

Systematicity as a Processing Constraint on Feature Centrality

Jason Jameson & Dedre Gentner

Department of Psychology
Northwestern University

Introduction

In judging the similarity of two objects, are some features more central than others? On one account (Murphy & Medin, 1985), the answer is “yes”: features are more central to the extent that they play an important explanatory role in the theoretical knowledge underlying an object’s category. For example, the feature “curvedness” is more central to boomerangs than to bananas, because the feature plays a critical explanatory role in the former case than in the latter. Much empirical evidence supports this view (e.g., Ahn, et al., 2000). What is missing, however, is a process model that incorporates the detailed explanatory knowledge that might underlie the evaluation of a feature’s centrality.

As a plausible starting point, we adopt structure-mapping theory (SMT), which describes the comparison process as an alignment of *structured representations* (e.g., Gentner, 1983). In SMT, a concept’s explanatory value and predictive power is indexed by systematicity, a measure of a conceptual system’s internal constraint. That is, a representation is more systematic to the extent that objects are constrained by first-order predicates (i.e., relations), which are themselves constrained by higher-order predicates (i.e., relations between relations), and so on, yielding a progressively deeper hierarchical structure. Though this principle has typically been applied to contexts involving two compared representations, it can easily be applied to the case of measuring the systematicity of a single representation. We investigated whether and to what extent systematicity influences the relative impact of differences during similarity comparisons. The prediction is that changes to more central features will reduce similarity more than changes to less central features.

Experiment

By assuming structured representations, SMT predicts a distinction between kinds of differences: *alignable* (connected to shared structure: “Cars have 4 wheels, motorcycles 2”), and *nonalignable* (not so connected: “Cars have wheels, magazines don’t”). The psychological validity of this distinction is supported by much empirical work (e.g., Markman & Gentner, 1993). Based on this distinction, because some elements may be more central than others, we propose a distinction between kinds of alignable differences. Since comparisons seek to maximize systematic structure, changes to elements that contribute the most to systematicity will be more influential, and will reduce similarity more than the same change to elements that contribute less.

To provide a relatively unambiguous test of this prediction, we operationalized systematicity as a perceptual figure’s goodness-of-form (*G*) (Palmer, 1977) using Palmer’s quantitative measure. It incorporates relations between features (line segments), and hierarchical structure binding relations. Centrality of a feature *i* was indexed by the difference in *G* for a figure with *i* and *G* without it.

Participants were 72 Northwestern undergraduates, who saw 20 triads (10 test, 10 fillers) comprising a standard (*St*) and two comparison figures (*CF*), one involving a change to a central element (*Hi-Imp Ch*), and one to a less central element (*Lo-Imp Ch*). The 10 test standards were taken from Palmer’s study, for which estimates of *G* had been empirically supported. Below is a sample item.

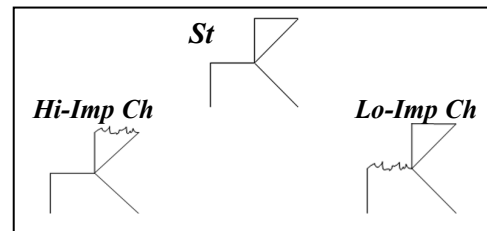


Figure 1: Sample test item.

As predicted, changes to more central features led to a greater reduction in similarity: *Ps* chose the *Low-Imp Ch* most often as most similar to the *St* ($M=.56$, $SD=.18$, $t(71)=2.89$, $p<.01$). Overall, the results suggest that systematicity can act as a process-based determinant of feature centrality.

Future work should include conceptually richer stimuli, such as causal knowledge, which has tended to be the focus of much previous research on feature centrality (e.g., Ahn, et al. 2000).

References

- Ahn, W., Kim, N. S., Lassaline, M. E., & Dennis, M. J. (2000). Causal status as a determinant of feature centrality. *Cognitive Psychology*, 41, 361 - 416.
- Gentner, D. (1983). Structure-mapping: A theoretical framework for analogy. *Cognitive Science*, 7, 155-170.
- Markman, A. B., & Gentner, D. (1993). Splitting the differences: A structural alignment view of similarity. *Journal of Memory and Language*, 32, 517-535.
- Murphy, G., & Medin, D. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92, 289-316.
- Palmer, S. E. (1977) Hierarchical structure in perceptual representation. *Cognitive Psychology*, 9, 441-474.