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Attention Augmented Prototype Representation

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The results of previous quantitative modeling research collectively suggest the competitive advantage of exemplar over prototype accounts of internal representation in human categorization processes. However, the present research: a) raises a concern that unsuccessful outcomes by some previous prototype models may be the unintentional consequence of the algorithmic constraints imposed on the models, but not of implausibility of the theory itself, and b) introduces a prototype model with more flexible attention allocation mechanisms consisting of algorithms that can be qualitatively interpretable and plausibly sound to facilitate fairer comparisons between prototype and exemplar theories in order to better understand the nature of human categorization processes.

Two New Selective Attention Processes

Sensitivity to Correlations: The present prototype model incorporates the capability of paying attention to correlations among feature dimensions. Paying attention to or being sensitive to correlations among the feature dimensions can also be interpreted as dimensionality reduction or mental rotation in the perception and learning of stimuli, by which people may increase the interpretability of stimuli in categorization tasks.

Locally-Tuned Processes: The present model also incorporates the capability of processing attention locally, i.e., each prototype has its own unique attention coverage structure. It allows models to be sensitive to one particular feature dimension when the input stimulus is compared with a particular reference point that is highly associated with category X, while the same feature dimension receives little or no attention when compared with another reference point associated with category Y. Thus the local attention coverage structure causes models to learn and be sensitive to within-cluster or within-category feature configurations, while the traditional global attention coverage structure essentially stretches or shrinks input feature dimensions in a consistent manner for all reference points and all categories

One way of interpreting the combination of the capability of paying attention to correlations among feature dimensions and having local attention coverage structures is that humans (and models) would learn to define what the feature dimensions are for each prototype and to allocate attention to those dimensions, whereas, for almost all previous adaptive models of category learning, the definition of the feature dimensions is static and supplied by individuals who use the models.

The model interpretation suggested tight correspondence between internal representation system and attention allocation mechanisms in categorization. In other words, in the present modeling framework, it seems necessary to deem those two elements as integrated machinery interacting with each other to form a proper augmented internal representation. Treating internal representation and attention processes as rather independent entities might have been one factor for the previous prototype model being unsuccessful in accounting for some psychological phenomena in the past.

Simulations

Two simulation studies were conducted to evaluate the descriptive validity of the present prototype based model with locally-tuned correlation attention mechanisms termed PLOC (Matsuka, 2005). The simulations were based on two influential study on categorization, namely Medin & Schaffer's 5-4 stimulus sets (1978) and Medin, Altom, Edelson, & Freko's (1982) XOR stimulus sets (MAEF82). In both simulations PLOC performed marginally better than GCM (Nosofsky, 1986), even though the previous research collectively suggest exemplar models had better accounts.

The present study showed that with proper attention mechanisms, a prototype model could perform as good as a exemplar model in replicating phenomena observed in the two influential studies, casting doubts on previous results reporting higher descriptive validity of the exemplar theory. The results are inconclusive for evaluating the theories, but a more sensible interpretation of the present research is that it is the first time that a prototype model stands at the same starting line as exemplar models.

Model	Sim1-MS78		Sim2-MAEF78	
	SSE	CORR^2	SSE	CORR^2
GCM	0.015	0.985	0.028	0.984
PLOC	0.008	0.991	0.020	0.985

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