Bulletin of the Psychonomic Society
1986, 24 (6), 413-415

"Robins are a part of birds": The confusion of semantic relations

DOUGLAS J. HERRMANN
Hamilton College, Clinton, New York

and

ROGER CHAFFIN and MORTON E. WINSTON
Trenton State College, Trenton, New Jersey

Multidimensional scaling, applied to similarity ratings of parts, was used to demonstrate that parts are not organized in memory in terms of similarity. Parts differ, in this way, from category members. Similarity is one element of the class inclusion relation, but not of the part-whole relation. Failure to attend to the properties of relations is one source of relation confusion. Relation confusion appears to be pervasive in relation comprehension and this raises doubts about the use of semantic relations as theoretical primitives in theories of semantic memory.

Studies of semantic decisions have focused primarily on the class inclusion relation (Chang, 1986; Danks & Glucksberg, 1980; Kintsch, 1980; Smith, 1977). In order to establish the generality of the empirical relations obtained in studies of class inclusion, it is necessary to study other semantic relations. One relation that has received little attention is the part-whole relation (Evens, Litowitz, Markowitz, Smith, & Werner, 1980; Winston & Chaffin, in press).

The part-whole relation is an important one. As a transitive inclusion relation, it has the same ability as class inclusion to provide structure to the lexicon (Cruse, 1979); it occurs frequently in lexical definitions (Amsler, 1981); and parts are frequently given as properties of objects (Tversky & Hemenway, 1984). The part-whole relation is also interesting because of its similarity to the class inclusion relation that has been the major focus of attention. Indeed, the two relations are often confused. For example, the Battig and Montague (1969) category norms include, along with such taxonomic categories as *precious stones* and *birds*, *part of a building* and *part of the human body*. Part-whole pairs have also appeared in many studies ostensibly about class inclusion decisions (e.g., Freedman & Loftus, 1971; Smith, Shoben, & Rips, 1974; Wilkins, 1971).

One procedure that has often been used to study the representation of categories in semantic memory is multidimensional scaling. For example, several researchers (e.g., Henley, 1969; Rips, Shoben, & Smith, 1973) have obtained similarity ratings for all possible pairings of sets of animal terms. Multidimensional scaling of the ratings allows the similarity of the concepts to be represented as distance in an *n*-dimensional space. Rips et al. (1973) obtained two dimensions that they interpreted as representing *size* (horse vs. hamster) and *predacity* (lion vs. sheep). They concluded that "the dimensions...presumably reflect underlying characteristic features of the category" (Smith et al., 1974, p. 219). The size and predacity dimensions, as well as the interpoint distances of the two-dimensional solutions, have been found to be highly replicable, even across different cultures (Herrmann & Raybeck, 1981). We used the same procedure to study the organization of a domain defined by the part-whole relation—parts of the human foot.

Correspondence should be sent to D. J. Herrmann, Department of Psychology, Hamilton College, Clinton, NY 13323.

METHOD

Twenty-two undergraduates at Trenton State College participated in the study.

Seven parts of the foot were selected for study: the heel, arch, big toe, second toe (next to the big toe), middle toe, fourth toe (next to the little toe), and little toe. Subjects rated the similarity of all pairwise comparisons of the seven parts on a 5-point scale on which 1 represented *very similar* and 5 represented *not similar*.

RESULTS

The mean ratings for all possible pairs (21 pairs, ignoring order) were submitted to the Shepard-Kruskal MDSCAL program in the OSIRIS package without a starting configuration for two- and three-dimensional solutions. The stress values for the two- and three-dimensional solutions were very similar (.006 and .007, respectively). The simpler two-dimensional solution is therefore presented in Figure 1.

Inspection of Figure 1 shows that, as in earlier studies (e.g., Rips et al., 1973), the solution provides insight into conceptual organization. The dimensions of the solution bear a striking resemblance to the size and predacity dimensions obtained for animals by Rips et al. The verti-

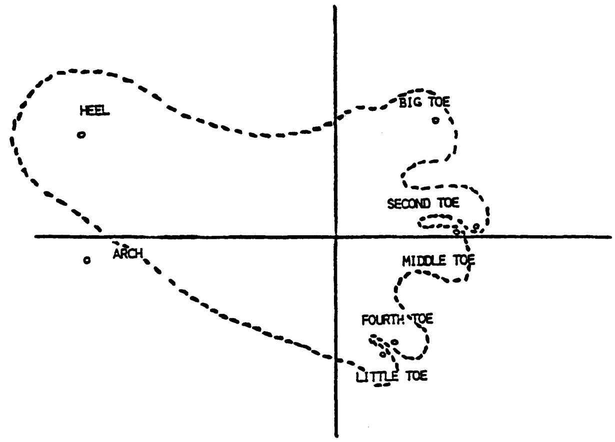

Figure 1. Multidimensional scaling solution of similarity ratings of seven parts of the foot.

cal dimension appears to represent size (big vs. little toe) and the horizontal dimension may be viewed as "pedacity" (toe vs. heel).

There is also a second plausible interpretation. This is suggested by the dotted line in Figure 1. The organization appears to be based on spatial proximity. The only point that does not fit this interpretation is the arch. This inconsistency was resolved by the three-dimensional solution, which, although not significantly different from the two-dimensional solution, positioned the arch above the plane of the other parts. The "fallen" arch in Figure 1 was, therefore, the result of forcing a three-dimensional spatial organization into a two-dimensional representation. Consistent with the spatial interpretation is the fact that the subjects appear to have rated their right feet, which may reflect the lateralization of spatial information.

DISCUSSION

Although the description of the results is intended to be humorous, the results do make two serious points. The part-whole and class inclusion relations are different, and differences between relations are easily overlooked. We will discuss each point in turn.

First, one glance at Figure 1 reveals that the organization is fundamentally different from that of any category. Spatial isomorphism with a physical object is impossible for category members because a category is not a physical object; there is no physical object for the similarity of category members to be isomorphic with. In contrast, it is not surprising to find that parts are organized spatially (Kosslyn & Pomerantz, 1977), because parts of a physical object are physically included in the whole. Categories, on the other hand, may plausibly be expected to be organized in terms of similarity. For taxonomic categories, similarity is one of the criteria for membership (Chaffin & Herrmann, in press; Wierzbicka, 1984). The use of similarity ratings to explore the structure of categories is reasonable; their use to study the organization of parts is ridiculous.

We suspect that the absurdity of the procedure was not apparent to the reader at the outset. Why not? One reason is that the part-whole and class inclusion relations are easily confused. They are similar because both are transitive inclusion relations (Cruse, 1979; Lyons, 1977). *Birds* includes robins in its denotation and a car includes its wheels. In addition, the verbal expressions for the two relations can be confused. So long as we simply use the expressions *kind of* and *part of*, there is no danger of confusion. It is clear that "a robin is a kind of bird" and "a wheel is part of a car"; there is no temptation to say that "a robin is part of a bird" or that "a wheel is a kind of car." But we have heard people argue that the two relations are the same because "robins are a part of birds," meaning "robins are members of the class of birds."

The source of the confusion is that membership in a group looks very much like membership in a class. Group membership is a part-whole relation; for example, "He is part of the group." The criteria for membership in a group involve a social transaction or simply spatial proximity (Markman, 1982). The criteria for membership in a taxonomic category, in contrast, involve similarity to other members (Chaffin & Herrmann, in press; Wierzbicka, 1984). The difference is easily overlooked, but its importance is illustrated by the absurd result in Figure 1.

The second point the study makes is that relations are easily confused, even when they are very dissimilar. If it was absurd to use similarity ratings to investigate the organization of parts in memory, why were the results so easily interpreted? How did we obtain a spatial organization from similarity ratings? Proximity and similarity are totally different relations.

The explanation appears to be that our subjects confused similarity with proximity. They were told to rate similarity, but proximity was a more salient relation, and proximity was what they rated. If Figure 1 represented an isolated result, we might attribute it to a coincidental isomorphism between the proximity and similarity of parts of the foot. But it is not an isolated result. Shepard and Arabie (1979) reported a scaling solution for similarity ratings of a wide variety of body parts in which the clusters represented spatially contiguous parts. Subjects are apparently willing to substitute proximity for similarity.

We have provided two examples of the confusion of relations. First, the difference between the class inclusion and part-whole relations has sometimes been overlooked by researchers in the field of semantic memory, and we may have led our readers into the same confusion with our rating procedure for parts of the foot. Second, subjects confused proximity with similarity in our experiment and in that of Shepard and Arabie (1979).

Three factors may contribute to such confusions. The confusion of the part-whole and class inclusion relations may be accounted for, in part, by their similarity—both are hierarchical inclusion relations. The confusion of similarity and proximity may also be due to the salience of proximity in the experimental task. A third factor that may contribute to relation confusion in both cases is the similarity of the verbal expressions of the two relations. Subjects may have justified their substitution of proximity for similarity on the grounds that proximity is "similarity in spatial location." This verbal transformation of one relation into another is similar to that accomplished by the justification for conflating the class inclusion and part-whole relations—"robins are a part of birds."

Confusion of semantic relations is a common phenomenon that should be explained by theories of semantic memory. The phenomenon is important because it raises doubts about the use of semantic relations as theoretical primitives in network models of semantic memory (e.g., Anderson, 1976; Norman & Rumelhart, 1975; see reviews by Chang, 1986; Johnson-Laird, Herrmann, & Chaffin, 1984). In these models, concepts are represented by nodes interconnected by labeled pointers that represent common semantic relations, for example, class inclusion and part-whole. Several investigators have questioned the assumption made by this use of semantic relations that the presence of a relation between two concepts is an all-or-nothing state (Rosch, 1975; Smith et al., 1974). The phenomenon of relation confusion raises doubts about a second assumption: that the relations represented by pointers are clearly distinct from one another. Semantic relations, it appears, are not clearly distinct, but are frequently confused with one another.

REFERENCES

Amsler, R. A. (1981). A taxonomy for English nouns and verbs. In *Proceedings of the 19th Annual Meeting of the Association for Computational Linguistics* (pp. 133-138). New York: Cambridge University Press.

Anderson, J. R. (1976). *Language, memory and thought.* Hillsdale, NJ: Erlbaum.

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monographs*, **80**(3, Pt. 2).

CHAFFIN, R., & HERRMANN, D. J. (in press). Relation element theory: A new account of the representation and processing of semantic relations. In D. Gorfein & R. Hoffman (Eds.), *Memory and learning: The Ebbinghaus Centennial Conference*. Hillsdale, NJ: Erlbaum.

CHANG, T. M. (1986). Semantic memory: Facts and models. *Psychological Bulletin*, **99**, 199-220.

CRUSE, D. A. (1979). On the transitivity of the part-whole relation. *Journal of Linguistics*, **15**, 29-38.

DANKS, J. H., & GLUCKSBERG, S. (1980). Experimental psycholinguistics. In M. R. Rosenzweig & L. W. Porter (Eds.), *Annual Review of Psychology* (Vol. 30). Palo Alto, CA: Annual Reviews.

EVENS, M. W., LITOWITZ, J. A., MARKOWITZ, R. N., SMITH, R., & WERNER, O. (1980). *Lexical-semantic relations: A comparative survey.* Edmonton, Canada: Linguistic Research, Inc.

FREEDMAN, J. L., & LOFTUS, E. F. (1971). Retrieval of words from long-term memory. *Journal of Verbal Learning & Verbal Behavior*, **10**, 107-115.

HENLEY, N. M. (1969). A psychological study of the semantics of animal terms. *Journal of Verbal Learning & Verbal Behavior*, **8**, 176-184.

HERRMANN, D. J., & RAYBECK, D. (1981). Similarities and differences in meaning in six cultures. *Journal of Cross-Cultural Psychology*, **12**, 194-206.

JOHNSON-LAIRD, P. N., HERRMANN, D. J., & CHAFFIN, R. (1984). Only connections: A critique of semantic networks. *Psychological Bulletin*, **96**, 292-315.

KINTSCH, J. (1980). Semantic memory: A tutorial. In R. S. Nickerson (Ed.), *Attention and Performance* (Vol. 8). Hillsdale, NJ: Erlbaum.

KOSSLYN, S. M., & POMERANTZ, J. R. (1977). Imagery, propositions, and the form of internal representations. *Cognitive Psychology*, **9**, 52-76.

LYONS, J. (1977). *Semantics: Vol. 1*. Cambridge, England: Cambridge University Press.

MARKMAN, E. M. (1982). Two different principles of conceptual organization. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology*. Hillsdale, NJ: Erlbaum.

NORMAN, D. A., & RUMELHART, D. E. (1975). *Explorations in cognition*. San Francisco: W. H. Freeman.

RIPS, L. J., SHOBEN, E. J., & SMITH, E. E. (1973). Semantic distance and the verification of semantic relations. *Journal of Verbal Learning & Verbal Behavior*, **12**, 1-20.

ROSCH, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General*, **4**, 192-206.

SHEPARD, R. N., & ARABIE, P. (1979). Additive clustering: Representation of similarities as combinations of discrete overlapping properties. *Psychological Review*, **86**, 87-123.

SMITH, E. E. (1977). Theories of semantic memory. In W. K. Estes (Ed.), *Handbook of learning and cognitive processes* (Vol. 5). Hillsdale, NJ: Erlbaum.

SMITH, E. E., SHOBEN, E. J., & RIPS, L. J. (1974). Structure and process in semantic memory: A feature model for semantic decisions. *Psychological Review*, **3**, 214-241.

TVERSKY, B., & HEMENWAY, K. (1984). Objects, parts, and categories. *Journal of Experimental Psychology: General*, **113**, 170-197.

WIERZBICKA, A. (1984). Apples are not a "kind of fruit": The semantics of human categorization. *American Ethnologist*, **11**, 313-328.

WILKINS, A. J. (1971). Conjoint frequency, category size, and categorization time. *Journal of Verbal Learning & Verbal Behavior*, **10**, 382-385.

WINSTON, M., & CHAFFIN, R. (in press). A taxonomy of part-whole relations. *Cognitive Science*.

(Manuscript received for publication June 28, 1986.)