The contributions of transient and sustained responses to audiovisual integration

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Introduction
Transient and sustained responses have been shown to play distinct functional roles in auditory processing. Transient responses may subserve rapid stimulus detection while sustained responses contribute to a more detailed sound characterization. While numerous fMRI studies have reported audiovisual interactions at multiple levels of the cortical hierarchy, they were not able to dissociate transient and sustained responses. This fMRI study optimized the experimental design to disentangle the contributions of sustained, onset and offset responses to superadditive and subadditive interactions and localize these effects within the visual and auditory processing hierarchies.

Scientific Aims
- Identify brain regions that respond to the onset and/or the offset of a continuous V, A or AV stimulation (transient response to rapid changes in stimulation).
- Identify brain regions that respond to ongoing continuous V, A or AV stimulation (sustained response to "no" change in stimulation).
- Identify brain regions that exhibit audiovisual response interactions:
  - on the transient onset, offset or
  - the sustained response.
- Examine the effect of an AV (in-phase) sinusoidal intensity modulation to further characterize their ability to follow slow changes in stimulation.

Stimuli
Radial starfield (V) and pink noise (A) with sinusoidal 0.1 Hz intensity modulation.

The V, A and AV stimuli were tested at different stimulus lengths:
Blocks of 10, 20, 30s.

fMRI Acquisition
- Data acquisition:
  - SIEMENS TimTrio 3T scanner, GE-EPI, TE=40ms, 38 axial slices, TR = 3.08s, voxel size 3 x 3 x 3 mm.
  - 17 subjects underwent 6 scanning sessions (206 volumes each).
- Data Analysis:
  - SPM5, modeling the canonical HRF of 5 response components.
  - Random Effects Analysis, 2nd level f-tests, p<0.05 corrected at cluster level.

fMRI Analysis
- Onsets and offsets of stimuli were modeled as delta functions (zero duration) & blocks of sustained stimulation as box car functions (adjusted for stimulus length) convolved with the canonical hemodynamic response function.
- The block (i.e. sustained) regressor had a parametric modulator encoding the sinusoidal 0.1 Hz intensity modulation (Mod. SUS).
- The offset regressor had parametric modulator linearly encoding the preceding block length (Mod. OFF).

Behavioral Measures
Subjects performed a target detection task on simple V, A or AV targets in order to maintain their attention to the visual and auditory modalities. Targets appeared in "target blocks" that were later modeled separately in the fMRI analysis.

Subjects showed a 100% detection accuracy and the redundant target RT effect.

Summary
- Superadditive audiovisual interactions were found exclusively for the ONSET-responsese in low-level and higher-order visual and auditory areas.
- Subadditive audiovisual interactions were found for the OFFSET-response in higher-order association areas, such as pSTS and AIpS.
- NO significant audiovisual interactions were observed for the sustained brain activity.
- Superadditive ONSET interactions in visual and auditory areas might detect the low-level spatiotemporal co-occurrence of auditory and visual stimuli and enable initial audiovisual scene segmentation.
- pSTS integrates rapid stimulus changes and shows enhanced sensitivity for slow (0.1Hz) changes under the AV condition. Thus, pSTS may sustain integration of auditory and visual signals at multiple temporal scales.