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Where Hypotheses Come From: Learning New Relations by Structural Alignment

Stella Christie and Dedre Gentner
Northwestern University

We test whether comparison can promote learning of new relational abstractions. In Experiment 1, preschoolers heard labels for novel spatial patterns and were asked to extend the label to one of two alternatives: one sharing an object with the standard or one having the same relational pattern as the standard. Children strongly preferred the object match when given one standard but were significantly more likely to choose the relational match when they compared two standards. Experiment 2 provided evidence that comparison processing—as opposed to simply seeing two exemplars—is necessary for this relational effect. Preschoolers who were shown the two standards sequentially without a prompt to compare them preferred object matches, as did those who viewed only one standard. In contrast, those who saw the exemplars together, with a prompt to compare them, showed the same elevated relational responding as found in Experiment 1. We suggest that structural alignment processes are crucial to developing new relational abstractions.

Learning relational abstractions is fundamental to the development of knowledge. Children must learn to categorize and reason over functional relations (X is edible), biological causal relations (X needs water to grow), mechanical causal relations (X can move things), and spatial relations such as those that underlie the meanings of prepositions and many verbs (X is moving upwards—*ascending*—or X is located *above* another object.) A critical question is *how* children achieve this learning.

Correspondence should be sent to Stella Christie, Psychology Department, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208, USA. E-mail: christie@northwestern.edu

Developmental theories often assume that children's learning involves some form of cross-situational learning based on explicit or implicit hypothesis testing (e.g., Roeper, 2007). Accounts of cross-situational learning generally rely on the child's having formed one or more possible hypotheses from earlier examples that can be tested against later examples (e.g., Crain & Pietroski, 2001; Gleitman, 1990; Siskind, 1996). Recent work in the Bayesian framework has refined the hypothesis-testing account and applied it to a range of developmental achievements, including concept learning and word learning (e.g., Tenenbaum & Griffiths, 2001; Xu & Tenenbaum, 2007).

But despite the appeal of the hypothesis-testing view, it requires an account of how these hypotheses arise. One possibility, famously argued by Fodor (1975), is that the relevant hypotheses are innate: "...One can learn the semantic properties of a term only if one already knows a language which contains a term having the same semantic properties" (p. 80). Other theorists, although willing to entertain the idea that some new hypotheses may emerge through learning, argue that general learning mechanisms are incapable of producing hypotheses at an adequate level of abstraction to capture human learning (e.g., Marcus & Keil, 2008). This problem is particularly acute for relational meanings. While it seems plausible that a child who sees a red ball and hears it called a "ball" might focus on *round* and *red* as possible meanings—allowing her to select the correct inference (*round*) when a green ball is similarly labeled—the problem of hypothesis formation is multiplied for relational terms, for which the set of possible meanings is much larger. Cross-linguistic studies illustrate the difficulty: In English-speaking environments, "support against gravity" is a successful hypothesis for encoding the label "put on" (when that refers to screwing the cap on a jar), but in a Korean-speaking environment the winning hypothesis must focus on tight fit (Choi & Bowerman, 1991). In Atsugewi, the shape of the cap might figure into the meaning (Talmy, 1978), and in Tzeltal, fine distinctions as to the spatial disposition of the cap relative to the jar would matter (Bohnemeyer & Brown, 2007).

How does this learning occur? One possibility, consistent with the hypothesis-testing view, is that a large set of hypotheses—sufficient to allow for the range of possible semantic categories—is formed when the first exemplar is encountered and is subsequently refined when the next exemplar appears. We propose another possibility: that comparison between pairs of co-labeled items acts as a mechanism by which new hypotheses—including relational hypotheses—can be formed.[1] According to structure-mapping

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[1]The question of whether and to what degree these analogical abilities are shared with other species has recently been the topic of much research and discussion (e.g., Gentner, 2003; Gentner & Christie, 2008; Penn, Holyoak, & Povinelli, 2008).

theory (Gentner, 1983; Gentner & Markman, 1997), the process of comparison involves a structural alignment between two representations that highlights common structure. The process is biased to focus on common interconnected relational structure (Clement & Gentner, 1991; A. B. Markman & Gentner, 1993). This systematicity bias (Gentner, 1983) is important, because although young children encountering a new situation have the potential to see a large variety of relations—size differences, spatial relations, etc.—their encodings typically focus strongly on the objects (Gentner & Boroditsky, 2001; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005). However, if another exemplar is encountered while the full set of impressions is still available and the child compares the two, then structural alignment will act to focus the child's attention on their commonalities, especially shared relational structure. The highlighted structure will then be more salient and more available for application to new instances of the category.

The benefits of comparison on relational learning have been repeatedly found for both adults (Gentner, Loewenstein, & Thompson, 2003; Gick & Holyoak, 1983) and children (Casenhiser & Goldberg, 2005; Childers & Paik, 2009; Gentner & Namy, 1999; Loewenstein & Gentner, 2001; Namy & Gentner, 2002; Oakes & Ribar, 2005; Pruden, Hirsh-Pasek, Shallcross, Golinkoff, 2008; Wang & Baillargeon, 2008). For example, Loewenstein, Thompson, and Gentner (1999) showed that business school students who compared two negotiation scenarios were more than twice as likely to transfer the negotiation strategy to an analogous test negotiation as those who studied the same two scenarios separately. In children's learning, there is evidence that comparison facilitates acquisition of verb meanings (Childers, 2008; Childers & Paik, 2009; Childers & Tomasello, 2001; Piccin & Waxman, 2007) and other relational categories (Gentner, Anggoro, & Klibanoff, in press).

In a study that relates to the present work, Gentner and Namy (1999) taught 4-year-olds a new name for a pictured object (e.g., a bicycle) and asked them to choose another with the same name. The alternatives were a perceptually distinct match from the same category (e.g., a skateboard) or a perceptually similar object from a different category (e.g., eyeglasses), thus pitting perceptual similarity against conceptual commonalities. When children saw a single standard, they tended to choose the perceptually similar alternative, consistent with prior studies (Baldwin, 1989; Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988). In contrast, children who initially compared two standards (e.g., bicycle and tricycle) showed a greater preference for the conceptual match. This was a striking result, because the two standards always shared the same properties with each other as they did with the perceptual alternative, so on a feature-overlap account, comparison should have led to *more* perceptual responding rather than less. Gentner and
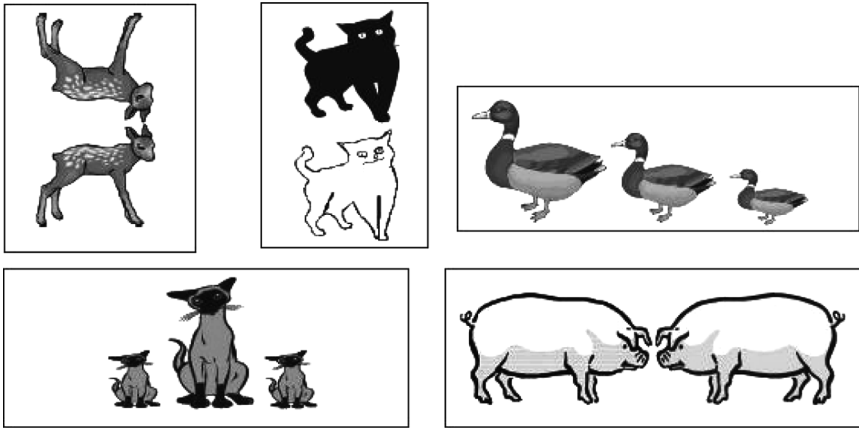
FIGURE 1   Sample of relational patterns tested.

Namy concluded that structural alignment between the two standards fostered noticing common (hitherto implicit) relational structure (such as "both can be ridden"; "both stay in the garage," etc.) and thus pointed the children toward the category choice.

Although Gentner and Namy's (1999) findings suggest that comparison may foster relational learning, a limitation of this study is that some of the conceptual matches were potentially familiar categories (such as *fruit*). The question we ask here is whether structural alignment can foster the learning of *new* relational abstractions. In Experiment 1, we probe this question using the same word extension task as in Gentner and Namy but with a critical difference: We use novel spatial relational configurations, which do not correspond to prior known categories. The question is whether comparison can foster the extraction of these novel relational patterns.

To test this, we constructed materials showing animals in novel spatial configurations for which young children were unlikely to possess the relational concept (see Figure 1). Importantly, the component relations (such as *above* or *identical*) were always visually available to children; but the overall relational configurations were novel. Some of the spatial patterns used—such as *symmetry* and *monotonicity*[2]—are concepts named in the adult lexicon; but others, such as "*white thing above black thing, otherwise*

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[2]Although these concepts are present in the adult lexicon, we think these descriptors are unlikely to be familiar to 3- and 4-year-olds (Chipman & Mendelson, 1979; Kotovsky & Gentner, 1996).

identical," do not correspond to any English word. Nonetheless, we suggest that children will need to learn this kind of complex relation.

Each pattern was labeled with a novel count noun, and children were asked to extend the word. We used novel count nouns (rather than other forms such as adjectives or verbs) for two reasons: 1) labeling the exemplars with a count noun ("Look, this is a jiggy") may bias children toward an object-centered interpretation (e.g., Hall & Waxman, 1993; E. M. Markman, 1989), enabling us to test whether comparison can result in significant shift toward relational interpretation; and 2) the challenge of learning relational nouns (such as "gift," "uncle," or "taxi") is one that children increasingly face beginning in the preschool years. Relational nouns—nouns whose meaning are defined not by their intrinsic features but by their relations to other entities (Gentner, 2005; Gentner & Kurtz, 2005; A. B. Markman & Stilwell, 2001)—are highly frequent in English (Asmuth & Gentner, 2005). They typically appear as count nouns; thus, an ambiguity between object construal and relational construal is present in many of the words young children learn. For example, a child who hears, "This is a gift," has no syntactic way to know that the word is a relational noun rather than the name of a kind of object. Indeed, the evidence shows that young children often take such relational nouns as referring to object categories (Gentner, 2005; Gentner & Rattermann, 1991; Keil & Batterman, 1984). For example, Hall and Waxman found that even when young children were told that a doll was a *passenger* "because he's riding in a bus," they nonetheless extended the term to another doll of similar appearance, rather than to one riding in a vehicle. Thus, children must often overcome an initial entity-based view to extract the relational meaning of such nouns. Our question is whether structural alignment provides a way for children to make this shift. If so, then children in the comparison group will be more likely to adopt a relational interpretation than those who do not compare.

EXPERIMENT 1

Children were given a word extension task on a triad of pictures. To ensure children's interest, the pictures were made up of animals. The standard was labeled with a novel noun, and children were asked to extend the label to one of two choices: a relational match (new animals in the same configuration) or an object match (same animal[s] in different configuration). We included the object match to provide a viable nonrelational choice, because previous studies have found that young children attend strongly to object similarity (Gentner, 1988; Gentner & Rattermann, 1991; Gentner & Toupin, 1986; Halford, 1987; Landau, Smith, & Jones, 1998; Paik & Mix, 2006;

Richland, Morrison, & Holyoak, 2006). As in the Gentner and Namy (1999) studies, half the children were given one standard (the solo condition), and the other half were given two standards and asked to compare them (the comparison condition). We predicted that the comparison group would be more likely to choose the relational match than the solo group.

Method

Participants. Twenty-six 3-year-olds ($M = 3;8$, range $= 3;6$–$4;2$) and thirty 4-year-olds ($M = 4;8$, range $= 4;5$–$5;1$) participated. The children were from predominantly White middle- to upper-middle-class families in the greater Chicago area.

Materials. There were eight sets of colored animal pictures, each consisting of two standards, plus an object match and a relational match. Each picture depicted two or three animals configured in a novel spatial relation (e.g., a black cat directly above an otherwise identical white cat). The second standard within a given set showed different animals in the same spatial configuration (e.g., a black dog above a white dog). The object match contained an exact animal match from each standard but in a different relational pattern (e.g., a black dog diagonally above a black dog). The relational match was composed of new animals in the same relational configuration as the two standards (e.g., a black bird directly above a white bird; Figure 2). Children were randomly assigned to either the solo condition (single standard) or the comparison condition (two standards presented together, as shown in Figure 2). Within the solo condition, which standard children saw was counterbalanced.

Procedure. Children were seated across from the experimenter. In the solo condition, the experimenter laid out a single standard and labeled it with a novel count noun: "Look, this is a jiggy! Can you say jiggy?" The experimenter then placed the two alternatives side by side below the standard and asked the child, "Can you tell me which of these two is a jiggy?" After the child made a choice, the experimenter continued with a new standard from a new set.

The comparison condition began in the same way: The experimenter presented and labeled the first standard. Then the experimenter placed the second standard near the first one. Half the standard pairs were laid out horizontally (side by side), the other half vertically. The experimenter named the second standard with the same label as the first and encouraged the child to repeat the word and to compare the two standards: "Can you see why these are both jiggies?" (As in Gentner and Namy's (1999) studies, no
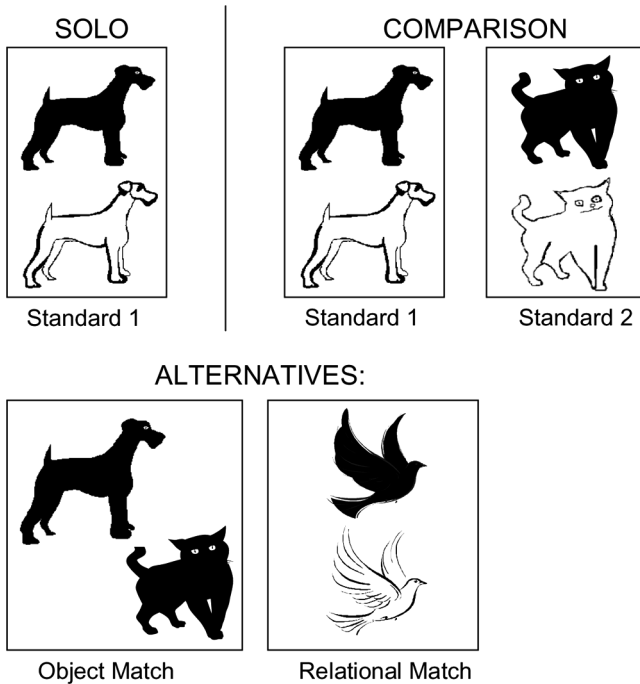
FIGURE 2   Triad arrangement of solo and comparison trials. The solo group saw one standard (either Standard 1 or Standard 2); the comparison group saw both standards juxtaposed. The sequential group (Experiment 2ab) saw both standards but presented one at a time. All groups saw the same two alternatives for each trial: an object match and a relational match.

answer was required; the idea was to invite children to think about it.) Then the two alternatives were presented as in the solo condition.

Eight different novel labels were used, one for each relational pattern. The order of novel words and the item order were varied in four semi-random orders, counterbalanced within each condition. Left-right placement of the two alternatives was also counterbalanced.

Results

Figure 3 shows the mean proportion of relational matches selected by 3- and 4-year-olds in solo and comparison conditions. A 2 (condition: solo and comparison) $\times$ 2 (age: 3-year-olds and 4-year-olds) analysis of variance (ANOVA) revealed a significant main effect of condition, $F(1, 52) = 23.83$, $p < .001$, $\eta^2 = .30$. There was no significant effect of age, $F(1, 52) = 0.31$,
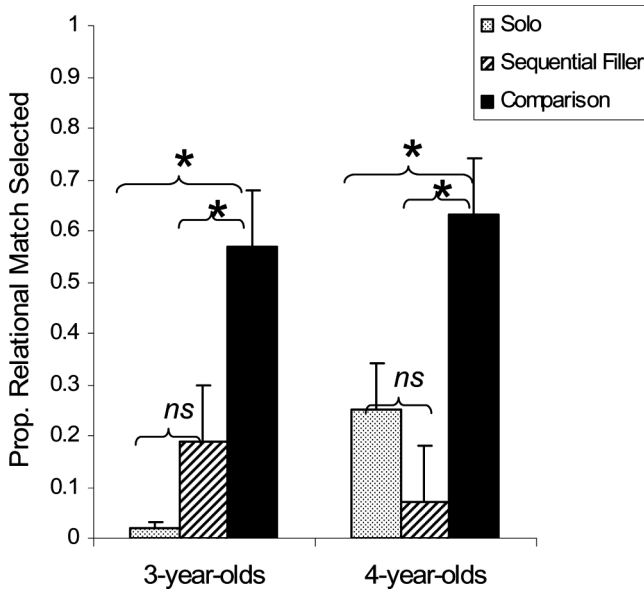
FIGURE 3   Mean proportion of relational responses in solo and comparison (Experiment 1) and in the sequential—with two intervening fillers—condition (Experiment 2a). $^*p < .05$.

ns, $\eta^2 = .03$, nor was the condition by age interaction significant, $F(1, 52) = 0.09$, ns, $\eta^2 = .009$. Because there was no significant difference between the two age groups, we collapsed the 3- and 4-year-olds' data in the subsequent analyses. Overall, the results showed the predicted effect of comparison in promoting attention to common relational structure: Children in the comparison condition selected the relational match more often ($M_{relational} = 0.60$, $SD = 0.41$) than those in the solo condition ($M_{relational} = 0.14$, $SD = 0.30$), $F(1, 54) = 22.86$, $p < .0001$, $\eta^2 = .30$. The results also showed a baseline preference for object matches; relational responding in the solo group was substantially below chance, $t(27) = -6.3$, $p < .0001$, two-tailed, showing that young children found object matches very compelling. Relational responding in the comparison group did not rise above chance, $t(27) = 1.3$, ns, underlining that young children found it difficult to match on the basis of relational structure. Nonetheless, the fact that children in the comparison condition chose relational matches more than twice as often as those in the solo condition is consistent with the claim that structural alignment is an effective way to induce children to focus on common relational structure.

The comparison effect also holds if we look at performance of individual children. Using the binomial formula, an individual child must select

the relational match (or the object match) on seven out of eight trials to be reliably above chance. Under this criterion, we found that 4 out of 13 of the 3-year-olds in the comparison group showed the relational pattern, in contrast to 0 out of 13 in the solo group. In contrast, 13 out of 13 children in the solo group showed the object pattern (choosing the object alternative on seven or eight trials), as compared with only 3 out of 13 children in the comparison group. Similar results were found for the 4-year-olds: 8 out of 15 children in the comparison group showed the relational pattern, in contrast to 2 out of 15 in the solo group. Taking the reverse perspective, 10 out of 15 children in the solo group showed the object pattern, as compared with only 5 out of 15 children in the comparison group.

Discussion

Children who viewed only one standard overwhelmingly preferred the object match. Children who compared two standards were significantly more likely to notice and use the common relational pattern, consistent with the claim that comparison entails a structured alignment process that highlights common relations.

However, before embracing this conclusion, we must ask whether cross-situational hypothesis testing could account for the data without invoking comparison. For example, we might suppose that on seeing the standard in Figure 2, the child forms two initial hypotheses about the meaning of *jiggy*—one centering on the objects in the standard (e.g., "It's about dogs and cats") and one centering on the relations (e.g., "It's about a black animal above a white animal that is otherwise identical"). The child perceives the object hypothesis as more likely, and so chooses the object match in the solo condition. However, when a second exemplar appears with different objects (in the comparison condition), the child rejects the object-based hypothesis and shifts to the relational hypothesis.

Experiment 2 addresses the question of whether it is specifically the comparison process that drives the relational insight or whether some other kind of cross-situational learning allowed children to shift to a relational hypothesis. To test this, we presented a new group of children with *both* standards but minimized their opportunity to compare in two ways: First, the two standards were presented sequentially (thus removing spatial juxtaposition); and second, we removed the explicit invitation to compare (that is, for the sequential group, we did not say, "Can you see why these are both jiggies?"). Of course, children might still be able to compare the two sequential standards, but (as Loewenstein et al.'s [1999] adult studies show) comparison is more apt to occur when two items are co-present.

EXPERIMENT 2a

In Experiment 2a, we showed children the same stimuli as in Experiment 1 but presented the standards sequentially, with two intervening fillers (pictures of familiar objects) in between. The two standards were still called by the same novel label, but children were not invited to compare them, and the standards never appeared together. If seeing more than one standard invites children to shift to a relational hypothesis, then we should expect the results to mimic those of the comparison condition in Experiment 1. If, however, comparison processing is crucial to the discovery of relational commonalities, then children given this sequential presentation should maintain a preference for the object match as in the solo condition of Experiment 1.

Method

Participants.   Eleven 3-year-olds ($M = 3;8$, range $= 3;6–4;2$) and thirteen 4-year-olds ($M = 4;7$, range $= 4;6–5;1$) participated.

Materials and procedure.   The same materials as in Experiment 1 were used, with the addition of filler cards—pictures of familiar objects (e.g., a ball, a book, a pencil, etc.). The experimenter presented one of the two standards from the set, labeled it with a novel count noun (e.g., "blicket"), and asked the child to repeat the label. Next, the experimenter showed a filler card and drew the child's attention to it ("See this?"). The first filler was then removed, and the second filler was presented in the same manner. Next, the second standard was presented and also labeled (as a "blicket," for example). The standard was then removed, and children were presented with the two alternatives and were asked, "Which one of these is a blicket?" just as in Experiment 1. To minimize working memory demand, the presentation of fillers was extremely brief, lasting no more than 2 seconds per filler.

Results

Figure 3 shows the results of sequential presentation with two intervening fillers. Three- and 4-year-olds in this experiment strongly preferred the object match, much like those in the solo condition in Experiment 1. Collapsing across age groups, the proportion of relational matches was significantly below chance ($M_{relational} = 0.13$, $SD = 0.24$), $t(23) = -7.54$, $p < .0001$).

Discussion

The results of Experiment 2a are consistent with the hypothesis that it is specifically the comparison process that drives attention to relational commonalities, rather than simply the fact of seeing more than one exemplar. In fact, seeing two exemplars without actively comparing them did not differ significantly from seeing only one standard: Children strongly preferred the object matches over the relational matches. These results are consistent with the claim that the structural alignment process acts to foster new relational abstractions.

But it is possible that the results of Experiment 2a could have been depressed by the use of fillers. Perhaps children were distracted by the fillers and failed to think of the prior "blicket" when they viewed the second standard. To rule out this possibility, we repeated the sequential condition but without fillers.

EXPERIMENT 2b

In Experiment 2b, we carried out a further test of whether comparison fosters relational insight. There were three conditions: a sequential condition like that of Experiment 2a but with no fillers between the two standards; and solo and comparison conditions, replicating Experiment 1. Because the two age groups did not differ in performance in either Experiment 1 or 2a, we focused only on the younger group (3-year-olds).

If children in the sequential group perform similarly to those in the comparison group and both groups outperform the Solo group, this will suggest that cross-situational learning (at least at close quarters) could explain the relational responding found in Experiment 1. However, if the comparison group performs better than the other two groups, this will support the claim that comparison is instrumental in the discovery of relational commonalities.

Method

Participants.   Forty-five 3-year-olds ($M = 3;11$, range $= 3;6–4;2$) participated. Children were randomly assigned to either the solo ($n = 15$), comparison ($n = 15$), or sequential ($n = 15$) condition.

Materials and procedure.   The materials and the solo and comparison conditions were the same as in Experiment 1. In the sequential condition, the experimenter presented one of the standards and labeled it. The experimenter then removed the first standard and immediately presented the

second, labeling it with the same novel name. Then, with the second standard still present, the child was shown the two alternatives and asked, as in Experiment 1, "Which one of these is a jiggy?"

After the children finished all eight trials of the naming task, we conducted a memory test to assess children's memory for the exemplars. On each trial, the child was presented with one of the previous standards, paired with a new card containing new animals in new relations. The child was asked to point to the one that she had seen before ("Which one did I already show you?") for a total of 10 trials (5 first standards and 5 second standards, each paired with a new card).

Results and Discussion

Figure 4 shows the mean proportion of relational matches selected in solo, comparison, and Sequential conditions. A one-way ANOVA revealed a significant effect of condition, $F(2, 42) = 12.34$, $p < .001$, $\eta^2 = .37$, and post-hoc analyses using Tukey's Honestly Significant Differences (HSD) criterion confirmed a significant difference between sequential and comparison ($p < .005$) and between solo and comparison ($p < .001$) but not between sequential and solo ($p = .37$).
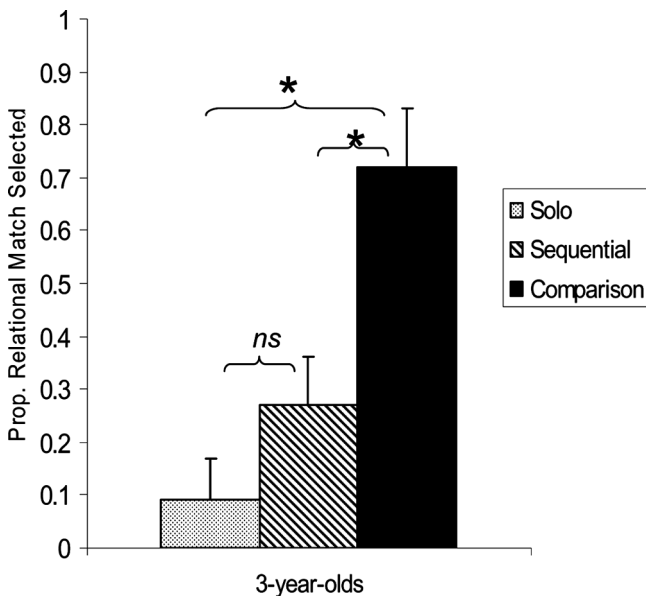

FIGURE 4   Mean proportion of relational responses in the sequential condition (Experiment 2b). $^*p < .05$.

The results for the solo and comparison groups replicated those of Experiment 1. The comparison group ($M_{relational} = 0.72$, $SD = 0.39$) chose the relational match significantly more often than the solo group ($M_{relational} = 0.09$, $SD = 0.26$), $F(1,28) = 26.33$, $p < .001$, $\eta^2 = .48$. As before, there was a baseline preference for the object match; children in the solo group chose the relational match significantly below chance, $t(14) = -6.06$, $p < .001$. In contrast to Experiment 1, the comparison group chose the relational match significantly above chance, $t(14) = 2.14$, $p < .05$. However, these two comparison groups (Experiments 1 and 2) did not differ significantly from each other, and both differed significantly from baseline.

The key question was whether the sequential group would show elevated relational responding. On the contrary, children in this condition chose relational matches at levels well below chance ($M_{relational} = 0.27$, $SD = 0.39$), $t(14) = -2.26$, $p < .05$; and, as in Experiment 2a, their pattern did not differ statistically from that of the solo group, $F(1, 28) = 2.10$, ns, $\eta^2 = .07$.

Using the same binomial formula (seven out of eight trials) as before, we found that 13 out of 15 children in the solo group showed the object pattern; only 1 child showed the relational pattern. A similar result held for the sequential group: 11 out of 15 children showed the object pattern; only 3 showed the relational pattern. In contrast, only 3 out of 15 children in the comparison group showed the object pattern, whereas 9 showed the relational pattern.

The Memory Test was given to 10 of the 15 children in the sequential group. (The remaining 5 declined to continue.) The average memory performance was 98% correct, indicating that the lack of relational insight was not due to failure to register the initial standards. Rather, the problem appears to be a failure to compare. We conclude that simply encountering two exemplars is not enough; it is the comparison process that calls forth a relational abstraction.

GENERAL DISCUSSION

These studies provide evidence that structural alignment can foster the learning of new relational concepts. When 3- and 4-year-olds were taught names for standards that had novel spatial relational structures, children given only one standard extended the terms on the basis of object matches rather than common relational structure; indeed, across both studies, more than 90% of the 3-year-olds in this condition chose the object match. In contrast, children who compared two standards were far more likely to choose the alternative based on common relational structure—even though the competing object alternative contained *two* object matches (one for each

standard). Evidence that comparison is crucial in bringing about this relational learning comes from Experiments 2a and b, in which we made it difficult for children to compare the standards by presenting and naming them sequentially. Children given sequential presentation showed the same pattern as those given only one standard. Only the comparison group showed a significant gain in relational responding over the solo group—consistent with the claim that structural alignment is a critical process in abstraction from examples.

The results are consistent with prior studies showing the benefit of comparison in category learning (Gentner & Namy, 1999; Hammer, Diesendruck, Weinshall, & Hochstein, 2009; Namy & Gentner, 2002) and extend these findings by showing that comparison can foster new relational abstractions. Further, whereas the earlier studies showed an advantage of comparison over solo presentation, the current work more specifically points to the importance of comparison by also showing an advantage of comparison over sequential presentation. The advantage of paired over sequential presentation has also been found for infants: Oakes and Ribar (2005) found that 4-month-old infants learned specific basic-level categories (dogs or cats) when given simultaneous paired presentation during familiarization but not when they viewed the same exemplars sequentially. Interestingly, the 4-month-olds in the paired familiarization condition often looked back and forth between the two items, consistent with an active comparison process.

Cross-Situational Learning and Sequential Alignment

A key question here was whether our results could be explained by cross-situational learning, without invoking comparison, by assuming that children formed a set of hypotheses when they saw the initial standard and then used the other standard to filter these guesses. Contrary to this account, children showed relational insight only when they saw the standards simultaneously and were invited to compare them. The clearest reading of the results is that the children did *not* entertain the relational hypothesis in any real sense until they engaged in comparison. The process of structurally aligning the parts and relations of the standards made the common relational structure more salient.

We suggest that relational abstraction requires structural alignment and therefore that comparison is critical for relational abstraction. However, we would not claim that simultaneous presentation is *necessary* for abstraction. It is clear that adults can align sequentially presented examples (e.g., Reed, 1987; Ross & Kennedy, 1990)—although adults also benefit from conditions that encourage comparison (Catrambone & Holyoak, 1989; Loewenstein

et al., 1999). Further, young children (Casenhiser & Goldberg, 2005; Childers, 2008; Kotovsky & Gentner, 1996) and even infants (Marcus, Vijayan, Bandi, & Vishton, 1999; Saffran, Pollak, Seibel, & Shkolnik, 2007) can learn new relational patterns given a sufficient set of sequential examples. We believe such learning depends on the learner's being able to align the sequential representations. If so, then future research should examine the factors that govern whether sequential alignment will occur (Namy & Gentner, 2005). Some obvious candidates are the surface similarity of the instances, the delay between instances, and the quality of the learner's existing domain knowledge. The answers to these questions will help explain how children learn so much so fast and why they sometimes fail.

Finally, we are not arguing against hypothesis testing as a useful way of thinking about some kinds of learning. On the contrary, a moment of introspection will convince anyone that we often entertain alternate possibilities for a new concept. Rather, we argue that structural alignment provides a natural mechanism for the generation of new hypotheses, which can then be used in subsequent learning.

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