# Event-related fMRI of goal-directed behavior in alert monkeys and humans: spatially-specific and nonspecific signals during delayed response tasks

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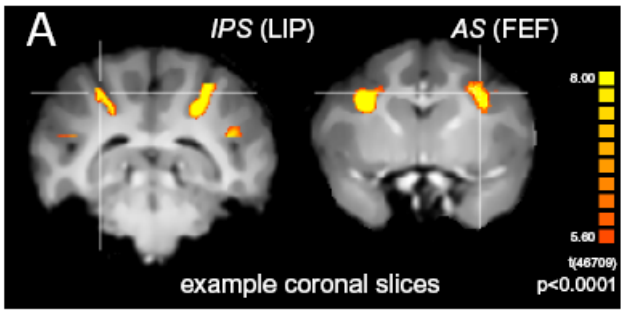
Delayed (memory) response paradigms have been used extensively in monkey electrophysiology and more recently in human fMRI studies, to dissociate visual and motor responses and to investigate intervening mechanisms of working memory, movement planning and decision-making. However, the exact relationship between these studies is not clear due to differences in methods and time-scales. In particular, most human imaging experiments utilize much longer delay periods (10-15 s) as compared to 0.5-2 s typically used in monkey electrophysiology. This may result in dissimilar mnemonic and preparatory strategies employed by the two species and thus in a difference in the dynamics of underlying neural signals. Hence, alert monkey fMRI studies are necessary to establish a link between large bodies of data accumulated with the two methods, and to interpret BOLD activity in terms of neuronal response.

Here we provide a direct comparison between monkeys and humans with the same tasks and techniques, using a high-field 4.7T vertical scanner for monkeys. We recorded BOLD activity and behavior while subjects made visually- and memory-guided saccades following long variable delays. Extending previous monkey fMRI studies that utilized a block design, we developed event-related analysis of BOLD time-courses, delineating responses from different epochs in the trial – fixation, cue, delay period, saccade execution and reward. In particular, we compared activation patterns preceding visually- and memory-guided saccades to extract persistent "cognitive" signals related to spatial working memory and motor preparation. In monkeys, frontal and parietal areas, including discrete bilateral regions in arcuate (AS), principal (PS), intraparietal (IPS), and superior temporal (STS) sulci, exhibited spatially-specific, contralateral cue and memory/preparation activity (Fig.1A). Event-related time-courses revealed differential activation seen as a separate peak or elevated activation in the middle and late memory period, distinguishable from the early cue response (Fig.1B). In the "no-memory" (visually-guided) condition we observed spatially-nonspecifc preparatory signals exhibited as activity ramp-up towards the end of the delay. Consistent patterns were found in functional human homologs, although exact time-course and contribution of these signals varied between subjects and species. Our results demonstrate that dynamics of mnemonic and preparatory signals can be detected in monkeys using event-related fMRI, making it a powerful link between human imaging and monkey electrophysiology.



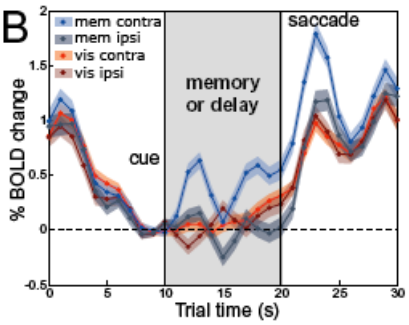




***Figure 1.*** **(A)** Activation maps for memory delay in slices showing IPS (LIP), STS, and AS (FEF). **(B)** Event-related average time-courses from the ROI in FEF. Note contralateral delay activation (light blue trace).

**Acknowledgments:** Supported by Moore Foundation, National Eye Institute, Boswell Foundation.