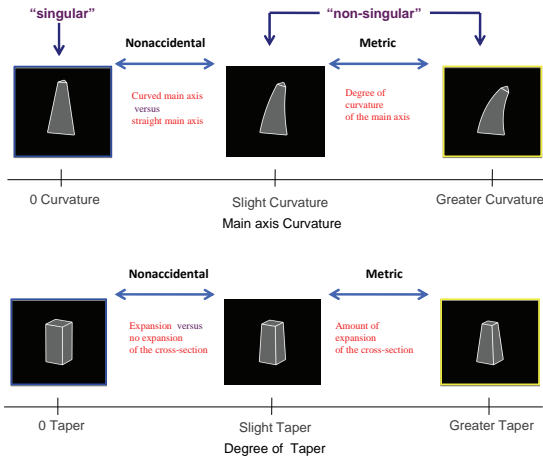


Background and Stimuli

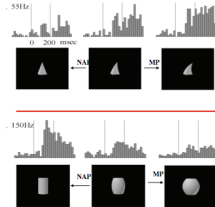
Several shape dimensions, such as curvature or parallelism (taper), can be regarded as extending from a **singular** or zero value (such as 0 curvature or 0 convergence) to an infinity of **non-singular** values. A singular value will remain singular at all orientations in depth; a non-singular value will vary but it will remain non-singular at all orientations (up to an "accident" of viewpoint). Singular or non-singular values are each **nonaccidental** in that rotation in depth will not alter whether they are singular or non-singular. The *difference* between two contours, one with a singular and the other with a non-singular value, e.g., a straight vs. a curved contour, defines an **invariant**, or **nonaccidental**, property (NAP) difference. A difference between two non-singular values define a **metric** property (MP) difference.



NAP differences are more discriminable than MP differences:

There is considerable evidence that humans more readily discriminate nonaccidental than metric differences (e.g., Biederman & Bar, 2000; Biederman et al., 2009). Consistent with this result are that macaque IT cells show more modulation to differences in NAPs than MPs (e.g., Kayaert, et al. 2003).

Right: Macaque IT cells modulate more to NAP differences (Kayaert et al., 2003).



QUESTION:

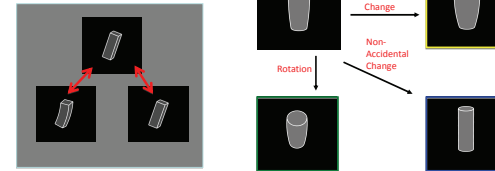
Do human infants and adults spontaneously prefer looking at a singular or a non-singular value of a shape dimension?

We first assessed whether a NAP discrimination advantage would be observed with our stimuli (by adults). The stimulus set for Discrimination consisted of 12 "base" generalized cylinders (middle images above) with two variants associated with each, one a NAP change and one an MP change. The image changes included differences in curvature of the axis and sides of the volumes as well as differences in parallelism. In addition, there was a rotation in depth variant used in the discrimination task.

Acknowledgments: To Kenneth Hayworth for writing the code to generate the stimuli, Nader Noori for his help with setting up the adults' eye-tracking experiment, and Laurent Itti for allowing us to use his eye-tracking facilities. We would also like to thank Paul Quinn, Denis Mareschal, Natasha Z. Kikham, and Mark Johnson, for their inputs and help with the infant shape preference study. The adults shape discrimination and preference studies were supported by NSF BCS 04-20794, 05-31177, 06-17699 to I.B. The infant study was supported by a grant to RW and NZK from the University of London Central Research Fund and a grant to Mark Johnson from the UK Medical Research Council, G0701484.

Match-to-Sample Shape Discrimination Task

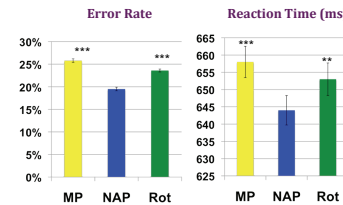
Match to Sample Task:



The matching stimulus was always identical to the sample. The distractor differed from the matching stimulus in either a NAP, MP, or by Rotation in Depth. The three kinds of distractor-matching differences were scaled to be equal by the Gabor-jet model, a multiscale, multiorientation model of V1 simple-cell filtering (Lades et al., 1993).

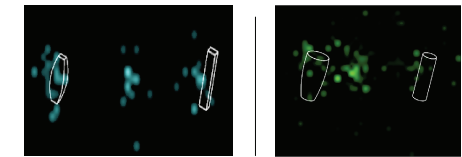
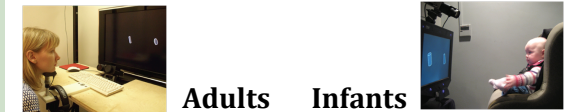
Results:

Adults (n=20) were significantly more sensitive to NAP differences than to either MP differences or rotation in depth. Consistent with IT cells modulation (Vogels & Biederman, 2000), discriminability of rotation and MP differences were equivalent.



Shape Preference

Nineteen 5-month-old infants and 9 adults (~20 yrs.) were eye-tracked while they freely viewed both the singular (NAP) and non-singular (MP) variants of one of the 12 base shapes. Each trial began with fixation at the center of the screen,



Results:

There was a clear bias in the preference:

Adults fixated first at the non-singular (MP) variant on 65% of the trials ($p < .01$ vs. 50% chance), and spent on average of 57% of their fixation dwell times on those non-singular images ($p < .01$).

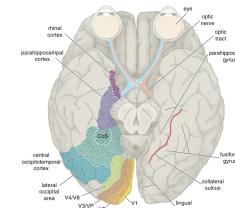
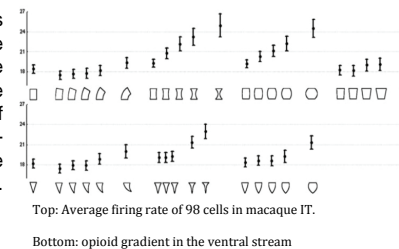
Infants also fixated first at the non-singular (MP) variant on 60% of the trials ($p < .02$) although (their more variable) dwell times (49 %) were not reliably different from chance.

Why the preference for the non-singular?

Almost all macaque IT cells that are responsive to simple shapes are tuned to the extremes of shape dimensions and most of those are tuned to the non-singular end of the dimension (Kayaert et al., 2005).

Opioid Hypothesis

There is a high density of opioid receptors in IT cortex (Lewis et al, 1981; Biederman & Vessel, 2006). Viewing non-singular stimuli would result in greater IT activity because of the greater number of cells tuned to that end of the continuum leading to (presumably) greater opioid release and, hence, greater preference (assuming that we prefer more opioid activity).



The non-singular preference included curved (vs. straight) comparisons (consistent with prior findings, e.g., Bar, 2006) but also included non-parallel (vs. parallel)

Conclusions

Both human adults and infants prefer looking at non-singular variants of stimuli.

This preference may be a consequence of a greater proportion of opioid-releasing IT cells tuned to the non-singular end of shape dimensions.

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