High Resolution fMRI in the Human Ventral Visual Pathway using a 32-channel Phased Array Receive Coil

C. Triantafyllou[1,2], L. L. Wald[2], M. A. Williams[3], L. Reddy[3], G. C. Wiggins[2], B. C. Dickerson[4], N. Kanwisher[3], and C. I. Baker[5]

[1]A.A. Martinos Imaging Center at McGovern Institute for Brain Research, Brain and Cognitive Sciences, MIT, Cambridge, MA, United States, [2]A.A. Martinos Center for Biomedical Imaging, Radiology, MGH, Charlestown, MA, United States, [3]Brain and Cognitive Sciences, MIT, Cambridge, MA, United States, [4]Neurology, MGH, Boston, MA, United States, [5]NIMH, NIH, Bethesda, MD, United States

Introduction :

High resolution functional MRI increases image specificity and allows the study of fine-grained activation patterns within cortical areas. However the images have lower Signal-to-Noise ratio (SNR) than lower resolution imaging due to the small voxel size (i.e. 1mm isotropic). Furthermore, single shot echo-planar imaging at high resolution can suffer increased distortion and T2* blurring. Image sensitivity and encoding can therefore be improved by using higher field strengths and/or large N-arrays of small receive coils. In this study we use high resolution imaging and a multiple channel phased array receive coil to explore the fine-grained structure of the ventral visual pathway in and around the FusiformArea (FFA) [1].

Methods :

MR Imaging was performed on four healthy human subjects on a Siemens 3T Tim Trio system (Siemens Medical Solutions, Erlangen, Germany) using a custom built 32-channel phased array receive head coil [2] and a whole-body coil for excitation. High resolution 1mm^3 isotropic BOLD measurements were achieved using a gradient-echo EPI sequence. The imaging parameters were TR=4000ms, twenty to twenty-five 1mm thick slices, inter-slice gap=0.1mm, FOV=208x208mm^2, matrix=208x208 and TE=30ms. To achieve short echo times, the images were acquired and reconstructed using GRAPPA (acceleration factor 2). Stimulus categories were presented in a blocked design (16 sec blocks) with pictures of faces, body parts, cars, chairs and vases, while the participants responded to immediate repeats of the same image. Selectivity for a given category was defined as a stronger response to that category than to the average of all of the others tested. Split-half analyses carried out on the unsmoothed data with two goals: (i) to identify voxels (outside retinotopic cortex and cerebellum) that responded significantly more to a given category than to the average of the other four ($p < .001$), and (ii) to test whether the selectivity of these voxels was replicated in the other half of the data.

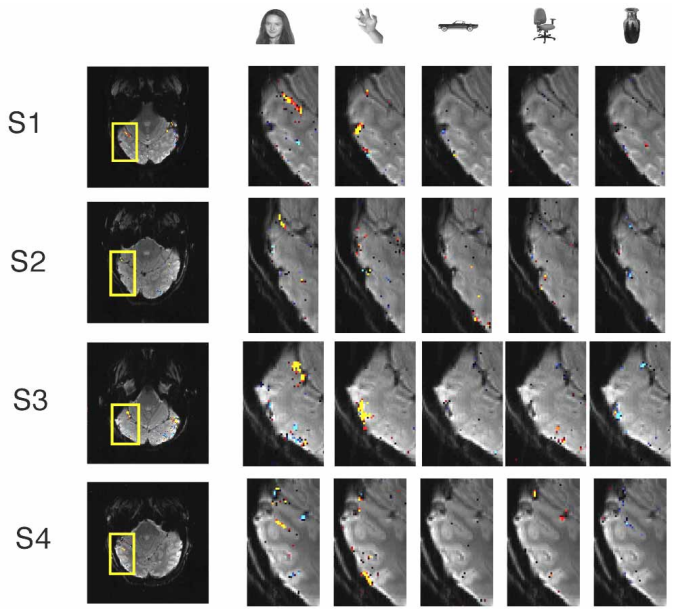

Figure 1. Activations maps from all 4 subjects (S1-S4) are illustrated. No evidence for selectivity in categories other than body parts in or around the FFA.

Results :

The results demonstrate that it is possible to identify high resolution functional units in the human brain using high resolution fMRI imaging and a 32-channel phased array receive coil. An average of 237 face selective and 663 body part selective voxels per subject were found. In both cases these voxels included clusters corresponding to previously described face and body selective regions. Critically, these face and body selective voxels replicated their strong selectivity in an independent test in the other half of the data. In contrast, an average of only 40 voxels per subject reached the $p < .0001$ threshold for selectivity for cars, and 65 for vases; these voxels did not demonstrate reliable selectivity and did not respond maximally to their preferred category in the other half of the data. For chairs, an average of 226 voxels were identified, mostly in the region of posterior occipitotemporal cortex; some weak selectivity was preserved in the other half of the data for these voxels but the selectivity was much weaker than that observed for face and body selective voxels. Thus despite clear replication of face and body selectivity, we find few voxels that are strongly and reliably selective for other visual categories even at 1mm isotropic resolution.

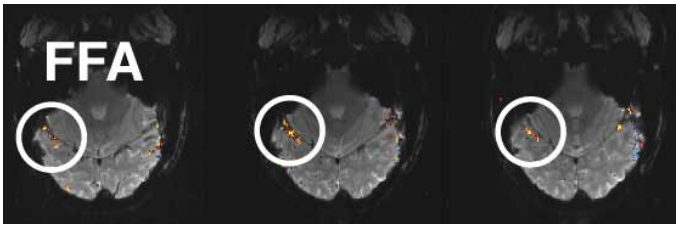

Figure 2. Three consecutive high resolution (1x1x1mm^3) EPI slices of a single subject. Activations maps superimposed onto the original EPI images.

Conclusion :

High resolution fMRI with a 32-channel phased array receive coil revealed strong selectivity for faces and body parts in occipitotemporal cortex, but selectivity for other categories (cars, chairs and vases) was either absent or weaker. Although whole-volume statistical analyses failed to identify strongly selective voxels for categories other than faces and bodies, we are also investigating classification methods to determine what category information is present in the pattern of response.

References : 1) Kanwisher, et al, J Neurosci., p4302-11, 1997 2)Wiggins, et al, MRM, p216-23, 2006.