Effect of Acoustic Imaging Noise and Recent Acoustic History on Auditory fMRI Response

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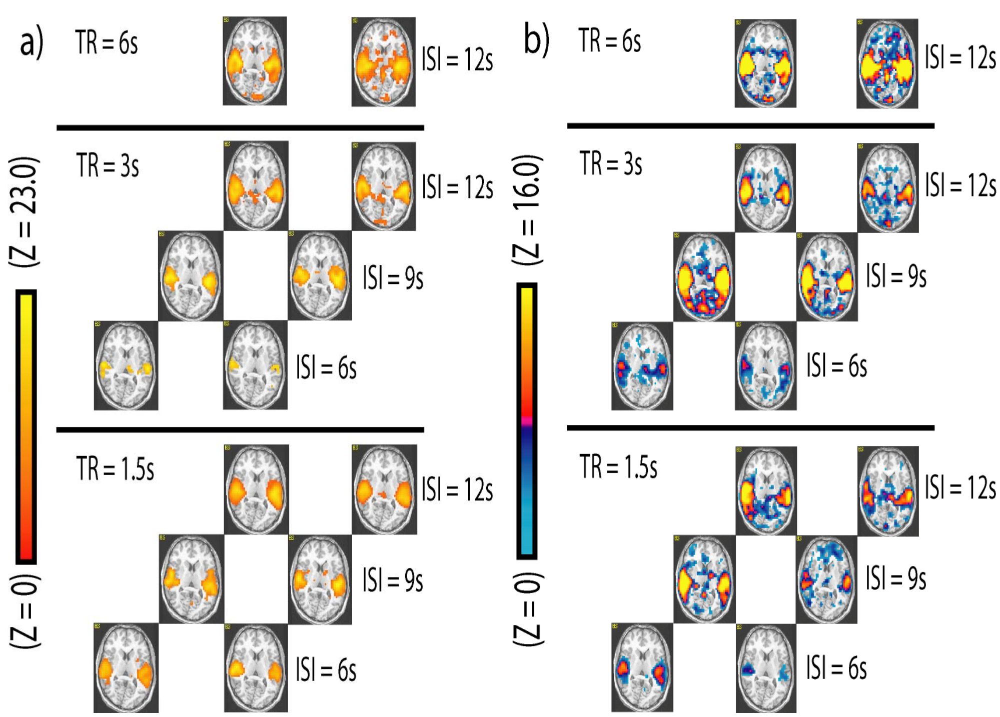
Objective:
A complicating factor in event-related auditory fMRI analysis is Acoustic Imaging Noise (AIN), produced by rapidly switching gradients during echo planar imaging. The presence of AIN alters fMRI detection of auditory stimuli by producing undesired neuronal activations that can mask stimulus-induced responses [1,2]. Additionally, activation accumulated over multiple stimuli can elevate the baseline, reducing the available dynamic range [3]. To best evaluate responses to auditory stimuli, there is a need to account for the presence of AIN, beginning with an understanding of the extent of memory in the system, herein referred to as the necessary duration of the acoustic time history of an experiment. A first step toward this goal is examination of the dependence of response attenuation on inter-stimulus interval (ISI) and repetition time (TR).

Methods:
Imaging: 10 subjects (6M/4F) were imaged on a 1.5T GE Signa CVi at the Medical College of Wisconsin. Five axial slices, centered on Heschl's gyrus, were obtained using auditory surface coils with a blipped echo-planar CVA [2] sequence.
Stimulus: Binaural instrumental music (0.75s duration; ISI = 6, 9 or 12s) was pneumatically presented, 0.5s after a volume acquisition.
Paradigm: Two runs, each consisting of 36 ISI periods, were conducted for each of 7 combinations of ISI/TR (ISI = 6, 9 or 12s with TR = 1.5s and 3s; ISI = 12s with TR = 6s). Paradigms were constructed based on pairs of ISI periods such that the stimulus was presented either only during the 2nd period or in both periods. The first ISI period in each run was discarded. The remaining 70 ISI pairs included 24 stimulus presentations preceded by a stimulus at a distance of one ISI period (I_1), 24 stimulus presentations preceded by a stimulus at a distance of two ISI periods (I_2), and 22 presentations of the null stimulus.
Analysis: Talairach-space regions of interest (ROIs) were selected in primary auditory cortex (medial Heschl's gyrus) for each subject. Trials for a given ISI/TR pair were averaged over the ROI. Group-average HDR estimates were generated for left and right auditory cortex [4]. Group statistical maps of activation were generated using all time-points from each TR/ISI combination. In addition, activation maps were generated comparing the measurement at 5.5s post-offset to the presentation immediately prior to presentation for the purpose of examining the extent of activity across all TR/ISI combinations under conditions of common statistical power due to sampling (i.e., variations will be due to the acoustic history of the auditory cortex response).

Results and Discussion:
Figure 1a shows group statistical maps at p = 0.02, while Figure 1b is a comparison of statistical power resulting from the acoustic history when statistical power due to sampling is held constant. In each case, I_1 maps are shown to the right of I_2 maps.



Results show that decreasing ISI for a given TR attenuates the observed response (Fig 1a), evidenced by the reduced statistical power for the common time-point analysis (Fig 1b). Reducing the TR for a fixed ISI is more complex as additional sampling points (Fig 1a) can increase net statistical power even when the amplitude has decreased (Fig 1b).

Critically, I1 and I2 responses differ even for ISI = 12s, suggesting that a time history window of 10s [5] is not likely to be sufficient for ideal analysis of auditory fMRI experiments.

References:
[1] Talavage et al., HBM, 7:79-88, 1999.
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[5] Langers et al., MRM 53:49-60, 2005