Multisensory Response Enhancement:
Contributions of multisensory integration and exogenous spatial attention

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Background

Responses to spatially and temporally aligned auditory and visual (AV) stimuli are generally much faster than responses to the onset of auditory (A) or visual (V) stimuli presented in isolation (Miller, 1986). Two processes that can give rise to this multisensory response enhancement (MRE) are multisensory integration (MSI) and crossmodal exogenous spatial attention (Spence & Driver, 2004). It is unclear, however, whether MSI and crossmodal exogenous spatial attention are essentially the same process or not (McDonald, Teder-Sälejärvi, & Ward, 2001; Spence, 2010). One way in which they can be distinguished is based on their temporal profile: MSI occurs mainly when the stimuli are presented in close temporal proximity while the facilitatory effects of crossmodal exgenous spatial attention increase with increasing stimulus onset asynchronies (up until SOAs at which inhibition of return occurs).

Research question

What are the relative contributions of multisensory integration and crossmodal exogenous spatial attention to multisensory response enhancement?

Methods

- A, V, and AV targets were randomly presented from one of three locations (left, center, or right).
- On AV trials the unisensory component stimuli were either spatially and/or temporally aligned or misaligned (0, 50, 100, 200 ms SOA).
- There were three blocks: A Unimodal block (A and V mixed), an AV Integration block (redundant target effect), and an AV Cueing block (crossmodal exogenous spatial cueing).
- The participants were instructed to respond to A and V stimuli in the AV Integration block and to respond to V stimuli only in the Cueing block.
- In all blocks the participants were instructed to respond to left and right and to withhold their response to centrally presented stimuli.

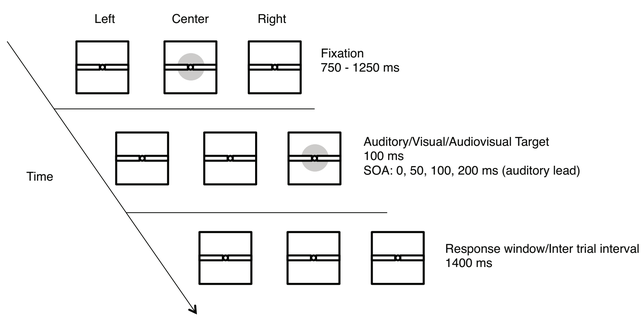

Fig. 1 Schematic representation of a trial. The grey filled circles indicate the onset of the fixation light and one of three possible locations of the onset of the visual target.

Results

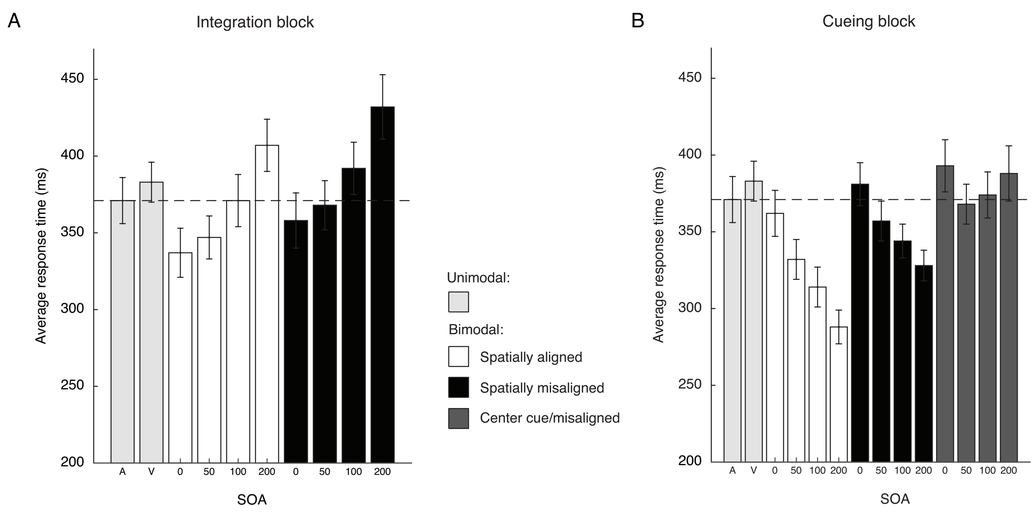

Fig. 2 Response times to A, V, and AV targets for each SOA and spatial alignment condition in the Integration and Cueing block.

Accuracy

On Go trials accuracy was ~99% and on No-go trials ~88%. Therefore, the accuracy was not analyzed further.

Response times

Responses to AV targets were faster than to unisensory targets in the Integration block. This facilitatory effect decreased as the SOA increased and depended on the spatial alignment of the A and V stimulus. The pattern of RTs to AV stimuli in the Cueing block was opposite to that seen in the Integration block: AV RTs decreased as SOA increased. This effect was modulated by the spatial alignment of the A and V stimulus.

Spatial alignment effects

Spatial alignment effects in the Integration block remained constant across SOAs. Spatial alignment effects increased with SOA in the Cueing block.

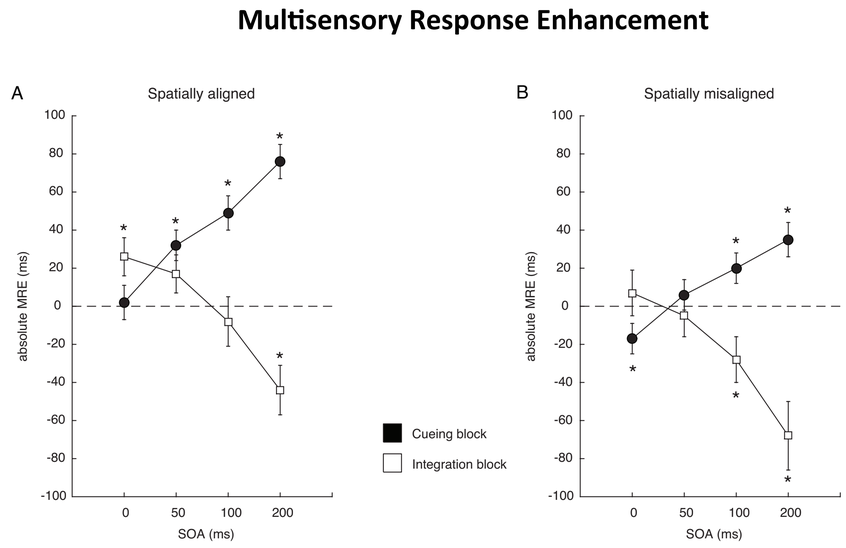

Fig. 3 The absolute MRE at four SOAs in the Integration (white squares) and Cueing block (black squares) in the spatially aligned (A) and misaligned condition (B). * $p < .05$

Absolute MRE = $\min(RT_A\ RT_V) - RT_{AV}$. MRE decreased with SOA in the Integration block but increased with SOA in the Cueing block when A and V were spatially aligned. No MRE was observed in the spatially misaligned conditions in the Integration block. At 100 and 200 ms SOA multisensory interference was observed in the Integration block. In the Cueing block, interference was observed at 0 ms SOA and MRE at 100 and 200 ms SOA when A and V were spatially misaligned.

Race model violation

To test whether MRE was due to statistical facilitation or multisensory integration the AV RTs were compared with the Race model (Fig. 4). Significant violations of the Race model (above the dashed line) are indicative of multisensory integration. Race model violations were observed at 0 and 50 ms in the Integration block when A and V stimuli were spatially aligned. In the Cueing block race model violation was observed at 50 ms SOA when A and V stimuli were spatially aligned. At longer SOAs violations likely further increased due to preparation as shown by the difference between the center cue (No-go) and valid/invalid cue (Go) conditon.

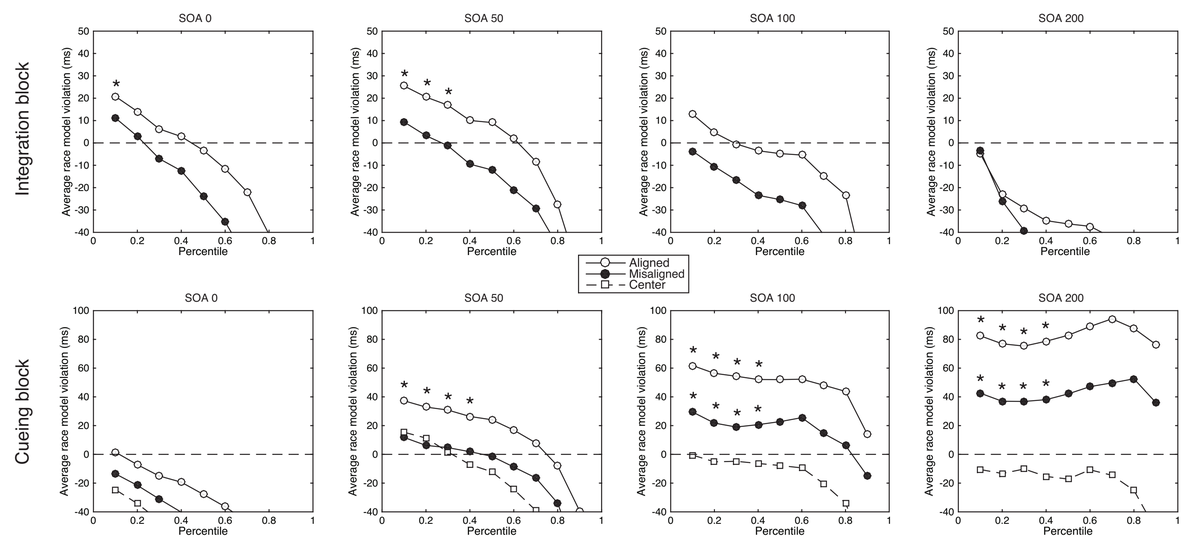

Fig. 4 Race model violation at each SOA in the spatially aligned (open circles) and misaligned (filled circles) condition in the Integration (top) and Cueing (bottom) block. Open squares = central cue in the Cueing block. * $p < .05$.

Conclusions

- At 0 ms SOA, MRE was explained by MSI.
- At 50 ms SOA, MSI and crossmodal exogenous spatial attention both contributed to MRE.
- At longer SOAs, MRE was due to crossmodal exogenous spatial attention and preparation, not MSI.
- These results indicate that there may be a temporal window in which attention and integration both contribute to MRE

References

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