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Brief Report

Children's sensitivity to circular explanations

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Abstract

The ability to evaluate the quality of explanations is an essential part of children's intellectual growth. Explanations can be faulty in structural ways such as when they are circular. A circular explanation reiterates the question as if it were an explanation rather than providing any new information. Two experiments ($N = 77$) examined children's preferences when faced with circular and noncircular explanations. The results demonstrate that a preference for noncircular explanations is present, albeit in a fragile form, by 5 or 6 years of age and that it appears robustly by 10 years of age. Thus, the ability to evaluate the quality of explanations based on structural grounds appears to develop rapidly during the elementary school years.

Keywords: Circularity; Structural properties; Explanation; Knowledge acquisition; Middle childhood; Cognitive development

Introduction

Young children will often ask why things are the way they are or how things work, and they ask about an enormous range of objects around them (Callanan & Jipson, 2001; Greif, Kemler Nelson, Keil, & Gutierrez, 2006). Moreover, they are often unsatisfied with the first explanation offered and may ask for further explanations, repeating the cycle until they either reach a point where they believe a compelling explanation has been offered or

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give up in frustration. This article explores the types of explanations children find satisfying. More specifically, we ask how children become sensitive to certain structural features that make some explanations better than others by examining children's evaluation of circular arguments.

Although existing research has examined what makes some arguments better than others (e.g., Kuhn, 1992), what makes certain ideas more persuasive than others (e.g., Cialdini, 1993), and what kinds of inconsistencies children notice (e.g., Markman, 1979), these studies have tended to focus on the content of the statements rather than on more abstract structural principles associated with good and bad explanations. Less common has been work on the logical structure of sentences such as Osherson and Markman's (1975) work on contradictions and tautologies and Braine and Rumain's (1981) work on the development of the understanding of *or*. Here we focus on another structural aspect of explanations that may influence judgments of their quality—circularity.

Circular arguments are statements that draw a conclusion by reiterating the information assumed in the original question or claim without adding any meaningful new information. They can be short and simple, such as "a can opener works by opening the can," or longer and more complex, such as "a can opener works by taking the lid off the can so that the top of the can has come off." Adults often unwittingly accept and create complex circular arguments, but they also reject the simplest ones as completely uninformative, raising questions about the origins of this ability and its relationship to metalinguistic skills. Adults are sensitive to elements such as verbatim repetition and paraphrasing as an indication of an argument's circularity, yet even they display limitations in their ability to recognize pragmatic factors that influence whether an argument is truly circular (Rips, 2002). A better sense of how children's abilities might emerge comes from a brief consideration of prior work on metalinguistic and metacognitive reasoning.

Because explanations are embedded in language, the ability to evaluate structural properties of explanations relies on some degree of metalinguistic skill. Children as young as 2 years of age show rudimentary metalinguistic functioning when they are asked to give judgments of grammaticality in modeling situations. By 5 to 8 years of age, children are able to give judgments of nonstandard sentences and explain why they judge some sentences as deviant (Gleitman, Gleitman, & Shipley, 1972). This more elaborated ability may be critical in evaluating structural flaws in explanations.

Multiple sources suggest that the ability to evaluate explanations develops between 5 and 10 years of age. For example, Ruffman (1999) demonstrated that when listening to longer passages, children under 6 years of age show difficulty in detecting logical inconsistencies, such as that the same character could be both tall and short, and that this is not a result of memory limitations. Studies on evaluations of the coherence of text passages also show developmental patterns during this period (Anderson & Beal, 1995; Markman, 1977).

One particularly relevant line of research on children's awareness of structural features examined children's ability to evaluate contradictions and tautologies (Osherson & Markman, 1975). Unlike statements in which truth value is determined by context, a tautological sentence is true by virtue of its logical form and a contradictory sentence is false by virtue of its logical form. When 8-year-olds were asked whether they thought the information in tautologies and contradictions was *true*, *false*, or something about which they *can't tell*, they had difficulty in evaluating both the contradictions and the tautologies. Because some statements containing nontautologous and noncontradictory statements, such as "either this chip is green or it is blue" and "this chip is yellow and it is not red," were readily understood, the difficulty of these statements did not seem to be caused by problems with the logical words used. Rather, children indiscriminately sought empirical evidence even though contradictions and tautologies are inherently nonempirical (i.e., no empirical evidence is required to falsify or verify contradictions and tautologies). Resisting the tendency to ask for empirical support for nonempirical sentences requires an ability to examine the form of the statement itself.

In addition to the work on contradictions and tautologies, circular arguments also are closely related to necessarily true sets of statements. Russell (1982) found that, by 5 years of age, children could distinguish between necessarily true and empirically testable sentences. This suggests that quite young children might be able to evaluate circular arguments when used as explanations even when they concern relatively novel phenomena. The experiments presented here build on this earlier work by asking children which explanations are inherently more satisfactory rather than simply asking them to discriminate between necessarily true and false statements. In many contexts, the naturalistic evaluation of an explanation's quality may be central to understanding why some answers are satisfying to children and others are not.

Existing research indicates that the ability to evaluate the coherence and explanatory value of statements, passages, and bodies of text may rest on a continuum. Even preschoolers can perform well on some tasks (Revelle, Wellman, & Karabenick, 1985), whereas adults will miss inconsistencies and other problems in longer and more complex bodies of text (Graesser, Kassler, Kreuz, & McLain-Allen, 1998). Circular arguments may be an important intermediate case. Because of their structural properties, circular explanations cannot go below a certain threshold of complexity—one that may be beyond the grasp of preschoolers and perhaps young elementary school children as well. At the same time, these structural features are ones that can be of considerable use in judging explanations and deciding whether to ask further questions, especially in cases where knowledge of content is weak. It is possible to know that an explanation is inadequate on structural grounds without understanding the explanatory details. Thus, reliance on structural properties may influence children to prefer some explanations over others in situations of near complete ignorance about the topic.

It appears likely that children are often provided with empty explanations. When confronted with a series of "why" questions that they cannot answer, exasperated adults may give empty explanations of the form "because that is the way it is" or "because it has always been that way." At some point, children must learn that these "explanations" are of little value. For these reasons, it is important to ask how the ability to evaluate explanations in this manner develops.

Although previous research has often used open-ended probes (e.g., Markman, 1977, 1979), there are such great individual differences among children in whether they request information in general that a forced-choice method may provide a clearer measure of their underlying abilities. Moreover, because children often perform better when they are forewarned about text problems (Zabrucky & Ratner, 1986), in the current experiments children were told that there are two or three people, one of whom knows more than the other(s), thereby making the children sensitive to the fact that one or two of the explanations should strike them as less acceptable. Finally, given memory load issues in related tasks, the current experiments decreased memory demands by using visual cues, repeating items on request, and asking questions to ensure that children remembered the necessary information.

Experiment 1

Method

Participants

A total of 17 kindergarteners (10 boys and 7 girls, mean age = 5 years 8 months) were interviewed individually in a quiet room at an elementary school in the New Haven, Connecticut area or in a laboratory at Yale University. Children were predominantly middle- and upper middle-class Caucasian Americans.

Materials and procedure

The experimenter began with the following instructions: "I'm going to tell you about three people who think they know about something. One of them knows a lot more than the others. I want you to tell me who you think knows the most; who's the smartest?" The experimenter made it clear that although each explanation had the speaker's name with it, the child did not personally know any of the speakers. Also, the experimenter told each participant that if he or she wanted to hear any item repeated, the experimenter would be happy to repeat it on request.

The experimenter then read each item and the accompanying options out loud saying, "I have three people who think they know about [topic]. Here's what they say." For each phenomenon, the participant heard a short circular explanation, a long circular explanation, and a noncircular explanation (Table 1). The short circular explanation did not provide any new information and was as short as possible (e.g., "A can opener works because it opens the can"). The long circular explanation also did not provide any new information but included more words (e.g., "A can opener works because it does something that takes the lid off so that when you are finished using the can opener the top of the can has come off"). The noncircular explanation contained approximately the same number of words as the long circular explanation but provided a real causal explanation (e.g., "A can opener works because it has a sharp wheel that cuts the lid and another wheel that goes under the lid of the can and turns it so that it can get cut"). These explanations were drawn primarily from science magazines and books (e.g., Macaulay, 1988). All items were pilot-tested with 27 adults who preferred the noncircular explanation 95% of the time.

Each explanation was presented in a small booklet with the hypothetical speaker's name printed on the cover, and the explanation was printed on the inside. The participant could indicate his or her choice by saying the person's name or by pointing to the booklet. There were a total of nine items. For at least one item chosen at random, the experimenter asked the participant why he or she chose a particular explanation. Also, the experimenter periodically asked the participant whether he or she remembered what the explanation said. The choices for each item were arranged in three random orders, and the items were in two random orders, resulting in a total of six versions of the task.

Results and discussion

Kindergarteners chose the short circular explanation 16.99% of the time, the long circular explanation 30.72% of the time, and the noncircular explanation 52.29% of the time. When

Table 1
Sample stimuli (Experiment 1)

Question	Circular explanations		Noncircular explanation
	Long	Short	
These people think they know why polar bears have white fur. Which one do you think knows the most?	They have white fur because the color in their fur is white, not black or another color. All polar bears are white; you will not see one that is a different color	They have white fur because their fur is always white	They have white fur because they live in snowy places. Since the snow is white, it's hard for the bear's enemies to find it and hurt it. So, the white bears live longer, and they make more white bears
These people think they know how dishwashers work. Which one do you think knows the most?	They work because the inside of the machine is really good at washing things. When you put your dishes and silverware inside and turn the dishwasher on, it makes them really clean	They work because they make things that you put in them clean	They work because they spray hot water from lots of directions and it reaches all the dishes and silverware inside. They then get rinsed by clean water, and then the machine dries them

Note. The full set of stimuli is available on request.

tested against chance levels (33.33%), children selected the noncircular explanation at levels far above chance levels, $t(16) = 6.060$, $p < .0001$, they selected the short circular explanation at below chance levels, $t(16) = 4.826$, $p < .0001$, and they selected the long circular explanation at chance levels, $t(16) = 0.939$, $p = .362$. Paired sample t tests also revealed significant differences between the rates of selecting each type of explanation. There was no effect of item order, suggesting that children did not select explanations based on the order in which they were presented.

These results reveal that kindergarteners prefer certain explanations over others. They rarely chose the short circular explanation—the explanation that adults also were least likely to choose. Likewise, kindergarteners chose the noncircular explanation at rates well above chance levels, suggesting that they consider circular arguments to be less satisfactory than noncircular ones. This suggests that even young children are not fooled by explanations that are circular, regardless of their length, and that they expect an explanation to provide them with new information.

The comments that participants made also suggest that certain explanations immediately strike young children as less satisfactory. In particular, when participants heard the short circular explanation, they would often make spontaneous remarks such as "That's stupid," "It's obviously not that," and "It's either that [noncircular] or that [long circular]." Although this reaction may have been partially based on the length of the explanation, the fact that children also preferred the noncircular explanation to the circular one of approximately equal length suggests that children recognize that circular explanations lack value compared with other options. Despite these relatively strong intuitions, kindergarteners still chose the noncircular explanation at rates far lower than did adults, suggesting that it is important to examine how the ability to evaluate circular explanations emerges during the elementary school years.

Experiment 2

The purpose of Experiment 2 was to examine how the ability to detect circularity emerges across a broader range of ages. Because both adults and young children were so unlikely to choose the short circular explanation in Experiment 1, this explanation was eliminated from Experiment 2.

Method

Participants

A total of 19 kindergarteners (9 boys and 10 girls, mean age = 6 years 1 month), 24 second graders (14 boys and 10 girls, mean age = 8 years 3 months), and 17 fourth graders (9 boys and 8 girls, mean age = 10 years 4 months) were interviewed in a quiet room at an elementary school in the New Haven area. Participants were predominantly middle- and upper middle-class Caucasian Americans.

Materials and procedure

The same procedure was followed as in Experiment 1 except that each participant was presented with only two choices for each question: the noncircular explanation and the long circular explanation.

Results and discussion

When presented with two options of equal length, kindergarteners chose the noncircular explanation 49.71% of the time, second graders chose the noncircular explanation 67.13% of the time, and fourth graders chose the noncircular explanation 84.97% of the time. For further analyses, participants were assigned a score of 0 to 9 based on the number of times they chose the noncircular explanation. Using this total score, an analysis of variance (ANOVA) found significant differences among the three age groups, $F(2, 59) = 21.197$, $p < .001$. Post hoc Scheffé's tests showed significant differences between each grade group at the $p < .004$ level or lower. Fourth graders were more likely to choose the noncircular explanation than were second graders, and second graders were more likely to choose the noncircular explanation than were kindergarteners (Fig. 1).

To ascertain whether each age group's performance on this task was related to the linguistic complexity of the explanations, we calculated the Flesch Reading Ease Score (Flesch, 1948) for each of the circular and noncircular explanations. There were no significant differences between scores for the two types of explanations ($M = 81.5$ for circular explanations and $M = 85.1$ for noncircular explanations), indicating that the explanations were of equal difficulty in terms of readability. We also tested whether the difference in scores (indicating whether each noncircular explanation differed in readability from the corresponding circular explanation) for each item correlated with preferences for the noncircular explanation at each grade level and found no significant correlations. Thus, it is unlikely that children were basing their choices on the linguistic complexity of each explanation; rather, it appears that they were actually focusing on the content of the explanation. Additional analyses also demonstrated that there were no effects of the order of the questions and explanation choices on children's preferences, suggesting that preferences were not based on differential memory for each of the explanation options.

A particularly striking finding in Experiment 2 is that the kindergarteners performed only at chance levels. This is a decrease in their performance from Experiment 1, where they chose the noncircular explanation at rates that were well above chance levels. Despite the task instructions indicating that one of the answers would be silly, kindergarteners

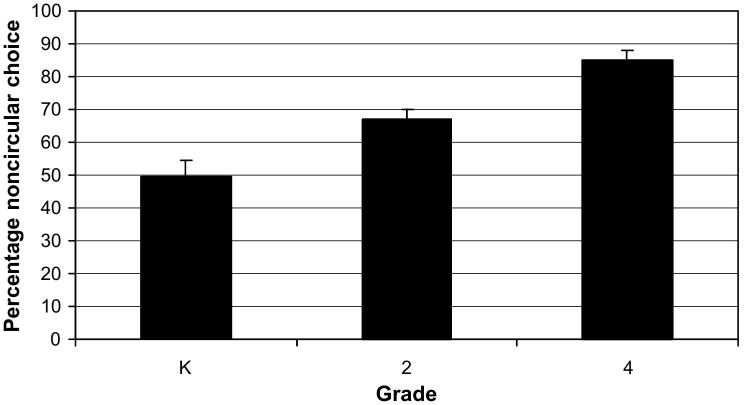

Fig. 1. Children's preferences for the noncircular explanation in Experiment 2. K, kindergarten.

might not be attuned to these kinds of distinctions unless they are given more salient cases of circularity on which to build. In Experiment 1, children may have viewed the short circular explanation as so ridiculous that it made them more sensitive when examining the other two explanations. Because Experiment 2 did not include an explanation that was as blatantly inadequate as the short circular explanation, participants might not have been as sensitive in their evaluations.

General discussion

Some explanations are inherently more satisfactory to both children and adults. Adults and children as young as kindergarteners are sensitive to the fact that noncircular explanations are superior to circular ones, but this ability remains fragile until the later elementary school years. Moreover, these effects do not appear to be related to memory limitations, nor are they explained by differences in the linguistic complexity of the explanations.

Any difficulties that kindergarteners experienced on this task were not likely to be caused by problems in remembering the explanation. Children usually answered affirmatively that they remembered what had been said and were able to repeat or paraphrase the statement. Children also were given visual cues (i.e., the booklets that contained the explanations) and were able to ask for an item to be repeated if they could not remember it. Experiment 1 presents the most convincing evidence that memory did not play a key role in the participants' performance. In that experiment, participants needed to remember an additional character and information because there was an additional explanation. However, it is in that experiment that kindergarteners showed the strongest preference for the noncircular explanation.

The participants' comments also revealed that they were not simply identifying longer explanations as *better* explanations. For instance, a fourth grader who had difficulty in choosing an explanation on the item about why identical twins look exactly alike commented, "Well, Courtney [the circular explanation] kinda describes them more, but Katie [the noncircular explanation] gives a reason. I don't know. [Pauses.] Katie said there's a recipe, and Courtney gives a reason. But that's what they're trying to ask you—why their faces are the same, so ... I think Katie's right." This monologue reveals that the participant was looking for an explanation that went beyond a reiteration of the original question. This might be how children approached this task. They seemed to ask themselves, "Have I learned anything new from this information?" Consider as another example a second grader who chose the noncircular explanation for why sleeping pills work because "he tells more description why it works." A more articulate second grader explained his choice of the noncircular sleeping pill explanation by saying, "Because Steve is just saying *that* they work; he's just saying there's a chemical in it. John is explaining how it makes the person tired." These comments suggest that children were attending to the nature of the information being provided rather than relying on more simple heuristics of answer length or complexity.

One clue to the origins of the developmental trends seen in these experiments lies in children's own comments on their choices. Even when children indicated that they preferred a noncircular explanation, those participants often made comments that were actually circular themselves. For example, when one kindergartener was asked why he chose the noncircular explanation for why leaves change color in the fall, he responded, "Because I think she's right." This child's response did not provide the experimenter with any new information and certainly can be considered circular even though the child rejected circular explanations in the task. Like adults, children may often have strong intuitions about one explanation offering more insight than another but are unable to articulate why. Additional research into children's explanations for their choices is necessary to clarify this possibility.

Another interesting observation is that when some of the children heard the initial question statement, they spontaneously indicated that they knew the answer. The experimenter allowed them to express their thoughts, and in most cases their explanations were not accurate. For example, a 6-year-old boy explained that leaves change color in the fall "because God sends his angels down to paint them."[3] Nevertheless, when this child heard the given explanations, he still chose the noncircular explanation. It is not the case, then, that children need to understand a phenomenon completely to choose which explanation they find more plausible. In fact, it may be more informative to examine how children react to explanations of unfamiliar concepts given that young children encounter so many of these situations and that it presumably would be easier to fool children into believing an implausible explanation when the children have less background knowledge about a particular topic.

It is important to note that children's ability to assess the accuracy of their own explanations also develops between kindergarten and fourth grade (Mills & Keil, 2004). Perhaps this improving awareness of their own understanding plays a role in children's ability to evaluate inconsistencies in others' explanations. This possibility could be addressed in future research by asking children to provide and evaluate their own explanations along with evaluating others' explanations. Similarly, another factor that may be underpinning performance in our tasks is that children's metalinguistic skills continue to improve during this time period (Ferreira & Morrison, 1994). In the future, it would be beneficial to measure metalinguistic abilities in conjunction with preferences for different types of explanations so as to assess exactly what role an understanding of language plays when evaluating explanations.

Our results suggest a potentially valuable educational intervention as well. One way to teach children how to evaluate sentences more carefully might be to give them examples of explanations that clearly are unsatisfactory, such as the short circular explanation in Experiment 1, and then build up to using explanations that may be harder to evaluate. Even in college-level instruction, it is often common to try to illustrate subtle circularities in complex arguments by pointing out their more blatant counterparts in much more abbreviated examples. Thus, it may well be that encounters with very simple cases of circularity provide children with insights that they can then use as a new platform for evaluating more complex arguments on the same grounds.

It is important to further explore cases where children accept an explanation that adults would not consider satisfactory, especially cases where they have relatively little knowledge about the phenomenon involved. In conjunction with ongoing research on how children come to understand the distribution of knowledge (Keil, 2006) and evaluate potential sources of information (Harris, 2007), our current findings suggest that it is also important

[3] This example raises the intriguing question of whether children find supernatural explanations more appealing than scientific causal explanations (see Bering, 2006, for a review of the literature on children's beliefs in supernatural events).

to consider how children evaluate the answers that they receive. From classrooms to courtrooms to clinics, the question of how children come to know that an explanation is unsatisfactory is of central interest. Anecdotally, many parents know that their children constantly ask "Why?" These experiments may be a first step in knowing how they learn to stop.

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