The CALLED Model of Early Word Learning

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The name I have given my model is an acronym for Competition, Attention, and Learned LExical Descriptions. The model grounds word learning in basic cognitive processes such as attention, associative learning, and memory retrieval. I will outline the model's basic operations, then show how effects that have been attributed to the Mutual Exclusivity bias in children's word learning (Markman, 1989) emerge from these operations.

The model has two parts: one that forms representations of words' permissible exemplars from hearing the words used for aspects of the world; and the other that stores lexical descriptions, which are semantic statements about words that are either copied directly or constructed from input (e.g., "Purple is a color" may be constructed from, "Do you know what color this is?....It's purple.") Acceptance of a label for something depends on how well that thing matches the representation of the label's attested exemplars and on what, if any, lexical descriptions involving the label are retrieved.

The exemplar memory part of the model, which will be my focus, is an altered version of MacWhinney's (1987) Competition Model. The main modification was to allow the competition between words at retrieval to be affected by learned attentional responses to words, as well as by other forces that direct attention.

When a novel word is introduced for something, mental connections are established in exemplar memory between a representation of the word and representations of both the thing's features and the dimensions to which those features belong. So, for example, a child who hears "sparrow" may form a connection between this word and the feature, BROWN FEATHERS, as well as the dimension, COLOR OF FEATHERS. The particular feature-dimension pairs that get connected to the word depend on what the child attends to. The greater the attention to a feature from a dimension, the greater the boost in the strength of the connection to this feature and its dimension. A feature may be an intrinsic aspect of the exemplar or some aspect of its external context.

When a child is asked, "Is this a sparrow?," of a bird, for example, the dimension connection strengths, or weights, that have been learned for sparrow will partly determine the dimensions of the referent and its context that receive the most attention. Attention will also be affected by other factors, including the child's disposition to continue to attend to the dimensions encoded in the most recent thing encountered in the context (see Merriman, in press, for a review of this tendency, referred to as dimensional inertia).

The word comprehension decision is based on a variant of Luce's (1959) choice rule. The probability of accepting a test word for something is directly proportional to Atest word / (Aall words + noise), where Atest word = activation of the test word that results from encoding the features of the referent and its context, and Aall words = total activation of all words in the vocabulary (including the test word) that results from this act of encoding. Whether a child accepts the word depends on whether this activation fraction exceeds some threshold value that varies according to the child's cautiousness. Thus, as in the Competition Model, a word will only be accepted if it beats the competition from other words the child knows.

The extent to which a particular encoded feature activates a particular word depends on: (a) how well it matches a feature representation that is connected with the word; (b) the strength of this feature-word connection; and c) the amount of attention directed to the dimension to which the feature belongs. Attention has a multiplier effect on feature connections, serving to either minimize or magnify their impact.

The child's willingness to tolerate two names for something increases as the attentional weights associated with the names diverge. The reason is that these weights partially determine the impact that different feature matches/mismatches have on the word's activation fraction. So, for example, the model would accept that a sparrow is both a bird and a sparrow if the most heavily weighted dimensions for bird were various shape dimensions, +/- has feathers, and +/- can fly, but the most heavily weighted ones for sparrow were color of features and size. The Mutual Exclusivity Bias

Despite this potential for multiple name acceptance, the nature of the retrieval mechanism in the exemplar memory component causes words to gravitate toward mutual exclusive relations. The model tends to produce the three phenomena that are the primary evidence for the Mutual Exclusivity bias: (1) preferring to map novel labels onto unfamiliar rather than familiar kinds; (2) restricting familiar label extension in response to learning second labels; and (3) learning second labels less readily than first labels.

1. Mapping Onto Unfamiliar Kinds. This phenomenon is quite robust. Even older 1-year-olds will pick a honey dipper over a spoon when asked, "Which one is a zav?", for example (Mervis & Bertram, 1994). According to CALLED, the likelihood of choosing the unfamiliar kind is proportional to how much this object activates the novel name relative to how much the familiar object activates this name. The value of Anovel name/ (Aall words + noise) for the unfamiliar kind is compared to the value of this fraction for the familiar kind. Even though the name is novel, it receives some activation from each object because there is noise in the system, and the syntactic category of the word supports assigning it to an object rather than to an attribute or action. Although Anovel name is tiny for both objects, the denominator term, Aall words, is much larger for the familiar kind than for the unfamiliar kind. Because the activation fraction for the unfamiliar kind is greater, children select it.

2. Familiar Label Restriction. Youngsters sometimes respond to hearing a second label for something by deciding that they cannot in fact already name the thing (see Merriman & Stevenson, 1997, for a recent demonstration). According to CALLED, after a second label is presented, the first label has one more competitor than it did before. The likelihood of accepting the first label for the thing should decline to the extent that the second label is activated when the first label is tested. If distinctive features receive most of the attention during second label learning, then restriction of the first label should only result if the dimensions to which these distinctive features belong receive attention when the first label is tested; otherwise the second label will not receive much activation during this test.

3. Greater Difficulty Learning Second Labels. This effect has been documented by Liittschwager and Markman (1994). According to CALLED, training a new label for something that is an exemplar of another word will only succeed if the child devotes considerable attention at both training and test to unique intrinsic or extrinsic features, ones not strongly connected to the first label or to other known labels. Otherwise, substantial competition will arise from activation of these other labels at test.

References

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