
1-4-11: Skin-stretch stimulator

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We have developed a novel nonmagnetic hand-held device to produce skin stretch, known to activate slowly adapting type 2 (SA2) mechanoreceptors, i.e., Ruffini endings.

Our skin stretch stimulator is manually operated and the force applied on the skin is measured by means of strain gages.

We measured somatosensory evoked fields (SEFs) in 9 subjects to light skin stretch stimuli, presented on the dorsal skin of the hand at interstimulus intervals between 5 to 8 s.

Skin stretch elicited clear and reproducible SEFs peaking at about 60 ms after the stimulus onset agreeing with the activation of the hand region of the primary somatosensory cortex. Additional cortical activity in the contralateral hemisphere was detected in 9 subjects and in the ipsilateral hemisphere in 5 subject. The device seems feasible for MEG experiments to address functional anatomy of the human somatosensory system using natural, ecologically relevant skin stretch stimuli. Such a selective stimulus offers new possibilities for experimental designs and to study the human mechanoreceptor system.

References

Acknowledgments
Health and Labour Sciences Research Grants for Comprehensive Research on Aging and Health (H15-022), the Japan Society for the Promotion of Science, and the Grants-in-Aid for Scientific Research 15300111 (Japan), the Academy of Finland, and the Scandinavia-Japan Sasakawa Foundation. We thank Mr. Helge Kainulainen and Mr. Ronny Schreiber for the help in preparation of the stimulus device.

Poster: 1-5 Basic MEG: Cognitive function

1-5-1: Attention effect on neural spatio-temporal activity to emotional faces presented in central and peripheral visual fields

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Facial expression recognition is important for non-verbal communication. fMRI studies have largely highlighted the neural correlates of this process, while electrophysiological research has demonstrated that it can occur before 130 ms. However, it remains difficult to link these data to specific spatio-temporal dynamics following emotional face presentation. It also remains unclear how this perception can be altered or enhanced by attention. Combining high temporal and spatial resolution, MEG was used to investigate the spatio-temporal processing of emotional faces and determine the effect of attention. We used photographs of faces that expressed 3 different emotions: neutral, fear or happy. Stimuli were presented randomly in central or peripheral (left or right) visual fields. Pictures were shown in 3 different blocks to 15 adults, who were asked to respond to a target. The target was a red dot in the first block and a specific facial expression in the two other blocks. MEG activity was recorded with a 151 sensor CTF/VSM system. Event-related-beamformer source analyses were performed at the individual latencies of the main magnetic peaks, for centrally presented stimuli. When attention was directed to the faces, fearful faces activated the orbito-frontal cortex more than neutral faces around 100ms after stimulus presentation, and the right fusiform gyrus around 150ms. If attention was not directed to the faces, the same effect was observed in the fronto-dorsal area around 100ms and in the left temporal cortex at 150ms. Further sources analyses are being completed to study the effect of peripheral presentation of emotional faces. Our first results showed that emotional processing starts in the first 100ms, implicating anterior regions. It also demonstrates that attention can modify the early brain responses to emotion.
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1-5-2: Neural substrate of target detection in an MEG oddball study with faces

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The detection of a rare target stimulus among frequent standard stimuli usually elicits the electric P300 component and its magnetic counterpart. The aim of this study was to identify the neural pathway of the target-related response in an oddball paradigm with faces in the time window 150-420 ms (including face-characteristic M170 response and P300). Eight young male subjects with MRI scans participated in the study. Grayscale faces were presented centrally for a duration of 150 ms with an inter-stimulus interval of 450 ms. Target face with glasses was presented among standard and non-target deviant faces. Measurements were carried out at the BioMag Laboratory using a 306-channel whole-head magnetometer (Elekta Neuromag Ltd., Helsinki). MEG data were analyzed assuming multiple dipoles in a sphere model and using the Cortical Start Spatio-Temporal (CSST) multi-start inverse procedure incorporated in the MRIVIEW software. Sources identified around 170 ms did not considerably differ for standards and targets except that target stimuli evoked additional frontal activity in four subjects. However, in the later time interval of 200-320 ms a strong target-related activity was evident and frontal activation was localized for all subjects despite rather large intersubject differences in cortical activations in other regions. The activity in the anterior regions was followed by the activation in the parietal cortex during the time window of 320-420 ms. The identified cortical pathway was selectively activated by the attentional switch to the target and consequently might represent a neural correlate of target detection.

1-5-3: Superior parietal lobule is common neural correlates underlying two types of rotation methods during mental rotation of 3D objects

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During mental rotation tasks, subjects were thought to perform mental simulation of rotating objects shown as visual stimuli. There were contradictory results concerning premotor activities related to mental simulation during these tasks. We hypothesize that a process based on environmental information is a key factor affecting the utilization of higher motor areas based on the concept of affordance. We measured brain activities relating to two rotation methods, 2D and 3D rotation, during mental rotation of 3D objects using fMRI and MEG. Only the 3D rotation requires subjects to rotate in the depth plane. As a result, we showed activities in the right premotor were correlated with 3D rotation angles [1], [2]. On the other hand, common neural correlates for rotation methods should be more clarified. For investigating the detailed brain activities, we analyzed peak activated time of ROI of both the side of superior parietal lobule (SPL) and premotor and waveform of individual subjects. Peak activated time for each ROI did not show significant difference between two rotation methods except the case of right ROI of premotor. With regard to the waveforms near SPL, there were typical cases that showed differences in the waveforms based on the angular differences after 200 ms between responses for identical pairs of images with a difference of 180° during 2D or 3D rotation and those with a difference of 0°. These results implied that the difference was related to mental simulation processes in SPL only required for responses to the images with a difference of 180°. In addition, activities in the SPL were commonly shown related to both 2D and 3D rotation angles.[1] Kawamichi et al., NeuroImage, 37, 956-965, (2007)[2] Kawamichi et al., Brain Res., 1144, 117-126, (2007)

1-5-4: Coherence estimates of the cortical functional connectivity during silent counting and solfege notes naming: a MEG study.

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Previous fMRI and TMS studies have shown the involvement of a parieto-frontal network during counting process in the human brain. The posterior parietal cortex might be engaged in number magnitude estimation and the ventral premotor cortex play a role in discrete number representation. In this study we used MEG measurements to assess functional connectivity between the parietal and frontal areas by coherence estimates during counting process. We also recorded MEG signals during solfege notes naming for comparison. Nine subjects participated in this study. We presented successive visual stimuli in the form of gray squares on a white screen, and in 4 different tasks we asked the subjects to perform silent counting (upward/downward) or internal solfege notes naming (forward/backward) when
they saw the stimuli. 306-channel MEG data were collected using a whole-head device. Frequency decomposition was performed by a multiteraper method. Single-trial Fourier spectra for all pairs of gradiometer data and coherence values between a selected reference channel and all other channels were computed. Finally the analysis was focused on 4 selected channels located over parietal and frontal areas bilaterally. Dependent measures F-statistics and post-hoc paired samples t-statistics were used to assess significance. Task dependent coherent changes were shown, and a significantly larger functional connectivity between left parietal and frontal areas was observed in a narrow frequency band around 18 Hz during counting downwards. Parieto-frontal and parieto-parietal coherent activity at 20 Hz was also present on the right during naming backward and forward of solfege notes. These results may indicate cooperative roles of the parietal and frontal areas in each task condition.

**1-5-5: Complexity dependent changes in the neuromagnetic brain responses to mental arithmetic**

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Previous fMRI studies have shown that the prefrontal, frontal and parietal regions are involved in mental arithmetic, however, it remains unclear how the spatiotemporal neural activities in these regions during arithmetic operations are modulated by the complexity of mental arithmetic. In this study, we used MEG to investigate the cortical dynamics involved in the mental arithmetic and their modulation by arithmetic complexity. Neuromagnetic signals were measured while the eleven subjects were performing a calculation task in which three different complexity conditions were considered. The calculation trials were visually presented and MEG signals were recorded using 122-channel whole-cortex-type neuromagnetometer. Increased neural activities in the bilateral frontal/prefrontal and the parietal regions during arithmetic operations were observed in the latencies around 700 - 900 ms. The activities in the bilateral prefrontal and the left parietal areas were found to be complexity-dependent. Event-related suppression in alpha-band activities over the bilateral superior parietal regions was also modulated by the arithmetic complexity. Previous non-invasive neuroimaging studies suggest the involvement of both the prefrontal and the parietal cortices in the mental arithmetic operations. Our results add further insight into the temporal characteristics of the neural activities in these regions. In the present study, we also observed the complexity-dependent event-related suppression of alpha-band spontaneous activities in the bilateral superior parietal regions. It is well known that local suppression in alpha-band activities indicate that those regions are involved in the cognitive processing required to perform the current task. Recent fMRI study also reported the complexity dependant changes in BOLD responses in the overlapping regions (the intra-parietal region), which is in agreement with our current results observed in the suppression of MEG alpha-band activity.

**1-5-6: MEG response to visual item load, in short-term memory and attentional monitoring tasks**

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An electrophysiological marker of the limited contents of visual short-term memory has been developed using EEG (Vogel & Machizawa, 2004, *Nature*. 428:748-751). This consists of a more negative-going, posterior potential contralateral to a memorised array of items, the amplitude of which predicts individual differences in memory capacity. Here we investigate the magnetic counterpart to this effect, using a similar paradigm while recording MEG signals across 306 sensors. Simultaneous EEG was also recorded in a subset of subjects. It is currently unclear whether the item-related activity is specific to short-term memory, or reflects underlying object representations that are also common to perceptual and attentional tasks. To investigate this, all subjects also performed a task in which identical item arrays were presented, but they remained visible throughout each trial and had to be monitored, thus requiring sustained attention but not visual short-term memory. The signal evoked by the stimuli showed a similar, bilateral pattern in both tasks, which persisted throughout the 900-1500ms memory/attention period, and whose amplitude increased with item load. Its generators localised to posterior parietal and occipital cortex, and are compared to activity peaks in a similar fMRI experiment (Mitchell & Cusack, in press, *Cerebral Cortex*). Induced effects and individual differences are also considered. Results are discussed in terms of the lateralisation of signal, comparison between the different measurement modalities, and the relationship between attention and visual short-term memory.