

996 - MEG measurement of cortical responses to sound in guinea pig and mouse

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ABSTRACT

Using a newly developed magnetoencephalography (MEG) for small animals, we have recorded auditory-evoked cortical responses non-invasively in both guinea pig and mouse. The amplifield MEG system has 9 magnetometers placed in an 8x8 mm square array at 3 mm from the outer surface of the liquid helium-filled dewar. An additional set of 3 magnetometers and one accelerometer are used to measure and suppress environmental noise. Sound is delivered either free-field, or via short tubes from Eyring-type transducers. Signal processing is crucial to extract the tiny brain responses from noise, and several new techniques have been developed for that purpose. Using these techniques, we can detect cortical responses evoked by sound onsets, transitions and tonal disparities in tone, noise and chirp stimuli, in both guinea pigs and mice. Up to 5 distinct spatio-temporal response components have been observed in these datasets. Additionally, we demonstrate that stimulus-specific adaptation (SSA), hypothesized to be a neural correlate of mismatch negativity (MMN), can be observed in MEG responses to deviant events within trains of standards, and we compare these responses to similar responses observed in humans. These results pave the way for joint MEG and electrophysiology in the same animals to elucidate the neural basis of the MEG responses, bridging the gap between human brain imaging and invasive animal electrophysiology.

INTRODUCTION

Currents in apical dendrites of pyramidal neurons produce magnetic fields that can be measured outside the skull using magnetoencephalography.

Small animal MEG offers:

- a non-invasive measure of cortical response to sound
- a bridge between invasive electrophysiology in animals and brain imaging in humans
- a measure of global activity

RESULTS

Tone onset response in guinea pig:

Stimulus: 2500 repetitions of 50ms 2kHz tone pip, IOI = 1000 ms, -50dB SPL

Gap detection in guinea pig:

Stimulus: ongoing noise, 10000 gaps, IOI=301ms, -70dB SPL

Tone onset response in mouse:

Stimulus: 10000 repetitions of 15ms 2kHz tone pip, IOI = 301 ms, -65dB SPL

MMN / SSA in guinea pig:

Stimulus: 10000 tone pips, IOI=301ms, f=1kHz / 2 kHz, p=0.8 / 0.2

METHODS

APPARATUS

9 magnetometers over brain + 3 reference sensors (noise)

ANIMALS & BRAINS

SIGNAL PROCESSING

Noise is a major issue

suppresses environmental noise

$$\hat{s}_k(t) = s_k(t) - \sum_{j=1}^N \alpha_{kj} r_j(t + \tau)$$

• de Cheveigné A, Simon JZ. Denoising based on time-spatial PCA. *J Neurosci Methods* 2005; 145: 291-303.
 • de Cheveigné A, Simon JZ. Sensor Noise Suppression. *J Neurosci Methods* 2006; 151: 192-201.
 • de Cheveigné A, Simon JZ. Denoising based on spatial filtering. *J Neurosci Methods* 2006b; 151: 331-339.

DSS

$$\hat{s}_k(t) = \sum_{l=1}^K \alpha_{kl} s_k(t)$$

Designs a set of optimal spatial filters to improve signal-to-noise ratio.

• Sarek J. Exploratory source separation in biomedical systems. Technical University of Helsinki unpublished thesis, 2004.
 • Sarek J, Vajapeyam R. Denoising source separation. *J Mach Learn Res* 2005; 6: 253-72.

CONCLUSIONS

- We can measure magnetic correlates of brain activity in response to sound in common animal models such as guinea pig, mouse or gerbil.
- This technique offers a "stepping stone" between invasive electrophysiology and human brain imaging.
- Other potentially useful features: measure of large scale activity, non-terminal (limits number of animals required), enables longitudinal studies in same animal.
- Future: joint MEG / electrophysiology.