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Explaining prompts children to privilege inductively rich properties

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ABSTRACT

Four experiments with preschool-aged children test the hypothesis that engaging in explanation promotes inductive reasoning on the basis of shared causal properties as opposed to salient (but superficial) perceptual properties. In Experiments 1a and 1b, 3- to 5-year-old children prompted to explain during a causal learning task were more likely to override a tendency to generalize according to perceptual similarity and instead extend an internal feature to an object that shared a causal property. Experiment 2 replicated this effect of explanation in a case of label extension (i.e., categorization). Experiment 3 demonstrated that explanation improves memory for clusters of causally relevant (non-perceptual) features, but impairs memory for superficial (perceptual) features, providing evidence that effects of explanation are selective in scope and apply to memory as well as inference. In sum, our data support the proposal that engaging in explanation influences children's reasoning by privileging inductively rich, causal properties.

1. Introduction

The challenge of causal reasoning is to discover the underlying structure of the world to facilitate prediction and action. This is non-trivial task. Despite the often strong correlation between what an object looks like and its causal properties (see Gelman & Medin, 1993), it is not uncommon to observe dissociations. In fact, perceptually similar objects can be endowed with very different causal properties: Poison hemlock may *look* identical to wild carrot, but it is certainly not good to eat. Learning how and when to override perceptual properties as a basis for judgment and action, and to instead favor inductively rich properties (such as causal affordances), is thus an important step in cognitive development.

We propose that the process of seeking, generating, and evaluating explanations plays an important role in encouraging children to recognize and privilege inductively-rich properties as a basis for reasoning, even when those properties are not perceptually salient. In particular, engaging in explanation could help children appreciate causal properties and subtle but reliable cues to causal structure, such as internal parts and category membership. For example, trying to explain why consuming hemlock generates one outcome (namely death) while consuming wild carrots generates another (perhaps pleasure) could help children appreciate that each plant has important internal properties, and that these internal properties are correlated with causal consequences they may wish to prevent (e.g., death) or to predict (e.g., pleasure).

In what follows, we first outline our proposal for the effects of explanation, motivating our hypothesis that explaining leads children to privilege inductively rich properties (i.e., those that facilitate a broad set of useful inferences). We then provide a brief review of prior

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research on children's inductive generalizations in tasks that require choosing between a salient perceptual property (e.g., an object's color and shape) and a causal property (e.g., activating a machine). This body of research helps lay out the methods and developmental changes that motivate the current experiments.

1.1. Explanation and inference

Accounts of explanation from both philosophy and psychology suggest that explaining past and present observations can foster the acquisition of information that supports future actions and predictions (e.g., Craik, 1943; Friedman, 1974; Gopnik, 2000; Heider, 1958; Kitcher, 1989; Lombrozo, 2012; Lombrozo & Carey, 2006; Walker, Lombrozo, Williams, & Gopnik, submitted for publication; Walker, Williams, Lombrozo, & Gopnik, 2012). These ideas about the *functions or consequences* of explanation are consistent with several accounts of the *form and content* of explanations. In particular, according to subsumption and unification theories, explanations appeal to regularities that subsume what's being explained under some kind of law (e.g., Hempel & Oppenheim, 1948) or explanatory pattern (e.g., Friedman, 1974; Kitcher, 1989). In so doing, they relate the particular fact or observation to a generalization that supports further inferences (Lombrozo, 2006, 2012; Wellman & Liu, 2007). For example, by explaining Socrates' death by appeal to the consumption of a poisonous chemical contained within hemlock (i.e., coniine), one implicitly invokes the generalization that the chemical can cause death in humans. This generalization in turn supports predictions about the consequences of future coniine consumption, provides guidance about how to avoid a particular kind of death (i.e., don't consume hemlock), and even supports counterfactuals about how things could have been otherwise (e.g., if Socrates hadn't consumed hemlock, or if he'd had an antidote to coniine, he would have lived to see another day).

If explanations typically subsume what is being explained under some generalization, then engaging in explanation could influence learning and inference by driving reasoners to form broad generalizations and to consult them as a basis for further reasoning (Lombrozo, 2012). Consistent with this idea, research with adults has shown that prompts to explain can promote the discovery and extension of broad patterns that govern membership in novel categories (e.g., Williams & Lombrozo, 2010; Williams & Lombrozo, 2013; Williams, Lombrozo, & Rehder, 2013; see also Chi, DeLeeuw, Chiu, & LaVancher, 1994). Recent developmental work likewise suggests that when prompted to explain, even young children are more likely to favor broad patterns (Walker et al., 2012; Walker et al., submitted for publication) and to develop abstract theories, such as a theory of mind (Amsterlaw & Wellman, 2006), that can accommodate otherwise-puzzling observations (e.g., a character looking for an object in the wrong location). For example, Walker et al. (2012), Walker et al. (submitted for publication) found that when prompted to explain why particular types of objects activate a machine while others do not, preschool-aged children were more likely to rely on a feature that accounted for all observations (as opposed to a subset) in deciding which new objects were likely to activate the machine.

Many of the most far-reaching and useful generalizations are those that involve causal relationships, as they support interventions in addition to predictions. Generalizations relating hemlock and death (in the example with Socrates), or beliefs and behaviors (in theory of mind), are cases in point. Some accounts of explanation *require* that explanations be causal (e.g., Strevens, 2008; Woodward, 2005; Woodward, 2011), but one need not subscribe to a strictly causal theory of explanation to accommodate the observation that explanation and causation are often closely linked: the view that explanations privilege broad and useful generalizations is enough to support the idea that causation will often (if not always) be central to explanations. In line with this idea, previous research with adults has demonstrated that explanations help guide causal inferences (Heit & Rubinstein, 1994; Rehder, 2006; Sloman, 1994). There is also indirect evidence that causation is central to children's explanations (e.g., Hickling & Wellman, 2001). For example, young children's explanations often posit unobserved causes (Buchanan & Sobel, 2011; Legare, 2012; Legare, Gelman, & Wellman, 2010; Legare, Wellman, & Gelman, 2009), and Legare and Lombrozo (2014) found that children who explained learned a novel toy's causal (functional) mechanism (i.e., interlocking gears make a fan turn), but not other superficial properties (i.e., the color of the gears), more readily than children who did not. In the experiments that follow, we focus on causality as a canonical, inductively-rich property that's likely to be privileged in explanation, and we investigate the prediction that prompting young children to explain will help them appreciate and use causal similarities as a basis for learning and inference.

1.2. Inductive generalization: a shift from perceptual to conceptual?

A large body of research has examined the role of obvious (perceptual) properties versus non-obvious (hidden or abstract) properties, such as causal affordances, in guiding children's inductive inferences (e.g., Gelman, 2003; Gelman & Markman, 1986; Gelman & Markman, 1987; Gopnik & Sobel, 2000; Keil, 1989; Keil & Batterman, 1984; Nazzi & Gopnik, 2000; Newman, Herrmann, Wynn, & Keil, 2008). This research demonstrates that even young children are able to use both perceptual and non-perceptual properties in categorizing objects (e.g., Gelman & Markman, 1987; Gopnik & Sobel, 2000). Nonetheless, young children tend to spontaneously focus on highly salient surface features. Specifically, while older children and adults often group objects according to complex cues such as common internal properties, labels, and causal affordances, regardless of perceptual similarity (Carey, 1985; Keil, 1989; Medin, 1989; Rips, 1989), young children tend to group objects based on perceptual similarity, and only later shift to favoring other properties (e.g., Gelman & Davidson, 2013; Gentner, 2010; Keil & Batterman, 1984).

To illustrate, consider the findings from Nazzi and Gopnik (2000). In this study, children observed four objects placed on a toy, one at a time. Two of these objects were