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Influence of visual stimulation on auditory object formation

Summary

The task of assigning concurrent sounds to different auditory objects is known to depend on temporal and spectral cues. When tones of high and low frequencies are presented in alternation, they can be perceived as a single ('integrated') melody, or as two parallel ('segregated') melodic lines, according to the presentation rate and frequency distance between the sounds. At an intermediate distance, the percept is ambiguous and alternates between segregated and integrated. This thesis studies whether an ambiguous sound organization could be modulated toward an robust integrated or segregated percept by the synchronous presentation of visual cues. It also accounts non-ambiguous stimulus configurations where the sounds are automatically percepted as segregated or integrated melody lines. Further, the underlying neural mechanisms of streaming were investigated by identifying the neural origin of the measured electrophysiological and biomagnetical responses.

Electrophysiological, biomagnetical, and psychoacoustical experiments with normal-hearing humans provide the framework to approach this question. Each experiment consisted of two interleaved sets of sounds, one high frequency and one low frequency set. The low frequency set consisted of repeating three-tone pattern (triplets). Across the frequency sets an additional sound intensity pattern was installed. To promote integration or segregation, visual stimuli were synchronized to either the within-set frequency pattern or to the across-set intensity pattern. Elicitation of the mismatch negativity (MMN) component of event-related brain potentials and the mismatch field as its biomagnetic counterpart served as indices for the segregated organization, when no task was performed with the sounds.

As a result, MMN was elicited only when the visual pattern promoted the segregation of the sounds. By spatial analysis of the distribution of electromagnetic potentials and fields, four separated neuronal sources underlying the obtained MMN response were identified. One pair was located bilaterally in temporal cortical structures and another pair in occipital areas, representing the auditory and visual origin of the MMN response, evoked by inverted triplets as used in this studies. The subjective auditory perception reported by the subjects of the psychoacoustical experiment was also shifted by visual cues. Thus the results demonstrate cross-modal effects of visual information on auditory object perception: Sound ambiguity was resolved by synchronous presentation of visual stimuli, which promoted either an integrated or a segregated perception of the sounds. Even at non-ambiguous stimulus configurations visual cues shifted the auditory perception towards the alternative type of percept.