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A temporal comparison of blood oxygen level dependent functional magnetic resonance imaging and magnetoencephalography in the auditory cortex

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MEG and BOLD fMRI are both valuable non-invasive methods used to investigate neuronal functionalities of sensory systems and cognitive processes in the brain. On the one hand, both methods provide complementary strengths and limitations concerning their spatio-temporal properties. On the other hand, both methods share a common biophysical substrate (PSPs), on which their signal is based. These are two important reasons why the combination and comparison of MEG and fMRI to investigate stimulus induced neuronal activation is of great interest.

However, the integration of MEG source waveforms with spatial activation patterns defined by the results of BOLD fMRI can fail for various reasons, which are based on the different mechanisms of signal generation. To provide a meaningful proposition about the comparability of MEG and BOLD signal, more knowledge about the relation of both signals to simple and well defined activation pattern is needed.

The aim of the experiments that were performed in the context of this thesis was to investigate fMRI correlates of distinct, well known MEG components in the auditory cortex of humans. Listeners were presented with the same acoustic stimulation in MEG as well as fMRI. All sounds were presented in relatively long stimulation blocks (32 s in the first and 24 s in the second study), to separate in fMRI the sustained from the slow, overlapping transient response.

In the first study the relation of BOLD signal to a phase-locked SSR was investigated. To separate the SSR, the neuronal response to a 40-Hz AM tone was contrasted versus the response to a pure tone. Both tones produced in MEG a large sustained field in comparison to a silent baseline, while the AM tone evoked additionally a 40-Hz SSR, with much smaller amplitudes. In fMRI, the AM tone produced in comparison to the pure tone a sustained BOLD

enhancement in the medial part of HG, where the processing of SSR was expected. The pure tone showed in comparison to a silent baseline just a very weak increment of sustained BOLD response. Thus, the small phase-locked 40-Hz SSR had a stronger coupling to the sustained BOLD enhancement than the large sustained field, that is supposed to reflect non-phase-locked activity.

The aim of the second study was to investigate in fMRI the correlates of pitch-specific long-latency components (N1m and sustained field). The neuronal response to two different sounds (IRN and regCT) with similar pitch strength, but with different spectro-temporal properties was contrasted versus the response to their particular spectrally matched non-pitch sounds (noise and jitCT). Both pitch sounds, IRN and regCT, evoked in MEG a phase-locked N1m transient and a sustained field in comparison to their particular non-pitch baselines. Furthermore, IRN, noise and jitCT evoked in the MEG signal fluctuations in the theta-band range. These fluctuations are potentially small phase-locked N1m transients evoked by the envelope or the fluctuating finestructure of these sounds. In contrary, regCT evoked an unruffled source waveform in MEG. Only the sounds that evoked small (potentially) phase-locked fluctuations in the theta-band range in MEG, produced in comparison to a silent baseline a sustained BOLD response in fMRI. Thus, the BOLD response evoked by regCT showed, in comparison to a silent baseline, absolutely no sustained behavior. These results support the findings of the first study, that sustained BOLD signal in the auditory cortex seems to be more sensitive to phase-locked neuronal processes (N1m in this case), but not to non-phase-locked neuronal events (sustained fields). Based on the findings of intracranial studies, the results reported in the second study indicate furthermore, that sustained BOLD response in the auditory cortex could potentially be coupled to the presence of high-gamma activity.

In conclusion, the results presented in this thesis demonstrate that, in the auditory cortex, a comparison of stimulus induced activity recorded in MEG and fMRI is only meaningful if the evoked neuronal activity shows phase-locking, but can fail for non-phase-locked activity.