Scaling Models of Visual Working Memory to Natural Images: A Case Study in Human Faces

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Motivation

- Visual working memory (VWM) studies have typically focused on simple visual stimuli, such as line orientation, where it is easy to characterize response biases
- We investigate how to scale VWM studies to classes of natural images, starting with the domain of human faces
- Our goal is to characterize and model human VWM representations for faces. Being able to describe response biases is important for understanding what a model captures or doesn't capture about human memory.

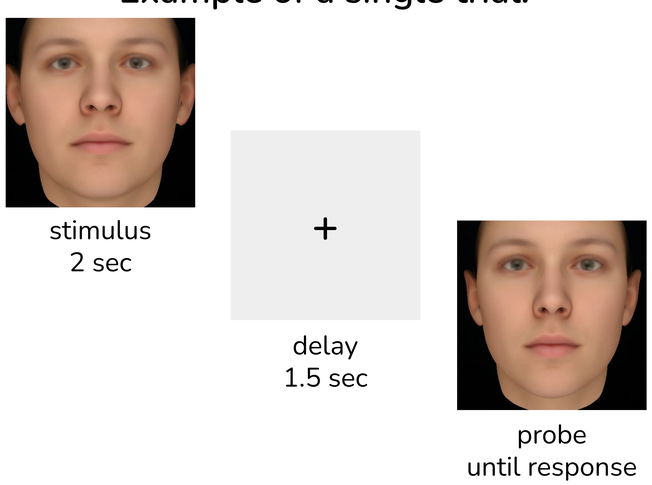
Basel Face Model (BFM)

- Probabilistic morphable model based on principal component analysis applied to shape, color, and expression data from a set of real human faces (Gerig et al., 2018)

Experiment

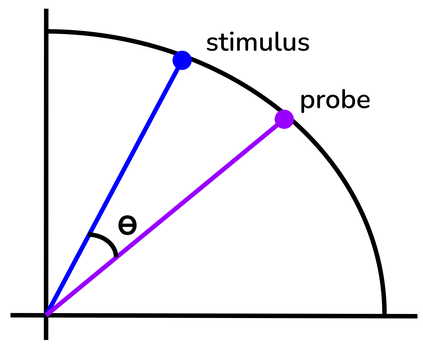
- 20 participants, 200 trials
- Change-detection task: determining if the probe is the same or different as the stimulus

Example of a single trial:



Stimulus/Probe Generation

Faces are represented by points in the (high-dimensional) BFM face-space



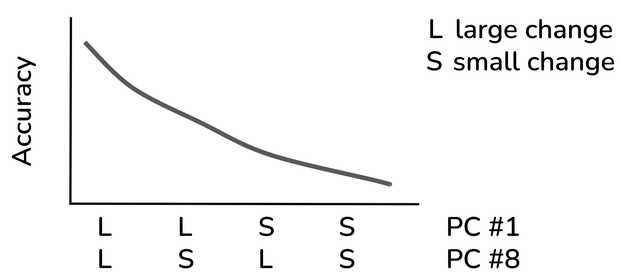
Stimulus-probe distance determined by angle between them in BFM face-space

Predictions

1. Is distance in BFM's face-space psychophysically meaningful? If so, increasing stimulus-probe distance, *d*, should result in easier-to-detect changes

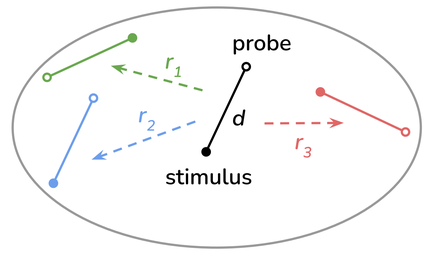
2. Are VWM representations sensitive to directions of largest variance in shape or color space? If so, large changes along the first principal components should cause more perceptual change than larger changes along later principal components

Accuracy as a function of change in principal components

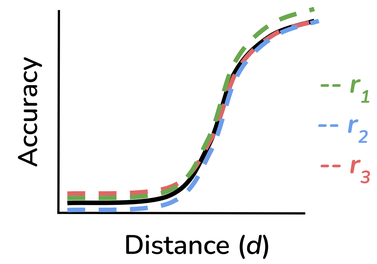


3. Is accuracy in our task rotation-invariant in BFM? If so, for fixed stimulus-probe distance, any rotation, *r*, of stimulus-probe pair should not affect accuracy

Representational Space



Accuracy as a function of distance between stim and probe (with rotations)



Future Directions

- Effects of categories: Is VWM especially sensitive to changes along certain categorical dimensions, e.g. sex, age, which are not captured by distances in BFM face-space?
- Modeling work: Previous work has investigated whether VWM efficiently compresses stimulus signals (e.g. Bates et al., 2019). We can test this hypothesis here, using image-computable neural network models.

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References

Bates, C. J., Lerch, R. A., Sims, C. R., & Jacobs, R. A. (2019). Adaptive allocation of human visual working memory capacity during statistical and categorical learning. *Journal of vision*, *19*(2), 11-11.

Thomas Gerig, Andreas Morel-Forster, Clemens Blumer, Bernhard Egger, Marcel Luethi, Sandro Schoenborn and Thomas Vetter, "Morphable Face Models - An Open Framework", IN: 13th IEEE Conference on Automatic Face and Gesture Recognition (FG 2018)