The Choice of Basis Functions in event-related fMRI

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To accommodate variability in its shape, the BOLD impulse response can be modelled by a set of basis functions within the General Linear Model (GLM). Choices of basis functions include a Fourier set [1], lagged gamma functions [2], or a canonical response function and its partial derivatives [3]. Another choice is a Finite Impulse Response (FIR) set, which captures any shape of response up to a given frequency limit. We discuss its practical advantages, and contrast it with the partial derivatives of a canonical function.

Advantages

The FIR set consists of a number of successive poststimulus timebins (“mini-boxcars”). The implementation of the FIR set in a GLM effectively averages the BOLD response at each poststimulus time (without requiring counterbalancing of stimuli [2]). These averages, corresponding to the parameter estimate for each timebin, can be entered into univariate analyses-of-variance with time as a factor (with appropriate corrections for nonsphericity), or multivariate analyses [4]. Inspection of timecourses may be necessary to confirm that effects are haemodynamic (rather than, say, movement artifact). Alternatively, assumptions about the shape of the BOLD response can be realised by appropriately weighted contrasts of the parameter estimates (without needing to refit a model).

Comparison

Twelve subjects made fame judgments on faces using a right finger press. Faces were presented for 500ms against a baseline chequerboard, with an exponential distribution of SOAs (minimal=4.5s). Echoplanar images (3x3mm^2 pixels, TE=40ms, TR=2s) were acquired at 2T with blood oxygenation level dependent (BOLD) contrast. Images were realigned spatially and temporally, normalised, smoothed by 8mm and highpass filtered to 1/120Hz. Serial autocorrelations were modelled with an AR(1) model. Famous and nonfamous faces were modelled with both a “canonical” set of three functions - the canonical response, its temporal derivative and its dispersion derivative [3] - and an FIR set of twelve 2s bins from 0-24s poststimulus (Fig. 1).

Fixed-effect F-tests on the main effect of faces, collapsing across subjects, were thresholded at $p<.05$ corrected. The canonical response captured significant variability in fusiform and left motor regions (Fig. 2). The temporal (Fig. 3) and dispersion (Fig. 4) derivatives captured additional variability, mainly in fusiform regions. The FIR did not capture much further variability (Fig. 5).

Conclusion

The findings confirm that the canonical HRF alone may be insufficient to capture the range of possible BOLD impulse responses, in that significant additional variability was captured by including its partial derivatives (with respect to onset time and peak duration). However, the combination of all three functions was sufficient, in that little additional variability was captured by the FIR set. More complex tasks that engage temporally protracted processes may be associated with BOLD responses that cannot be captured by the canonical set, and so benefit from the FIR set. Nonetheless, such responses may be better modelled as multiple responses to a compound of neuronal causes (comprising stimulus, delay and response components for example).

References

1. Josephs,O. et al. (1997). *Hum.Brain.Map,5,243*.
2. Dale,A. & Buckner,R. (1997). *Hum.Brain.Map,5,329*.
3. Friston,K. et al. (1998). *Neuroimage*,*7*,30.
4. Henson,R. et al. (2000). *HBM2000*.

Fig. 1 Design

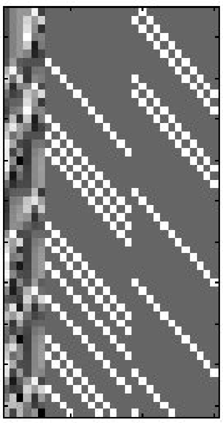

Fig. 2 Canonical

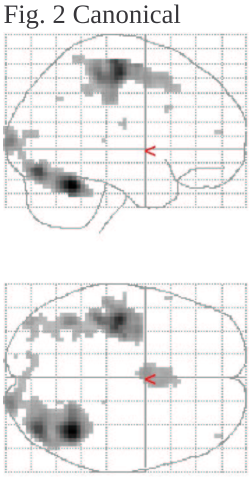

Fig. 3 Temporal

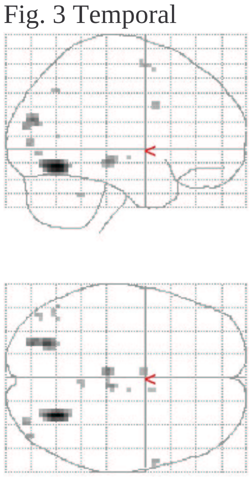

Fig. 4 Dispersion

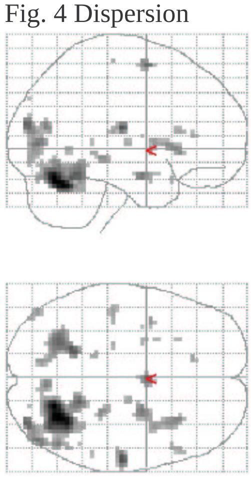

Fig. 5 FIR