What might be the General Visual Deficit that Underlies Developmental Prosopagnosia?

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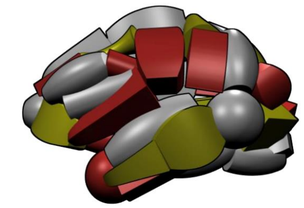
Image Understanding Lab



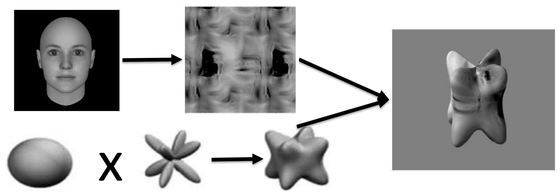
Are DPs deficient in discriminating faces and complex non-face stimuli?

Developmental Prosopagnosics (DPs) have generally been evaluated with memory-based tasks, including celebrity recognition tasks and short-term memory tasks such as the Cambridge Face Memory Test (Duchaine and Nakayama, 2006). While some tasks, such as the Benton Face Recognition Test, have examined the ability of DPs to discriminate stimuli, those tasks may contain information beyond facial identity (Duchaine and Nakayama, 2004), allowing DPs to achieve high accuracy despite impaired face perception.

We developed a discrimination task with equivalently scaled face and non-face stimuli that allowed an assessment of the underlying visual deficit in developmental prosopagnosia.

Blobs (control stimuli for faces)

Smooth-sculpted volumes (spherical harmonics) without the approximate symmetry and features characteristic of faces. Albedo variation was produced by the projection of synthesized face-image texture onto the visible surface (Portilla & Simoncelli, 2000). Blobs show minimal activation of FFA (Yue et al., 2006).



Subjects

DPs

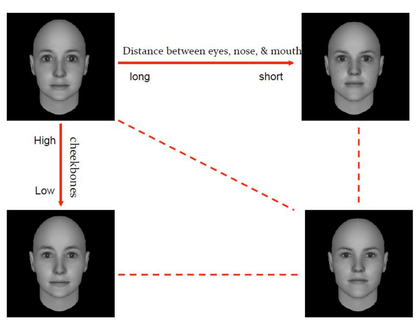
4 USC undergraduates selected by the conjunction of two criteria:

1. An acknowledgement of difficulty recognizing familiar faces (celebrities, family members, or roommates)
2. Poor performance on celebrity recognition task despite general familiarity with those celebrities (mean accuracy = 54% > 2 SD below control mean of 89%)

Controls

68 USC undergraduates without apparent face perception deficits

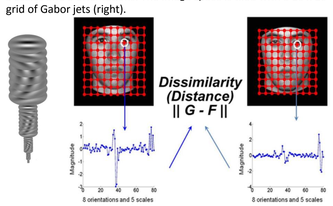
Above: "Blobs" are combinations of spherical harmonics with face texture wrapped around their visible surface. We created a set of 64 textured blobs by systematically varying the magnitude of the spherical harmonics (Nederhouser et al., 2007).



Above: 64 artificial face images were created by systematically varying the height of cheekbones and the distance between eyes, attributes designed to avoid the production of distinguishing local features. **The combined difference between faces were thus largely ineffable.**

Gabor Scaling of Stimuli

The Gabor jet (left), a model V1 hypercolumn, with Gabor kernels at 5 scales and 8 orientations. The image space is tiled with a 10 x 10 grid of Gabor jets (right).



Above: Image dissimilarity is computed as the Euclidean distance between two 4000-value vectors (5 scales x 8 orientations x 100 jets). Dissimilarity computed by the Gabor-jet model predicts human behavior on discrimination tasks almost perfectly (**right**, Yue et al., 2012)!

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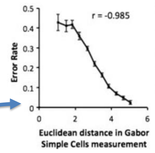
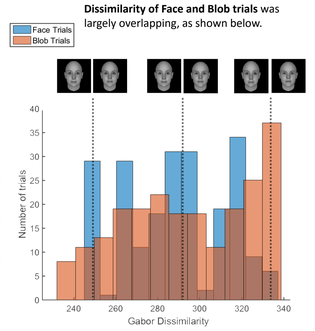
Check out our online Gabor-jet demonstration! (Margalit et al., A,P, & P, *in press)*

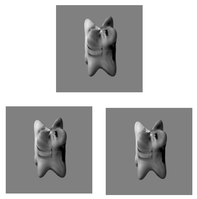


Dissimilarity of Face and Blob trials was largely overlapping, as shown below.



Are DPs sensitive to differences in Faces and Blobs?

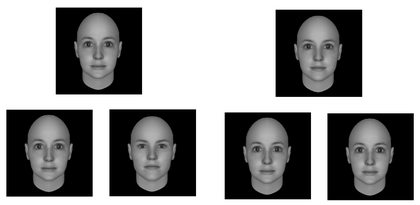
In these three trials, which of the bottom two images is an exact match to the top image?



High Dissimilarity (Gabor distance = 338)

Correct answer: Left

Sample trials with blob stimuli (left) and face stimuli (right). Subjects were instructed to indicate via button press which of the bottom two images was an exact match to the top image.



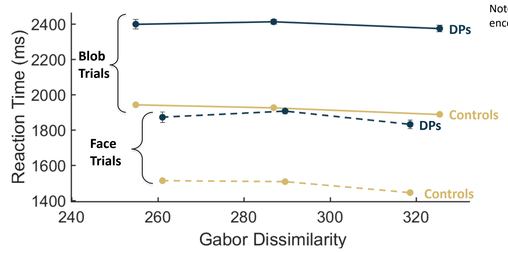
High Dissimilarity (Gabor distance = 337)

Correct answer: Left

Low Dissimilarity (Gabor distance = 250)

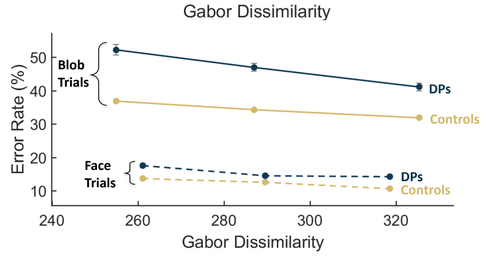
Correct answer: Right

DPs are Deficient in Discriminating not only Faces, but Blobs as well



Note: Smaller error bars are sometimes encompassed within the data points.

Controls (gold lines) responded more quickly than DPs (blue lines) on the Face trials, $p < .001$, and on the Blob trials, $p < 0.001$.

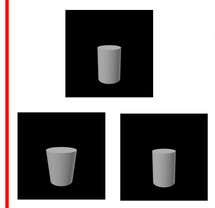


Controls (gold lines) made fewer errors than DPs (blue lines) on the Face trials, $p < .001$, and on the Blob trials, $p < 0.001$.

The higher error rates and reaction times of DPs on both Faces *and* Blobs suggest that the deficit in DP may not be restricted to faces.

Are DPs sensitive to differences in geons?

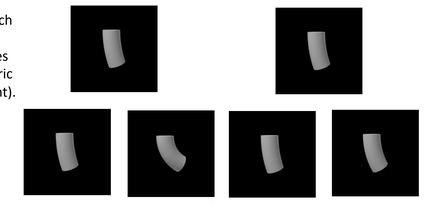
In these three trials, which of the bottom two images is an exact match to the top image?



High Dissimilarity (Gabor distance = 521)

Correct answer: Right

Sample trials in which geons differ in non-accidental properties (**NAP**; left) and metric properties (**MP**; right).



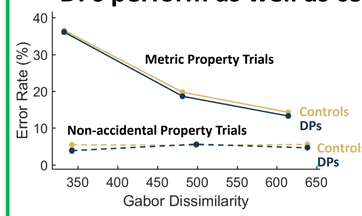
High Dissimilarity (Gabor distance = 447)

Correct answer: Left

Low Dissimilarity (Gabor distance = 321)

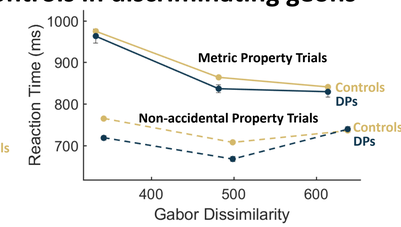
Correct answer: Left

DPs perform as well as controls in discriminating geons



Note: Smaller error bars are sometimes encompassed within the data points.

Controls (gold lines) *did not* make fewer errors than DPs (blue lines) on either trial type. DPs responded as quickly or more quickly than controls on both trial types.



DPs and controls performed similarly in discriminating geons, suggesting that the deficit is restricted to complex, biologically plausible shapes (such as faces and blobs).

Conclusions

1. **DPs are deficient in discriminating smoothly curved, complex, metrically-varying stimuli such as Blobs and Faces.**
2. **This deficit does not extend to simple geometric volumes, suggesting a selective impairment in the discrimination of biologically plausible stimuli.**

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Acknowledgements

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