Supplemental materials for “Neural correlates of sustained spatial attention in human early visual cortex”, by Michael A. Silver, David Ress, and David J. Heeger

Supplemental Materials and Methods

An additional analysis was performed to compare the actual delay-period duration from each trial with an estimate of the duration of sustained neural activity. After the response amplitudes were estimated, the mean amplitudes for each subject and each ROI were computed for every experimental session. These amplitude values were then held fixed while the duration of sustained neural activity was estimated independently for each trial, using an iterative optimization algorithm (a sequential quadratic programming method, implemented as the function fmincon in MATLAB), to minimize the mean squared difference between the modeled and measured time series.

The starting values for the delay periods were selected randomly between 4 and 18 seconds. The 4-second value corresponded to the interval between the auditory cue and the end of the response period for the shortest delay period, and the 18-second value was the interval for the longest delay periods. The model fitting procedure was run 10 times, with different randomly selected starting values, for each subject/ROI combination, and the estimate of sustained neural activity for each trial was chosen from the run that resulted in the smallest mean squared error (i.e., the best fit to the observed time courses). Using random starting values of delay-period duration ensured that the model would not be biased in favor of either transient or sustained time courses. In fact, when the optimization was performed using a starting value for each trial that corresponded to the actual delay period duration for that trial, the mean squared error of the estimates was always higher than the error obtained by using the procedure described above (multiple runs with randomized starting values). In addition, when the actual delay period durations were used as starting values, the correlation between estimated and actual delay period durations was extremely high in all cases. This suggests that the optimization algorithm converged on local minima near the original starting values, resulting in artifactual correlations. This result underscores the importance of choosing random starting values to avoid bias and to increase the likelihood of finding the global minimum of the search space for each ROI.

Supplemental Figure Legends

Supplemental Figure 1. Sustained delay-period activity in early visual cortex (example data from the two subjects not shown in Figure 2). fMRI responses were aligned at the beginning of each trial and binned into four groups (magenta, green, cyan, black curves) based on delay-period duration. A, C. fMRI responses in a portion of V1 corresponding to the attended portion of visual field. Sustained activity during the delay period was evident for subject RAS but not for JM. B, D. Peripheral, unattended portions of V1. Sustained activity decreases during the delay period were observed for both subjects.

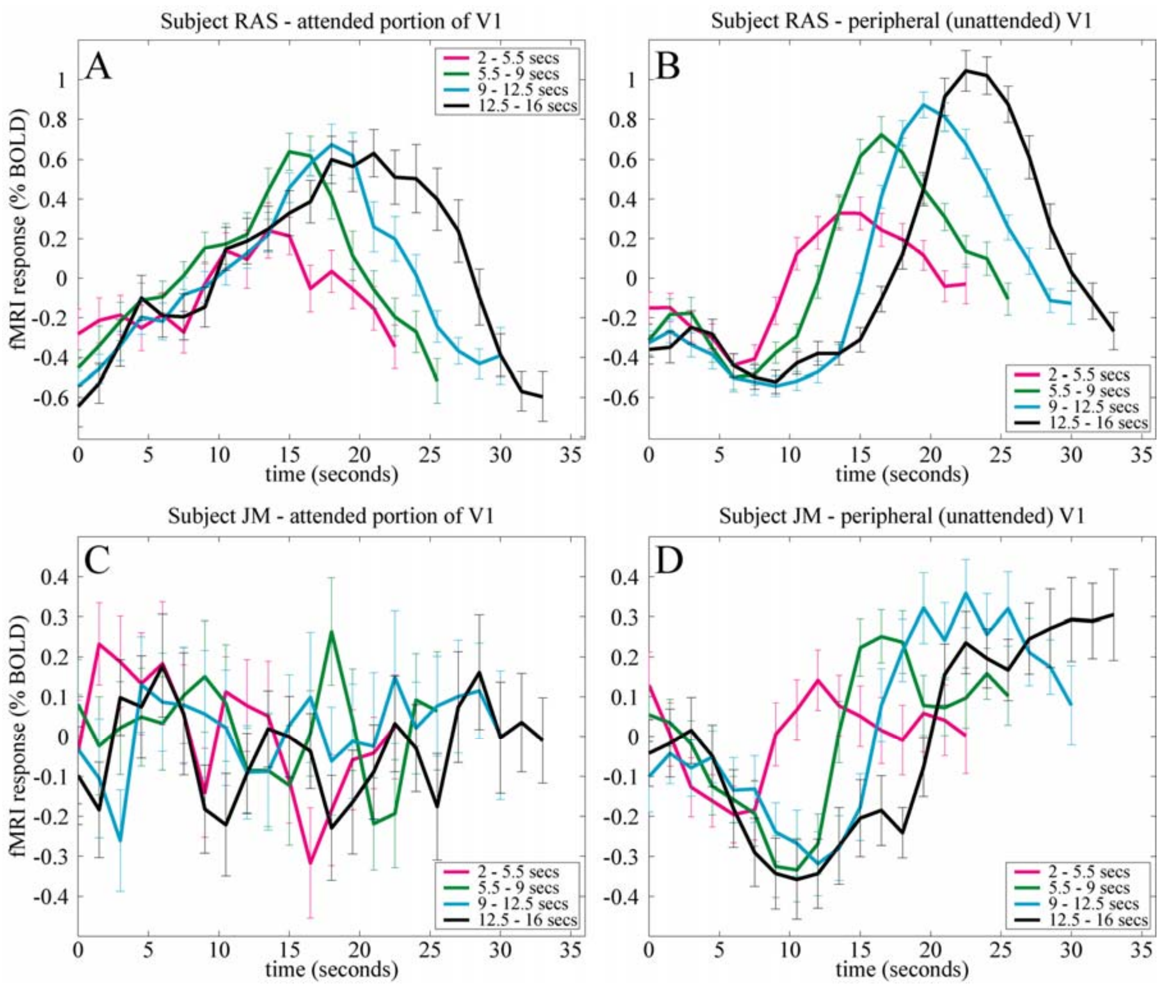
Supplemental Figure 2. Delay-period activity in portions of early visual cortex representing central (foveal) visual field locations. Sustained activity was generally not observed in the foveal confluence (corresponding to visual field locations within the inner border of the attended annulus). A, Subject MAS. B, Subject DBR. C, Subject RAS.

Supplemental Figure 3. Model fits. Green bars, mean delay-period duration for each bin. Blue curves, mean fMRI responses. Cyan regions, standard errors of the mean across trials. Red curves, model fits. Neural activity was modeled as a sustained increase in activity that started at the beginning of the delay period and was maintained at a constant level until the subject made a response. Convolution of these step functions with a canonical hemodynamic response function resulted in the estimated time courses. A, B. The measured fMRI responses were well fit by this step-function model for subjects MAS and DBR. C. Subject RAS showed clear evidence of sustained activity but also had a substantial transient off-response that occurred at the end of the delay period (see Materials and Methods). D. Subject JM exhibited no evidence of sustained delay-period activity in the attended portion of cortical area V2. The example data depicted here for each subject are from different visual areas than those shown in Figure 2 and Supplemental Figure 1.

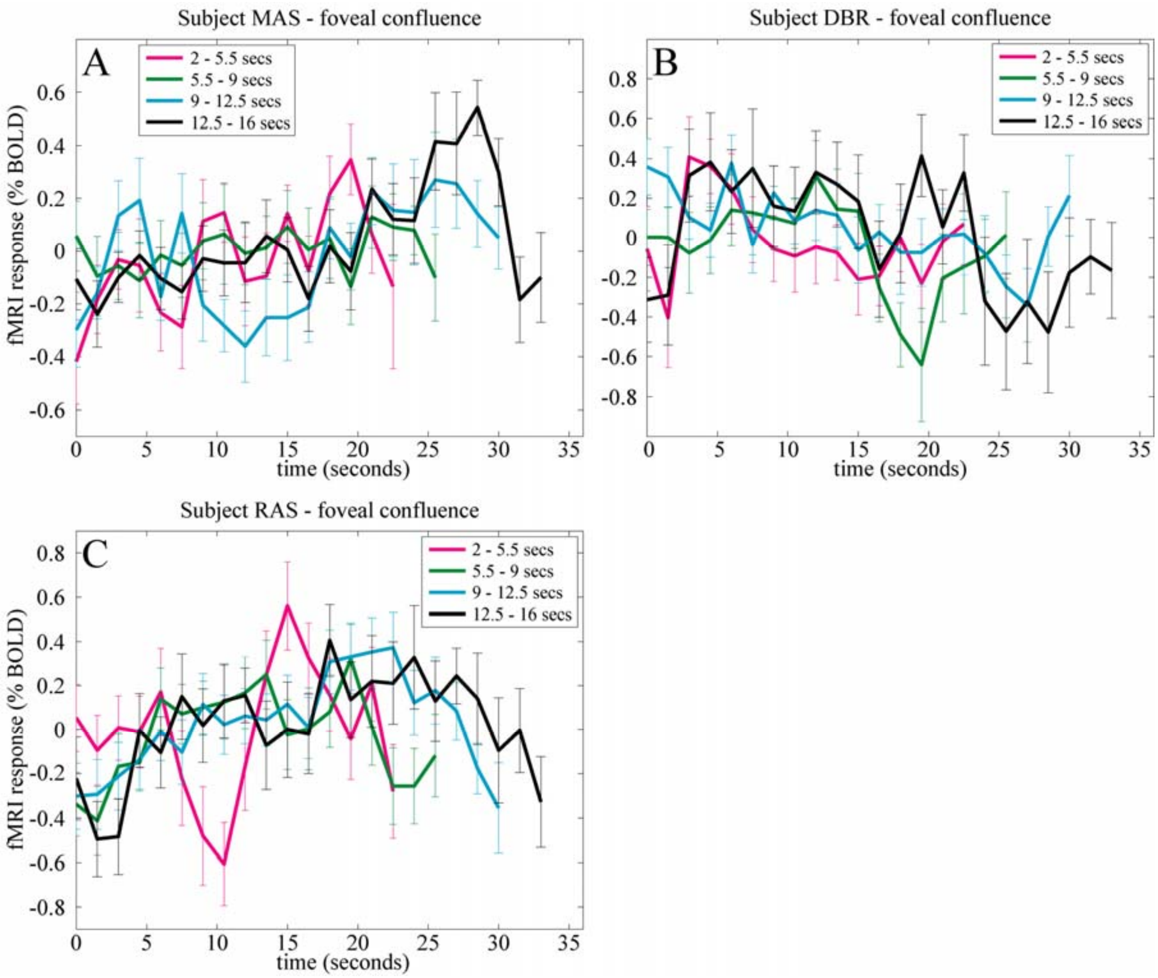
Supplemental Figure 4. The estimated duration of sustained neural activity was highly correlated with actual delay-period duration (subjects MAS and DBR). Each data point corresponds to a single trial. Thin lines, unity slope passing through the origin. If the estimated durations were exactly equal to the actual delay-period durations, the data points would fall on the thin lines. Thick lines, regression lines indicating the measured relationship between actual and estimated durations. Correlation coefficients are displayed in the upper left corner of each scatter plot.

Supplemental Figure 5. Correlation between estimated duration of neural activity and actual delay period duration for single trials (subjects RAS and JM). Same conventions as Supplemental Figure 4.

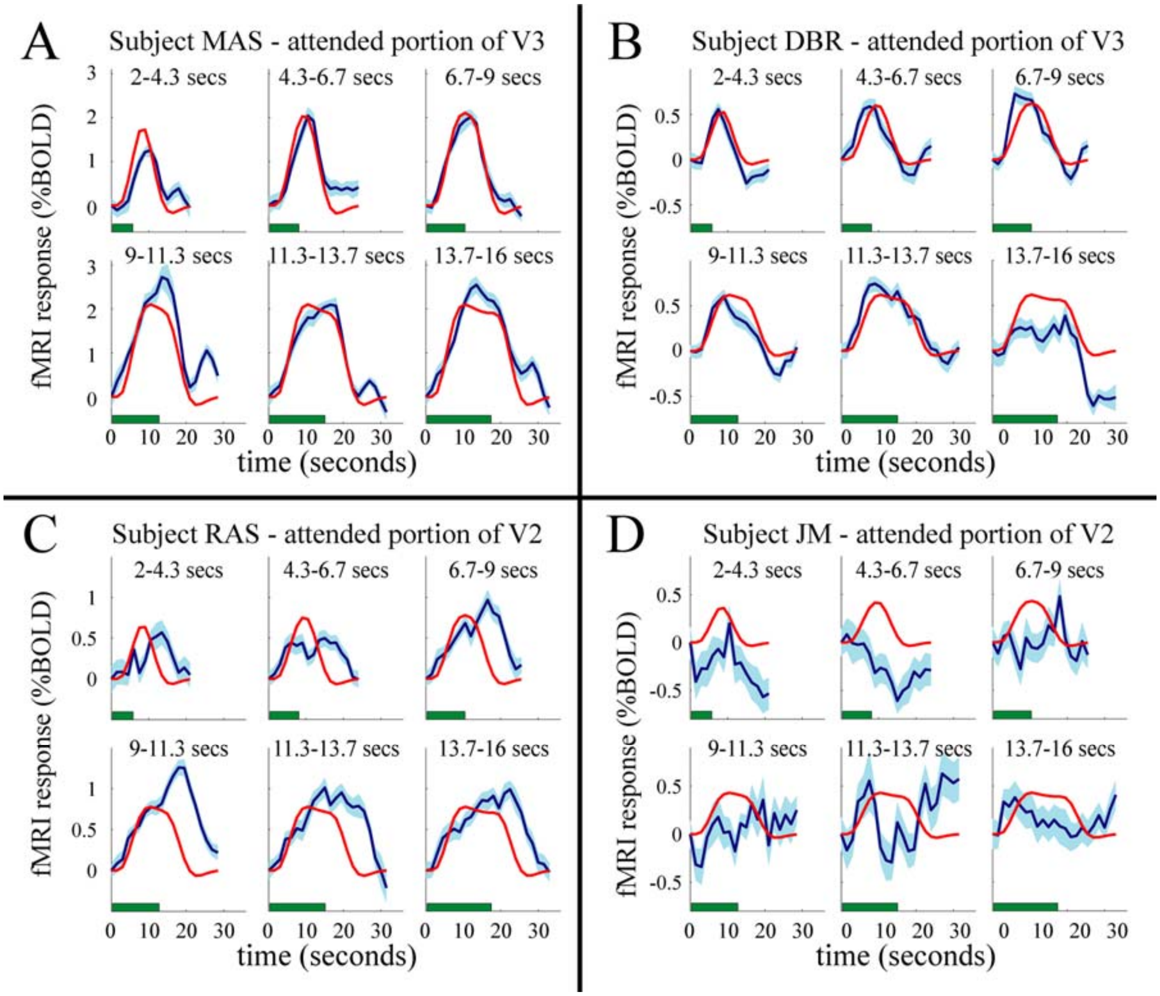
Supplemental Figure 1.



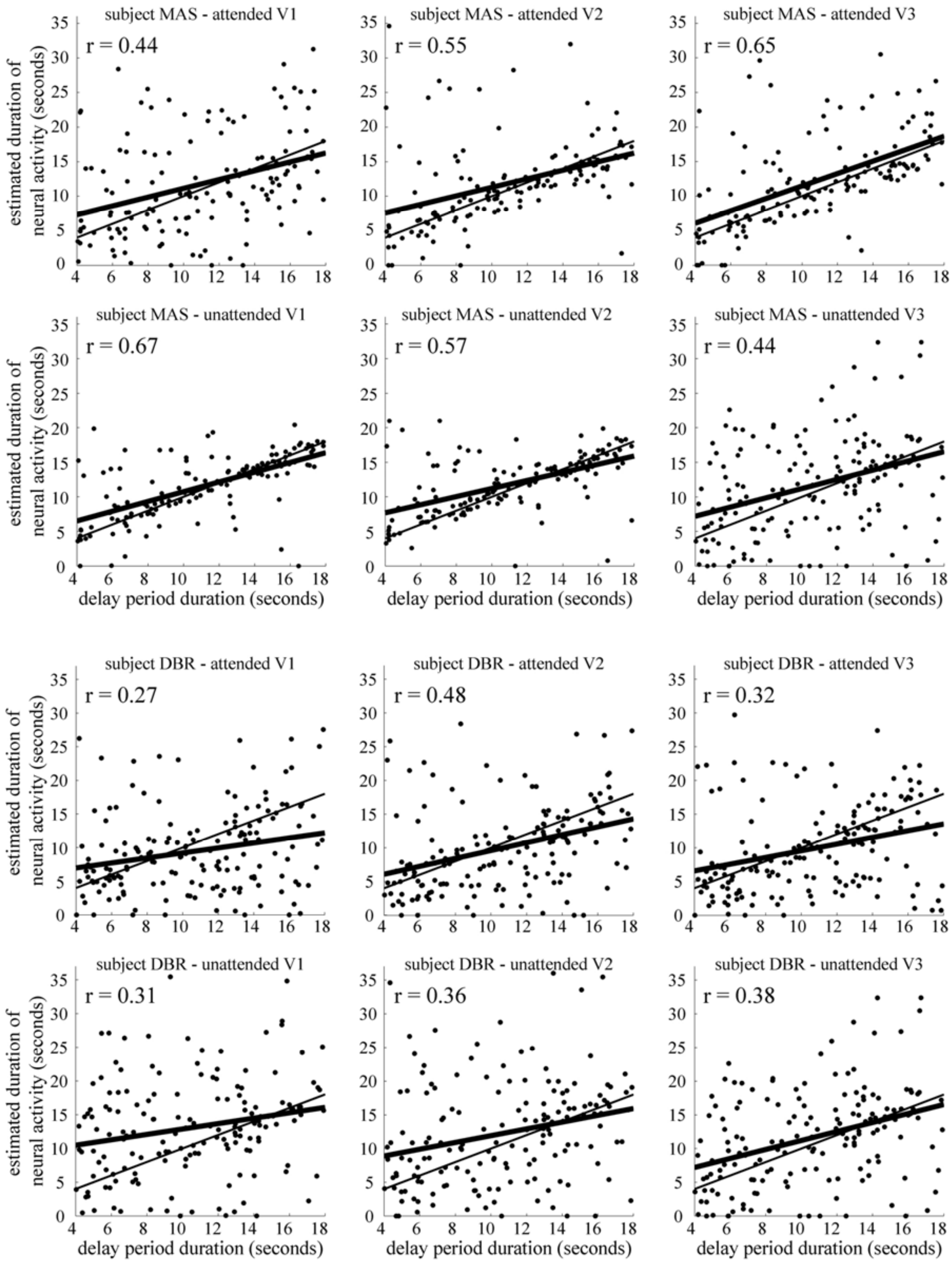
Supplemental Figure 2.



Supplemental Figure 3.



Supplemental Figure 4.



Supplemental Figure 5.