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Symbolic, spreading-activation models of semantic memory represent subset-superset relationships among concepts as distinct, hierarchical levels of nodes connected by "isa" links (e.g., Quillian, 1968). Numerous theoretical and empirical arguments have been leveled against this approach (e.g., Dean & Sloman, 1995; Rumelhart & Todd, 1993), including (1) the difficulty such models have in accounting for familiarity and typicality effects, (2) that category membership is often unclear, (3) that items can belong to multiple categories, (4) that some categories are more internally coherent than others, (5) that general properties do not necessarily take longer to verify than specific properties, and (6) that some general category membership relations can be verified faster than specific category membership relations.

We present a novel connectionist model of semantic memory that offers potential solutions to these problems. The model, an extension of McRae, de Sa & Seidenberg's (1997) and Cree, McRae & McNorgan's (1999) models of semantic memory, was trained to compute distributed patterns of semantic features from word forms. Semantic feature production norms were used to derive basic-level representations and category membership for 181 concepts taken from McRae et al's (1997) property norms. Basic-level (e.g., dog) and superordinate-level (e.g., animal) concepts were represented over the same set of semantic features.

The training scheme was designed to mimic the fact that people sometimes refer to an exemplar with its basic-level label, and sometimes with its superordinate-level label. Two types of training trials were used. In 90% of the training trials, basic-level word forms mapped to their semantic representation, instantiating a one-to-one mapping. The occurrence of each of the 181 basic-level exemplars during training was scaled by familiarity ratings that were collected from human participants. In the remaining 10% of the trials, a superordinate word form was trained by pairing it with one of its exemplars' semantic representations. Importantly, each semantic representation included in a category was paired with that superordinate word form with equal frequency (i.e., typicality was not built in).

The model was used to simulate data from typicality, superordinate-exemplar priming, and category-verification experiments. In explaining the human data, emphasis was placed on the role of correlations among features, the familiarity of concepts, category size, and on the distinction between off-line and on-line processing dynamics. Specifically, settled attractor states for superordinate-level concepts are composed of a greater number of units with states on the linear component of the sigmoidal activation function, making it easier, for example, for the network to move from a superordinate representation to any other during temporal, on-line processing.

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References

Cree, G.S., McRae, K. & McNorgan, C. (1999). An attractor model of lexical conceptual processing: Simulating semantic priming. Cognitive Science, 23, 371-414.

Dean, W. & Sloman, S.A. (1995). A connectionist model of semantic memory. Unpublished Manuscript.

McRae, K., de Sa, V.R. & Seidenberg, M.S. (1997). On the nature and scope of featural representations of word meaning. Journal of Experimental Psychology: General, 126, 99-130.

Quillian, M.R. (1968). Semantic Memory. In M. Minsky [Ed.], Semantic Information Processing (pp. 216-270). Cambridge, MA: MIT Press.

Rumelhart, D.E. & Todd, P.M. (1993). Learning and connectionist representations. In D.E. Meyer and S. Kornblum [Eds.], Attention and Performance XIV: Synergies in experimental psychology, artificial intelligence, and cognitive neuroscience (pp. 3-30). Cambridge, MA: MIT Press.