Models of Categorization
Psychology 351 : Seminar in Cognitive Psychology
Fall 1999

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Course Overview
The primary aim of this course is to provide a survey of some contemporary formal models of categorization. A secondary aim is to introduce techniques of mathematical and computational modeling in psychological theorizing. The structure of the course will be a combination of lecture and discussion.

Course Requirement
- ◊ 20-30 minute presentation of an empirical or theoretical papers (🏛's) 20%
- ◊ 15-20 page paper on a topic of your choosing 50%
- ◊ 30 minute presentation of your paper 10%
- ◊ Class participation 20%

Course Readings
- ◊ Copies of articles and book chapters will be available in a folder in the Psychology mailroom. Other readings are available from me (🏛's).

Schedule of Topics
- ◊ **Week 1 : Overview, Classical View, and Prototype Models**

  Komatsu, L.K. (1992). Recent views of conceptual structure. *Psychological Bulletin*, 112, 500-526.

  Medin, D.L. (1989). Concepts and conceptual structure. *American Psychologist*, 44, 1469-1481.

- ◊ **Week 2 : Representation and Similarity**

  Shepard, R.N. (1980). Multidimensional scaling, tree-fitting, and clustering. *Science*, 210, 390-398.

  Shepard, R.N. (1987). Toward a universal law of generalization for psychological science. *Science*, 237, 1317-1323.

  Tversky, A. (1977). Features of similarity. *Psychological Review*, 84, 327-352.

- ◊ **Week 3 : More on Similarity**

  Medin, D.L., Goldstone, R.L., & Gentner, D. (1993). Respects for similarity. *Psychological Review*, 100, 254-278.

  Nosofsky, R.M. (1991). Stimulus bias, asymmetric similarity, and classification. *Cognitive Psychology*, 23, 94-140.

◊ **Week 4 : Introduction to Exemplar models**

Hintzman, D.L. (1986). "Schema abstraction" in a multiple-trace model. *Psychological Review*, 93, 411-428.

Medin, D.L., & Schaffer, M.M. (1978). Context theory of classification learning. *Psychological Review*, 85, 207-238.

◊ **Weeks 5 : The Generalized Context Model**

Nosofsky, R.M. (1984). Choice, similarity, and the context theory of classification. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, 104-114.

Nosofsky, R.M. (1986). Attention, similarity, and the identification-categorization relationship. *Journal of Experimental Psychology: General*, 115, 39-57.

Lamberts, K. (1997). Process models of categorization. In K. Lamberts & D.R. Shanks (Eds.), *Knowledge, concepts and categories. Studies in cognition.* (pp. 371-403). Cambridge, MA, USA: The MIT Press.

◊ **Week 6 : Categorization, Recognition Memory, and Automaticity**

Nosofsky, R.M. (1988). Exemplar-based accounts of relations between classification, recognition, and typicality. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 700-708.

Nosofsky, R.M., & Palmeri, T.J. (1997). An exemplar-based random walk model of speeded classification. *Psychological Review*, 104, 266-300

◊ **Week 7 : Rational Model of Categorization**

Anderson, J.R. (1990). *The adaptive character of thought*. Hillsdale, NJ: Erlbaum. Chapters 1 and 3. (on reserve in psychology mail room).

Anderson, J.R. (1991). The adaptive nature of human categorization. *Psychological Review*. 98, 408-429.

◊ **Weeks 8 and 9 : Connectionist Models of Categorization**

Gluck, M.A., & Bower, G.H. (1988). From conditioning to category learning: An adaptive network model. *Journal of Experimental Psychology: General*, 117, 227-247.

Kruschke, J. (1992). ALCOVE: An exemplar-based connectionist model of category learning. *Psychological Review*, 99, 22-44.

Kosslyn, S., & Koenig, O. (1992). Chapter 2 : Computation in the brain. In *Wet Minds* (pp.17-51). New York: The Free Press. (Optional)

◊ **Week 10 : General Recognition Theory**

Ashby, F.G., & Gott, R.E. (1988). Decision rules in the perception and categorization of multidimensional stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 33-53.

Ashby, F.G., & Lee, W.W. (1991). Predicting similarity and categorization from identification. *Journal of Experimental Psychology: General*, 120, 150-172.

◊ **Week 11 : Rule-based Models**

Erickson, M.A., Kruschke, J.K. (1998). Rules and exemplars in category learning. *Journal of Experimental Psychology: General*, 127, 107-140.

Nosofsky, R.M., Palmeri, T.J., & McKinley, S.C. (1994). Rule-plus-exception model of classification learning. *Psychological Review*, 101, 53-79.

◊ **Week 12 : Interaction Between Perception and Conception**

Schyns, P.G., Goldstone, R.L., & Thibaut, J.P. (1998). The development of features in object concepts. *Behavioral and Brain Sciences*, 21, 1-54.

Goldstone, R.L. (1994). Influences of categorization on perceptual discrimination. *Journal of Experimental Psychology: General*, 123, 178-200.

◊ **Week 13 : "Theory" Theories of Categorization**

Murphy, G.L., & Medin, D.L. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92, 289-316.

◊ **Weeks 14-15 : Wrap-up and Presentation of Projects**

Note on the paper/project:

This paper should be on an original research topic that bears (at least loosely) on some theory (or theories) of similarity, categorization, concept formation, and related areas. Possibilities for projects include: applying one or more of the theories to account for data from some set of experimental phenomena; discussing how the various theories can (or cannot) be applied to issues in development, aging, or dementia; developing a new theory of similarity, categorization, or concept formation (or extending an existing theory in some way); elaborating upon one of the areas we discussed in class, with an emphasis on a critical evaluation of what has been done and what unanswered questions remain to be solved; design a set of experiments to contrast predictions of various models. I'd be especially interested in seeing how some of the ideas we discuss in class might be applied to your own area of research. I am generally very flexible with the topics of such paper. However, please okay all paper topics with me first. These papers should be submitted by the final week of class.

Additional references for your reading pleasure

◊ Classical View

Armstrong, S.L., Gleitman, L.R., & Gleitman, H. (1983). What some concepts might not be. *Cognition*, 13, 263-308.

Hunt, E.B., Marin, J., & Stone, P.J. (1966). *Experiments in induction*. San Diego, CA: Academic Press.

◊ Prototype Models

Homa, D. (1984). On the nature of categories. In G.H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 18, pp. 49-94). San Diego, CA: Academic Press.

Massaro, D.W., & Friedman, D. (1990). Models of integration given multiple sources of information. *Psychological Review*, 97, 225-252.

◊ Multidimensional Scaling

Carroll, J.D., & Wish, M. (1974). Models and methods for three-way multidimensional scaling. In D.H. Krantz, R.C. Atkinson, R.D. Luce, & P. Suppes (Eds.), *Contemporary developments in mathematical psychology* (Vol. 2). San Francisco: W.H. Freeman.

Schiffman, S.S., Reynolds, M.L., & Young, F.W. (1981). *Introduction to multidimensional scaling: Theory, methods, and applications*. New York: Academic Press.

Shepard, R.N., & Kannappan, S. (1991). Connectionist implementation of a theory of generalization. In R.P. Lippmann, J. Moody, & D.S. Touretzky (Eds.), *Advances in neural information processing systems*. San Mateo, CA: Morgan Kaufmann.

◊ Clustering

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

◊ Exemplar Models and the Context Theory of Categorization

Brooks, L.R. (1978). Nonanalytic concept formation and memory for instances. In E. Rosch and B.B. Lloyd (Eds.), *Cognition and categorization*. Hillsdale, NJ: Erlbaum.

Brooks, L.R. (1987). Decentralized control of categorization: The role of prior processing episodes. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization*. Cambridge: Cambridge University Press.

Busemeyer, J.R., Dewey, G.I., & Medin, D.L. (1984). Evaluation of exemplar-based generalization and the abstraction of categorical information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, 638-648.

Estes, W.K. (1986). Memory storage and retrieval processes in category learning. *Journal of Experimental Psychology: General*, 115, 155-174.

Estes, W.K. (1994). *Classification and cognition*. Oxford University Press.

Jacoby, L.L., & Brooks, L.R. (1984). Nonanalytic cognition: Memory, perception, and concept learning. *Psychology of Learning and Motivation*, 18, 1-47.

Medin, D.L., Altom, M.W., Edelson, S.M., & Freko, D. (1982). Correlated symptoms and simulated medical classification. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 8, 37-50.

Medin, D.L., & Schwanenflugel, P.J. (1981). Linear separability in classification learning. *Journal of Experimental Psychology: Human Learning and Memory*, 7, 355-368.

Myers, J.L., Lohmeier, J.H., & Well, A.D. (1994). Modeling probabilistic categorization data: Exemplar memory and connectionist nets. *Psychological Science*, 5, 83-89.

◊ Generalized Context Model

Lamberts, K. (1995). Categorization under time pressure. *Journal of Experimental Psychology: General*, 124, 161-180.

Nosofsky, R.M. (1987). Attention and learning processes in the identification and categorization of integral stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13, 87-108.

Nosofsky, R.M. (1988). Similarity, frequency, and category representations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 54-65.

Nosofsky, R.M. (1991). Tests of an exemplar model for relating perceptual classification and recognition memory. *Journal of Experimental Psychology: Human Perception and Performance*, 17, 3-27.

Nosofsky, R.M. (1992a). Exemplar-based approach to relating categorization, identification, and recognition. In F.G. Ashby (Ed.), *Multidimensional models of perception and cognition*, Hillsdale, NJ: Erlbaum.

Nosofsky, R.M. (1992b). Similarity scaling and cognitive process models. *Annual Review of Psychology*, 43, 25-53.

Nosofsky, R.M. (in press). Optimal performance and exemplar models of classification. In M. Oaksford & N. Chater (Eds.), *Rational models of cognition*. Oxford University Press.

◊ Automaticity

Logan, G.D. (1988). Toward an instance theory of automatization. *Psychological Review*, 95, 492-527.

Logan, G.D. (1990). Repetition priming and automaticity: Common underlying mechanisms? *Cognitive Psychology*, 22, 1-35.

Palmeri, T.J. (in press). Exemplar similarity and the development of automaticity. *Journal of Experimental Psychology: Learning, Memory, and Cognition.*

◊ Rational Model

Anderson, J.R., & Milson, R. (1989). Human memory: An adaptive perspective. *Psychological Review*, 96, 703-719.

Anderson, J. R. (1991). Is human cognition adaptive? *Behavioral and Brain Sciences*, 14, 471-484.

Anderson, J. R. (1993). *Rules of the Mind*. Hillsdale, NJ: Erlbaum.

Nosofsky, R.M. (1991). Relations between the rational model and the context model of categorization. *Psychological Science*, 2, 416-421.

◊ General Recognition Theory

Ashby, F.G. (1992). *Multidimensional models of perception and cognition*. Hillsdale, NJ: Erlbaum.

Ashby, F.G., Boynton, G., & Lee, W.W. (1994). Categorization response times with multidimensional stimuli. *Perception & Psychophysics*, 55, 11-27.

Ashby, F.G., & Maddox, W.T. (1993). Relations between prototype, exemplar, and decision bound models of categorization. *Journal of Mathematical Psychology*, 37, 372-400.

Ashby, F.G., & Perrin, N.A. (1988). Toward a unified theory of similarity and recognition. *Psychological Review*, 95, 124-150.

Ashby, F.G., & Townsend, J.T. (1986). Varieties of perceptual independence. *Psychological Review*, 93, 154-179.

Nosofsky, R.M. (1990). Relations between exemplar-similarity and likelihood models of classification. *Journal of Mathematical Psychology*, 34, 393-418.

◊ Connectionist Models

Carpenter, G.A., Grossberg, S., & Reynolds, J.H. (1991). ARTMAP: Supervised real-time learning and classification of nonstationary data by a self-organizing neural network. *Neural Networks*, 4, 565-588.

Gluck, M.A. (1991). Stimulus generalization and representation in adaptive network models of category learning. *Psychological Science*, 2, 50-55.

Knapp, A.G., & Anderson, J.A. (1984). Theory of categorization based on distributed memory storage. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, 616-637.

McClelland, J.L., & Rumelhart, D.E. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General*, 114, 159-188.

McClelland, J.L., & Rumelhart, D.E. (1986). *Parallel distributed processing: Explorations in the Microstructure of Cognition. Volume 2: Psychological and Biological models*. Cambridge, MA: MIT Press.

Nosofsky, R.M., Gluck, M.A., Palmeri, T.J., McKinley, S.C., & Glauthier, P.T. (1994). Comparing models of rule-based classification learning: A replication of Shepard, Hovland, and Jenkins (1961). *Memory & Cognition*, 22, 352-369.

Nosofsky, R.M., & Kruschke, J.K. (1992). Investigations of an exemplar-based connectionist model of category learning. In G.H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 28, pp. 207-250). San Diego, CA: Academic Press.

Rumelhart, D.E., & McClelland, J.L. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition. Volume I: Foundations*. Cambridge, MA: MIT Press.

Shanks, D.R. (1991). Categorization by a connectionist network. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17, 433-443.

◊ Rule-based Models

Martin, R.C., & Caramazza, A. (1980). Classification of well-defined and ill-defined categories: Evidence for common processing strategies. *Journal of Experimental Psychology: General*, 109, 320-353.

Nosofsky, R.M., Clark, S.E., & Shin, H.J. (1989). Rules and exemplars in categorization, identification, and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 282-304.

Nosofsky, R.M., & Palmeri, T.J. (1998). A rule-plus-exception model for classify objects in continuous-dimension spaces. *Psychonomic Bulletin & Review*, 5, 345-369.

Palmeri, T.J., & Nosofsky, R.M. (1995). Recognition memory for exceptions to the category rule. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 548-568.

◊ Role of Background and Causal Knowledge in Categorization

Pazzani, M.J. (1991). Influence of prior knowledge on concept acquisition: Experimental and computational results. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 416-432.

Waldmann, M.R., Holyoak, K.J., & Fratianne, A. (1995). Causal models and the acquisition of category structure. *Journal of Experimental Psychology: General*, 124, 181-206.

Wattenmaker, W.D., Dewey, G.I., Murphy, T.D., & Medin, D.L. (1986). Linear separability and concept learning: Context, relational properties, and concept naturalness. *Cognitive Psychology*, 18, 158-194.

Wisniewski, E.J., & Medin, D.L. (1994). On the interaction of theory and data in concept learning. *Cognitive Science*, 18, 221-281.