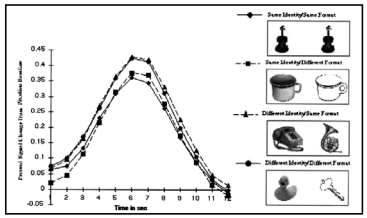
The release from adaptation in LOC: An effect of shape or semantics?

Jiye G. Kim[1*], Mark D. Lescroart[2], Kenneth J. Hayworth[2], & Irving Biederman[1,2]
[1]Department of Psychology, [2]Neuroscience Program, University of Southern California
*(jiyekim@usc.edu)
http://geon.usc.edu/~jiyekim/

Problem:

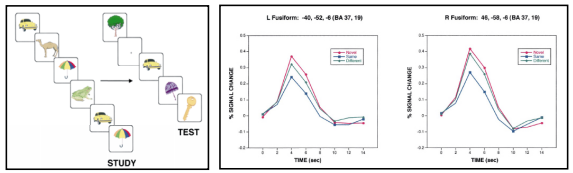
Changing object category from a duck to a key produces a large release from adaptation in LOC compared to when the same images are repeated (Grill-Spector et al., 2001). **Is this an effect of shape or semantics?**



from Grill-Spector, Kourtzi, & Kanwisher (2001)

Background

There is suggestive evidence that LOC may be relatively insensitive to physical variations, in that adaptation is maintained—equivalent to that for identical images--when objects vary in "format (photograph vs. line drawing)," size, and translation (Grill-Spector et al.,1999), as well as the lines and vertices in complementary line drawings (Hayworth & Biederman, 2006). That there may be semantic effects is suggested by Koustaal et al. (2001) and Simons et al. (2003) who observed that left pFs showed a significant reduction in activation for images belonging to the same than different basic level class.

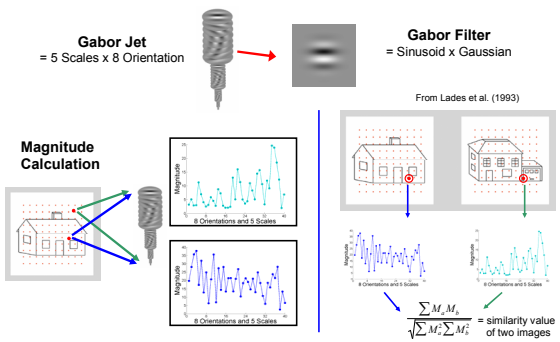


from Koustaal et al. (2001)

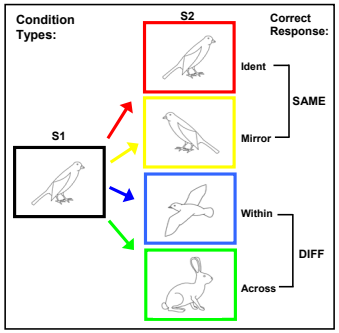
Scaling shape similarity for Within- vs. Across-basic level shape variations.

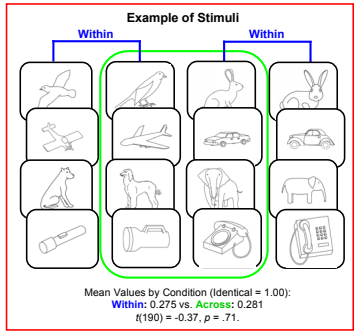
Our design assessed the release from adaptation when pairs of stimuli were exemplars from the same vs. different basic level categories. A principled comparison of shape vs. semantics for this design requires that the change in shape that necessarily occurs when objects are varied across classes be equivalent to the shape changes when objects are varied within classes.

We scaled the physical similarity between pairs of objects with the Gabor-jet system (Lades et al, 1993), a model of simple cell similarity.



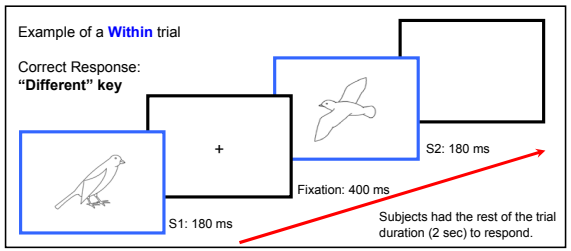
Fast event-related fMRIa design





Task and presentation sequence:

Subjects judged whether pairs of images were identical in shape, ignoring whether they were mirror-reversed. Thus the same response "different" was required for both the **Within-** as well as the **Across**-category trials.

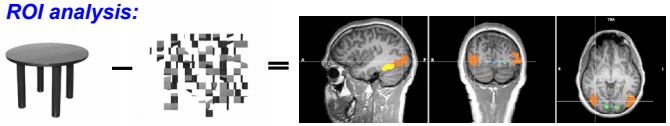


In Exp 2, S2 was always translated 2° diagonally in one of four possible positions with respect to S1, in an attempt to avoid ceiling effects.

Hypotheses and predictions:

If LOC is sensitive to semantic, i.e., basic-level, differences, BOLD responses in the **Within** condition should show significantly less release from adaptation than that of the **Across** condition.
If LOC is merely sensitive to shape information, BOLD responses should not differ for the **Within** and **Across** conditions.

ROI analysis:



LOC was defined by comparing BOLD activation for intact minus scrambled images with a thresholded t-map of $p < .05$, Bonferroni corrected.

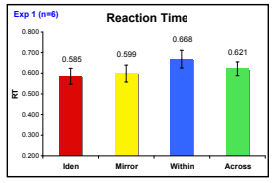
This comparison resulted in two regions, **LO** (orange) and **pFs** (yellow).

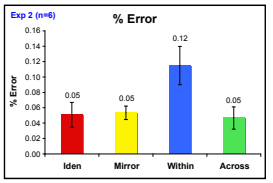
References:
Grill-Spector, K., Kourtzi, Z., & Kanwisher, N. (2001). The lateral occipital complex and its role in object recognition. *Vision Research, 41*, 1409-1422.
Grill-Spector, K. et al. (1999). Differential processing of objects under various viewing conditions in the human lateral occipital complex. *Neuron, 24*, 187-203.
Hayworth, K. J. & Biederman, I. (2006). Neural evidence for intermediate representations in object recognition. *Vision Research, 46*, 4024-4031.
Koutstaal, W. et al. (2001). Perceptual specificity in visual object priming: Functional magnetic resonance imaging evidence for a laterality difference in fusiform cortex. *Neuropsychologia, 39*, 184-199.
Lades, M. et al. (1993). Distortion invariant object recognition in the dynamic link architecture. *IEEE Transactions on Computers, 42*, 300-311.
Simons, J. S. et al. (2003). Neural mechanisms of visual object priming: Evidence for perceptual and semantic distinctions in fusiform cortex.

Results

Behavioral:

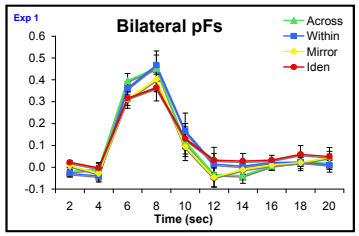
RTs (both Exps) and error rates (Exp 2) were significantly higher in the **Within** than the **Across** condition. RTs were also significantly higher in the **Mirror** than the **Ident** condition (both Exps.).

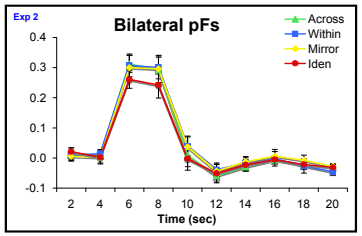




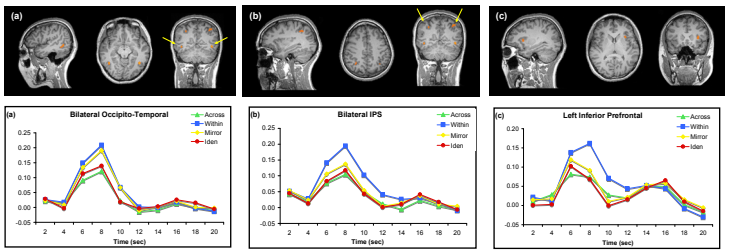
fMRIa:

A change of shape in both the **Within-** and **Across**-class conditions resulted in a significant release from adaptation compared to the **Ident** condition in both experiments. The magnitude of this release was equivalent for the two conditions, indicating that LOC is insensitive to changes in basic-level categories. Insofar as the change of shape resulted in a release from adaptation, the results suggest that LOC is primarily sensitive to variations in shape rather than category.





Where was there an effect of Within- vs. Across- basic-level class variation? Although somewhat weak, we found greater activation for the Within condition in three areas outside of LOC. However rather than this activity reflecting category differences, it might merely have been a consequence of the greater task difficulty of the Within condition.



Conclusions:

- By matching the physical similarity of object pairs, we determined that LOC is not sensitive to changes in basic-level categories.
- LOC is invariant to mirror reflection and translation when these factors are varied singly (Exp 1; Grill-Spector et al., 1999) but not when varied simultaneously (Exp 2).
- Greater activation for the **Within** than **Across** conditions in the occipito-temporal junction, IPS, and LIP suggest that these regions outside of LOC are sensitive to task difficulty.

VSS, May 9, 2008

Supported by NSF BCS 04-20794, 05-31177, 06-17699 to I.B.
We would like to thank J. Jansson Prindle, Robby Ratan, Ben Files, Hannah Luo, and Hao Wang for their helpful inputs for initiating the project, Xiaomin Yue with the Gabor-jet scaling, and Jiancheng Zhuang for assistance in MRI scanning.