimuli belonged to level 2.

Two additional attributes of entities, the number of buttons and the number of fingers were used to identify category membership. Each number could range from 1 to 6. Category membership could be determined on the basis of the relation between these two attributes: Members of one category (C_1 stimuli) had more fingers than buttons, while members of the contrasting category (C_2 stimuli) had fewer fingers than buttons. Note that the category identification rule had only minimal perceptual basis (i.e., children were required to compare buttons and fingers to determine category membership). The use of such rule ensured that category-membership information was not correlated with appearance and thus could be pitted against appearance.

Overall, four types of items were created: A_1C_1 and A_2C_1 items (i.e., stimuli that were members of Category 1, with either A_1 or A_2 appearance) as well as A_1C_2 and A_2C_2 items (i.e., stimuli that were members of Category 2, with either A_1 or A_2 appearance). Figure 1 shows an example of each type of item.

Design and Procedure

The experiment was administered on a computer and controlled by SuperLab Pro 2.0 software. Children were tested in a quiet room in their preschool by hypothesis-blind experimenters. The cover story involved a child who would like to get a nice and friendly pet. However the pet store carries two kinds of animals, nice and friendly *Ziblets* and wild and dangerous *Flurps*. Children's task was to determine whether an animal is a Ziblet or a Flurp.

The procedure consisted of four phases: category learning, initial categorization, induction, and final categorization. During category learning, children were given information about categories. Specifically, they were told: "To tell if an animal is a Ziblet or a Flurp, you have to count the buttons and the fingers. Ziblets always have more fingers than buttons." Two examples followed, each consisting of the correct combination of the number of fingers and buttons (with no other features present). Then children were presented with eight training trials, in which they were asked to determine whether a creature was a Ziblet or a Flurp. After responding, participants received corrective feedback and were reminded of the rule for determining category membership. Note that during training participants were presented with A_1C_1, A_1C_2, A_2C_1, and A_2C_2 items (two training trials per item), with only the rule (but not appearance) being predictive of the category membership.

During the initial categorization task, children were presented with new A_1C_1, A_1C_2, A_2C_1, and A_2C_2 items (again two trials per each item, with a total of eight trials), and asked to determine whether an item was a Ziblet or a Flurp. No feedback was given during this part of the task, and the experimenter did not repeat the rule to the child. To be included in the sample, children had to perform correctly on at least six out of eight initial categorization trials (i.e., respond with at least 75% accuracy). Four participants were excluded because they did not reach this criterion.

After the initial categorization task, children were presented with an induction task. They were told: "The pet store owner has a few questions for those who want to buy a pet. Can you help get those questions right?" On each trial, children were shown a triad consisting of a target item and two test items located underneath the target (see Figure 2A), with neither the target nor the test items being used in category learning or initial categorization tasks. For a subset of children, the target was an A_1C_1 item, and for the rest of the children, the target was an A_2C_2 item. The two test items were A_1C_2 and A_2C_1 (displayed next to each other underneath the target, counterbalanced for position on the screen). On each trial, children were told about a hidden property of the target (e.g., "thick blood") and asked to pick the test item that had the same hidden property. Twelve induction trials were presented in random order, with each hidden property being used twice. No labels were given during induction, with all items being referred to as "this one." Notice that the selection of A_1C_1 and A_2C_2 items as targets and A_1C_2 and A_2C_1 items as test items enabled us to directly pit appearance against category membership.

After the induction task, participants were presented with a final categorization task, which was similar to the initial categorization task. The goal of the final categorization task was to ascertain that children could correctly categorize the induction items and that they did not forget the category-identification rule in the course of the experiment. The items used in the final categorization task were the test items used during induction intermixed with four catch items (the catch items were cartoon-like drawings of completely new animals and they were used to control for the overall alertness). Children were asked to determine whether or not a presented item was a Ziblet. The catch items were correctly rejected by all participants.

Results and Discussion

Results are presented in Figure 3A. Participants were highly accurate in the initial categorization task (M = .95, above chance, one-sample $t(15)$ = 27.8, *p-rep* = .998, d = 6.9) and final categorization task (M = .82, above chance, one-sample $t(15)$ = 6.95, *p-rep* = .998, d = 1.74). However, they ignored category information in the induction task (M = .27, below chance, one-sample $t(15)$ = -4.28, p = .001, *p-rep* = .99, d = -1.07), relying instead on appearance information. This tendency to ignore category information was especially striking given that children clearly knew which kinds the items belonged to: children accurately categorized items in the final categorization task, which used the same stimuli as the induction task. Therefore, while knowing which categories items belonged to, children ignored this information when performing induction.

Could it be that young children failed to perform category-based induction under these conditions because they cannot simultaneously pay attention to the rule and generalize a hidden property? To eliminate this possibility, we conducted a control experiment in which a separate group of 16 4- and 5-year-olds participated in the same induction task as before. However, prior to the induction task, children were trained to rely on the rule when performing induction. Specifically, children were first told that "all animals that have more fingers than buttons also have the same stuff inside." They were then given eight induction training trials accompanied by corrective feedback. Finally, they were tested on 12 no-feedback induction trials using pictures of creatures and the to-be-generalized properties different from those used in training trials. Neither labels nor category information were given during induction training or testing. The results of test trials indicated that participants reliably used the rule when inducing hidden properties ($M = 0.92$, above chance, one-sample $t(15) = 15.34$, *p-rep* = .998, $d = 4.84$). Therefore, results of Experiment 1 are unlikely to stem from young children being unable to perform the induction task.

It could be also argued that the results stemmed from the inclusion rule (i.e., more fingers than buttons) being accidental rather than biologically important. To eliminate this possibility, we conducted a second control experiment with a separate group of 16 4- and 5-year-olds. The procedure was identical to the one used in Experiment 1, with the only difference being an initial training phase in which children were taught about the biological relevance of the category-inclusion rule. Specifically, they were told that Ziblets catch their food with fingers (they have a chemical in their blood that makes their fingers really sticky), while they do not need their buttons for anything. Despite the fact that children accurately remembered the explanation at the end of the experiment, the results replicated those of Experiment 1. Children were accurate on both the initial and final categorization tasks (*M*s > .81, above chance, one-sample *ts* > 7.8, both *p-rep* = .998, *d*s > 1.96), yet they again ignored category information in the induction task ($M = .31$, below chance, one-sample $t(15) = -5.56$, *p-rep* = .998, $d = -1.39$), relying instead on appearance similarity.

Overall, results of Experiment 1 point to an important dissociation: when appearance information is pitted against category information, children spontaneously use appearance and not category information when performing induction. These findings support the idea that early induction is similarity-based rather than category-based.

EXPERIMENT 2

The goal of Experiment 2 was to test the boundary conditions of children's similarity-based induction. One could argue that children induce properties on the basis of appearance similarity only when category information is in direct conflict with appearance. In other words, children might rely on similarity only when appearance is much more salient than category membership. At the same time, when appearances are not predictive, children might rely on category membership, thereby exhibiting category-based induction. Experiment 2 examined this possibility by using an induction task in which both test items were equally similar to the target, thus rendering appearances non-predictive (see Figure 2B). Therefore, Experiment 2 eliminated the conflict between item appearance and category membership, with category membership being the only possible basis for induction. Because appearance information was not predictive, an attempt to use this information when performing induction should result in a chance-level performance.

Method

Participants

Fifteen 4- and 5-year-olds (*M* = 60.27 months, *SD* = 3.4 months; 8 girls and 7 boys) participated in the experiment. One additional child was excluded because s/he did not meet the learning criterion (the learning criterion was the same as in Experiment 1).

Materials, Design and Procedure

Stimuli and procedure were similar to those used in Experiment 1 with one critical difference: during the induction and final categorization tasks a new set of test items was used, such that target and test items looked alike and one test item shared category membership with the target. As in Experiment 1, the stimuli used in the final categorization task were identical to the test items used during induction.

Results and Discussion

As shown in Figure 3B, similar to Experiment 1, participants were highly accurate in the initial categorization task ($M = .98$, above chance, one-sample $t(14) = 26.25$, *p-rep* = .998, $d = 6.78$) and the final categorization task ($M = .89$, above chance, one-sample $t\,(14) = 12.94$, $p = .0001$, *p-rep* = .998, $d = 3.34$), whereas their performance in the induction task did not exceed chance ($M = .53$, $t < 1$). Moreover, as indicated by the binomial probability test, none of the children exhibited reliable above-chance category-based induction performance. Therefore, even though category-membership was the only predictive information, children did not use this information when performing induction. Instead children might have attempted to use appearance information, which rendered chance performance, given that it was not predictive. These findings, together with the results of Experiment 1, indicate that young children do not spontaneously use category information when performing induction. Their spontaneous induction is based instead (when possible) on appearance information.

GENERAL DISCUSSION

The main finding of the two reported experiments is that young children induced hidden properties on the basis of appearance similarity rather than on the basis of shared membership in a natural kind category. Furthermore, even when the category information was the only basis for induction, young children still did not use this information, although they could ably categorize the induction items. While young children ably learned categories and used category information when categorizing items, they ignored this information when performing induction, relying instead on appearance similarity. These findings present direct evidence that early induction is similarity-based and not category-based. The reported results also indicate a dissociation between category information and induction when natural kind category is not based on similar appearance.

A proponent of the knowledge-based approach could argue, of course, that the reported findings pertain only to unfamiliar categories, whereas category-based induction is limited to familiar categories. However, this argument has important theoretical consequences. If children's conceptual assumptions are limited to familiar categories, this knowledge must be a product of learning and therefore could not explain acquisition of new categories. Instead, the emergence of this conceptual knowledge itself requires an explanation. Furthermore, there is no reason as to why this conceptual knowledge could not be acquired by means of bottom-up associative learning. At the same time, if these conceptual assumptions are to provide a top-down non-associationist account of acquisition of new categories (as argued by Keil et al., 1998 in their criticism of conceptual empiricism, and also by Gelman, 2004), these assumptions cannot be limited to familiar categories. Results of current research are consistent with the former possibility, whereas they do challenge to the latter one.

Another argument could be that the reported results are limited to artificial situations in which there is no correlation between appearance and category membership.   In our view, these situations are not artificial – they are isomorphic to situations in which participants who acquired categories of MAMMAL and FISH have to generalize a hidden property from a dolphin to either a shark (i.e., same appearance item) or a bear (i.e., same category item). Although situations where appearance does not correlate with category information might not be very frequent, they are highly diagnostic in terms of the nature of induction. Note that under more regular conditions appearance information and category information are highly correlated. Therefore, under these more regular conditions it is difficult to distinguish between similarity-based and category-based induction.

The idea of pitting category information against appearance information was exploited by researchers arguing for category-based induction in young children (e.g., Gelman & Markman, 1986). However, in most of the studies using this idea, category information was conflated with linguistic information. For example, a child could be presented with a bird and told that the *bird* had a particular property, and asked whether a dissimilarly looking *bird* or a similarly looking *bat* is more likely to have the same property. Induction from one bird to another bird has been often taken as evidence for reliance on category information. However, it is also possible that participants rely on linguistic information, thereby exhibiting label-based rather than category-based induction.

The research reported here offers a novel paradigm that enables a distinction between category-based and label-based induction. Indeed, in both experiments young children were trained to categorize entities into two natural kind categories, and yet this kind information played little or no role in their induction. These findings seem to suggest that the reliance on category labels in the course of induction does not necessary indicate that this label-based induction is category-based.

The empirical case for label-based induction is rather non-controversial, although the mechanism underlying effects of labels is (see Sloutsky & Napolitano, 2003, for a summary of existing theoretical positions). In particular, there is much supporting evidence indicating that when two items are referred by the same word, young children are more likely to generalize properties from one item to another than when words are different or no words are introduced (Gelman & Markman, 1986; Sloutsky & Fisher, 2004a; Welder & Graham, 2001).

At the same time, the empirical case for category-based induction (which is independent of common labels) early in development is much more controversial. Whereas some researchers have presented supportive evidence (see Gelman, 1988; Gelman & Markman, 1986, Experiment 3), others have presented evidence challenging the idea of category-based induction early in development (see Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004b), with both sets of evidence being indirect. The main contribution of the reported research is that it presents direct evidence that when category information is pitted against appearance information and no labels are provided, young children rely on appearance and not on category information. This research supports the idea that early in development similarity-based induction is a default and challenges the idea that even early in development people spontaneously perform category-based induction.

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Author Note

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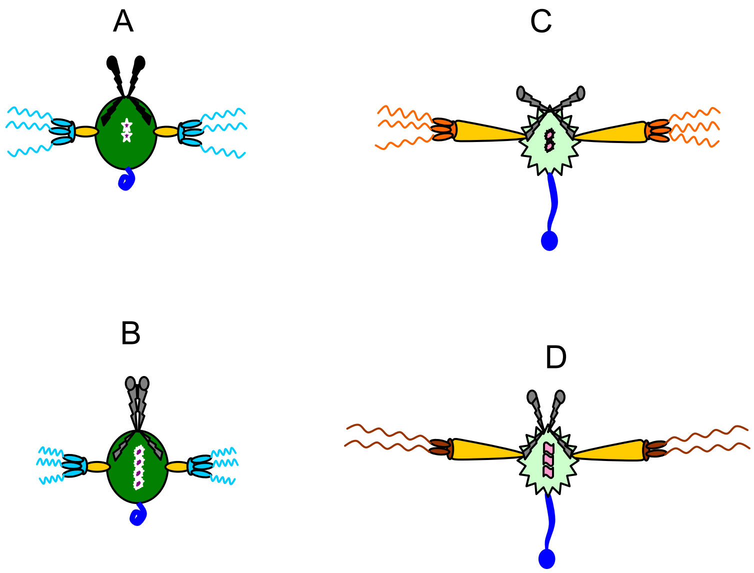
Figure Captions

Figure 1. Examples of stimuli in Experiment 1: A. A_1C_1, B. A_1C_2, C. A_2C_1, and D. A_2C_2. Items A and C belong to Category 1 (Ziblets), and items B and D belong to Category 2 (Flurps)

Figure 2. Examples of triads used in induction task of Experiment 1 (A) and Experiment 2 (B). In both triads, Test 2 belongs to the same category as the Target.

Figure 3. Proportion of Category-Based Responses. Error bars represent standard errors. The dashed line represents chance responding. A. Experiment 1 B. Experiment 2.

Figure 1

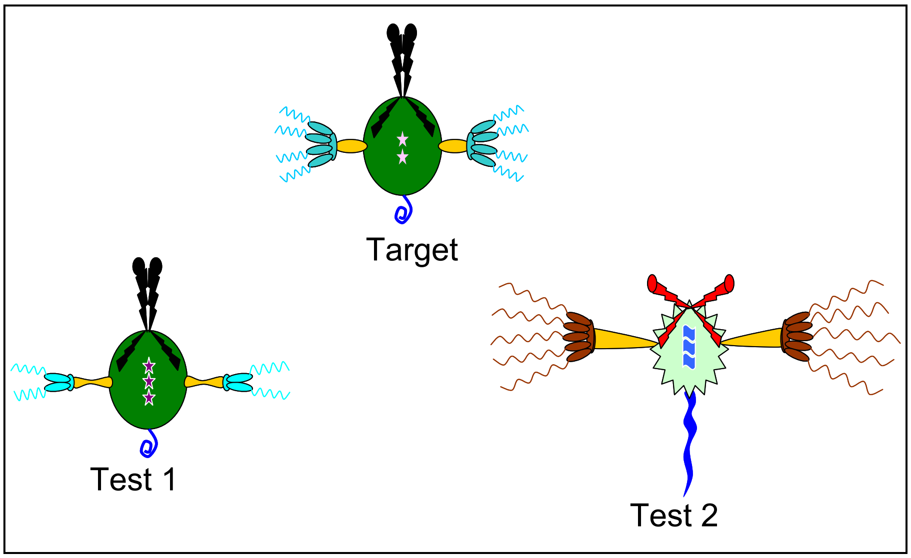


Items A and C belong to Category 1 (Ziblets)

Items B and D belong to Category 2 (Flurps)

Figure 2

A.



B.

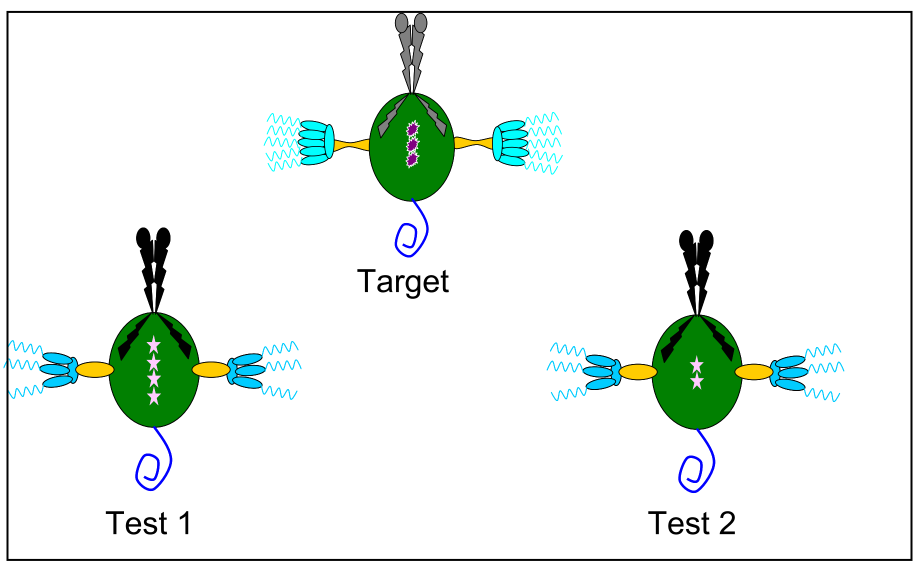
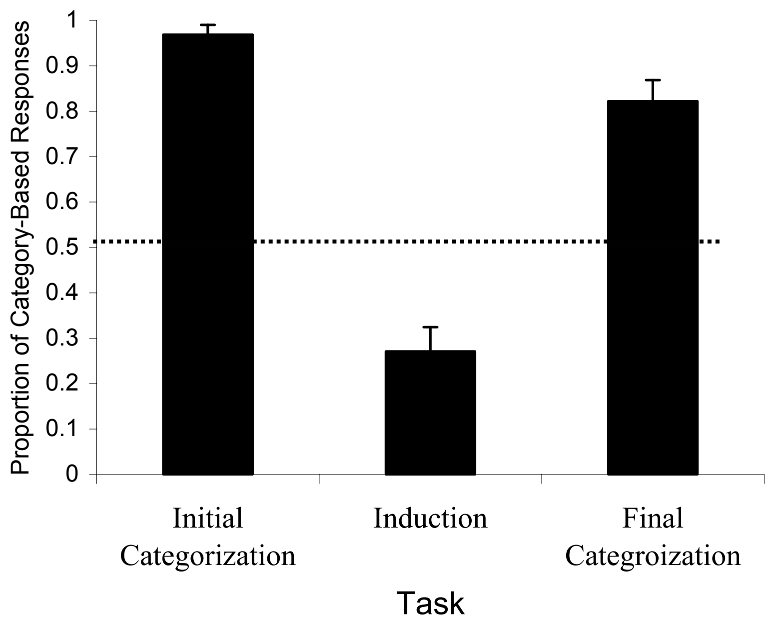
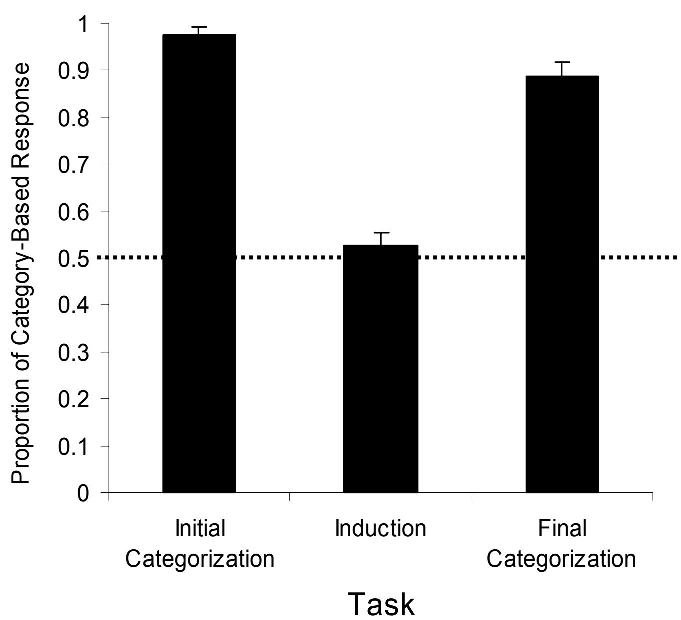


Figure 3

A.


Proportion of Category-Based Responses
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Initial Categorization
Induction
Final Categroization
Task

B


Proportion of Category-Based Response
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Initial Categorization
Induction
Final Categorization
Task