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Early attentional modulation of the neural network evoked with the auditory paired-click paradigm: An MEG study

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Abstract

Although numerous research studies have explored the functional attributes of the human duration perception, the spatio-temporal information on cortical networks underlying this process is still an open question. Moreover, the issue of possible differences in the nature of timing mechanisms responsible for perception of sub- and supra-second intervals requires the implementation of the functional brain imaging techniques with both high spatial and temporal resolution. Attention is very frequently used as a modulating factor for the perceived duration of a sensory stimulus. The non-attended stimuli appear to last shorter than the attended ones, increasing the perceived duration of a concurrent stimulus (Gorea, 2011). This study challenges the accepted model of early sensory responses, activated during the first 100 ms after stimulus presentation, as preattentive, automatic processes which modulate the neural sensitivity to incoming stimuli (gating phenomena). We utilized Elekta Neuromag 306-channel whole-head system for magnetoencephalography (MEG) measurements and multi-dipole Calibrated Start Spatio Temporal (CSST) localization technique (Ranken et al., 2002) to investigate whether voluntary attention directed at the second tone of a pair in the standard paired-click paradigm could affect cortical networks underlying the gating out phenomenon. MEG recordings were obtained in a magnetically shielded room at the Biomagnetic Center in Jena, Germany. Two consecutive (ISI=500 ms) identical short tonnes (S1 and S2; duration=20ms; f=1200Hz; ITI=8±1s) were used to evoke standard gating cortical responses in 19 healthy participants (21-38 years). In the second condition, the task was to direct attention toward the second tone and to respond to a rarely presented non-identical second tone of the pair (R=1300Hz, p(S1R)=0.3). MEG recordings showed transient early and middle latency responses with peak amplitudes over the temporo-parietal sensors followed by a peak of a sustained activity. Less prominent transient activity was recorded over the frontal sensors, accompanied with a more steady-state component from 100 until 400 ms post-stimulus for both conditions. Preliminary results of the CSST spatio-temporal analyses revealed 4-6 brain regions activated during 20-500 ms time interval including bilateral superior temporal gyrus (STG), bilateral and medial prefrontal (PF), bilateral parietal (PA) regions, and central motor cortex area. A cortical source underlying the steady-state component was identified in the left prefrontal region for S1 tone, and in central posterior regions (PA) for the

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repeated tone S2. During the standard paradigm the M50 gating suppression was observed only for bilateral STG sources while bilateral PF and PA sources did not show any reduction in the response during the first 100 ms post-stimulus. Targeting the attention towards the second tone enhanced the M50 amplitude of the bilateral STG responses in respect to the repeated stimulus S2 and caused a change in the activated network evident by the emergence of a new generator in the medial PF area (orbitofrontal) instead of dorsolateral PF generators evoked in non-attended condition. These results demonstrate that voluntary attention can exert a topological and functional modulatory influence on the neural network even during early stages of auditory processing.

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Keywords: Magnetoencephalography; Auditory attention; Cortical neurodynamics; Paired-click paradigm; Auditory gating; M50 complex

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