Feature diagnosticity affects the representation of novel object categories

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INTRODUCTION

Sensorimotor theories of semantic memory posit that object knowledge is stored in a distributed, modality-specific manner [1-5]. Within this theoretical framework, it has often been observed that certain object features are diagnostic. These features “occur almost exclusively for one item within a category and serve to conspicuously differentiate that item from related ones” [6].

The term “diagnostic” is a bit inconsistent in the literature. However, how diagnostic information is used to distinguish items may rely on a feature’s necessity, rather than its availability.

The yellow of a lemon is necessary; it distinguishes the item from related ones (e.g., limes). In this example, color (and not shape, taste, texture, etc.) is necessary. By contrast, the red of a stop sign is available; it is not needed to distinguish the item from related ones (e.g., a yield sign). Color information is equally as available for a stop sign as it is for lemons, but in this example, color information is not necessary to distinguish the items. Here, we manipulated color as the diagnostic feature and used a training paradigm to investigate the behavioral and neural measures of feature diagnosticity.

METHODS

First, subjects were trained on one of two novel object sets by watching a series of videos over the course of four sessions (examples from each are below):

- **Color set**: Color is necessary, shape is not sufficient
  - P (object | shape) = 0.33
  - P (object | color) = 0.50
  - P (object | shape AND color) = 1.00

- **Shape set**: Color is available, shape is sufficient
  - P (object | shape) = 1.00
  - P (object | color) = 0.50
  - P (object | shape AND color) = 1.00

Second, following training, subjects performed a number of behavioral tasks, including adjective generation (where features listed earlier might be considered more diagnostic) and pairwise similarity ratings:

- **Adjective generation task**
  - klave: 1. purple
  - chulge: 2. solid
  - yorts: 3. round
  - yerts: 4.

- **Pairwise similarity task**

When generating adjectives associated with the objects, color-trained subjects listed a color as the first adjective 93% of the time, whereas shape-trained subjects listed a color as the first adjective only 47% of the time (p < 0.001). Notably, when explicitly asked, the groups did not differ in object color knowledge.

When rating pairs of objects in which both were the same color, color-trained subjects assigned higher similarity ratings than did shape-trained subjects (p < 0.08). Additionally, when rating pairs of objects in which the colors were the most different (e.g., red and green), as assessed by an independent group of subjects who viewed images of the objects, color-trained subjects assigned lower similarity ratings than did shape-trained subjects (p < 0.001).

METHODS (continued)

Third, 12 of these subjects (n = 6 for each group) performed a shape retrieval task while undergoing fMRI scanning. They answered 50 yes/no questions about the objects that encouraged retrieval of shape information. We hypothesized that for the color group, as subjects retrieved shape information, color information would also be retrieved. This task was followed by color (indicating if the wedges making up the wheel are sequentially organized) and shape (1-back) perception localizers.

By the end of training, color-trained subjects (n = 21) and shape-trained subjects (n = 26) did not differ in their knowledge of the object sets, as assessed by a naming task.

FMRI RESULTS

We identified ~ 100 voxel clusters that surpassed t = 3.5 in a priori regions (left fusiform, lingual for color perception; bilateral LOC, lingual for shape perception) for both localizers:

- **Color perception**: Color perception task
- **Shape perception**: Shape perception task

BEHAVIORAL RESULTS

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REFERENCES


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