Top-down Attention in the Face-Processing Network: an MRI-guided MEG Study using Multiple Simultaneous Frequency Tags

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Neuroimaging and electrophysiology have revealed multiple cortical face-selective regions that are spatially and functionally separable and form a distributed cortical network specialized for face perception. The aim of the present study was to investigate this functional specialization of the areas OFA, FFA, and STS by demonstrating the differential entrainment with the respective tagging-frequencies embedded in a face compound stimulus, as well as to investigate the attentional modulation of the related neural activations at those specific frequencies. For this, we used a frequency-tagging paradigm that allowed for independently frequency-tagging various parts of a face (eyes, mouth) as well as rhythmic changes in facial identity.

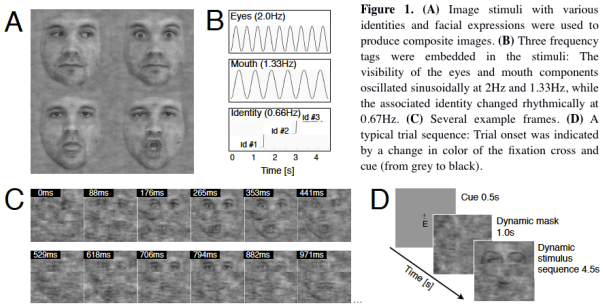

Figure 1. (A) Image stimuli with various identities and facial expressions were used to produce composite images. **(B)** Three frequency tags were embedded in the stimuli: The visibility of the eyes and mouth components oscillated sinusoidally at 2Hz and 1.33Hz, while the associated identity changed rhythmically at 0.67Hz. **(C)** Several example frames. **(D)** A typical trial sequence: Trial onset was indicated by a change in color of the fixation cross and cue (from grey to black).

Top-down attention to any one of the three face components (face identity, face parts, and eye gaze) was found to facilitate both the neural activity in the respective sub-network related to processing of the attended stimulus and the behavioral performance in a target detection task.

We first identified the respective network components (ROIs) functionally with independent localizers. These functional localizers were also based on the MEG recordings, but instead of analyzing the rhythmic modulation of the signal during the complete, highly repetitive stimulus period, the functional localizers were solely based on the evoked magnetic fields (ERFs) in response to very first appearance of a face stimulus at the beginning of each trial. All regions of interest were defined in each subject's individual MRI space, which was co-registered with the MEG Squid array to guide the reconstruction of neural sources within their individual anatomical frame of reference.

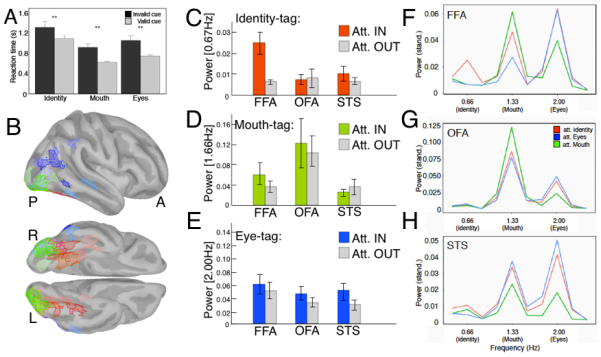

Figure 2. (A) Behavioral responses were significantly faster and more accurate for validly cued targets compared to invalidly cued targets. **(B)** Mean coordinates of the FFA (red), OFA (greed), and STS (blue), as defined in each experimental participant of the present study. **(C-D)** Entrainments of the three ROIs with the respective frequency-tags of the respectively preferred face-aspect. **(F-H)** Mean MEG power spectra of the Minimum-norm-estimates (MNE) for each ROI and attention condition.

The following spectroanalyses of the time-series in all three regions of interest of the face-processing network showed that it is possible to entrain several functionally specialized neural populations with the presentation rhythms of respectively relevant information.

By investigating – for the first time in MEG - the temporal dynamics of the complete occipital face processing network (OFA, FFA, and STS), we were able to dissect the functional compartmentalization of the system and the functional specialization of its components by demonstrating selective attentional modulation in each of the three regions.

In general, our MEG results are consistent with the view of an hierarchical organization of the three sub-networks : The network populations at an earlier level, such as OFA, and in parts also STS, are preferentially concerned with the analysis of crucial features or facial sub-components and seem to feed those representations of object parts forward to higher level face processing networks in inferior-temporal cortex, e.g. FFA, where the information about facial features and sub-components is integrated into a representation of facial identity. This relative arrangement in a hierarchical face-processing network is also supported by the telling differences in response latencies.

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