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Causal knowledge and the development of inductive reasoning

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ABSTRACT

We explored the development of sensitivity to causal relations in children's inductive reasoning. Children (5-, 8-, and 12-year-olds) and adults were given trials in which they decided whether a property known to be possessed by members of one category was also possessed by members of (a) a taxonomically related category or (b) a causally related category. The direction of the causal link was either predictive (prey → predator) or diagnostic (predator → prey), and the property that participants reasoned about established either a taxonomic or causal context. There was a causal asymmetry effect across all age groups, with more causal choices when the causal link was predictive than when it was diagnostic. Furthermore, context-sensitive causal reasoning showed a curvilinear development, with causal choices being most frequent for 8-year-olds regardless of context. Causal inductions decreased thereafter because 12-year-olds and adults made more taxonomic choices when reasoning in the taxonomic context. These findings suggest that simple causal relations may often be the default knowledge structure in young children's inductive reasoning, that sensitivity to causal direction is present early on, and that children overgeneralize their causal knowledge when reasoning.

Introduction

Children make category-based inductions when they infer properties and features in novel categories based on what they know to be true about familiar related categories (for reviews, see chapters in

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Feeney & Heit, 2007, and Hayes, Heit, & Swendson, 2010). Many different types of relations between categories can support such inferences. For example, the fact that *tigers* have a property or that *antelopes* have a property may be equally good evidence that *lions* have the property. The first inference might be strong because lions and tigers are taxonomically related, whereas the second may be strong because lions eat antelopes and this food chain relation provides a plausible causal mechanism for property transmission. This example is consistent with claims based on structured Bayesian approaches to inductive reasoning (see Kemp & Tenenbaum, 2009) that our knowledge about the relations that hold between categories of objects can be structured in a variety of ways. One of our aims in this study was to examine whether causal or taxonomic relations are more privileged in young children's category-based inductive reasoning. It was unclear which knowledge structure might serve as the default because some researchers suggest that taxonomic reasoning is a default strategy (e.g., Kemp & Tenenbaum, 2009; Shafto & Coley, 2003), whereas others emphasize the primacy of causal knowledge (e.g., Rehder, 2006; Rehder, 2009).

Because they are inductive, category-based inferences are probabilistic, but they effectively reduce uncertainty about the world. Understanding the constraints placed on inductive inferences by the underlying structure of different knowledge sources is crucial if we want to understand the processes that allow inductive inferences to be flexible yet effective. Several recent studies (Kemp & Tenenbaum, 2009; Shafto, Kemp, Bonawitz, Coley, & Tenenbaum, 2008) show that adults' inferences are especially sensitive to knowledge about how causal relations are structured. However, little is known about whether children and adults use causal knowledge in similar ways to support their inductive inferences. Our second aim of this study was to examine whether, like adults (see Rehder, 2009; Shafto, Coley, & Baldwin, 2007; Shafto, Coley, & Vitkin, 2007; Shafto et al., 2008), children are sensitive to the direction of the causal relation that holds between categories. Thus, in addition to examining when children's inductive inference becomes sensitive to causal relations, we examined how sophisticated children are in their use of such knowledge for reasoning.

Causal knowledge in inductive reasoning

The effects of causal knowledge on reasoning are not very well captured by older models of category-based induction that emphasize featural similarity (Sloman, 1993) and/or class membership (Osherson, Smith, Wilkie, Lopez, & Shafir, 1990). Such similarity-based models are powerful at accounting for patterns of inductive reasoning about taxonomic properties (i.e., properties such as genes whose distribution in the population may depend on taxonomic relations) and about blank properties (i.e., properties that participants possess no knowledge about). However, they fail to capture induction across a broader variety of properties and in expert populations (see Medin, Coley, Storms, & Hayes, 2003; Rehder & Hastie, 2001; Shafto & Coley, 2003), especially when there is a causal explanation for the occurrence of shared properties (Rehder, 2006).

Causal knowledge plays a vital role in cognition from infancy onward (Sobel & Kirkham, 2007). The ability to understand causal structures provides children with tools that help them to successfully predict future events and understand the outcome of active intervention, allowing them to gain increasing control over their environment (Gopnik et al., 2004). By 4 years of age, children are capable of understanding simple causal mechanisms across the domains of biology (Wellman, Hickling, & Schult, 1997) and psychology (Flavell, Green, & Flavell, 1995) as well as causal explanations in social and physical domains (Hickling & Wellman, 2001). Similarly, children use causal knowledge to classify objects (Ahn, Gelman, Amsterlaw, Hohenstein, & Kalish, 2000) and natural kinds (Meunier & Cordier, 2009).

The fact that children make use of causal information across diverse domains and tasks underscores its potential importance in children's category-based reasoning. Indeed, evidence suggests that children can use causal knowledge when making inductive inferences. For example, Hayes and Thompson (2007) taught children (5- and 8-year-olds) and adults about features of two artificial base creatures, followed by a target that was more similar to one base but shared a causal antecedent with the other base. Results indicated that when the causal link was explicit, all age groups preferred to make causal rather than similarity-based inductions. That is, they preferred to project a property to the target from the causally related base creature than from the more similar base creature. When