Similarity & Structural Alignment: You Can Have One Without the Other

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Abstract

Several studies have shown that similarity judgements involve a process of structural alignment akin to analogical mapping. In particular, it has been shown that people appear to rely more on the relational structure of scenes involving cross-mappings, if they have previously carried out a similarity judgement task on these scenes (e.g., Markman & Gentner, 1993b). We report a study which shows that similarity judgements do not necessarily invoke structural alignment but that other task demands and the materials presented are more critical in selecting the comparison mechanism used in a given situation. The wider implications of these results for models of similarity and comparison are considered.

Introduction

A considerable body of recent research has shown that similarity comparisons can involve a process of structural alignment (see e.g., Goldstone, 1994; Goldstone & Medin, 1994; Goldstone, Medin & Gentner, 1991; Markman & Gentner 1993a, 1993b, 1997; Medin, Goldstone & Gentner, 1993). Representationally, this view characterises knowledge as structured hierarchies encoding objects, object attributes, relations between objects and relations between relations. Given these representations it is assumed that similarity comparisons involve the alignment of relational structure to find the most structurally consistent match between two systems of concepts, that satisfies the constraints of parallel connectivity (if two relations match, their arguments must match) and one-to-one mapping (that each item in one structure may only be mapped to one other item). Computationally, these ideas have been realised by a family of models that simulate analogical mapping (see e.g., Falkenhainer, Forbus & Gentner, 1989; Gentner, 1983, 1989; Holyoak & Thagard, 1989; Hummel & Holyoak, 1998; Keane, 1988, 1997; Keane & Brayshaw, 1988; Keane, Ledgeway & Duff, 1994; Veale & Keane, 1994, 1997, 1998). Indeed, structural alignment is fast emerging as a unified account of a diverse range of phenomena including similarity, analogy, metaphor and concept combination (see Keane & Costello, 1998).

Markman & Gentner (1993b) provided one of the key pieces of evidence supporting the role of structural alignment in similarity judgements. They used a one-shot mapping task in which subjects had to identify a cross-mapped object between two drawn scenes (see Appendix A). A cross-mapped object was defined as an object in one drawing that was perceptually similar to an object in a different relational role in the other drawing. So, for example, in the baseball scenes shown in Appendix A, the cross-mapped object would be the pitcher with the "C" on his uniform, because he is pitching in the upper scene and being pitched to in the other scene. Markman & Gentner have proposed that structural alignment is reflected in this task when subjects make relational responses (i.e., choosing the object in the same role) as opposed to object responses based on perceptual, feature similarity (i.e., choosing the perceptually similar object in a different role). The key manipulation asked participants to perform a similarity judgement task on the picture-pairs either before or after the mapping task. They found that when participants made the similarity judgement *before* the mapping task they made more relational responses than when it was presented *after* the mapping task. Thus, the result strongly suggested that the similarity judgement task invoked a structural alignment process which then carried over to the mapping task increasing the proportion of relational responses (significantly, when an aesthetic-appreciation task was given before the mapping task no facilitation in relational responding was found). However, we believe that this conclusion is unwarranted given the nature of the materials used and task demands. We argue that the similarity judgement task does not necessarily invoke structural alignment.

First, Markman & Gentner's materials may have contained unintended cues that promoted relational responding in participants. While the pictures used were designed to be understood without introducing linguistic factors, we believe that to understand the scenes subjects

has to consider word-labels in the drawings. For example, in the feeding-pair, to understand that the woman is *receiving* food rather than *giving* food, one needs to use the written dialogue of the woman saying "Thank You" (see Appendix A). This dependence on linguistic factors in the picture may have promoted relational responding over a more perceptually-based response. More seriously, in some of their materials, the critical relations underlying the relational response are named in the picture (see e.g., the baseball pair in which "Pitch" is written) thereby drawing attention to responses using this relation.

Second, the task demands governing the way in which the pictures were presented may also have promoted relational responding. Participants were given 8 stimuli all of which portrayed picture pairs with relational similarities. So, independent of any effects of the similarity judgement task, participants may just have "guessed the game" and responded appropriately: that is, during the course of the similarity task subjects may have decided from the predominantly relational nature of the pictures that they were meant to map on a relational basis. Additionally, the fact that subjects were asked to make comparisons on a series of pictures of approximately equivalent similarity may also have been an added extraneous variable.

To remedy these possible deficiencies we constructed a set of materials that involved cross-mappings as defined by Markman & Gentner, but omitted any linguistic cues and names of key relations. We then expanded the set of presented materials to include 16 fillers that lacked relational similarities to balance the 8 pairs designed to have relational similarities (akin to Markman & Gentner's set). As in Markman & Gentner's study, participants either performed the similarity judgement task before or after the mapping task. The new variable introduced was the presentation order of the materials (relational-first versus relational-distributed). In the *relational-first* condition the 8 relational materials were blocked at the beginning of the booklet followed by the fillers (akin to the way in which Markman & Gentner's participants would have encountered them). In the *relational-distributed* condition, the 8 relational materials were randomly distributed among the fillers.

As such, we had a 2 x 2 between-subject design where the variables were task-order (similarity task before or after mapping task) and stimulus-order (relational materials blocked at beginning of stimuli set or randomly distributed throughout the set). As the relational stimuli meet the constraints set down by Markman & Gentner, they would predict that task-order should affect relational responding, with more relational responses being made when the similarity-judgement task is before as opposed to after the mapping task. Taking the opposing view, we do not believe that similarity judgements necessarily induce a structural alignment process and would argue that the nature of the material set is more important, that structural alignment is used when stimulus conditions appear to require it. Hence, we predict that stimulus-order should have the dominant effect on relational responding, with more relational responses being induced when the relational materials are blocked to the front of the stimulus set as opposed to distributed throughout the set.

Method

Subjects. Forty-eight undergraduate students and staff members at University College Dublin took part voluntarily in the experiment and were randomly assigned to one of the four between-subjects conditions.

Stimuli. The stimuli for this experiment consisted of 8 pairs of pictures depicting causal scenes with matching relational structure and 16 filler pairs. Each of these 8 pairs contained a cross-mapping as operationalized by Markman and Gentner (1993b) in which a pair of perceptually-similar objects were shown which played different roles in the matching relational structure of the two scenes (see Appendix B for an example). The pictures were designed so that in half of the pairs the perceptually-similar objects were in approximately the same spatial position while in the other half the objects in the same relational roles were in the same position. Additionally, half of the pairs had relations moving in the same direction, while the other half had relations moving in opposite directions.

Eight of the filler pairs depicted comparable scenarios without matching relational structure (e.g. two beach scenes, one with a man surfing another with a child is building a sand castle) and the other 8 pairs did not match in either scenario or relational structure (e.g. a scene of an artist and a scene of a man in a grocery store).

The stimuli were presented in booklet form with one pair on each page (one picture above the other). The stimuli for the mapping task had an arrow placed above an object in the top scene. For the 8 relational pairs this was the cross-mapped object, otherwise it was an object which appeared in both scenes. The stimuli used for the similarity rating task had a scale with the numbers 1 through 9 at the bottom of the page. The words Low Similarity appeared under the 1 and the words High Similarity appeared under the 9.

Booklets in the relational-distributed condition had a completely randomised presentation of the 24 pairs for both the mapping and the similarity tasks. Booklets in the relational-first condition had a randomised block of the 8 matching relational pairs to the front of the booklet followed by the filler pairs.

Procedure. As in Gentner & Markman's study, the first page of the mapping section of the booklet instructed subjects to draw a line from the object under the arrow to the object in the bottom scene that "best went with that object". The first page of the similarity judgement section instructed subjects to rate the similarity of the two scenes by circling a number on the scale at the bottom of the page.

Subjects in the similarity-after conditions received a booklet with the mapping task followed by the similarity

judgement task while subjects in the similarity-before condition received a booklet with the similarity judgement task first.

Subjects were tested in small groups of varying sizes and each experimental session took between 10 and 15 minutes.

Scoring. As in Gentner & Markman's study, participants' responses to the 8 relational pairs in the mapping task were determined as an *object mapping* if a line was drawn from the cross-mapped object to the featurally-similar object in the bottom scene; a *relational mapping*, if a line was drawn to the object in the same relational role in the bottom scene; or a *spurious mapping* if a line was drawn to another, unrelated object. As spurious mappings occurred in less than 1% of the responses, they were not considered.

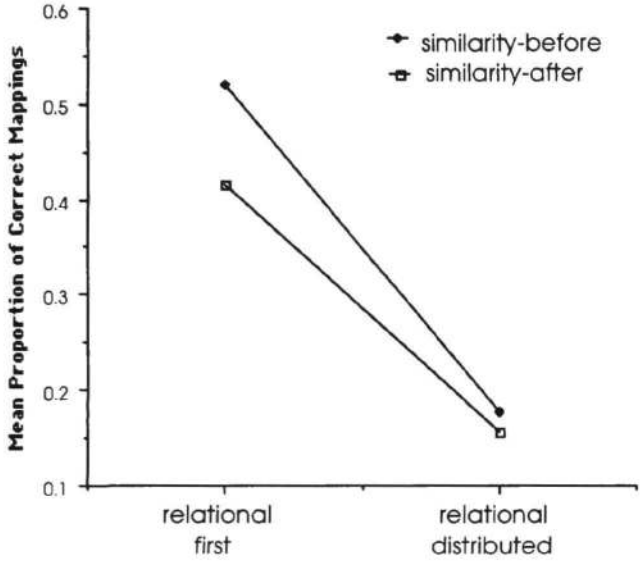

Figure 1. The Proportion of Relational Responses Made

Results & Discussion

A two-way, between-subjects ANOVA found a reliable effect of stimulus-order with a higher proportion of relational responses in the relational-first conditions (M = 0.52 and M=.42) than in the relational-distributed conditions (M = 0.18 and M = .16), $F(1,44) = 10.51$, $p<.01$, $MSError$ = 0.104 (see Figure 1). This effect demonstrates that relational responding increases when the relational pictures are presented in a block before the fillers, and decreases markedly when the relational pictures are distributed among filler materials. Contrary to Markman and Gentner's predictions, no reliable effect was found for the task-order variable, $F(1,44) = .450$, $p > .10$. Finally there was no reliable interaction between task-order and materials-order, $F(1,44) = .200$, $p > .10$.

General Discussion

Markman & Gentner suggested that similarity judgements invoked structural alignment and that this promoted relational responding in a subsequent one-shot, cross-mapping task; that in this task you can't have a similarity without structural alignment. We have found that when the possible extraneous influences on the materials are ruled out and they are presented in the context of fillers, markedly different results are found. First, we found that the similarity-task produced had no sole effect or interaction effects on relational responses. So, following the logic of Markman & Gentner's study similarity must not necessarily involve structural alignment. Second, the marked increase in relational responses in the relational-first condition demonstrates that the way the materials are presented is more important in determining whether structural alignment is used or not. This suggests a more contingent interaction between people and the task situation which is not well captured by current models of structural alignment and analogy. It also shifts the focus of research in this field to the issue of the "calling conditions" for the use of one similarity mechanism rather than another.

There is one remaining mystery about the relationship of these results to those of Markman & Gentner; namely, why was it that a preceding similarity judgement task increased relational responding when an aesthetic-appreciation task with the same materials did not ? We would argue that it was not the structural alignment *per se* that produced this effect, but rather that the materials drew attention to the fact that every picture was similar to its partner in sharing the same relation. The similarity judgement task helped in "guessing the game", the aesthetic-appreciation task did not. Thus when asked to perform the relatively ambiguous mapping task, subjects responded accordingly.

The current research reveals a lack of featural or relational dominance in similarity judgements, suggesting that similarity is a pluralistic process, that is very sensitive to the conditions at hand (as has been partly argued by Medin, Goldstone & Gentner, 1993). Similarity does not *necessarily* invoke an analogical structural-alignment mechanism, but involves dynamic switching between a structural alignment and a feature-comparison mechanism. More broadly, as similarity does not appear to be governed by a process of structural alignment in every instance, a unified account of comparison in general (e.g., similarity, analogy, metaphor and concept combination) as being based on structural alignment becomes less tenable (see Keane & Costello, 1998; Costello & Keane, in press).

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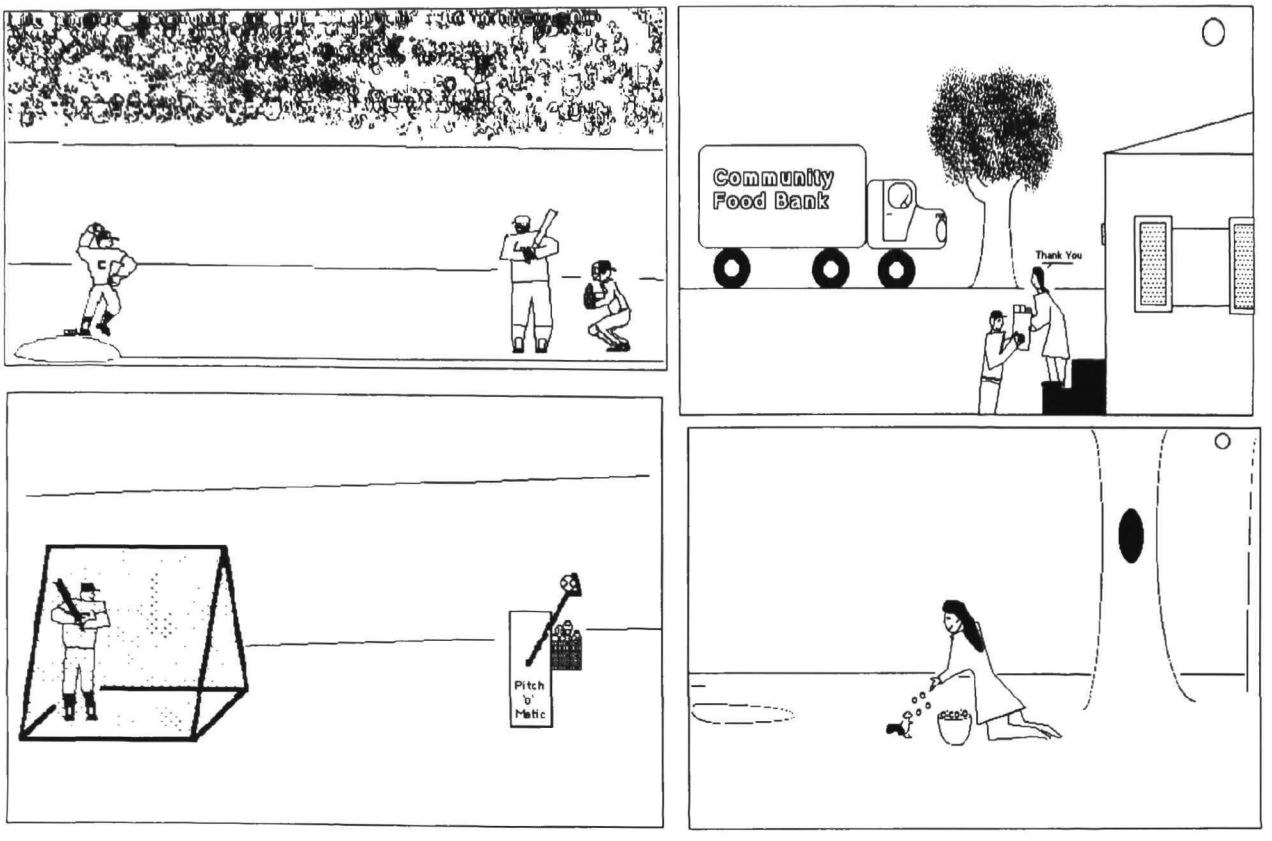
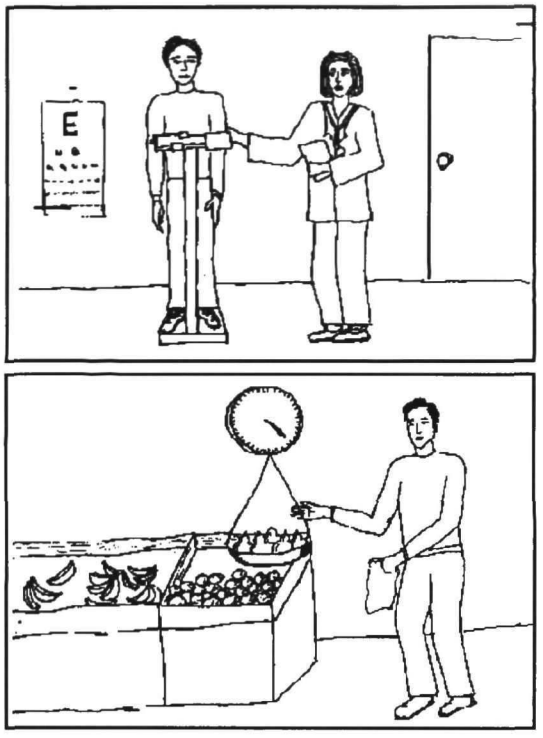
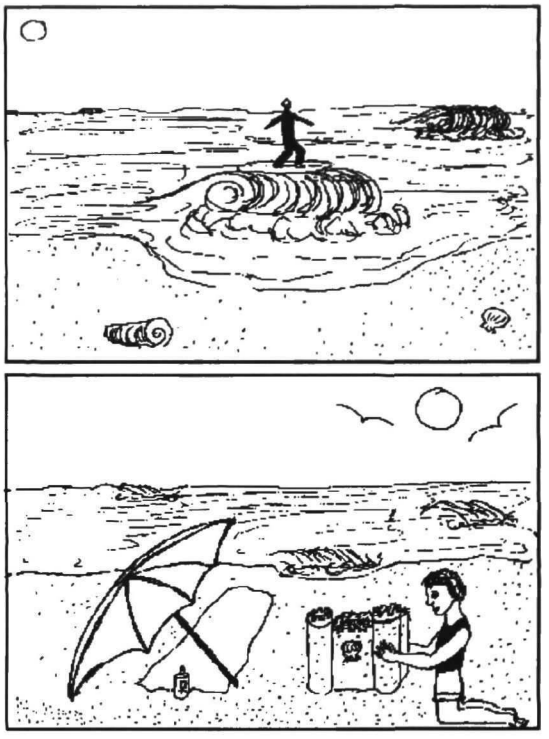
Appendix A. Two of the Materials. -- the Baseball and Giving Materials -- Used by Markman & Gentner (1993b)



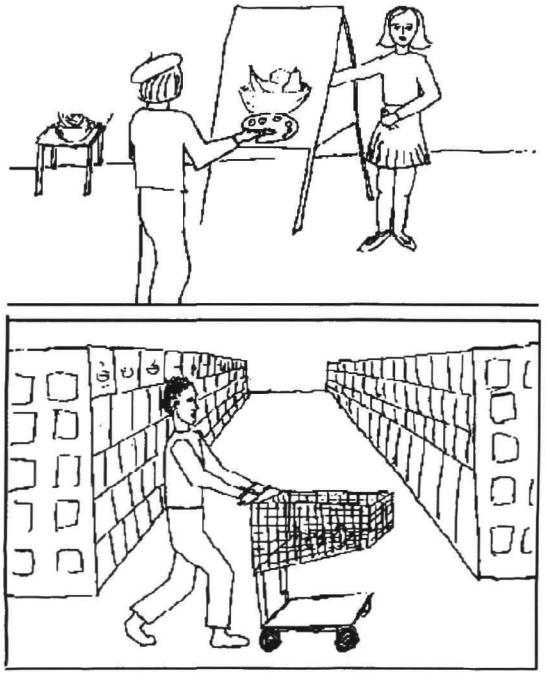
Appendix B. An example of the materials used in the present study showing (a) a relational pair, (b) a filler with featural rather than relational overlap and (c) a filler with little featural or relational overlap.



a.



b.



c.