Words that Evoke Schemas: The Need for Optimal Vagueness

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Abstract

Although young children typically have trouble reasoning relationally, they are aided by the presence of relational words (e.g., Gentner & Rattermann, 1991) and can reason well about commonly experienced event structures (e.g., Fivush, 1984). Two experiments examine how schema-evoking words help preschool-aged children generalize relational patterns. Experiment 1 shows the superiority of schema-evoking words and Experiment 2 further reveals that these words must be applied to vaguely related events in order to draw attention to structure.

Keywords: schema, analogy, labels, relational reasoning.

Introduction

All forms of similarity inherently depend on context and point of view. Structural or analogical forms of similarity, which are about the relations organizing an event rather than surface perceptual similarities, seem to be particularly dependent on context and the participants' *interpretation* of the event. Theoretical constructs such as schemas (Rumelhart, 1975, Rumelhart, & Ortony, 1977) and the related notions of frames (Minsky, 1975) and scripts (Schank & Abelson, 1977, 1995) seem like plausible representations for analogical reasoning. Roughly defined as structured representations that bring order to chunks of knowledge (Minsky, 1975), schemas have slots filled by different units of knowledge suitably representing information required for responding to a situation in terms of relational structure.

This characterization of relational reasoning as a process drawing upon schemas may be particularly helpful in understanding the development of relational reasoning. Three previous results are relevant to the developmental question. First, relational reasoning is particularly difficult for novices and young children who have difficulty picking out relevant relational information from more salient object features (see Gentner & Rattermann, 1991; Keil & Batterman, 1994). Second, words help children notice, comprehend, and make use of relations (Kotovsky & Gentner, 1996; Gentner & Rattermann, 1991; Loewenstein & Gentner, 2005; Gelman, 1988). Third, even very young children reason well about well-understood event structures (such as buying fast food or going to the movie), an ability that seems derived from schema-like representations (Bauer & Mandler, 1989; Fivush, 1984; Hudson, Fivush, & Kuebli, 1992). The aim of the present research is to examine how language might foster schema-like interpretations and in so doing enable young children to use analogical forms of similarity.

The key hypothesis underlying this work is that words through their past associations might invite interpretative schemas that then enable children to reason analogically about structural similarities despite surface differences. However, there are two related issues pertinent to examining this hypothesis. The "schema" hypothesis is that words that draw upon these schemas, well-understood structure-sensitive event structures, enable relational thinking. However another view is that language offers a discrete and arbitrary code associated with rich experiences and having these discrete representations acts as a filter on irrelevant information. The effect of such codes is less about evoking structure sensitive interpretations than it is about serving as an explicit representation of structure.

A second issue concerns the flexibility of the schema. For example, if children recall a story that invites a highly fixed and specified narrative rather than a story schema with slots in its structure, they may be less likely to respond according to relational similarity in analogous stories (Brown, Kane, & Echols, 1986). When the interpretation of a situation is *too* specific and the slots are already filled in, children may have difficulty attending to relations so the "vague schema" hypothesis suggests that less specified, less concrete, and sparsely detailed schemas direct attention to structure better than richly detailed concrete situations. In two experiments with four and five-year-old children, we examined how language might evoke schemas useful for understanding two relational patterns, ABA and BAA (previously used by Kotovsky & Gentner, 1996), made up of different objects and features presented on flashcards (shown in Table 1 and Figure 1).

Experiment 1

First we tested the "schema" hypothesis by creating three possible ways that language could act as a cue to relational information: as an arbitrary code, an iconic representation, or a schema-evoking label. The arbitrary word (i.e. "Koli" for ABA; "Teemo" for BAA) serves as a control for any general effects of naming. The iconic condition is included because words could foster relational perspectives by providing a schema-representation in their very form (i.e. "Ko-Li-Ko" for ABA patterns; "Tee-mo-mo" for BAA) but is not based on event structures well understood by young children. And lastly, perhaps schema-evoking words draw attention to well understood events with similar structural

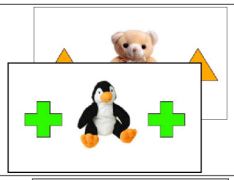
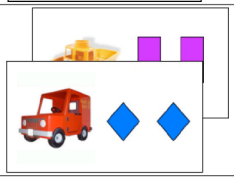
relations, thus possibly acting as a pointer to many relationally similar events in past experience. To do this, we drew upon words that (1) refer to well-organized events for young children and (2) have relational meanings so that they can help children relationally interpret ambiguous scenes (i.e. "Sharing" with ABA patterns, "Pulling" with BAA).

Method

Participants. Forty-four children, average age 57 months (range 46-68 months) from Bloomington daycares participated in this experiment. They were randomly assigned to one of the label conditions: arbitrary, iconic, or schema-evoking.

Materials and Procedure. Children were shown two instances of each relation on flashcards, shown in Table 1 (i.e., ABA relation cards were cross-penguin-cross and triangle-bear-triangle; BAA cards were boat-rectangle-rectangle and car-diamond-diamond). ABA cards were labeled with the same word/phrase and BAA cards were labeled with another word/phrase.

Table 1: Design of Experiment 1.

Learning instances	Arbitrary Label	Iconic Label	Schema-evoking Label
ABA relation 	"Koli"	"Ko-Li-Ko"	"Sharing"
BAA relation 	"Teemo"	"Tee-mo-mo"	"Pulling"

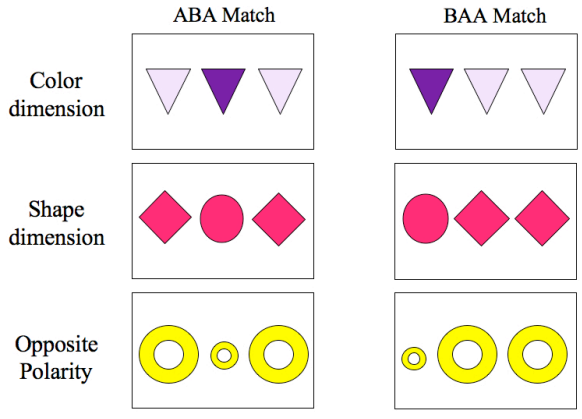


Figure 1: Test trials from Experiment 1 and 2.

After this brief four-card training, children completed twelve lexical generalization trials with new instances of ABA and BAA (shown in Figure 1). On half of the trials, children were asked to get the ABA card ("Can you get the koli/ko-li-ko/sharing card?") and shown both an ABA (relational match) and BAA card (distracter). Children were asked for the BAA card on the other six trials. Interspersed with the generalization trials were memory trials where children were shown the card used during label training (i.e., cross-penguin-cross) and a distracter (i.e., penguin-cross-cross) and had to retrieve the koli/ko-li-ko/sharing card. These trials tested whether children were even able to learn the words and their referents from the brief training segment.

Results and Discussion

Children's memory performances for the instances labeled in training are shown in Table 2. Although all children successfully memorized the learning instances at levels significantly above chance, $p<.01$, those trained with schema-evoking labels showed significantly better memorization than children in either the arbitrary or iconic conditions, $t > 11.6$, $p<.05$.

Analysis of generalization trial performance revealed that children in the iconic label condition chose relational matches to the given label more often than those with arbitrary label training, $t(30) = 6.3$, $p<.05$. However, those in the schema-evoking condition significantly outperformed both the iconic and arbitrary conditions, $t > 12.20$, $p<.01$. Given that this effect might merely be a reflection of better memory for the label training, we included memory trial performance as a covariate – even so, there was a significant effect of label condition, $F(2, 40) = 8.75$, $p<.01$. The same univariate analysis performed on only children who answered 6 or more out of 8 memory trials correctly (also shown in Table 2) continued to confirm this enhanced performance by the schema-evoking condition, $F(2, 26) = 9.06$, $p<.01$.

Table 2: Results from Experiment 1.

	All Children		Memory Performance >= 6/8	
	Memory Trials	Generalization Trials	Memory Trials	Generalization Trials
Arbitrary Label (Koli/Teemo)	.71 (*SD* = .19)	.54 (*SD* = .12)	.88 (*SD* = .13)	.56 (*SD* = .09)
Iconic Label (Ko-Li-Ko/ Tee-Mo-Mo)	.75 (*SD* = .17)	.64 (*SD* = .12)	.86 (*SD* = .09)	.63 (*SD* = .14)
Schema-evoking Label (Sharing/Pulling)	.94 (*SD* = .12)	.85 (*SD* = .20)	.97 (*SD* = .07)	.88 (*SD* = .16)

In one sense, the iconic label condition is the best example of language embodying a schema or rule since "ko" and "li" can potentially act as slots to be filled by arbitrary objects. "Sharing" is not an explicit representation of the ABA relation (in the way that "ko-li-ko" actually is) but only indirectly, via schema representations. The choice of schema-evoking words such as "Sharing" and "Pulling" is similar to Rattermann and Gentner's (1998) use of the word "Daddy" and "Baby" to help young children respond to size relations. Words like "Sharing" or "Daddy" may

foster analogical reasoning by vaguely reminding children of relevant past experiences. These words conveniently emphasize relations by because the schemas they activate are well-known and well-structured. Evoking these relational frames may facilitate processes such as alignment and comparison to provide interpretive contexts for perceptually ambiguous situations.

This brings us to our second hypothesis concerned with what *kind* of schema leads to relational interpretations. The "vague schema" hypothesis suggests that a less specified schema highlights relational structure (see also Gick & Holyoak, 1983) more than a concretely filled-in story. Although the label "sharing" evokes a familiar event context to young children, the perceptual situation that receives the label can lead to a vague and general idea of sharing *or* a specified version of sharing. A vague and schematic understanding of sharing might be multiple parties equally wanting or distributing something. Vague conceptualizations are better at distinguishing roles from their fillers leading to a relational perspective. However, a more specified example of sharing told more like a narrative story, such as two girls equally wanting one toy penguin, does not highlight the relational structure since roles are overlooked for their salient fillers. Experiment 2 provides a test for the differing influences of flexible generic schemas and specific concrete stories.

Experiment 2

Only evoked schemas that are vague and general may position children to notice relational structure. The idea motivating Experiment 2 is that these labels are not "schematic" in and of themselves but the application of these words to certain perceptual situations creates schematic construals. Experiment 2 attempts to test this "vague schema" hypothesis by training all children with the schema-evoking labels -- "sharing" and "pulling" -- but applying them to different types of training cards.

Method

Participants. Thirty-nine children, average age 57 months (range 50-68 months) from Indiana daycares participated in this experiment. They were randomly assigned to one of three training card conditions: Specifically-related, Vaguely-related, or Unrelated (controls).

Materials and Procedure. Examples of the training cards are shown in Table 3. The Specifically-related training cards are designed to evoke a specific instance of "sharing" whereas the Vaguely-related scenes only evoke an ambiguous sense of "sharing."

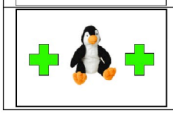
Additionally, faced with concerns that the arbitrary labels in Experiment 1 were *too* arbitrary to serve as an adequate control, we created a new control group where the labels were known English words that would be unrelated to the situation depicted on the card. One way we could have done this is to take the training cards from Experiment 1 and apply unrelated words such as "kicking" for ABA cards and "cooking" for BAA cards. Another way to create an unrelated labeling situation is to take the words "sharing" and "pulling" and change the training cards. We opted for this second choice and designed depictions less related to the labels (i.e. cross-tree-cross is less related to "sharing" than cross-stuffed animal-cross since young children probably think about sharing toys more often than trees).

Label training and generalization testing procedure was identical to Experiment 1. During memory trials, each participant chose between condition-specific cards (i.e. Specifically-related participants chose between girl-penguin-girl and penguin-girl-girl).

Results and Discussion

The three conditions showed no differences in memory performance (see Table 3), $p>.80$, but did show differences in generalization performance, $t(38) = 3.96$, $p<.05$. Vaguely-related participants made significantly more relational generalizations than those in both Unrelated, $t(24) = 4.83$, $p<.05$, and Specifically-related conditions, $t(26) = 7.12$, $p<.05$.

Table 3: Results from Experiment 2.

Learning Cards Labeled "Sharing"	Memory Trials	Generalization Trials
 Unrelated	.75 (*SD* = .18)	.63 (*SD* = .19)
 Specifically-related	.72 (*SD* = .30)	.60 (*SD* = .19)
 Vaguely-related	.69 (*SD* = .22)	.79 (*SD* = .18)

Typically, studies of analogy and language examine the effect of particular labels on structural sensitivity (e.g., Rattermann & Gentner, 1998; Loewenstein & Gentner, 2005). Our results corroborate previous demonstrations in the developmental literature where training with known words fosters relational generalization. However, it is not the mere use of a particularly right word that cues relational judgments. Our results suggest that the schematic interpretations created between words and their referents results in structural sensitivity. Words that are associated with familiar, structurally-organized schemas is only part of the story. Perceptual instances that are optimally vague, ones that can be interpreted in terms of those familiar schemas, allows children to attend to relational slots. The match between a known schema and a sufficiently ambiguous instance reflects *optimal* vagueness because there is enough similarity to evoke relevant past instances but enough differences to enable generalization to highly dissimilar instances. Additionally, vagueness requires interpretive work and optimal vagueness allows this additional processing to yield a relational perspective.

Although our experiments do not speak to this, the notion of optimal vagueness suggests that there may be some instances are *too* vague. For example, future studies should address whether applying "sharing" to simple shapes such as diamond-circle-diamond would be effective or not. If such training is ineffective, it may be that such a situation does not sufficiently evoke relevant past instances.

Conclusion

The present studies, in addition to expanding on the role of words and schemas in fostering analogical construals, are potentially important to our very understanding of the meaning of words. In other studies where words benefit relational reasoning (i.e. "Daddy" from Rattermann & Gentner, 1998; "Even" from Kotovsky & Gentner, 1996), it might be tempting to think that the *meaning* of particular words is the source of the facilitation. Our results suggest that meanings are not static features of words. Rather meaning is created between a word and the situation at hand. Words that are related to well-ordered schemas allow children to take on a relational perspective – but that perspective must be applied to a situation that is conducive to developing relational meaning. A full account of language would probably help us understand how to promote analogical reasoning. But for now, a partial account of creating relational similarity might help us toward a better account of language.

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