Subtle differences in the perceptual spaces of low-level features and objects
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Introduction
As signals pass through the network of visual areas, purely visual information is transformed into semantic information. But how does the representation of early-stage visual information differ from the representation of semantic information? We study the mental representations of five distinct stimulus domains varying in their semantic content, using the framework of perceptual spaces. A perceptual space is a mental representation in which points in a space denote stimuli and distances denote perceived dissimilarity. Hypothesis: The mental representations of low-level features and semantic information have different geometric properties.

Methods
Using 5 stimulus domains varying in their level of semantic content (examples below), we ran parallel psychophysical experiments, with 9 subjects. We assessed the geometry of the representation of each domain by analyzing subjects’ similarity judgments. All stimuli were based on a set of 37 familiar animals derived from WordNet.

Stimulus Domains
- Textures: fully scrambled textures of checks with colors taken from the image-like stimuli
- Texture-like Stimuli: texturized images of the animals
- Image-like Stimuli: slightly pixelated images of the animals
- Images: 37 unique recognizable images of the animals
- Word: the names of the animals

Similarity judgments were not dependent on context

Data Collection:
- Subjects (7, 2M, VA, 20/20
- Image stimuli:
  - Image size: 2.25 deg
  - Check size (Textures): ~13.3 arcmin
  - Diameter of the display: 12.2 deg
  - Data were collected via zoom and remote screen control for 2 subjects in-person and the remaining on a 15-inch laptop screen.

Experimental Paradigm: In a typical experiment, a series of trials are presented in which 8 stimuli from one domain are shown around a central reference (Fig. A). The task is to click stimuli in the surround in order of similarity to the reference. There are 222 unique trials, in which each stimulus serves as the central item in 6 trials and is paired with each of the other 36 items at least once. These 222 unique trials are each repeated 5 times in the course of 12 sessions of 11 trials each. Subjects were debriefed and asked what strategies they used to gauge similarity.

Geometric Modeling: We derived Euclidean models (Fig. B) of perceptual spaces of 2 to 7 dimensions using a variant of multidimensional scaling, where the log-likelihood of observed choice probabilities was maximized by adjusting the coordinates assigned to each stimulus. The paradigm included trials in which the central reference appeared with a pair of stimuli in two different groupings, judgments were highly consistent across contexts. Data shown are from the word experiment.

Conclusions
- All similarity spaces require at least 7 dimensions.
- Semantic space is more tree-like than the early-stage texture and intermediate Texture spaces.

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