# Statistical Regularities In Input Lead To A Naming Bias: A Connectionist Model Of The Shape Bias

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## Background: The Shape Bias

Studies of children's novel word generalizations have provided a detailed picture of the changing knowledge children bring to early word learning. In one version of this task the child is presented with an object, the object is named with a novel count noun (i.e. "this is a dax"), and then the child is asked if other objects can be called by the novel name (i.e. "is this a dax?").

This general procedure has been used with count nouns, mass nouns and adjective syntactic frames and with various kinds of stimuli including rigid objects, objects with glittery colors and objects with eyes. These experiments have demonstrated that in some syntactic and stimulus contexts children systematically generalize a novel word by shape while in other syntactic and stimulus contexts they generalize by other properties. Moreover, the results from all these studies suggest that the contextual forces on novel word generalization change with age. A summary of the extant results is provided in figure 1.

As can be seen in the figure, children's tendency to generalize novel words to new instances by shape increases with age, becomes more exclusive to count nouns, and becomes more specific to particular kinds of objects. One hypothesis is that the pattern of word generalizations depicted in figure 1 results from statistical regularities among the first words children know. This poster provides support for this hypothesis by (1) presenting data on the kinds of similarities inherent in different lexical categories (animals v. concrete objects v. substances) and (2) by demonstrating that the pattern in figure 1 is easily replicated by a simple learner of statistical regularities-- a connectionist network.

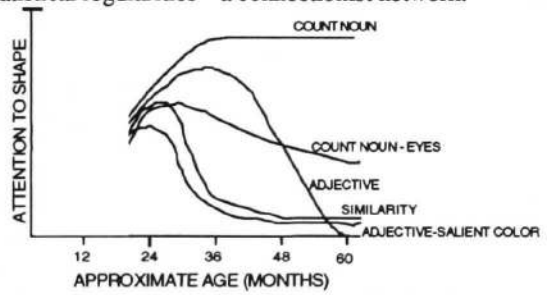


Figure 1: The shape bias changes with development

## Methods

The network had three input/output layers which corresponded to words, object dimensions, and syntax. These layers were connected via bidirectional connections to a hidden layer. The object layer consisted of 20 nodes divided into "dimensions" which corresponded to real-world object properties such as shape, color, and rigidity. The syntax layer contained two nodes which corresponded to different syntax contexts such as count noun, mass noun and adjective. The word layer consisted of 10 nodes. Individual words were represented by activation of single word layer nodes.

### Training

The network was trained via contrastive hebbian learning (Movellan, 1991) on four consecutive sets of words in two conditions. In the ordered condition the sets of words were designed to closely model the growth of children's vocabulary between the ages of 18- and 30-months. The MacArthur Communicative Development Inventory database was used to find the total number of words in children's productive vocabulary at each month as well as a breakdown of this total into twenty-one word categories. Adult judgments of the perceptual similarities in these categories were used to structure the sets of training stimuli given to the network. In a control condition word sets did not closely model the growth of children's vocabularies. If the order of the words children know contribute to the emergence of a shape bias, we should see a shape bias in the ordered condition only.

### Testing

After the network learned a set of words, it was tested on generalization to new instances. In testing phases a "novel" object, word, and corresponding syntax were presented to the network. These inputs were clamped and the network was allowed to settle. The network was then "asked" what object dimension it was paying attention to by unclamping the activations on the object layer, allowing the network to re-settle and observing what object dimension was most active.

## Results

The network developed a shape bias in the ordered condition only. Specifically, as more words were learned, the network's attention to shape initially increased and later became more exclusive to specific kinds of words and specific kinds of objects. Overall, the results suggest that statistical regularities among the word-referent pairs in the first words learned by children are related to the observed developmental patterns of novel word generalization.

## References

Movellan, J. R. (1991) Contrastive hebbian learning in the continuous hopfield model. In D.S. Touetzky, J.E. Elman, T. J. Sejnowski, & G.E. Hinton (Eds.), Connectionist Models, Proceedings of the 1990 Summer School. San Mateo, CA: Morgan Kaufmann.