THE EFFECTS OF AMBIENT MRI SCANNER-GENERATED AUDITORY NOISE ON RAT AUDITORY PERCEPTION AT 9.4T

C. F. Schmidt[1], B. W. Zheng[1], S. Graham[2], and X. Golay[1,3]

[1]Singapore Bioimaging Consortium, Biomedical Sciences Institutes, Singapore, Singapore, [2]Department of Psychology, National University of Singapore, Singapore, Singapore, [3]Deptartment of Neuroradiology, National Neuroscience Institute, Singapore, Singapore

Introduction: Translational animal models of brain disorders such as dementia and schizophrenia have gained increasing importance recently and many experimental paradigms exist to help provide links to findings in humans [1]. Pioneering and seminal work using fMRI has been done on auditory processing and vocal learning in songbirds [2], and sensory cross-modality effects have been studied in rats [3]. Simple primary sensory stimulation paradigms are well-established in rodent fMRI [4] yet little is known about the effects of scanner-produced acoustic noise on brain activity. Studies in humans have demonstrated that ambient scanner noise interferes with the perception of, and functional response to a dedicated auditory stimulus, which is modulated by acoustic masking, neuronal habituation and hemodynamic saturation. One approach to alleviate this problem is the use of 'silent' fMRI sequences. In the present study we devised a 'silent' clustered-sparse temporal acquisition, similar to the interleaved silent steady state sampling scheme [5,6], to image the functional topography of rat auditory cortical fields without interference from ambient scanner noise.

Methods: *Animals & Preparation:* Experiments were conducted on four adult male Hooded Listar rats (300-380g). Animals were anesthethized using 1.2% isoflurane in 30% O_2:70% medical air, intubated and ventilated, under an approved IACUC protocol. Rectal temperature and respiration rate were monitored throughout the experiment and maintained in physiological range. *Stimulus & Paradigm:* Animals were presented with 4s acoustic "scanner noise" (7.1 Hz center frequency, ≥120 dB – as provided by the manufacturer), followed by the fMRI data acquisition and a silent interval of 8 s. Trial duration was 16 s and one experimental run included 30 stimulus and 30 empty trials (silence), resulting in a total run duration of 16 min. *Data Acquisition:* Data were collected on a 9.4 T/31 cm horizontal small animal MR unit (Varian, CA) equipped with an actively detuned two-coil system (Rapid Biomedical) with a 72 mm volume coil for excitation and a 4-loop phase-arrayed head coil for reception. Functional time series were acquired using a spin-echo two-shot EPI sequence (TE = 18 ms, 0.5 x 0.5 x 1.0 mm^3 spatial resolution, acquisition matrix 64 x 64, 6 axial slices). During each trial two volume scans were collected in rapid succession ('cluster', Tacq = 2s), followed by an 8 s silent inter-scan-interval (ISI), which allows to separate the functional response to the stimulus from the response to the scanner acoustic noise (Fig. 1). Steady-state of the magnetization in the silent inter-scan-intervals was maintained by repetitive slice-selective excitation, implemented by way of a continuous acquisition and without playing out readout and phase-encoding gradients during the silent periods. The functional response was acquired 4 s after stimulus onset. *Data Analysis:* Time series statistical analysis was carried out using FEAT v5.63 (www.fmrib.ox.ac.uk/fsl/). All volumes were spatially filtered with a 0.8 mm FWHM Gaussian kernel. Statistical analysis on the functional time series was performed using an epoch-based GLM approach.

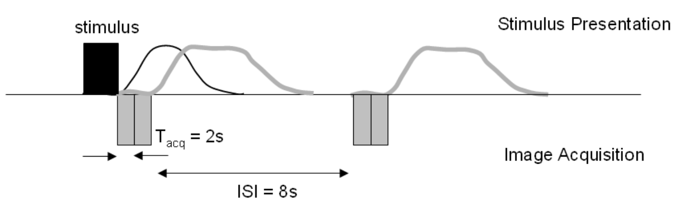

Fig. 1: 'Silent' clustered-sparse temporal acquisition scheme (ssCTA). EPI readout is omitted during 'silent' ISI, but slice-selective excitation is maintained for steady-state condition (not shown). Functional response evoked by the auditory stimulus at issue (black) is separated from the response to acoustic scanner noise of the acquisition (grey).

Results and Discussion: Our preliminary data show a significant functional response in bilateral superior temporal cortices (analogous to human primary auditory sensory cortices) following the scanner noise stimuli compared to the silent baseline. Comparison with the anatomical atlas also shows activation located in primary and secondary auditory fields (Fig. 2). This suggests that acoustic scanner noise itself is a potent auditory stimulus that would normally elevate the baseline activity in auditory sensory cortices during regular fMRI scanning. Further studies are necessary to optimize and test the robustness of the paradigm with respect to the temporal characteristics of the auditory hemodynamic response function, the spatial specificity and statistical sensitivity. However, because most auditory fMRI studies are currently performed in the presence of continuous scanner noise, we believe it will be helpful to complement such studies with a 'silent' fMRI paradigm in order to more reliably detect functional responses to auditory stimuli (which would otherwise be dampened by background activity).

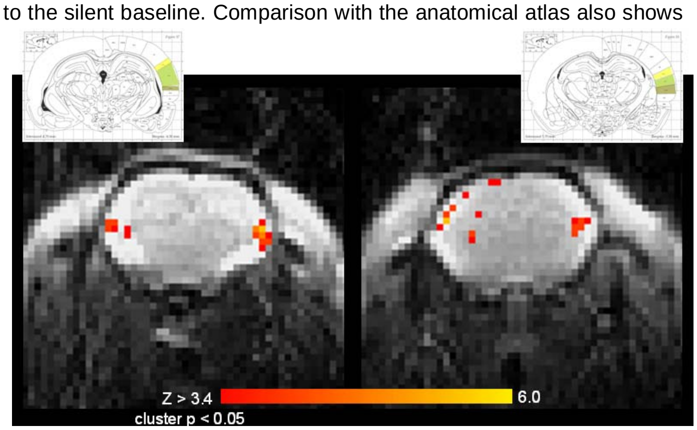

Fig. 2: Functional activation evoked by scanner acoustic noise as compared to silence. Shown are the statistical maps from two animals overlaid on sample SE-EPI images taken from the functional time series. Inserts show corresponding slices from the anatomical atlas [7] with primary surrounded by secondary dorsal and ventral auditory fields are highlighted in shades of green.

In summary our data suggest 'silent' fMRI is a promising tool for translational functional imaging studies of auditory processing in animals and humans.

References

[1] van der Linden et al. (2007), NMR Biomed 20: 522-545
[2] Van Meir et al. (2005), NeuroImage 25: 1242-1255
[3] Burke et al. (2000), MRM 44:317-321
[4] Silva et al. (2007), MRM 57: 1110-1118
[5] Schwarzbauer et al. (2005), NeuroImage 29: 774-782
[6] Hennel et al. (1998), ESMRMB # 218
[7] Paxinos & Watson (1998), Academic Press, New York