Children’s Attention to Property Likelihood as a Guide to Property Projection

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Abstract
Induction is a fundamentally important cognitive process. The standard method for studying induction isolates specific effects of interest by controlling for the variability inherent to many features of an inductive problem. For instance, it is common to supply evidence about stable properties and ask participants to generalize these properties to a range of targets. The present study examined the effects of property likelihood on children’s inductive inferences. Participants were supplied evidence about a property that was always (10 out of 10) or sometimes (7 out of 10) attributed to an individual animal. Participants were then asked if the property was true of a range of exemplars. Property likelihood influenced the breadth of children’s, but not adults’, inferences; children were more conservative in their projections of probabilistic properties. The results are discussed with reference to current developmental accounts of induction.

Keywords: induction, development, probabilistic reasoning

Introduction
Among the number of skills indicating a remarkable level of sophistication in young children is an early ability to generalize evidence from what is known or experienced to new cases. Induction involves using available evidence to generate “best guesses” about the way the world will work. From a developmental perspective a critical question concerns the basis from which children make inductive generalizations. Of particular interest to developmentalists is how children make inferences despite so much variability in the world – properties are never absolutely true, and evidence often applies to some, rather than all cases. How do children make sense of uncertain evidence to generate predictions about the way the world works? The present study addresses this question by examining children’s projections drawn from evidence about properties with different past likelihoods.

In most developmental studies of induction children are presented with a fact about an animal (e.g., “this bird has 3-chambered heart”) and asked to predict whether other animals are likely to share the same properties (e.g., Gelman, 1988). This method has revealed a number of important findings concerning the development of induction. For instance, it is fairly well established that young children attend to conceptual likeness (Carey, 1985; Gelman, 1988) and perceptual similarities (Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004) when generalizing properties to new cases. That two things appear, or are believed to be similar, serves as a guide to predict the two will share novel properties. This expectation appears quite early in development, having been demonstrated in children as young as 2-years of age (Gelman & Coley, 1990). Property content also has an early influence. By the age of 4-years children understand that specific properties mark a relevant connection to specific concepts (Coley, 1995; Hayes & Thompson, 2007; Kalish & Gelman, 1992; Nguyen, 2007).

These and many other findings on early induction describe reasoning from properties that are implied to be stable. In fact, an explicit goal of many studies has been to control for property variability by marking properties as stable or enduring (Osherson, Smith, Wilkie, & Lopez, 1990). Providing stable properties renders other factors, such as exemplar relations, more focal cues for induction. In the context of most experiments this leads to a focus on the degree to which evidence and conclusion exemplars are similar or related. For example, in Carey’s classic study, 4-year-olds who were taught about a stable property of an individual animal (“a dog with a spleen”) predicted the property would be true of other exemplars as a function of the similarity between evidence and conclusion targets (also Gelman, 1988).

Critically, stable properties make up some, but certainly not all, of the evidence available to children and adults. While some properties are relatively stable (e.g., gender, blood type), other properties often vary, both within categories (e.g., different members of the same category may have different eye color) and within individuals (the same individual may wear different clothes or have different levels of a particular hormone on different occasions). The latter phenomenon was the focus of the present research.

Whether a property is always, usually, or rarely true of an individual may influence the range of inferences one is willing to endorse. In particular, probabilistic and stable properties may support qualitatively different patterns of projection. It has been argued that reasoning about probabilistic evidence increases computational demands, causing people to endorse a simple strategy, predicting the probabilistic evidence highlights a single typical or representative category member (Murphy & Ross, 2007; see also Kahneman, Slovic, & Tversky, 1982). In the context of studies on category induction increased computational demands posed by probabilistic evidence may lead to a pattern of projection only to the single most similar exemplar. In contrast, reasoning about stable evidence may lead to a pattern of projection that is a function of the evidence-conclusion similarity between presented exemplars.
There is reason to believe children would be inclined to adopt the conservative approach when reasoning about probabilistic evidence. For instance, before the age of 6-years children often fail on probabilistic tasks that require attention to multiple sources of information (Anderson, 1991; Schlottman, 2001). More recent findings suggest that in the context of a category induction task young children will generalize probabilistic evidence conservatively (only to a single category) and stable properties more liberally (to multiple categories as a function of similarity to the exemplar; Lawson, 2007).

The present study examined the role of probabilistic evidence on children’s inductive generalization. The method introduced here presents a novel induction task. Participants were given evidence about an exemplar on ten trials in which property attribution was either stable (10 of 10) or probabilistic (7 of 10). In the projection phase participants were asked to make predictions about this property across a broad range of exemplars: same, basic-, superordinate-, and living kind-level matches. These exemplars were designed to mark a step-wise decrease in similarity to the target exemplar. Overall, children were expected to generalize probabilistic properties more narrowly than stable properties, whereas adults were expected to show a common pattern of projections across targets – with rates of projections decreasing as a function of similarity.

In addition to manipulating property likelihood the present study also manipulated property type. It has been suggested in the literature that the distinction between internal and external properties is marked by a difference in their generalizability, with internal properties being more generalizable than external properties (Gelman, 1988). In this case participants should be more willing to generalize internal than external properties. However, inductive potential of different property types may also be rooted in their prior likelihoods – many internal properties are usually stable within individuals, while a considerable number of external properties often vary within individuals. Thus, it is possible that property likelihood (rather than property type) determines children’s willingness to generalize properties. Manipulation of the property type made it possible to examine these possibilities.

**Experiment**

**Method**

**Participants.** One hundred and twenty-eight individuals participated in this study. There were sixty-four individuals from each of two age groups: Adults (undergraduates), and Young children ($M = 4;10$, range, $4;5 - 5;6$). Adults received course credit for participation. All participants were recruited from a predominately white, medium-sized US city. There were approximately equal numbers of male and female participants in each group.

**Design.** The experiment involved a training and projection phase. In the training phase participants were presented with an image of the same animal (rabbit) on ten different occasions. The study involved a $2 \times 2$ between subjects manipulation of property likelihood and property type. In the Stable condition the evidence exemplar was attributed a property on all ten occasions, whereas in the Probabilistic condition the evidence exemplar was attributed this property on seven out of ten occasions.). In the Internal Property condition participants learned about a property inside the animal (“has omat in it”) while in the External Property condition participants learned about an external property (“has omat on it”).

The projection phase involved judgments about the properties of evidence targets. The targets were twenty exemplars with five instances from each of four groups: *same* (the same rabbit), *basic-level* (different rabbits), *superordinate* (various mammals), and *living kinds* (various non-mammals). All items were presented in random order.

**Procedure.** Children were interviewed in a quiet location at their preschool. Adults participated in small groups. The tasks for all participants were completed on individual computers. Participants were told they were going to play a game that involved learning about some animals and answering some questions. Both phases required participants click to “see the animal behind the tree.” When the first item emerged in the test phase, children were told, “Look at this animal. It has omat in/on it.” With subsequent items participants were told, “Here it is again. And look! It has <does not have> omat in/on it.” The only feature determining whether the property was internal or external was the way the property was verbally presented. The picture representing the evidence case was a rabbit with a circle above it indicating an ambiguous brownish spot. The pictures were designed such that the spot could plausibly apply to the inside (e.g., organ) or outside (e.g., dirt) of the animal. For the training trials in which the animal was said to not have the property (3 of the 10 items in the Probabilistic condition), the circle above the animal was left blank. The projection phase began after the presentation of the final evidence exemplar. In the projection phase items were individually presented in a self-paced manner – targets appeared when participants clicked on the tree. On each trial participants were presented with a picture of an animal with a portion of its body covered by a question mark. For each target participants were presented with an image of an animal and asked, “Do you think this one has omat inside/on it?” After responding participants proceeded to the next item. Across both phases the experiment lasted approximately 15 minutes.

**Results**

Analyses were conducted on the proportion of projections for each of the evidence targets (the number of times, out of five, participants said the exemplar would have the modal property). Both age groups projected evidence to the *same* targets at rates above chance across both likelihood and
property manipulations (all \( p < .05 \)) indicating participants were quite willing to generate inferences in this context.

In the next analysis scores were subject to a 2 (Age: adults, children) X 2 (Property: internal, external) X 2 (Likelihood: stable, probabilistic) X 4 (Target: same individual, basic-level, superordinate, living kind) ANOVA with the last factor within subjects. The analysis revealed two main effects: Age \( F(1, 120) = 7.21, p < .01 \); Tukey’s HSD tests revealed that children’s responses were higher than adults. The effect of Similarity \( F(3, 360) = 175.76, p < .0001 \) revealed responses followed a pattern of decreasing projections as a function of decreasing similarity (same > basic > superordinate > living kind).

The main effects were mediated by two interactions. There was an Age X Similarity interaction \( F(3, 360) = 12.96, p < .0001 \); Simple effects showed the proportion of adult projections to the same targets was higher than children’s \( F(1, 126) = 9.76, p < .01 \); while the rate of children’s projections to living kind items was higher than adults \( F(1, 126) = 36.7, p < .00001 \). There was also a Likelihood X Similarity interaction \( F(3, 360) = 3.57, p < .02 \). Simple effects analysis showed the effect was driven by higher rates of projections for probabilistic than stable properties for two of the targets: superordinate items \( F(1, 126) = 6.1, p = .01 \), and moderately higher rates of projections for living kind items \( F(1, 126) = 4.2, p = .06 \), targets. Finally, the Likelihood X Similarity interaction was significantly different across age groups, as reflected in a 3-way interaction \( F(3, 360) = 3.62, p < .05 \). As indicated in Figures 1 and 2, likelihood had a different influence on the range of projections for each group. The following analyses were designed to explore the nature of these age differences.

The final set of analyses involved separate t-test comparisons for responses to each of the evidence targets in the probabilistic and stable evidence conditions. Family-wise error was controlled using Holm’s method. Comparisons revealed adult projections followed the similarity pattern of same > basic > superordinate in both conditions, all \( p < .01 \). Rates of projections to living kind exemplars were less than those to the basic-level items in the probabilistic, but not the stable condition, largely due to overall low levels of projecting stable properties to low similarity items. For adults similarity had a common influence across property conditions.

A different pattern emerged for children, who were equally likely to generalize stable properties to the same (\( M = .76 \)) and basic-level (\( M = .69 \)) items, but projected probabilistic properties at rates above chance only to the same items (\( M = .75 \)). For young children stable properties were a warrant to generalize properties broadly (to all rabbits), while probabilistic properties served as evidence the properties applied only to the single most similar category, and at chance levels for all other exemplars.

**Discussion**

The present study was designed to investigate a feature of induction that has received little attention in the literature – the influence of property likelihood. Much of the evidence available to us is probabilistic (e.g., *most* dogs bark, *some* dogs slobber, etc.) yet the traditional studies on induction evaluate projections drawn from stable properties (e.g., *all* dogs have dog DNA) (Heit, in press; Osherson Smith, Wilkie, & Lopez, 1990; Rips, 1975; Sloman, 1993).
and adults, whereas the pattern of projections given probabilistic properties differed between age groups. In particular, both children and adults followed a similarity-based pattern of projections when generalizing stable properties. However, when presented with probabilistic evidence children exhibited a more conservative pattern of projections than adults, restricting their generalizations to identical exemplars only, whereas adults followed the same similarity-based pattern of projection as in the stable condition. Thus, property likelihood had a direct influence on the range of inferences children were willing to endorse: stable properties generalized broadly, probabilistic properties generalized narrowly.

These results are consistent with the interpretation that children use a conservative strategy for generalizing probabilistic evidence. Whereas adults tend to treat probabilistic and stable properties as different in degree, children seemed to adopt a qualitatively different approach to reasoning about both types of evidence. One possible cause for this difference is that children are focusing on the rate, or variability of the property, making it difficult to attend to other important features (such as similarity). The task of attending to both features simultaneously may be too computationally demanding for young children (Anderson, 1991, draws a similar conclusion). Another possibility is that children have heightened expectations that the evidence was meant to point out something meaningful about the exemplar they were learning about (e.g., Medin, Coley, Hayes, & Storms, 2003). We are currently investigating these two possibilities. While the exact cause of children’s conservative projections is unclear, what is clear is that they treat probabilistic and stable properties quite differently, while adults treat both types of properties in a common way.

A second focus of the present study was the influence of property likelihood on property content. The results suggest that in no case did children or adults project novel internal properties at higher rates than novel external properties. It could be argued that the sparse difference between the conditions (e.g., “has omat in it” vs. “has omat on it”) was not sensitive enough to indicate that properties marked different content. However, children’s spontaneous comments suggest that children attended to the different content implied by each property (e.g., for internal properties - “what is it, something they ate”; for external properties - “oh, I know, it’s like fur”).

The finding of similar patterns of projection of novel internal and external properties conflicts with previous findings suggesting that children are more likely to generalize internal properties (such as “has omentum inside”) than external properties (such “has dirt on it”; Gelman, 1988). One possibility is that during induction instead of relying on property type (external or internal) children rely on property likelihood, restricting generalization of properties that are known to vary and occur infrequently within an individual (such as having dirt on one’s back). This possibility remains to be addressed in future research that will explore participants’ willingness to generalize properties occurring across a wider range of likelihoods than those examined in the present research. Importantly, the result is consistent with the interpretation that property likelihood is a strong influence on children’s inductive inferences.

It is worth noting an additional difference in patterns of responses of children and adults. In both likelihood conditions adults projected properties to superordinate and living kind animals at rates significantly lower than chance. This means that adults interpreted positive evidence that an individual animal has a particular property as negative evidence with regards to other kinds of animals possessing this property. Children followed the same pattern for stable but not probabilistic properties, which they consistently projected at chance. Though the finding was not the explicit focus of the present study, it points to an important direction for future work.

It is important to note some methodological differences of the present study from other studies in the literature. First, the present study provided weak verbal support for category membership. All instances were attributed the label “animal,” yet in the evidence case the same animal was presented on ten cases and across a diverse set of evidence exemplars. Labels are important cues to property projection, particularly when they mark similar exemplars. Despite a common label for all items, the results indicate participants in all groups showed a strong preference to treat exemplars differently. Also, evidence involved attribution of properties to the same individual, rather than an entire category. Elsewhere it has been demonstrated that narrow projection of probabilistic evidence characterizes projections of evidence attributed to basic level category members (Lawson, 2007). Thus, the present findings aren’t isolated to reasoning about individuals, but reflect more generally a disposition of young children to project probabilistic evidence narrowly.

The findings presented in this paper have important implications for current theories of induction. Most studies of children’s early induction focus on situations that imply stability of to-be-generalized properties. The present findings suggesting that breadth of generalization differs between stable and probabilistic evidence point to the need for greater attention to the role uncertain evidence plays in children’s inductive behavior. Doing so will provide opportunities to examine induction in a context analogous to the one encountered by children and adults on a daily basis. Accounting for the role of probabilistic evidence on children’s inductive inferences can broaden the scope of current models of induction, uncovering how children develop a unified system for generalizing evidence in new circumstances.

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