

- Joshi, A., K. Vijay-Shanker, and D. Weir. (1991). The convergence of mildly context-sensitive formalisms. In P. Sells, S. Shieber, and T. Wasow, Eds., *Processing of Linguistic Structure*. Cambridge MA: MIT Press, pp. 31–81.
- Karttunen, L. (1989). Radical lexicalism. In M. R. Baltin and A. S. Kroch, Eds., *Alternative Conceptions of Phrase Structure*. Chicago: University of Chicago Press.
- Lambek, J. (1958). The mathematics of sentence structure. *American Mathematical Monthly* 65: 154–170.
- Lewis, D. (1970). General semantics. *Synthese* 22: 18–67.
- Lyons, J. (1968). *Introduction to Theoretical Linguistics*. Cambridge: Cambridge University Press.
- Montague, R. (1974). *Formal philosophy: Papers of Richard Montague*, Richmond H. Thomason, Ed. New Haven: Yale University Press.
- Moortgat, M. (1988). *Categorial Investigations*. Ph.D. diss., Universiteit van Amsterdam. (Published by Foris, 1989).
- Morrill, G. (1994). *Type-Logical Grammar*. Dordrecht: Kluwer.
- Oehrle, R. T. (1988). Multidimensional compositional functions as a basis for grammatical analysis. In R. T. Oehrle, E. Bach, and D. Wheeler, Eds., *Categorial Grammars and Natural Language Structures*. (Proceedings of the Conference on Categorial Grammar, Tucson, AZ, June 1985). Dordrecht: Reidel, pp. 349–390.
- Prevost, S. (1995). *A Semantics of Contrast and Information Structure for Specifying Intonation in Spoken Language Generation*. Ph.D. diss., University of Pennsylvania, Philadelphia, PA.
- Szabolcsi, A. (1989). Bound variables in syntax: are there any? In R. Bartsch, J. van Benthem, and P. van Emde Boas, Eds., *Semantics and Contextual Expression*. Dordrecht: Foris, pp. 295–318.
- van Benthem, J. (1986). *Essays in Logical Semantics*. Dordrecht: Reidel.

Further Readings

- Buszkowski, W., W. Marciszewski, and J. van Benthem, Eds. (1988). *Categorial Grammar*. Amsterdam: John Benjamins.
- Moortgat, M. (1997). Categorial type logics. In J. van Benthem and A. ter Meulen, Eds., *Handbook of Logic and Language*. Amsterdam: North Holland, pp. 93–177.
- Oehrle, R., E. Bach, and D. Wheeler. (1988). *Categorial Grammars and Natural Language Structures*. Dordrecht: Reidel.
- Steedman, M. (1996). *Surface Structure and Interpretation*. Linguistic Inquiry Monograph 30. Cambridge MA: MIT Press.
- Wood, M. M. (1993). *Categorial Grammar*. Routledge.

Categorization

Categorization, the process by which distinct entities are treated as equivalent, is one of the most fundamental and pervasive cognitive activities. It is fundamental because categorization permits us to understand and make predictions about objects and events in our world. People (necessarily) make use of only the tiniest fraction of the possible categorization schemes, but even a modest-sized set of entities can be grouped in a limitless number of ways. Therefore, a fundamental question is why we have the categories we have and not others. Further, what do our categorization schemes allow us to do that other schemes would not?

There has been a plethora of work on the structure of categories, mostly examining natural object categories (see Smith and Medin 1981; Rips 1990; Komatsu 1992 for

reviews). A powerful but controversial idea is that SIMILARITY is an organizing principle. Within this framework, there are important distinctions concerning just how similarity operates, but we will not be concerned with them here (see Medin 1989 for a review). Simply stated, this view suggests that we put things in the same categories because they are similar to each other. A robin and a hawk (both birds) seem obviously more similar than a robin and an elephant (not a bird); elephants are not birds because they are not sufficiently similar to them. A natural consequence of this similarity view is that the world is organized for us and our categories map onto this reality (e.g., Rosch and Mervis 1975).

Why is this notion that categories are defined by some "objective" similarity controversial? The main criticism has been that the notion of similarity is too unconstrained to be useful as an explanatory principle (Goodman 1972; Murphy and Medin 1985). Similarity is usually defined in terms of shared properties, but Goodman argued that any two things share an unlimited number of properties (e.g., robins and elephants can move, weigh more than an ounce, weigh more than two ounces, take up space, can be thought about, etc.). Given this apparent flexibility, it may be that we see things as similar *because* they belong to the same category and not vice versa. That is, maybe we can explain similarity in terms of categories.

An alternative to the similarity view of categorization is that *theories* provide conceptual coherence (Carey 1985; Keil 1989; Medin 1989; Rips 1989; Hirschfeld and Gelman 1994). The theory-based explanation of categorization is consistent with the idea that CONCEPTS are comprised of features or properties. By concept, we mean the mental representation of a category that presumably includes more than procedures for identifying or classifying. These explanations go beyond similarity models in arguing that underlying principles (often causal) determine which features are relevant and how they might be interrelated (Komatsu 1992; see also Billman and Knutson 1996).

In current cognitive science theorizing, similarity has a role to play but a limited one that, in many respects, changes its character. Researchers who focus on similarity (e.g., Nosofsky 1988) use models of selective feature weighting such that similarity is, in part, a byproduct of category learning. Other researchers derive a role for similarity from an analysis of how categories might be used to satisfy human goals such as in drawing inferences (e.g., Anderson 1991). Finally, investigators who argue that categories are organized around knowledge structures (e.g., Wisniewski and Medin 1994) allow theories to determine the very notion of what a feature is.

Is there a single set of principles that applies to all categories? Evidence suggests that there may be important differences among them. First of all, a great deal of attention has been directed to the hierarchical component of categories. Objects can be categorized at different levels of abstraction; for example, your pet Fido can be categorized as a living thing, an animal, a mammal, a dog, or a poodle. Work by Eleanor Rosch and her colleagues (Rosch et al. 1976; see Berlin, Breedlove, and Raven 1973 for related work in anthropology) has shown that one level in this hierarchy,

dubbed the "basic level," seems to be psychologically privileged. In our example, *dog* would be a basic level term, and Rosch et al. found that a number of measures of privilege all converged on this level. The basic level is the level preferred in naming by adults, is the first learned by children, and is the level at which adults can categorize most rapidly. It may be that similarity plays a bigger role in categorization at the basic level than for more superordinate levels. Currently, investigators are actively pursuing issues such as whether the basic level might change with expertise (e.g., Tanaka and Taylor 1991) or vary across cultures (Berlin 1992; Coley, Medin, and Atran 1997). These questions bear on the respective roles of mind and world in categorization (variability with culture or expertise would tend to support the former).

Other researchers have attempted to extend this hierarchical structure to social categories (e.g., race, gender, occupation, etc.). There has been some work applying Rosch's measures of basic levels to the domains of person concepts and routine social events with moderate success (Cantor and Mischel 1979; Morris and Murphy 1990). Note, however, that many social categories are nonhierarchical and categories at the same level of abstractness may be overlapping rather than mutually exclusive. For example, a person can be categorized as a woman, an ethnic minority member, a millionaire, and a celebrity all at the same time. None of these categories are subordinate or superordinate to any other. This raises a new set of questions about which categories are activated in a given situation and how the corresponding concepts are updated with experience. There is even evidence that alternative social categories may compete and inhibit one another (Macrae, Bodenhausen, and Milne 1995). In short, there may be major differences between object and social categories (see Wattenmaker 1995 for a further example).

Goal-derived categories also differ from common taxonomic categories. Barsalou (1983, 1985) has shown that categories activated in the service of goals (e.g., things to take on a camping trip, things to eat when on a diet) may follow different processing principles. For instance, goodness of example for many object categories seems to be based on having typical properties (a robin is judged to be a very typical bird because it looks and acts like many other birds; ostriches are not typical for the opposite reason; see Rosch and Mervis 1975), but for goal-derived categories, goodness of example seems to be based on ideals or extremes. More specifically, the best example of a diet food is one with zero calories, even though zero may not be typical.

Still other researchers have suggested that categorization principles show DOMAIN SPECIFICITY. For example, some have suggested that biological categories constitute a distinct (and innate) domain and that people universally assume that biological categories have an underlying essence that makes things the way they are (Atran 1990). Domain-specificity is a topic that is currently receiving much attention (see chapters in Hirschfeld and Gelman 1994).

Categorization touches on many important applied and theoretical questions. How does the perception of social groups lead to stereotypes (see STEREOTYPING) and other forms of bias? What is the role of language in categorization and conceptual development? To what extent do people who

categorize the same way also have the same concept? These are but a small sample of the fascinating issues associated with research on categorization.

See also ANALOGY; COLOR CLASSIFICATION; CONCEPTUAL CHANGE; FOLK BIOLOGY; NATIVISM; NATURAL KINDS

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References

- Anderson, J. R. (1991). The adaptive nature of human categorization. *Psychological Review* 98: 409–429.
- Atran, S. (1990). *Cognitive Foundations of Natural History: Towards an Anthropology of Science*. Cambridge: Cambridge University Press.
- Barsalou, L. W. (1983). Ad hoc categories. *Memory and Cognition* 11: 211–227.
- Barsalou, L. W. (1985). Ideals, central tendency, and frequency of instantiation as determinants of graded structure of categories. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 11: 629–654.
- Berlin, B. (1992). *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies*. Princeton, NJ: Princeton University Press.
- Berlin, B., D. Breedlove, and P. Raven. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist* 74: 214–242.
- Billman, D., and J. F. Knutson. (1996). Unsupervised concept learning and value systematicity: a complex whole aids learning the parts. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 22: 539–555.
- Cantor, N., and W. Mischel. (1979). Prototypes in person perception. In L. Berkowitz, Ed., *Advances in Experimental Social Psychology*, vol. 12. New York: Academic Press, pp. 3–52.
- Carey, S. (1985). *Conceptual Change in Childhood*. Cambridge, MA: Bradford Books.
- Coley, J. D., S. Atran, and D. L. Medin. (1997). Does rank have its privilege? Inductive inferences within folk biological taxonomies. *Cognition* 64: 73–112.
- Goodman, N. (1972). Seven structures on similarity. In N. Goodman, Ed., *Problems and Projects*. New York: Bobbs-Merrill.
- Hirschfeld, L. A., and S. A. Gelman, Eds. (1994). *Mapping the Mind: Domain Specificity in Cognition and Culture*. New York: Cambridge University Press.
- Keil, F. C. (1989). *Concepts, Kinds and Cognitive Development*. Cambridge, MA: MIT Press.
- Komatsu, L. K. (1992). Recent views of conceptual structure. *Psychological Bulletin* 112: 500–526.
- Macrae, C. N., G. V. Bodenhausen, and A. B. Milne. (1996). The dissection of selection in person perception: inhibitory processes in social stereotyping. *Journal of Personality and Social Psychology*.
- Medin, D. L. (1989). Concepts and conceptual structure. *American Psychologist* 44: 1469–1481.
- Morris, M., and G. L. Murphy. (1990). Converging operations on a basic level in event taxonomies. *Memory and Cognition* 18: 107–418.
- Murphy, G. L., and D. L. Medin. (1985). The role of theories in conceptual coherence. *Psychological Review* 92: 289–316.
- Nosofsky, R. M. (1988). Similarity, frequency and category representations. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14: 54–65.
- Rips, L. J. (1989). Similarity, typicality and categorization. In S. Vosniadou and A. Ortony, Eds., *Similarity and Analogical Reasoning*. Cambridge: Cambridge University Press.