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Effects of Experience on Relational Inferences in Children: The Case of Folk Biology

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Abstract

Recent research suggests that adults utilize thematic relations as well as taxonomic relations for guiding inductive inferences, and that thematic relations grow in salience with experience in a given domain. The present study examines the impact of experience on the salience of thematic versus taxonomic inferences. 151 kindergarten through sixth-grade children from urban, suburban, and rural communities in New England were given a forced choice triad induction task requiring them to project a novel internal substance or disease from a base species to a taxonomically or ecologically related target. Results indicate clear evidence of inductive selectivity; children projected insides taxonomically and disease ecologically, both at above-chance levels. Moreover, ecological projections of disease were more likely for older children and for children from more rural communities. Overall, results suggest that for children, like adults, experience renders non-taxonomic relations salient for selectively guiding inductive inferences.

Introduction

Acts of inductive reasoning—“inferential processes that expand knowledge in the face of uncertainty” (Holland, Holyoak, Nisbett & Thagard, 1986, p. 1)—are ubiquitous in everyday cognitive functioning and therefore a central issue in cognitive science. We are constantly using what we know to make inferences about what we don’t know. On what basis do we extend knowledge from known to unknown? Given the multitude of relations that exist among classes of entities, which relations do we rely on to guide inductive inferences? Most existing models of induction stress the importance of *taxonomic* relations; information known to be true of Class A is projected to Class B on the basis of overall similarity, specific shared features, common membership in the same superordinate class, or the presumption of a shared underlying essence (e.g., Osherson, Smith, Wilkie, López & Shafir, 1990; see Sloman, 1993 for a model which explicitly avoids invoking category membership but is based on featural similarity).

Taxonomic relations—in addition to being an important guide for adult inferences—are also extremely important for organizing knowledge and guiding inferences from early in development. For instance, two-year-old children expect objects that are similar in appearance (e.g., a bird and a pterosaur) to share other less obvious properties; however, when given information about category membership, two-year-olds expect members of plant and animal categories

(e.g., *birds*) to share properties even in spite of dissimilar outward appearances (Gelman & Coley, 1990). Moreover, parental speech to preschoolers is rich in references to taxonomic relations, and parents stress these relations more for living things than for human-made artifacts (Gelman, Coley, Rosengren, Hartman & Pappas, 1998).

But taxonomic relations are not the only candidate relations for guiding inductive inferences. Recent studies suggest that *thematic* relations—which emphasize external or complementary interactions between entities that co-occur in space and time—are also important for guiding induction. Information known to be true of Class A can be projected to Class B on the basis of causal or temporal interactions between the classes, regardless of taxonomic similarity. For instance, Ross and Murphy (1999) demonstrate that both script categories (e.g., *breakfast foods*) and taxonomic categories (e.g., *meats*) can support inductive inferences among food categories, depending on the property being inferred. Likewise, Lin and Murphy (2001) provide convincing evidence for the importance of thematic relations in adults’ categorization and inductive reasoning. Finally, Medin, Coley, Storms and Hayes (2003) provide evidence that relevant causal relations can outweigh taxonomic relations in guiding inferences.

Such thematic reasoning seems especially pervasive among individuals with relatively high levels of knowledge and experience, at least in the domain of folk biology. For example, López, Atran, Coley, Medin and Smith (1997) found that the Itza’ Maya of Guatemala utilize causal and ecological relations to guide inductive inferences about local mammals, whereas North American university students used taxonomic relations. Proffitt, Coley and Medin (2000) report a pattern of results for Chicago-area tree experts reasoning about trees that is virtually identical to that observed for Itza’ reasoning about mammals, suggesting that expertise, rather than culture, may be primarily responsible for the salience of thematic relations in reasoning. Shafto and Coley (2003) found that experts reasoned more thematically than novices, and also found that experts showed more inductive selectivity than novices. Specifically, when reasoning about novel diseases, commercial fishermen based projections among marine species on predator-prey relations among species; however, when reasoning about “property x,” experts relied on taxonomic relations. In contrast, undergraduate novices

based their inferences exclusively on taxonomic similarity regardless of the property being projected.

Although classic developmental research has emphasized the importance of thematic relations in early categorization (e.g., Smiley & Brown, 1979), few studies have explicitly examined children's use of thematic relations to guide inductive inferences. In one such study, Nguyen and Murphy (2003) found that by age 4, children could cross-classify food items (e.g., classify *grapes* as both a member of the taxonomic category *fruit* and the thematic script category *snack*). Moreover, by age 7, children could selectively use taxonomic and script relations to guide inductive inferences; children inferred that members of the same taxonomic category were likely to share a biochemical property, but that members of the same script category were likely to share a situational property.

In sum, both children and adults use taxonomic relations to guide inductive inferences. For adults, this may be especially true when they have little domain-specific knowledge. Adults also utilize thematic relations to guide inductive inferences; indeed, with extensive knowledge and experience in a domain, thematic relations not only augment but may eclipse taxonomic relations. There is some evidence that children are sensitive to thematic relations as potentially useful guides for inductive inference, but there has been little systematic exploration of the relation between children's experience in a domain and the salience of thematic versus taxonomic inferences.

In one study that did directly address this question, Coley and Blaszczuk (2003) examined the impact of informal experience with nature on the relative salience of taxonomic and ecological relations in folk biological categorization. Six- to ten-year-old children living in urban and rural communities in New England were given a sorting task that examined their use of taxonomic and ecological relations to group pictures of plants and animals. Participants were presented with detailed realistic color depictions of 15 local species, which fell into orthogonal taxonomic categories (*mammal, bird, insect, plant, tree*) and ecological categories (*forest species, meadow species, wetland species*), and asked to put together the ones that went together best, and to explain why they grouped the pictures as they did. Of primary interest was whether rural children would find ecological relations more salient than urban children. Results suggested that both groups sorted the species in very similar ways, primarily grouping taxonomically related species together. However, rural and urban children differed systematically in how they explained their groupings. Although both groups provided taxonomic explanations with equal frequency, rural children—like adult experts—were much more likely to provide ecological explanations for their groupings than urban children. These results suggest that urban and rural children differed with respect to the salience of thematic (in this case, ecological) relations, but that taxonomic relations were equally salient to both groups. This in turn suggests that general taxonomic relations may provide a foundation for organizing biological

knowledge regardless of experience, and that children with richer experience utilize alternative (e.g., ecological) relations to augment taxonomic relations for organizing folk biological knowledge.

Together, the findings reviewed above suggest that direct experience with plants and animals may render thematic (ecological) properties salient and facilitate the flexible use of taxonomic and thematic relations in folk biological thought. The present study builds on these findings by taking an explicitly developmental approach; we examine factors that may influence the relative salience of taxonomic versus thematic relations in guiding children's inductive inferences. Because we examine these issues in the domain of folk biology, we utilize ecological relations (shared habitat or predator-prey relations) as thematic relations. We hypothesize that if experience has the effect of increasing the salience of ecological relations, then indices of experience should predict higher levels of ecological versus taxonomic reasoning. Specifically, we expect children from less densely populated (i.e., more rural) areas, with more opportunities for direct informal experience with plants and animals in relatively intact ecosystems, to show higher levels of ecological reasoning than children from more urban, developed areas. We also expect children reasoning about local species, with which they are more likely to have direct experience, to show higher levels of ecological reasoning than children reasoning about exotic species they are unlikely to have encountered first-hand. Finally, we expect older children to show higher levels of ecological reasoning than younger children.

We are also interested in the issue of inductive selectivity. Specifically, are children sensitive to the idea that different relations might plausibly guide inferences about different kinds of properties? If so, then properties that are plausibly projected on the basis of spatio-temporal contiguity (e.g., disease) should be more likely to promote ecological reasoning than properties plausibly projected on the bases of shared physiological structure (e.g., internal substance). Finally, to extend the findings of Coley and Blaszczuk (2003) reported above, we expect experience-related differences in patterns of induction to be clearest for plausibly ecological inferences (i.e., those about disease).

Method

Participants

A total of 151 children in kindergarten through 6th grade were recruited through elementary schools and after-school programs in 8 communities in Massachusetts. Communities were classified as Rural (population density 22 - 263 people per square mile), Suburban (6851 - 8410 people/sq. mile) or urban (13488 people/sq. mile). Details on the grade distribution for each locale are given in Table 1.

Materials and Design

Stimuli consisted of 32 8.5 x 11 in. laminated cards. Each card contained three realistic color drawings of plant and/or

animal species: a base at the top, and two targets below. One target picture was taxonomically related to the base (from the same superordinate category), and the other was ecologically related by virtue of either sharing the same habitat or preying on the base (see Table 2 for examples). Sixteen cards depicted species native to Massachusetts, and 16 depicted exotic species. Children were randomly assigned to the Local or Exotic condition.

Table 1: Number of Children from each Grade in each Community Type.

Grade	Urban	Suburban	Rural	Total
Kind.	9	4	4	17
1 st	9	5	10	24
2 nd	22	17	9	48
3 rd	10	5	8	23
4 th	8	4	6	18
5 th	9	1	6	16
6 th	2	0	3	5
Total	69	36	46	151

Table 2. Sample Stimulus Categories

Picture Type	Base	Taxonomic Target	Ecological Target
Local			
Predator/Prey	Field Mouse	Moose	Snake
Habitat	Pelican	Blue Jay	Humpback Whale
Exotic			
Predator/Prey	Lemming	Wombat	Snowy Owl
Habitat	Jaguar	Kangaroo	Macaw

In general, children were taught a new property about the base species, and asked which of the two targets was most likely to share that property. We manipulated the property about which children made inferences. Children either reasoned about an internal, physio-anatomical property (“Has stuff inside called andro”) or a disease (e.g., “Has a sickness called andro”). Item type and Property were manipulated between subjects; triads were presented in random order, and different nonsense names were used for the property in each triad.

Procedure

Children who received parental permission to participate were interviewed individually at their school or after school program. Children were first given a warm-up task in which they were asked about what kinds of things they liked to do best. The triad induction task was presented along with two other conceptual tasks (sorting and open-ended inductive inference) in counterbalanced order across subjects. Children were never queried about the same species or relations in different tasks.

Children were shown the 16 triads in random order. For each triad, children were told (in the insides condition) “There’s this stuff called X. Lots of things have X inside. In fact, A’s have X inside. Now, do you think B’s have X inside like A’s, or do you think C’s have X inside, like A’s?” where A was the base, B and C were the targets, and X the nonsense name for that triad. Appropriate wording changes were made for the disease condition.

Results

On each item, children could make either a taxonomic choice or an ecological choice. Performance was scored by summing the number of ecological choices made by each child, yielding a score that could range from 0 (unanimous taxonomic choices) to 16 (unanimous ecological choices).

For ease of analysis, children were classified as urban, suburban, or rural as described above, and were also grouped according to grade as described below. In order to examine interactions among the various experimental factors, a 2 Property (Disease, Insides) x 2 Item Type (Local, Exotic) x 3 Locale (Urban, Suburban, Rural) x 3 Grade (Kindergarten and 1st, 2nd and 3rd, 4th through 6th) factorial ANOVA was run on total number of ecological inferences. Results showed clear evidence of inductive selectivity: children were more likely to draw ecological inferences when reasoning about disease ($M=10.03$) than when reasoning about insides ($M=5.93$), $F_{(1,115)}= 56.88$, $MS_E= 11.30$, $p<.0001$. Moreover, in the disease condition, children drew ecological inferences at rates that were higher than chance ($t_{(79)}= 4.90$, $p<.0001$), and likewise, in the insides condition, children drew taxonomic inferences at rates that were higher than chance ($t_{(70)}= 4.42$, $p<.0001$).

Results also showed a number of effects of experience on reasoning. As predicted, ecological reasoning differed as a function of the locale in which children lived ($F_{(2,115)}= 3.91$, $MS_E= 11.30$, $p=.023$); overall, rural children ($M=9.02$) were more likely to draw ecological inferences than urban children ($M=7.42$), whereas suburban children ($M=8.22$) fell between the two groups and differed from neither. Likewise, as predicted, children who were questioned about local species drew more ecological inferences ($M=8.93$) than children who were questioned about exotic species ($M=7.17$), $F_{(1,115)}= 6.77$, $MS_E= 11.30$, $p=.010$.

There was also evidence that experience influenced ecological inferences (i.e., those about disease) rather than taxonomic inferences (those about insides). First, rural and suburban children made more ecological inferences than urban children when reasoning about disease, but the groups did not differ when reasoning about insides, as indicated by a Locale x Property interaction ($F_{(2,115)}= 3.36$, $MS_E= 11.30$, $p=.038$; see fig. 1). Second, older children (those in grades 4 – 6) made more ecological inferences than younger children (in Kindergarten – 1st grade or 2nd – 3rd grade) when reasoning about disease, but the groups did not differ when reasoning about insides, as indicated by a Grade Level x Property interaction ($F_{(2,115)}= 4.52$, $MS_E= 11.30$, $p=.013$; see fig. 2).

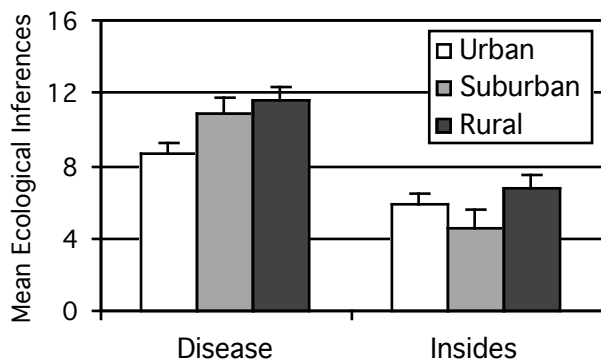


Figure 1: Differences in Ecological Inferences about Disease and Insides as a function of Locale

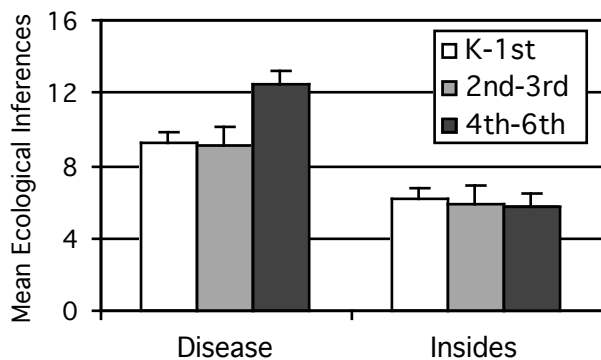


Figure 2: Differences in Ecological Inferences about Disease and Insides as a function of Grade

In order to insure that decisions about combining grades or communities did not unduly influence the results, we also conducted a multiple regression analysis construing these variables continuously rather than categorically. We used community population density (log transformed), age, property (disease or insides), and item type (local or exotic) as predictors of number of ecological inferences. Overall, the regression was significant ($F_{(4,146)} = 17.72$, $MS_E = 12.91$, $p < .0001$). The adjusted R^2 value was .308. Standardized regression coefficients and their associated p -values are given in Table 3. The results of this analysis reinforce the ANOVA. Frequency of ecological inferences was strongly related to the property being projected and item type. Age did not reliably predict ecological reasoning in either analysis. In contrast, population density was negatively related to ecological reasoning; the less densely populated a child's community was, the more likely the child was to draw ecological inferences, whether population density was represented as a continuous or as a categorical variable.

Table 3: Standardized Regression Coefficients and P-values for Predicting Ecological Inferences

Predictor	Standardized Regression Coefficient	P-value
Age	.116	.0938
Property (Disease, Insides)	.490	.0001
Item Type (Local, Exotic)	.213	.0021
Population Density (log people/sq. mile)	-.206	.0034

Discussion

Taken together, these results constitute clear evidence for pervasive effects of experience on children's developing folk biological reasoning. Children from less densely populated communities, with more opportunities for direct informal experience with plants and animals in relatively intact ecosystems, showed reliably higher levels of ecological reasoning than children from more urban areas. Children were also more likely to reason ecologically about familiar, local species than unfamiliar, exotic species. We also observed clear evidence for inductive selectivity; children reasoned ecologically about disease, and taxonomically about an internal, physiological property. Finally, we observed a remarkable interaction of inductive specificity and effects of experience, such that locale and age led to significantly different patterns of ecological reasoning about disease, but no experience-related factor influenced taxonomic reasoning about insides. These results persisted whether measures of experience were continuous or categorical.

The fact that experience showed specific effects on ecological reasoning about disease but did not influence taxonomic reasoning about insides is important for a number of reasons. First, it argues against some global correlate of population density (e.g., quality of education, SES) as being responsible for the differences we observed in inductive reasoning. Rather than suggesting that urban, suburban, and rural children differ across the board in how they reason about nature, it suggests that although differences do exist, they are primarily involved the utilization of thematic relations to guide induction.

Second, this interaction suggests differences in the developmental trajectories of different kinds of relational knowledge and reasoning. Taxonomic relations appear to be universally salient and accessible, and to exert their influence on inductive reasoning relatively early and in a developmentally stable manner. In this study, we find no evidence of age- or experience-related differences in children's tendencies to utilize taxonomic relations to guide inferences about living things' insides. In contrast to the stability of taxonomic reasoning, thematic reasoning—in this case, guided by ecological relations—was clearly influenced by experience in terms of both age and the general nature of the child's surroundings. This pattern is

consistent with the view that taxonomic relations may represent a more basic, all-purpose system for organizing biological knowledge that is relatively impervious to differences in experience or input. Children might initially organize biological knowledge primarily on the basis of taxonomic relations regardless of experience, and only later, given sufficiently rich environmental input, augment this foundational taxonomic structure with specific ecological relations derived from experience.

Finally, although this developmental account is currently speculative, it shows remarkable convergence with findings from the adult literature on expert-novice differences in folk biological reasoning, in at least two important ways. First, adult experts differ from novices in that they are more likely to base inferences on ecological relations, as we have shown rural children differ from urban children. Second, differences between adult experts and novices are most evident on reasoning tasks where causal and spatio-temporal relations are potentially most relevant (e.g., reasoning about diseases of marine creatures, rather than unspecified properties). It is on precisely such tasks (reasoning about disease rather than insides) that we find effects of age and locale on children's relational inferences. This convergence suggests a mechanism for optimizing relational inferences that may be in place early in development, and may function similarly across the lifespan.

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