Effects of Verbal Responding on Movement in fMRI

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Subject

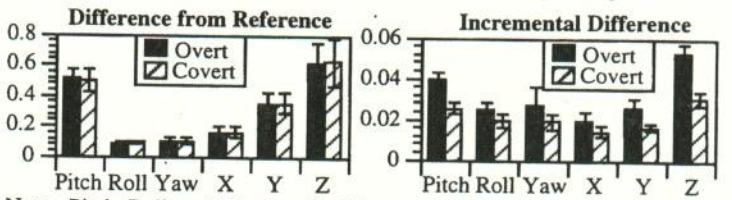
The ability to accurately acquire overt verbal responses during cognitive activation studies with fMRI would greatly expand the phenomena that could be investigated using this methodology. However, concerns have been raised regarding: (1) the magnitude of movement induced by overt verbal responding, (2) potential artifacts generated by changes in the sinus cavities and the pharynx; (3) the feasibility of accurately decoding the content of responses over scanner noise; and (4) potential artifacts from the use of a microphone in the scanner. The goal of this study was to examine the first two of these concerns, using two different pulse sequences: spiral and EPI.

Methods

Nine neurologically normal right-handed subjects were scanned while performing 1 minute blocks of the Stroop (1). A factorial design was used, with two response types (overt vs. covert) crossed with two Stroop conditions (neutral vs. incongruent). Trials lasted 5 sec, allowing the acquisition of 2 images per trial. Subjects performed a total of 56 blocks, half with a spiral pulse sequence, and half with an EPI pulse sequence. Spiral images were acquired using a 2D 2-interleave sequence (TR = 1250ms, TE = 35ms, FOV = 24cm, flip=60°) at 16 axial locations (3.75mm^3), with the bottom slice aligned parallel to the AC-PC. EPI images were acquired using a 2D sequence (TR = 2500ms, TE = 45ms, FOV = 20cm, flip=90°) at 25 axial locations (3.12mm^2 in plane, 3.75 mm thick), with the bottom of the 5th slice aligned parallel to the AC-PC. Scanning occurred on a 1.5T GE Signa scanner, with a standard head coil. Functional images were corrected for movement using a 3-D version of AIR (2), which provided two sets of estimated movement parameters: difference in six dimensions (pitch, roll, yaw, x, y, z) from the first image and incremental differences from the prior scan. The estimated movement parameters were analyzed using MANOVAs, with pulse sequence and response type as factors. Following movement correction, images were co-registered, smoothed (using an 8mm FWHM Gaussian filter), and pooled across subjects in a procedure described previously (3,4). The pooled functional data were then analyzed using planned contrasts.

Results

Planned contrasts comparing activation in the incongruent and neutral conditions for the spiral and EPI images separately indicated patterns of activation similar to those seen in previous PET studies using the Stroop task (e.g., 5). This included activation of the anterior cingulate, parietal cortex, and dorsolateral prefrontal cortex. Inspection of the images did not indicate any obvious artifacts associated with the changes in the sinus cavities and the posterior pharynx, likely related to our deliberate choice to end scanning four slices below the AC-PC line. Analyses of the estimated movement indices indicated no significant differences between EPI and Spiral. In addition, the estimated differences from the reference image did not differ significantly between covert and overt responding. There was a main effect of response type for the incremental difference parameters ($F(1,8)=14.06, p<.05$), with greater movement occurring during overt verbal responses. However, the magnitude of estimated movement during overt verbal responses was still relatively small (see Figure).



Note: Pitch, Roll, and Yaw are % of degrees, and X, Y, and Z are % of mms.

Conclusions

These results suggest that the amount of movement introduced by overt verbal responses during fMRI is manageable, and that changes in the sinus cavities and the posterior pharynx during overt responding did not introduce artifacts in the range of regions over which we scanned. In further work, we have investigated the second two concerns described above, and have developed usable methods for accurately acquiring the content of subjects' overt responses with a microphone during fMRI. Taken together, such findings suggest that the acquisition of overt verbal responses during cognitive activation studies with fMRI is a viable technique.

References

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