Processing objects at different levels of specificity

L. K. Tyler, E. A. Stamatakis, K. Acres, S. Abdallah & H. Moss

Introduction
How objects are represented and processed in the brain is a central topic in cognitive neuroscience. Previous studies have shown that knowledge of objects is represented in a feature-based distributed neural system primarily involving occipital and temporal cortical regions. Research with non-human primates suggests that these features are hierarchically structured with posterior neurons in IT representing simple features and anterior neurons in perirhinal cortex representing complex conjunctions of features [eg Murray & Bussey, 1999; Bussey & Saksida, 2002]. On this account, perirhinal cortex plays a crucial role in object identification by integrating information into more complex feature conjunctions. We tested the implications of this claim for human object processing in an event-related fMRI study, by presenting coloured pictures of common objects for 19 subjects to name at two levels of specificity – basic [eg dog] and domain-levels [eg living thing]. We reasoned that basic level naming requires fine-grained differentiation among similar objects and should therefore activate anteromedial regions of temporal cortex [eg perirhinal cortex] responsive to complex feature conjunctions, whereas domain level naming does not require such subtle differentiation and thus should primarily involve neurons in lateral and ventral regions of IT.

Method
Scans were corrected for slice timing and were realigned, spatially normalised and smoothed with an isotropic 12 mm FWHM Gaussian kernel. Each subject’s data was analysed using the GLM (Friston et al., 1995), and combined into a RFX analysis. We entered three variables (familiarity of the name of each item, imageability and visual complexity of the picture) as parametric modulators with linear expansion.

Results
Basic level naming generated extensive bilateral activation in the entire posterior to anterior extent of the fusiform gyrus including the occipital cortex [Fig 1a]. Domain level naming engaged posterior regions of occipital cortex and fusiform gyrus bilaterally, but did not extend as far anteriorly as activation resulting from basic level naming [Figure 1b]. Directly comparing basic and domain level naming, only basic level naming produced significant activation in perirhinal cortex [BA 34] and this activation was confined to the left hemisphere [Fig 1c].
Conclusions
These novel findings show differences in cortical activation when processing the same object in different ways. When the task requires access only to the general properties of an object [domain level naming], activation remains within the fusiform gyrus where attributes of visual form are processed. When more detailed information is required [basic level naming], processing the same object recruits anterior temporal regions in the left hemisphere, especially in the perirhinal cortex - perhaps because neurons in this region integrate information over multiple sensory systems, thus providing the basis for more fine-grained discriminations.

Fig1 Significant activations superimposed on a T1 anatomical image transformed into the standard stereotactic space of Talairach & Tournoux. The colour bars indicate strength of activation (voxel level T values). The areas shown survived $p<0.05$ correction for multiple comparisons at the cluster level and were thresholded at 0.001; (a) domain naming minus baseline; (b) unique naming minus baseline, (c) unique naming minus domain naming.