Taxonomic and Ecological Relations in Open-ended Induction

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Abstract

Recent research suggests that inductive inference may be based on salient relations between premise and/or conclusion categories (Medin, Coley, Storms and Hayes, 2003). The types of relations deemed relevant may be influenced by experience (e.g. López, Atran, Coley, Medin and Smith, 1997; Shafto & Coley, 2003). Novices in a given domain have been shown to rely primarily on taxonomic relationships to guide their inductive inferences. In contrast, experts show flexible use of both taxonomic and non-taxonomic relations. Previous research has assessed induction using forced choice tasks or ratings of argument strength, measures that may underestimate the salience of non-taxonomic relations for novices. The present study investigated the use of taxonomic and non-taxonomic relations among novices in the domain of local animal species using an open-ended task. Participants were given 12 pairs of taxonomically or ecologically related animals both known to have a certain property and asked to list other animals that might also have that property. Results show that relations among premise pairs had systematic effects on open-ended inferences. Overall, responses based on ecological relations were more frequent than taxonomic responses for novices. These results suggest that given an open-ended task, novices do demonstrate sensitivity to relevant relations among premise categories in generating inductive inference.

Keywords: Inductive inference: Reasoning

Introduction

One important role of categorization is to support inductive inference, that is, using what we know to make guesses about what we don't know. If, for example, we know that two animals, say owls and ducks, have a certain property, we might reason that other similar animals, perhaps woodpeckers, may share the property, but not dissimilar animals, like snakes. In this case, our extension of the property from the premises (owl and duck) to the conclusion (woodpecker) is based on overall similarity, specific shared features, or common membership in the same superordinate class (i.e. birds). We conclude that woodpeckers may have the property, but not snakes, because woodpeckers are taxonomically related to the premises, that is, similar to the class that includes both owls and ducks, and snakes are not.

If, on the other hand, a property is known to be true of both owls and mice, we might generalize that property somewhat differently. In this case, if we notice that mice and owls have a unique relationship, that is that owls prey on mice, we might assume that the property in question is more appropriately extended to other animals that also participate in that relationship. Here, we might extend the property to garter snakes who also eat mice.

Many recent models of category-based induction emphasize the importance of taxonomic relations (e.g., Osherson, Smith, Wilkie, López & Shafir, 1990; Sloman, 1993). But, as is evident in the example above, taxonomic relations may not be the only available relations for guiding inductive inferences. A recent proposal by Medin, Coley, Storms and Hayes (2003) suggests that inductive inferences are guided in part by salient relationships that exist between premise categories or between premise and conclusion categories that are relevant to the context in which the inference is being made. Specifically, they propose the principle of relevance, the idea that people are sensitive to relations between premise categories and they assume that those relations should inform the process of evaluating potential conclusion categories. The most distinctive feature shared by the premise categories provides a basis for projecting a property shared by the premises to other entities. Recent research suggests that sensitivity to relevant relations may emerge as a function of experience in a given domain.

López, Atran, Coley, Medin and Smith (1997) compared inductive inferences made about local mammal species by the Itza' Maya of Guatemala and by North American university students. Participants were asked to judge the relative strength of two arguments. For example, the item: "Mice have a disease. Foxes have another disease. Do you think rats have the disease of mice or the disease of foxes?" contrasts the argument Mouse/Rat with the argument Fox/Rat. They found that American undergraduates, who were relative novices in the domain of local mammals, tended to base their answers on the taxonomic similarity among the categories. In terms of the example above, novices might rate Mouse/Rat to be the stronger argument because rats are taxonomically closer to mice than to foxes. Itza' Maya, on the other hand, who have considerable knowledge of their local mammals, often used ecological categories or causal relationships between categories to guide their inductions. In terms of the example, experts might find Fox/Rat to be the stronger argument because foxes and rats have similar feeding habits. These findings suggest that sensitivity to relevant relationships among premise categories and inductive selectivity may change as a function of experience in a given domain. Specifically, they find that novices tend to rely on taxonomic relations while experts may seek out other types of relations (such as ecological relations) that may be relevant to the context of the inference.

Is taxonomic similarity always the most relevant relation for novices? The methods used to assess inductive inference

in studies such as those reviewed above often ask participants to choose the stronger of two arguments, or to select the most likely conclusion category from among a small set of alternatives. These tasks constrain participants' responses and may underestimate the salience of non-taxonomic relations for novices. A more open-ended task such as one in which participants are presented with premises and asked to generate their own conclusions may be more like real-world reasoning tasks and may reveal flexible use of relevant relations in novices.

The present study investigated novices' use of relevant relations, both taxonomic and non-taxonomic, in the domain of local animal species using an open-ended task. If novices are sensitive to relevant relationships among premise categories in evaluating potential conclusions, manipulating those relations may lead to systematic differences in the nature of inductive inferences.

To this end, participants were presented with pairs of local animals known to have a certain property. These animal pairs were either taxonomically similar or dissimilar. Varied orthogonally with taxonomic similarity was ecological relationship. Each pair either possessed an ecological relation (predator/prey or similar habitat) or did not. If participants are sensitive to the relations among premise pairs, taxonomically similar pairs should yield more taxonomic inferences than dissimilar pairs. Ecologically related pairs should yield more ecological inferences than unrelated pairs.

Method

Participants

Participants were 30 Northeastern University undergraduates with no stated expertise in the domain of local animals. Undergraduates were recruited from introductory psychology classes and participated for course credit.

Materials and Design

Stimuli consisted of 12 pairs of animal species native to Massachusetts. Relations between paired animals varied according to taxonomic distance and ecological relatedness (see Table 1). Pairs were either drawn from the same taxonomic order (taxonomically near pairs) or from different orders (taxonomically far pairs). Ecological relatedness (related or unrelated) varied orthogonally with taxonomic distance and involved either a predatory/prey relation or a shared habitat.

Table 1: Examples of stimulus pairs.

Ecological relation	Taxonomic relation	
	Near	Far
Related	*Coyote, Bobcat* *Heron, Duck*	*Hawk, Field Mouse* *Owl, Garter Snake*
Unrelated	*River Otter, Deer* *Turtle, Tree Frog*	*Chipmunk, Bullfrog* *Muskrat, Woodpecker*

Procedure

Participants were interviewed individually or in small groups in the laboratory. They were presented with a packet containing 12 pairs of animal names; each pair was presented on a separate page. Instructions were as follows.

> On each page of this packet you will find a pair of local animals which have been discovered to have a certain property. All you know about the property is that these two kinds of animals have it. You will be asked to list other animals or kinds of animals you think might also have that property, as well as reasons for your answers.

Response sheets contained one area in which participants listed other animals might share the property known to be true of the two premises, as well as a separate area to provide justifications for their answers. Participants were instructed to treat each pair independently.

Coding

Reponses were coded according to the relationship between the given premise pair and the conclusion categories generated by the participants. The basis of an inference was judged to be taxonomic if participants' explanations emphasized that premise and conclusion categories belonged to the same class or kind, were similar in appearance, or similar in general. Responses were coded as ecological if participants' explanations relied on an interaction between premise and conclusion categories that highlighted a non-taxonomic relation such as a predator/prey relation, shared diet or habitat. Four or five coders agreed on over 90% of codes. Disagreements were resolved by discussion.

Results

Analyses revealed that across items, ecologically based responses were more frequent than taxonomically based responses, $t(29) = 4.017$, $p<.001$. Taxonomic and ecologically based responses were then analyzed separately using a 2 (taxonomic distance, near/far) X 2 (ecological relatedness, related/unrelated) repeated measures analysis of variance.

For taxonomically based responses, analyses reveal a significant effect of taxonomic distance, $F(1,29)=14.57$, $p<.001$. Participants were more likely to make taxonomic projections for taxonomically near than taxonomically far pairs. This analysis also revealed a main effect of ecological relatedness, $F(1,29)=24.93$, $p <.001$. Participants were more likely to make taxonomic projections from ecologically unrelated pairs than related pairs (see Fig.1).

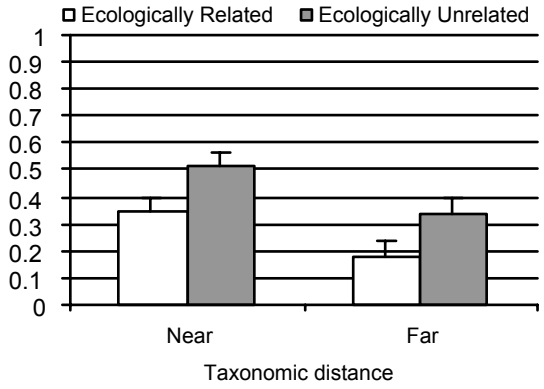

Figure 1. Relative frequency of taxonomic inferences

For ecologically based responses, analyses reveal a significant main effect of ecological relatedness, $F(1,28)=29.52$, $p < .001$. Participants were more likely to make ecological projections for ecologically related than unrelated pairs. This analysis revealed no effect of taxonomic distance, $F(1,28)=2.14$, $p=.15$ (see Fig. 2).

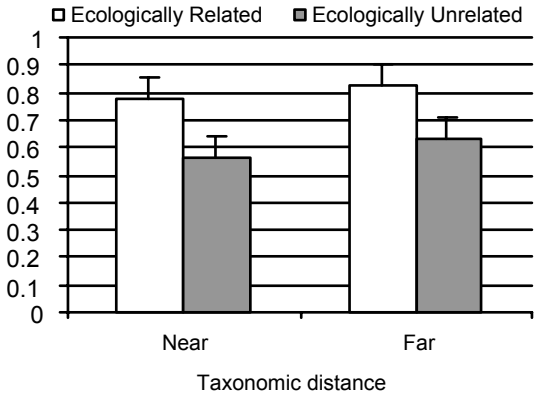

Figure 2. Relative frequency of ecological inferences

Discussion

These results provide compelling evidence for novices' use of relevant relations to guide their inductions. Overall, participants chose to base their inferences on ecological relationships more frequently than on taxonomic relationships. This result diverges from the findings of previous research. Instead of relying exclusively on taxonomic relations, for our participants, ecological relationships seem to have been quite salient. This suggests that past methods used for assessing inductive inference may have underestimated novices' sensitivity to ecological relations. The open-ended methodology employed in this experiment placed fewer constraints on responses and revealed a surprising flexibility in novices' use of both taxonomic and ecological relations.

Participants' use of salient relations to guide their reasoning is consistent with the principle of relevance. When reasoning about pairs of animals that possessed a salient taxonomic relation, participants made projections to other similar animals. They were less likely to make taxonomic projections when the taxonomic relationship was more distant.

When reasoning about animals that had an ecological relationship, our participants used that relation to guide their inferences and projected the property to other ecologically related animals.

Interestingly, the frequency of taxonomic inferences was influenced not only by taxonomic distance, but also by ecological relatedness. Participants were more likely to generate taxonomic projections for pairs of animals that were ecologically unrelated than for pairs that possessed an ecological relationship. Ecological projections, however, were not influenced by the taxonomic distance of the pair. Participants were equally likely to generate ecologically based conclusions regardless of taxonomic relation. These findings suggest that the relations among the premise pairs had systematic and specific effects on open-ended inferences. It was not the case that taxonomic relatedness had a pervasive effect on novices' inferences.

In sum, the results of the current study challenge previous characterizations of novice inductive inference. Our results suggest that novices may not be limited to similarity or taxonomically-based reasoning strategies. In this experiment, novices in the domain of local animals exhibited flexible and systematic use of relevant ecological and taxonomic relations to inform their inferences. Further, the use of open-ended reasoning tasks may capture more ecologically valid inferences, and thus may prove a fruitful method for examining reasoning strategies.

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