COGNITION

Cognition 76 (2000) B35–B43

www.elsevier.com/locate/cognit

Causal status effect in children's categorization

Woo-kyoung Ahn[a,*], Susan A. Gelman[b], Jennifer A. Amsterlaw[b], Jill Hohenstein[c], Charles W. Kalish[d]

[a]*Department of Psychology, Vanderbilt University, 534 Wilson Hall, Nashville, TN 37240, USA*
[b]*University of Michigan, Ann Arbor, MI, USA*
[c]*Yale University, New Haven, CT, USA*
[d]*University of Wisconsin, Madison, WI, USA*

Received 29 October 1999; received in revised form 11 January 2000; accepted 17 March 2000

Abstract

The current study examined the causal status effect (weighing cause features more than effect features in categorization) in children. Adults (Study 1) and 7–9-year-old children (Study 2) learned descriptions of novel animals, in which one feature caused two other features. When asked to determine which transfer item was more likely to be an example of the animal they had learned, both adults and children preferred an animal with a cause feature and an effect feature rather than an animal with two effect features. This study is the first direct demonstration of the causal status effect in children.

Keywords: Concept learning; Causal reasoning; Cognition; Development

1. Introduction

When children categorize objects or make use of concepts, they value some features more than others. For instance, Gelman (1988) found that second-graders are more likely to generalize internal parts of an animal (e.g. a spleen inside a rabbit), than functional features (e.g. 'you can loll with it'), to other instances of the same kind. Similarly, Keil (1989) demonstrated that fourth-graders base decisions about an animal's category membership on its origin (e.g. being born from

* Corresponding author. Fax: +1-615-343-8449.
E-mail address: woo-kyoung.ahn@vanderbilt.edu (W. Ahn).

PII: S0010-0277(00)00077-9

another raccoon) rather than on certain salient aspects of perceptual appearance (e.g. black with a white stripe on the back). Why do children focus on some kinds of features more than others?

We propose that one of the reasons is that children have a bias towards weighting cause features more than their effect features (causal status hypothesis, henceforth). For example, origins or internal parts of animals are more essential in children's categorization because they determine the physical appearance and behavior of animals. Examples of this causal status effect are abundant in adult categorization. We often categorize an illness by the virus that causes the symptoms of that illness rather than by the symptoms alone. Similarly, DNA structure is considered the most important feature in the classification of plants and animals because it causes many other properties. Ahn (1998); Ahn, Kim, Lassaline and Dennis (2000) directly manipulated the causal status of features using artificial categories and found that identical features were weighted more heavily in adults' categorization when they served as causes than when they served as effects.

We believe that children use the same heuristic. Even very young children are sensitive to causality (e.g. Leslie & Keeble, 1987), and are biased to view phenomena causally (e.g. Piaget, 1951, 1952; see Gelman & Kalish, 1993 for review). More importantly, causality and categorization seem linked in the mind of children (e.g. Carey, 1985; Gelman, 1988; Gopnik & Sobel, 1999; Kalish & Gelman, 1990; Keil, 1989; Keil, Smith, Simon and Levin (1998)) argue against the common assumption that the earliest concepts are mere associations of features and instead suggest that even young children attend to causal relations. More recently, Gopnik and Sobel (1999) showed that 2-, 3-, and 4-year-old children categorize objects on the basis of their causal power (e.g. whether an object would set off a machine) rather than on perceptual similarity.[1]

There are also reasons to expect that children – even as old as 7–9 years – will not show the causal status effect. Children at this age do not have well developed biological knowledge, so their attention to internal parts and origins may not derive from any real understanding of these features' causal status. Moreover, the studies of Keil, 1992 showed that when children were asked to judge whether entities with similar endings to causal sequences but different paths of origin were of the same type, few second-graders and only half of the sample of fourth-graders were swayed by origins. Keil's earlier transformation experiments (Keil, 1989) further showed that the fourth-graders differed from adults: half the fourth-graders thought that changing a tiger into a lion via an injection given early in life would make it a lion, whereas most adults did not. As in Keil, 1992, we argue that this developmental difference is due to the fact that understanding is knowledge-dependent; rather than lacking a bias toward causal features, the fourth-graders did not have adequate knowledge about what kinds of transformations are possible. However, this interpretation remains untested.

[1] It should be noted that Gopnik and Sobel (1999) did not directly test the causal status hypothesis because they compared causally related features (i.e. setting off a machine) with causally unrelated features (i.e. perceptual appearance) rather than with effect features.

The main goal of the current study is to provide direct evidence that given appropriate causal knowledge, a feature's causal status will determine its centrality in children's categorization. Accordingly, we used novel categories as stimulus materials and manipulated only the causal status of the features. Half of the participants learned the three features (say, X, Y, and Z) of each animal and the causal relations among them (the Causal condition). The other half learned the same three features but no causal relations (the Control condition). Because learning novel features along with their novel causal relations might be cognitively demanding to children, causal relations presented in the Causal condition were constructed to be compatible with the naive biology of animals. Laypeople's animal concepts seem to take a common-cause structure where an internal feature (e.g. DNA) causes many surface features (Keil, 1989). Likewise, feature X served as a common cause for features Y and Z, where X was a substance (e.g. protein) in an internal organ. All participants were then presented with two options, one missing X (i.e. cause in the Causal condition), and the other missing Y (i.e. effect in the Causal condition), and chose which one was more likely to be a member of the target category.

If children think that in categorizing animals internal substances are more central than other features regardless of their causal status, there should be no difference between the Causal and the Control conditions. That is, in both conditions, children will pick the option with the internal substance, regardless of its causal status. But if children weight features based on their causal status, then children's preference for the option with the internal substance should be greater in the Causal condition (where the internal substance serves as a cause) than in the Control condition (where the internal substances has no explicit causal role).

2. Study 1: adult categorization

2.1. Method

2.1.1. Participants

Sixty-five students at Yale University participated in this experiment in partial fulfillment of requirements for an Introductory Psychology course.

2.1.2. Materials and design

Seven novel animal categories were developed. Each animal category was described as having three features, one of which was a fictitious internal substance (e.g. blickem in their blood) and two of which were morphological features (e.g. small lungs, purple skin). Within each animal category, the features were selected such that people would be unlikely to spontaneously infer causal relations. See Appendix A for stimulus materials.

Participants were divided into two groups, causal and control. In the Causal condition, 33 participants learned that the novel internal substance caused the other two features in each category (e.g. 'Pizers have blickem in their blood that causes them to have small lungs and to have purple skin'). In the Control condition, 32 participants simply learned three features of a novel category (e.g. 'Pizers have blickem in their blood, they have small lungs, and they have purple skin'). The order in which the three features appeared in the control passage was the same as in the Causal condition.

For each item, following the description of the three features, participants in both conditions were presented with descriptions of two animals and were asked to determine which one was more likely to be the novel animal they had just learned. One animal had two morphological features but was missing the substance of the novel category (e.g. 'This animal has small lungs and purple skin, but it has no blickem present in its blood'). Since this animal is missing a feature serving as a cause in the Causal condition, it is called the Missing-Cause option. The other animal had the novel substance and one of the two morphological features, but was missing the other morphological feature (e.g. 'This animal has purple skin and blickem in its blood, but does not have small lungs'). Since this animal is missing a feature serving as an effect in the Causal condition, it is called the Missing-Effect option. These two options were presented side-by-side, labeled A and B, and their positions were counterbalanced.

2.1.3. Procedure

Each participant received a booklet with instructions on the cover, followed by seven randomly ordered problems. Participants were instructed to read each of the passages describing the novel creature, and asked to decide which animal, A or B, was more likely to be an example of the novel category they just learned. No pictures of the animals were shown to the participants.

2.2. Result

In the Causal condition, almost all participants judged that the Missing-Effect option was more likely to be a member of a target category than was the Missing-Cause option (95.7% of responses). This preference for the Missing-Effect option might have been due in part to the content of the features, because the Missing-Cause option is always missing an internal substance, which might be perceived as an essential feature regardless of its causal status. Indeed, participants in the Control condition also tended to prefer the Missing-Effect option (74.5%). Importantly, however, the result in the Causal condition cannot be entirely due to the content effect because the preference for the Missing-Effect option is stronger in the Causal condition (mean of 6.7 items out of 7) than in the Control condition (5.2 items out of 7) ($t(63) = 4.11$, $P < 0.001$). This result indicates that identical features were given more weight when serving as a cause. In all seven problems, preference for the Missing-Effect option was stronger in the Causal condition than in the Control condition. Thus, Study 1 used a common-cause structure to demonstrate the causal status effect in adults. Using similar materials, Study 2 tested this effect in children.

3. Study 2: children's categorization

3.1. Method

3.1.1. Participants

Twenty-two children aged between 7 and 9 years were recruited for participation through local New Haven summer school programs and a Yale child-study database. The children's average age was 8 years 6 months (range 7 years 1 month to 9 years 4 months). Children were randomly assigned to one of the two conditions described below.

3.1.2. Materials

Five of the seven problems used in Study 1 were used. The number of items was reduced in order to avoid fatigue or boredom in children. The problems that showed the least difference between the Missing-Effect and the Missing-Cause options in the Control condition of Experiment 1 were chosen, so that a content effect would be minimized.

To help children remember the features of novel categories, pictures of animals and their three features were developed. A target card presented a silhouette of the animal and depicted three of its features (see Fig. 1 for an example). Silhouettes were used because they provided children with a concrete representation of the animal but nevertheless revealed little information about the animal's features beyond the three features described by the experimenter. Two options in each problem included the same silhouette and the three features, with the missing feature for each option covered by a large 'X' to indicate that the animal did not have that feature.

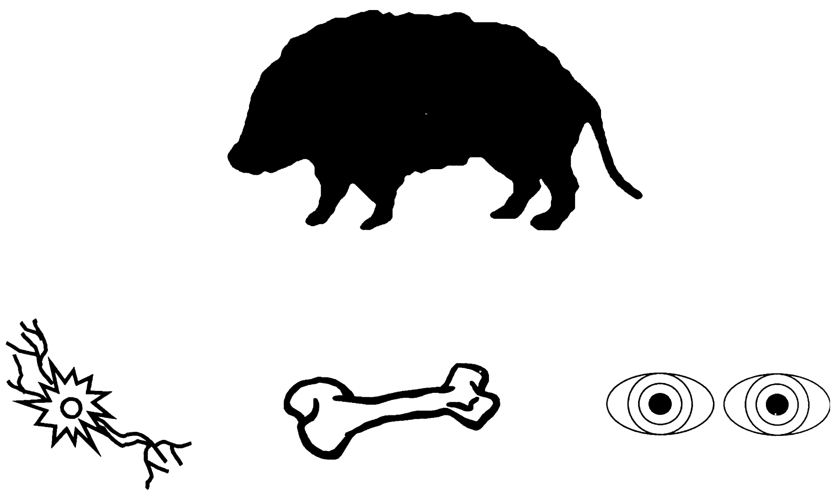

Fig. 1. Sample picture used in Study 2.

3.1.3. Procedure

Each child was tested individually, either alone in a classroom, in the presence of the child's parent in the laboratory, or at the child's home. Initially the child was given two practice items to make sure that he/she understood how to answer the questions. For example, one practice animal was a cat. The cat's silhouette was shown with a picture of 'long whiskers', 'soft fur', and 'sharp claws' while the experimenter told the child that the cat had these qualities. Then the child was shown two cards: in one, the animal had all of the three features of the target, and in the other, the animal was missing all three features. The child was asked which of the second two cards also showed a cat. If the child chose the animal with all three of the target features, she/he was praised and the experiment continued. All children chose correctly on the practice trials. During the presentation of both the practice items and test trials, the experimenter pointed to the picture of the feature on the card each time the feature was named.

After the two practice animals, the novel animals were presented in random order. Children were first told about the three features of the animal (e.g. 'Taliboos have something called promicin in their nerves, they have thick bones, and they have large eyes' for the animal in Fig. 1). Afterwards, children in the Causal condition were told that one of the animal's features was a cause of the other two (e.g. 'Promicin in their nerves makes taliboos have thick bones and large eyes'). In order to insure that children in each condition heard the stimulus words equally often, children in the Control condition heard a repetition of the properties' names (e.g. 'Did you understand? Taliboos have promicin in their nerves, they have thick bones, and they have large eyes').

To be certain that children understood the presentation, they were asked to name the properties that were either effects of the causal property (Causal condition) or were the last two properties presented (Control condition). For instance, children in the Causal condition were asked, 'So what does the promicin in their nerves do?' and children in the Control condition were asked, 'Taliboos have promicin in their nerves. What else do they have?' If the child could not correctly answer the question, the material was repeated once. This occurred with three different children in three items total. After the question had been satisfactorily answered, the two alternative options (i.e. Missing-Cause and Missing-Effect) were presented, and the child was asked which represented the same kind of animal as the target (e.g. 'Here are two animals. Let's see if we can find out which one is a taliboo'). For half of the children, the Missing-Cause option was presented first in three problems and the Missing-Effect was presented first in the rest of the problems; for the other half, the order was reversed.

3.2. Results

In the Control condition, children did not show any preference for the Missing-Effect option (43.6%). However, in the Causal condition, 74.5% of responses favored the Missing-Effect option over the Missing-Cause option. The difference between the Control and the Causal conditions was statistically significant

($t(20) = 2.21$, $P < 0.05$). Item analyses showed that the same pattern of results appeared in all five items.

4. General discussion

The current investigation found that in categorizing animals, 7–9-year-olds, like adults, were more influenced by features that cause other features than features that are effects. Thus, the current study provides the first direct demonstration of the causal status effect in children.

As discussed earlier, Keil 1989, 1992 found content-specific differences between adults and even second- and fourth-graders in their appreciation for deeper features in concepts. Similarly, Keil and Batterman (1984) found a 'characteristic-to-defining shift' in which characteristic features predominate in word meanings at first, and only later in development do defining features become more central. The reliance on characteristic features would seem to conflict with the causal status effect, because characteristic features tend to be effect features of defining features (e.g. churches are built to look beautiful because people worship God in there). In Keil and Batterman (1984), second-graders were still in transitional stages where either both characteristic and defining features or idiosyncratic defining features were used. We proposed that this failure to rely on defining features or deeper features in the above studies might simply be due to a lack of appropriate causal background knowledge, rather than a lack of a bias toward weighting cause features (see also Keil, 1989, 1992). Our results with a similar age group provide evidence that it indeed is unlikely to be due to a lack of appreciation for cause features.

The Gelman and Wellman (1991) study suggests that the current results might extend to preschoolers. They found that 3–4-year-old children understand that insides of objects (e.g. blood and bones for dogs) are more essential than outer coverings (e.g. fur for dogs) for an object's identity. The insides of an object are often critical for its proper functioning or for its appropriate use. Thus, appreciation of insides could be construed as an example of the causal status effect. In contrast, other studies from preschoolers showed reliance on surface features (e.g. Keil, 1989, 1992) and characteristic features (e.g. Keil & Batterman, 1984). Hence, it would be valuable to extend the current work to younger children. Doing so would require developing a different task that would include all of the relevant features of the current task without overloading a younger child's information-processing limitations. The current results provide a stepping stone for understanding the developmental changes in children's appreciation for causal features.

In addition, they provide important developmental data suggesting the presence of psychological essentialism in children. Medin and Ortony (1989) argued that people act as if things have essences that make them the thing that they are. According to this view, people believe that essences generate or constrain surface features of objects. Gelman and Wellman (1991) found that children have an impressive understanding of essences (e.g. a seed from an apple which was planted in a flower pot would become an apple tree rather than a flower). However, they did not provide direct evidence that children believe that essential features cause other features, because their results could have been due to children's past knowledge about essences (e.g. apple trees are inherent in apple seeds). The current study provides direct evidence that children weigh cause features more heavily, making psychological essentialism an attractive possibility as a basic cognitive mechanism in development.

One open question remains concerning the generality of the current findings across domains. Nominal kinds (i.e. conventionally established kinds such as 'white things') may be only weakly affected by causal status because as discussed by Schwartz (1979), nominal kinds do not have real essences. Indeed, Kalish (1998) showed that children also understand natural kinds as being discovered in the world, whereas artifact kinds are understood as being constructed. This presupposition may also affect the degree to which the causal status effect occurs in children.

Acknowledgements

This research was supported in part by a National Institute of Mental Health Grant (RO1 MH57737) given to Woo-kyoung Ahn, and a NICHD grant (HD36043) given to Susan Gelman. We are grateful to Paul Bloom, Frank Keil, and Karen Wynn for helpful comments on this study. We also gratefully acknowledge the children, teachers, and staff of the following day care centers for their participation: Creative Arts Workshop, the Neighborhood Music School, the St. Thomas's Day School.

Appendix A. Seven sets of stimuli used in Study 1

Note that in each item, the first feature is internal substance and the last two features are morphological features. Items 1–5 were used in Study 2.

1. blickem in the blood, small lungs, purple skin
2. peptide crotase in the heart, bluish blood, rough texture in skin
3. promicin in the nerves, thick bones, large eyes
4. cadmius in the brain, brown blood, curved backbones
5. bone enzyme somaline, webbed feet, large lungs
6. protein spirens in the muscles, long arms, thin blood vessels
7. substance-m under the skin, very thin bones, curled tail

References

Ahn, W. (1998). Why are different features central for natural kinds and artifacts? The role of causal status in determining feature centrality. *Cognition*, *69*, 135–178.

Ahn, W., Kim, N. S., Lassaline, M. E., & Dennis, M. (in press). Causal status as a determinant of feature centrality. *Cognitive Psychology*.

Carey, S. (1985). *Conceptual change in childhood.* Cambridge, MA: Plenum.

Gelman, S. A. (1988). The development of induction within natural kind and artifact categories. *Cognitive Psychology*, *20*, 65–95.

Gelman, S. A., & Kalish, C. W. (1993). Categories and causality. In R. Pasnak, & M. L. Howe (Eds.), *Emerging themes in cognitive development* (pp. 3–32). New York: Springer.
Gelman, S. A., & Wellman, H. M. (1991). Insides and essences: early understandings of the nonobvious. *Cognition*, *38*, 213–244.
Gopnik, A., & Sobel, D. (1999, April). *Detecting blickets: how young children use novel causal information in categorization and induction.* Paper presented at the Society for Research in Child Development, Albuquerque, NM.
Kalish, C. (1998). Natural and artifactual kinds: are children realists or relativists about categories? *Developmental Psychology*, *34*, 376–391.
Kalish, C. W., & Gelman, S. A. (1990, June). *Preschoolers' sensitivity to differences in category implications.* Paper presented at the meeting of the Jean Piaget Society, Philadelphia, PA.
Keil, F. C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: MIT Press.
Keil, F. C. (1992). The origins of an autonomous biology. In M. R. Gunmar, & K. M. Maratsos (Eds.), *Modularity and constraints in language and cognition*: The Minnesota Symposium on Child Psychology: (Vol. 25, pp. 102–137). Hillsdale, NJ: Erlbaum.
Keil, F. C., & Batterman, N. (1984). A characteristic-to-defining shift in the development of word meaning. *Journal of Verbal Learning and Verbal Behavior*, *23*, 221–236.
Keil, F. C., Smith, W. C., Simons, D. J., & Levin, D. T. (1998). Two dogmas of conceptual empiricism: implications for hybrid models of the structure of knowledge. *Cognition*, *65*, 103–135.
Leslie, A. M., & Keeble, S. (1987). Do six-month-old infants perceive causality? *Cognition*, *25*, 265–288.
Medin, D. L., & Ortony, A. (1989). Psychological essentialism. In S. Vosniadou, & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179–195). Cambridge: Cambridge University Press.
Piaget, J. (1951). *The child's conception of the world*. London: Routledge and Kegan Paul.
Piaget, J. (1952). *The language and thought of the child*. London: Routledge and Kegan Paul.
Schwartz, S. P. (1979). Natural kind terms. *Cognition*, *7*, 301–315.