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# Perceptual and Conceptual Cues in Classification and Inference Tasks

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**Abstract**

We are able to use many types of information available in the environment when categorizing or making inferences. This research explores how two types of information—perceptual and conceptual—may be used to different extents in different tasks. The method takes advantage of the distinction between animate and artifact categories. In two experiments, adult participants were given perceptual and conceptual information about the animacy of novel categories, and then were tested on three tasks. Participants categorized items by classifying with a given novel name, with a given fact, or by inferring untrained facts about the items. Results showed that participants used different sources of information depending on the task. These results are discussed in terms of how they could add to an account of the mechanisms of categorization.

**Keywords:** Categorization; classification; inference; animacy; perceptual and conceptual information.

## Introduction

A fundamental question of cognitive psychology centers on how we use the information available to us in the environment to accomplish cognitive tasks such as categorization. An intuitive view is that categorization is based on similarity information (Shepard, 1987). For example, objects that have perceptual features in common are often categorized together; cup-shaped objects tend to be grouped with other cup-shaped objects. More abstract commonalities, such as functional attributes, can also be involved in categorization (Rosch & Mervis, 1975). For example, the category of vehicles is well characterized by the functional attribute of being used for transportation. Categorization is highly complex and based on multiple types and sources of information.

In this paper we focus on two specific types of information that contribute to categorization: perceptual and conceptual. Perceptual information refers to directly perceptible features of items we encounter, such as size and shape. Conceptual information refers to more abstract facts about these items, such as internal characteristics and function that may not be directly observable. The dichotomy between perceptual and conceptual information is at the heart of a lively debate in the developmental literature in which proponents of either side argue that category learning is a top-down, conceptually driven process (e.g., Booth & Waxman, 2008) or that it is a bottom-up, associative process (e.g., Colunga & Smith, 2008). The research with adults in this paper contributes by offering a method of comparing the contributions of both perceptual and conceptual information to several types of category learning and use.

In the current work we explore the contributions of perceptual and conceptual information to categorization, and particularly how each type of information is weighed in different kinds of categorization tasks. We do this in the domain of animacy in order to take advantage of a well-known characteristic of animacy categories.

### Animate and Artifact Categories

Animacy is an apt domain for the exploration of the uses of different sources of information because people exhibit distinct patterns of categorization for animates versus artifacts. One way to characterize these different patterns is that artifact categories tend to be broader and more inclusive whereas animate categories tend to be narrower and more conservative. These distinctive patterns have been shown in both developmental and adult studies.

Developmental studies have examined how children categorize animates and artifacts with novel name generalization tasks. In such tasks, a child is trained on a novel exemplar with a novel label. The child is then presented with various other novel test items that match the original in specific dimensions such as shape, size, and/or texture, while varying in other dimensions. When asked which of the test items would be labeled with the same name, children show distinct generalization patterns depending on whether the exemplar was presented as an artifact or as an animate. By three years of age children use shape as the only critical feature in categorizing novel artifact-like objects, but they use a more stringent criteria of both shape and texture for novel objects presented as animates (Jones, Smith, & Landau, 1991).

The pattern of categorizing animates by multiple similarities, making for more restrictive categories, and categorizing artifacts by fewer similarities develops early in life and endures into adulthood. One study found that adults tended to classify items with more feature variability as artifacts, and only classified highly consistent items as animates (Freeman & Sera, 1996). Another explored the structural nature of animacy categories and found that artifact categories tend to be more flexible and spread out in similarity space whereas natural kinds, including animates, are more tightly clustered by similarities (Malt, Sloman, Gennari, Shi, & Wang, 1999).

In sum, previous work indicates that the animacy distinction is basic and pervasive, emerging early in life; moreover, there are distinct and consistent patterns in how people categorize animates compared to artifacts. That is, people generalize animates more conservatively and generalize artifacts less conservatively. In the current research we take advantage of these distinct patterns to explore the contributions of perceptual and conceptual information to categorization. To briefly foreshadow our measure and the logic behind it, we associated each type of information with an animacy category. In each condition, we offered both perceptual (the way the item looks) and conceptual (verbally labeling it as a living or man-made thing) information. Then we looked at how these different animacy cues influenced people's construal of the categories as animate or inanimate by measuring the shift in generalization patterns in response to the given cues. Before further fleshing out the details of this measure, we will introduce the categorization tasks used in the current research.

## Tasks

The current experiments explore the question of how perceptual and conceptual information are used in the context of three categorization tasks: novel name extension, ontological category extension, and inference making. The first two tasks involve generalizing items at test based on information given at training, that is, a novel name and an ontological type (animate or artifact). These can also be thought of as classification tasks because participants must classify items based on trained information. The third task involves making an inductive inference about items at test based on the ontological category information given at training. For example, if an item were presented as being alive, the participant would be asked to infer whether it breathes.

Some previous research has investigated the uses of perceptual and conceptual information in these types of tasks, with mixed results. For example, Freeman and Sera (1996) found that children and adults were able to use either visual or verbal information in both classification and induction tasks involving animals and machines. The resulting patterns of categorization were in line with what has been discussed about animacy categories, but did not differ by task. In contrast, a study that focused on induction found that children preferred perceptual similarity information to conceptual kind information to guide inferences about novel items (Sloutsky, Kloos, & Fisher, 2007). These mixed results suggest a need to further investigate the uses of perceptual and conceptual sources of information across different tasks. The experiments presented here will directly compare uses of information across three tasks to contribute to this area of research.

## The Current Experiments

The current question of interest is how people use perceptual and conceptual information in various categorization tasks. The experiments investigate how these two types of information influence people's construal of objects as animate or artifacts. In two experiments we offered perceptual cues in the form of visual features and conceptual cues in the form of written facts. Perceptual and conceptual cues were crossed so there were four possible combinations of cues (see Figure 1): two were congruent (both cues indicated animate or both artifact) and two were incongruent.

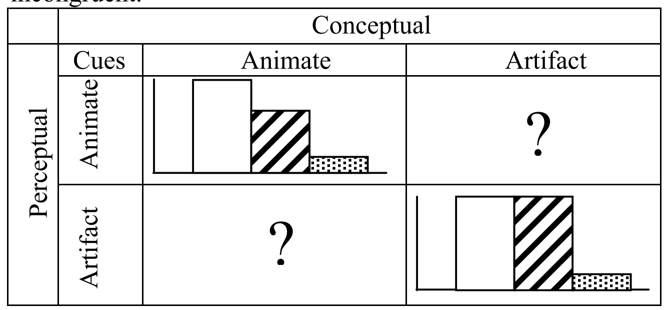


Figure 1: Diagram of study design and predicted generalization patterns; bars represent old, new, and distractor items, respectively.

Generalization behavior at test, measured through the three tasks, was used to explore whether participants weighed the perceptual or conceptual dimension more strongly. It is important to note that this measure captures implicit patterns of generalization. That is, although we asked participants questions like "is this alive?" the patterns of responses could still be in line with either an animate or artifact category. For example, in looking at the responses to the "is this alive?" question, a pattern of saying "yes" only to the old items would be taken as a conservative generalization pattern, typical of animate categories, but saying "yes" equivalently to new than old items would indicate an artifact generalization pattern. In this way our measure focuses on the implicit patterns of generalization rather than explicit responses at test.

We also examined these implicit generalization patterns in terms of whether they were associated with perceptual or conceptual cues. For example, if the perceptual cue indicated an animate while the conceptual cue indicated an artifact, a relatively highly conservative generalization pattern would indicate that the item was treated as an animate, and in turn that the perceptual cue was used preferentially in the task. Based on previous findings about the relative breadth of animate and artifact categories, we looked for two distinct generalization patterns: relatively more conservative generalization to indicate an animate, and relatively less conservative generalization to indicate an artifact. The idea of using *relative* generalization patterns is key; by this we mean that we will compare patterns on the incongruent blocks to those on the congruent blocks. This is illustrated in Figure 1: from the predicted patterns in the congruent blocks, we can explore whether the incongruent blocks show similar patterns along the perceptual or conceptual dimension. In this way we are not arbitrarily deciding which patterns count as "conservative" and "not conservative," but will instead report generalization relative to a standard, the congruent blocks.

The two experiments presented here have the same design but use different stimuli. The perceptual cues in Experiment 1 were implemented using two sets of novel object images (Tarr, 2006; see Figure 2). The animate stimuli consisted of the image set called Greebles, which are rounded, uniform in color and texture, and organized into categories such that global relations between their features cue to category membership. Previous research indicates that Greebles are processed in ways similar to faces (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999). The artifact stimuli consisted of the Fribble novel image set which are angular, have distinct parts with varying colors and textures, and are categorized based on the presence or absence of specific parts, characteristics typical of artifacts. In contrast, in Experiment 2 the perceptual manipulation relied on single visual features, eyes for animates or wheels for artifacts, added to one type of animacy ambiguous novel image set. In both experiments conceptual cues were provided as written facts that explicitly indicated whether the object was an animate or an artifact (i.e., "is alive" and "was made in a factory").

Several specific predictions can be made. First, the conditions in which perceptual and conceptual cues are congruent should reveal the distinctive generalization patterns of animates and artifacts (see Figure 1). When the cues are congruent and both indicate an animate, generalization should be more conservative, with participants generalizing to a more limited variety of items. Conversely, when cues are congruent and both indicate an artifact, generalization behavior should be less conservative, with participants generalizing to a larger variety of items. Of particular interest are the two conditions in which perceptual and conceptual cues are incongruent. Within these conditions, generalization behavior will act as an indicator of whether one cue type is preferentially used to determine whether items belong to the animate or artifact category. If no clear preference emerges from generalization behavior, both perceptual and conceptual cues may be interacting and contributing to categorization equivalently.

We are particularly interested in how the perceptual and conceptual cues are used in the different tasks. The question is, do different types of information carry more weight in some tasks than others? For example, is perceptual information more important for naming, but conceptual information more important in making inferences?

## Experiment 1

### Method

**Participants** Thirty-one undergraduate students recruited from the University of Colorado at Boulder psychology department subject pool participated for course credit.

**Materials** Participants were trained on categories drawn from the Greeble and Fribble novel image sets (Tarr, 2006; see Figure 2). There were four blocks total, one for each of the perceptual/conceptual cue combinations. Thus, two blocks used Greebles and two Fribbles. For each block, old, new, and distractor items were chosen from two sub-categories of the respective image set. Six old items and four new items came from one sub-category, and four distractor items came from a different sub-category.

Individual images were presented with conceptual cues consisting of sentences displayed beneath the image. The animate cue was "This is alive," and the artifact cue was "This was made in a factory." Each item was also presented with one of the following novel names at training: "wuz," "mek," "sim," or "dap."

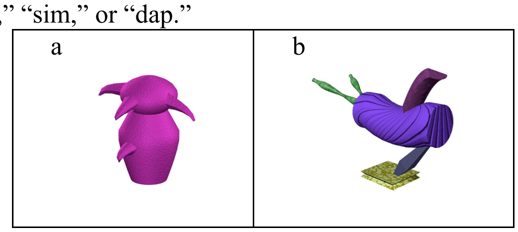


Figure 2: Image sets used in Experiment 1: (a) Greebles, (b) Fribbles.

Training slides consisted of old items (either Greebles or Fribbles depending on the block) presented with a novel name and conceptual cue. An example of the text that a participant saw at training is "This is a [novel name]. It is alive." Testing slides consisted of old, new, and distractor items presented one at a time with each of three questions, for the name extension, ontological category extension, and inference making tasks, respectively. On conceptually animate blocks the questions were "Is this a wuz?" "Is this alive?" and "Does this breathe?" On conceptually artifact blocks the questions were "Is this a wuz?" "Was this made in a factory?" and "Can you get this at a store?" For the incongruent blocks, the types of questions used (e.g., animate or artifact) were consistent with the animacy of the conceptual cue given at training.

**Procedure** Participants completed four blocks of training and testing sets; block order was counterbalanced across participants. All training and testing slides were presented on a computer screen using the program E-Prime.

Participants began by reading instructions given on the computer screen. They then proceeded to the training slides of the first block. Participants saw 24 training slides in random order: six old items shown four times each. Training was unsupervised and self-paced; participants used the space bar to proceed through the image slides interspersed with an inter-stimulus blank screen.

At the end of the training slides, participants proceeded to the testing slides of that block. The six old items from training, along with four new and four distractor items, appeared in testing. Each of these 14 items was shown twice with each of the three categorization questions, for a total of 84 testing slides per block, also presented in random order.

### Results

The first issue we explored in the data was whether participants successfully learned the categories of Greebles

Table 1: Experiment 1 means (standard deviations) of percentages of "yes" responses to old and new items presented as either animate or artifact through different cues. P = significant interaction between perceptual cues and trial type, C = significant interaction between conceptual cues and trial type ($F(1, 30) > 4.80$, $p < 0.05$ for all).

| | Perceptual | | | | Conceptual | | | |
|---|---|---|---|---|---|---|---|---|
| | Animate | | Artifact | | Animate | | Artifact | |
| Task | Old | New | Old | New | Old | New | Old | New |
| Naming[P] | 93.28 (9.54) | 62.30 (26.63) | 90.59 (13.69) | 91.13 (14.32) | 90.19 (13.16) | 75.61 (19.05) | 93.68 (9.09) | 77.82 (21.64) |
| Ontological[P] | 92.74 (10.81) | 59.07 (28.13) | 91.00 (13.13) | 89.00 (16.36) | 90.86 (12.71) | 72.78 (22.51) | 92.88 (9.99) | 75.29 (20.61) |
| Inferential[PC] | 63.31 (9.54) | 45.97 (26.64) | 61.69 (13.69) | 58.88 (14.32) | 72.18 (13.16) | 58.67 (19.05) | 52.82 (9.06) | 47.18 (21.64) |

and Fribbles based on responses to old, new, and distractor items. Percentages of "yes" responses were submitted to a one-way repeated measures ANOVA. Participants accepted old items most ($M = 82.35$, $SD = 29.02$), followed closely by new items ($M = 68.24$, $SD = 34.50$), but rarely accepted distractor items ($M = 4.84$, $SD = 12.40$), $F(2, 60) = 477.52$, $p < 0.001$. To focus more narrowly on generalization, and because responses to distractors were below chance (two-tailed $t(30) = 33.88$, $p < 0.001$), only responses to old and new items were included in subsequent analyses.

The next question was whether participants showed distinct generalization patterns for animates and artifacts. To verify our prediction, we began by looking at the two congruent blocks of the experiment, in which both cues indicated either an animate or an artifact. Percentages of "yes" responses were submitted to a 2 (animacy: animate or artifact) × 2 (trial type: old or new) repeated measures ANOVA. Results revealed main effects of both factors ($F(1, 30) > 6$, $p < 0.01$ for both) in addition to the key interaction between animacy and trial type ($F(1, 30) = 23.54$, $p < 0.001$). This interaction showed the expected distinct generalization patterns. On the congruent animate block, participants responsed "yes" more to old items ($M = 85.66$, $SD = 24.89$) than to new items ($M = 57.26$, $SD = 33.41$). However on the congruent artifact block, responses were equivalent to both old ($M = 79.03$, $SD = 32.43$) and new items ($M = 79.22$, $SD = 33.41$). These patterns are consistent with previous literature and verify our prediction of more conservative generalization of animates and less conservative generalization of artifacts.

Having established the presence of distinct generalization patterns in responses to the congruent blocks, we went on to explore the influences of perceptual and conceptual cues and task. We separated the name extension, ontology extension, and inference making tasks, and analyzed responses to all blocks. Percentages of "yes" responses from each task were separately submitted to a 2 (perceptual cue: animate or artifact) × 2 (conceptual cue: animate or artifact) × 2 (trial type: old or new) repeated measures ANOVA. All three tasks showed a pattern of more "yes" responses to old items compared to new items ($F(1, 30) > 22$, $p < 0.001$ for all).

The main question of interest in the separate task analyses was how the perceptual cue and conceptual cue variable interacted with trial type. These results are displayed in Table 1. In all of the significant interactions (indicated by superscript P and C), the pattern of results are similar to those discussed above in the context of the congruent blocks. That is, more conservative generalization of animates, as shown by more "yes" responses to old than to new items, and less conservative generalization of artifacts, as shown by equivalent responses to old and new items. The perceptual cue significantly interacted with trial type in all three of the categorization tasks, showing that participants generalized differently depending on the perceptual cue given no matter what kind of question they were answering. The conceptual cue significantly interacted with trial type only on the inferential task.

## Discussion

The results of Experiment 1 revealed that perceptual and conceptual information had varied influences in the different tasks. In all three tasks, participants showed more conservative generalization of the image set with perceptual animate cues and less conservative generalization of the set with perceptual artifact cues. In the inference making task in particular, there was an additional influence of conceptual cue: the distinct animacy patterns were also found to be in line with whether the items were described as being alive or as made in a factory. In sum, participants' responses in the two classification tasks were similarly influenced only by the perceptual cues. In the inferential task, on the other hand, responses were influenced by both the perceptual and conceptual cues. This may confirm basic differences between classification and inferential categorization tasks.

However, the strong perceptual effects throughout Experiment 1 may also indicate fundamental differences between the Greeble and Fribble image sets. It is possible that one of these sets is simply easier to generalize than the other. To control for any differences between the two sets, in Experiment 2 we used a single image set and made the perceptual cue a single added feature: eyes or wheels (see Figure 3). If the perceptual effects of Experiment 1 are a function of inherent differences in how easily Greebles and Fribbles are generalized, then any perceptual effects should

Table 2: Experiment 2 means (standard deviations) of percentages of "yes" responses to old and new items presented as either animate or artifact through different cues. P = significant interaction between perceptual cues and trial type, C = significant interaction between conceptual cues and trial type ($F(1, 31) > 4.75$, $p < 0.05$ for all).

| | Perceptual | | | | Conceptual | | | |
|---|---|---|---|---|---|---|---|---|
| | Animate | | Artifact | | Animate | | Artifact | |
| Task | Old | New | Old | New | Old | New | Old | New |
| Naming$^{P}$ | 81.90 (18.67) | 64.45 (27.72) | 83.72 (14.71) | 76.64 (18.67) | 83.20 (16.97) | 73.18 (21.50) | 82.42 (16.40) | 67.71 (26.02) |
| Ontological$^{P}$ | 80.73 (18.10) | 62.76 (28.85) | 83.46 (14.71) | 73.18 (20.36) | 82.92 (18.10) | 70.05 (22.63) | 81.25 (18.10) | 65.89 (27.72) |
| Inferential | 64.58 (27.15) | 55.86 (29.98) | 60.42 (30.55) | 52.08 (26.59) | 60.42 (32.24) | 52.08 (29.42) | 64.58 (28.28) | 59.77 (28.85) |

disappear in Experiment 2. If, on the other hand, the perceptual effects are a function of the animacy characteristics of the perceptual cues, then there should be similar perceptual interactions with trial type. That is, participants should generalize items with eyes more conservatively, and items with wheels less conservatively.

## Experiment 2

### Method

**Participants** Thirty-two undergraduate students recruited from the University of Colorado at Boulder psychology department subject pool participated for course credit.

**Materials** Participants were trained on categories drawn from the YUFO image set (Tarr, 2006; see Figure 3). For each block of the experiment, six old and six new items were drawn from one sub-category, and six distractors were drawn from a different sub-category.

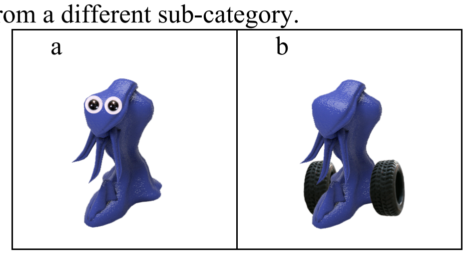


Figure 3: Images used in Experiment 2: YUFO stimuli with added eyes and wheels.

Perceptual cues consisted of simple visual features, eyes or wheels, added to the YUFO images. Conceptual cues, novel names, and test questions were the same as in Experiment 1, with the exception of the inferential question for conceptual artifacts, which was changed to "Was this put together?"[1]

**Procedure** Training and testing were conducted in the same way as in Experiment 1.

### Results

As in Experiment 1, we first checked whether participants successfully learned the YUFO categories based on responses to old, new, and distractor items. Percentages of "yes" responses were submitted to a one-way repeated measures ANOVA. Participants responded "yes" most to old items ($M = 77.60$, $SD = 27.65$), next most to new items ($M = 65.41$, $SD = 32.23$), and least to distractors ($M = 42.21$, $SD = 37.38$), $F(2, 62) = 82.69$, $p < 0.001$. Distractors tended to be accepted at lower than chance levels (two-tailed $t(31) = 1.59$, $p = 0.12$), and so were excluded from further analyses. As in Experiment 1, only old and new items were included in order to focus more directly on generalization patterns.

Next we analyzed the congruent blocks of Experiment 2. We submitted percentages of "yes" responses at test to a 2 (animacy) × 2 (trial type: old or new) repeated measures ANOVA. The results confirmed that participants responded "yes" more to old than to new items in the congruent blocks, $F(1, 31) = 22.61$, $p < 0.001$. There was also a trend toward the predicted animacy patterns in generalization, as shown through an interaction between animacy and trial type, $F(1, 31) = 1.44$, $p = 0.23$. On the congruent animate block, participants responded "yes" more to old items ($M = 77.26$, $SD = 27.80$) than to new items ($M = 61.98$, $SD = 32.44$). However on the congruent artifact block, responses to old items ($M = 77.95$, $SD = 27.65$) were not as much greater compared to new items ($M = 68.84$, $SD = 31.90$). This trend is similar to the patterns seen in the first experiment—more conservative on the congruent animate block and less conservative on the congruent artifact block.

Next, as in Experiment 1, we separated the data by task and conducted three separate 2 (perceptual cue) × 2 (conceptual cue) × 2 (trial type) repeated measures ANOVAs. A main effect of trial type reached significance in all three tasks, showing greater "yes" responses to old items than to new items ($F(1, 31) > 6.42$, $p \leq 0.01$ for all).

Next we explored whether there were any interactions between either the perceptual or conceptual cues and trial type; these results are displayed in Table 2. Significant effects in this table indicate generalization patterns similar to those discussed above. That is, more conservative generalization of animates, as shown by a greater difference between old and new responses, compared to artifacts. Only two interactions reached significance among the task analyses: perceptual cue influenced generalization in both the naming and ontological extension tasks. There was no perceptual cue interaction in the inferential task, and no conceptual cue interactions in any of the tasks.

[1] This question was changed to relate more directly to the conceptual cue for artifacts.

## Discussion

The results of Experiment 2 showed that overall, perceptual cues influenced generalization patterns. Across tasks participants showed more conservative generalization to items with added eyes and less conservative generalization to those with added wheels. This shows that simple features added to novel items had a similar effect to the rich perceptual cues to animacy (e.g., multiple features and distinct structures) used in Experiment 1. In the task analyses, the influence of perceptual cues was seen in the naming and ontological extension tasks, but not the inferential task. Conceptual cue did not reliably influence generalization patterns in any of the tasks.

# General Discussion

In this set of experiments participants showed distinct patterns of generalization for artifacts and animates. As expected based on previous work in the literature, participants demonstrated more conservative generalization of animates and less conservative generalization of artifacts in terms of how much they extended categories to old and new items. Furthermore, these patterns were in line with perceptual and conceptual cues differently depending on categorization task. In Experiment 1, perceptual cues had a dominant influence on participants' responses in the two classification tasks, naming and ontology extension, while both perceptual and conceptual cues influenced performance in the inferential task. In Experiment 2, perceptual cues were again dominant in the classification tasks, while neither type of cue had an effect on generalization in the inferential task.

The patterns of individual task effects are intriguing. In both experiments, the same type of information influenced the naming and ontology extension tasks. Although these tasks require classification at different levels, that is, the basic level of novel names and the superordinate level of ontological kinds, both tasks were selectively influenced by the perceptual cues. In contrast, the inferential task was set apart from the classification tasks in terms of cue influence by showing an influence of both cues in the first experiment and of neither cue in the second experiment. These task patterns can be interpreted in terms of previous findings on the differences between classification and inference (Sakamoto & Love, 2010). In the classification tasks participants focused on the perceptual cues likely because they found them to be most diagnostic of their categories. In the inferential task participants did not focus on one cue over the other, perhaps because neither cue on it's own was sufficient to determine how prototypical an item was of its category. It is still puzzling why neither cue influenced the inferential task in Experiment 2, and this will be a question for further research.

The current experiments show that people use perceptual and conceptual information in categorization in different ways depending on task. In the ongoing debate over the mechanisms of categorization, particularly in the developmental field, the methodology of these experiments may be quite useful. The technique of comparing the effects of perceptual and conceptual types of information both within and across tasks can be extended to other domains. For example, this method could be used to explore developmental patterns of perceptual and conceptual information use in children. It would be informative to test whether children favor conceptual, top down information or perceptual, bottom up information differently across tasks and contexts. The results also have implications for research on different categorization tasks. In particular, they are consistent with work showing differences between classification and inference learning, and raise the question of how specific tasks trigger certain strategies of information use. One possibility is that a task context itself cues a certain categorization mechanism or strategy of information use. Future work in categorization should consider how both the characteristics of the stimuli and the task context influence category learning and use.

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