Auditory spatial discrimination with visual vs. auditory attentional cueing.

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Abstract

We performed behavioral and EEG experiments to examine whether directing automatic auditory spatial attention affects listeners' performance and how neuronal activity changes during task performance. We found better performance following visual cue vs. auditory cue. Auditory cue presented from an incongruent location had a detrimental effect on performance. Analysis of ERPs showed that amplitudes of the late auditory components covary with the observed behavioral performance.

1 Introduction

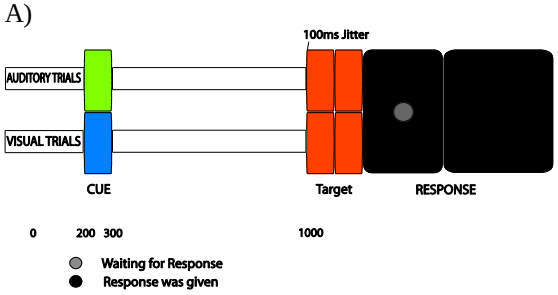
Attention facilitates processing of objects in complex scenes. Previous studies found that directing automatic or strategic attention by an auditory cue can improves reaction times (Spence & Driver, 94) but have small (Sach et al., 2000) or no (Kopco et al., 2001) improvements in localization accuracy. Recent study found enhancement of auditory discrimination when the listener's gaze was directed to stimulus, but not when cue was auditory (Maddox et al., 2014).

We performed behavioral and EEG experiments to examine: 1) whether directing automatic auditory spatial attention affects listeners' performance in a task when the gaze direction is fixed, 2) whether the effect depends on the modality of the attentional cue (auditory vs. visual), and 3) how neuronal activity, measured by EEG, changes during task performance.

2 Methods

14 subjects (9 male, aged 20 - 38 years) normal hearing participated in the two-session experiment.
The experiment consisted of 2 sessions divided into 20 blocks of 40 visual cue and auditory cue trials (FIG. 1A). During the trials eyes were fixated at 12.5° (for right hemifield setup). Target consisted of two 100-ms 170-Hz click trains (T1,T2), presented at 0° or 25°. Auditory cue was identical to T1 and visual cue was 100-ms white dot. They were presented from the same location as T1 (valid), or invalid location (25° - T1 loc) (FIG. 1B). Cue validity was 50%.

A)



B)

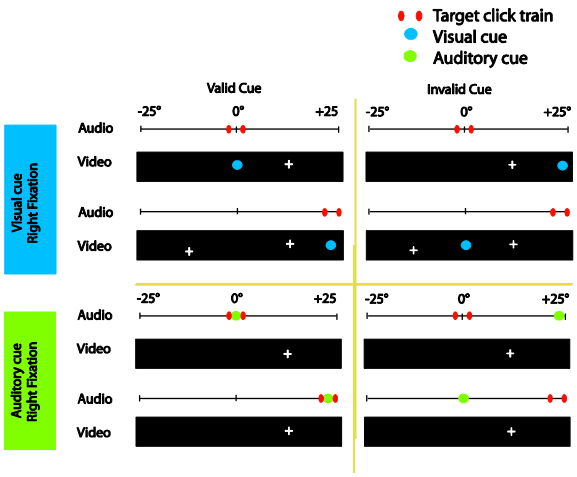


FIG 1: Experimental setup. A) Temporal structure of a single trial. B) Spatial arrangement of stimuli in different experimental conditions for FP on the right (mirror-flipped setups were used with FP on the left).

3 Results

3.1 Behavioral analysis

Overall visual cue performance was better than auditory cue performance ($p=0.017$). Validity of cue (FIG 2) has little impact for visual cue (n.s.). On the other hand we found large impact for auditory cue ($p<0.001$): invalid cue acts as a distractor (valid cue has a small effect re. visual).

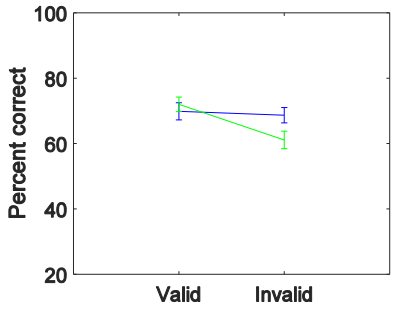


FIG 2: Percent correct responses as a function of cue validity plotted separately for the visual and auditory cues.

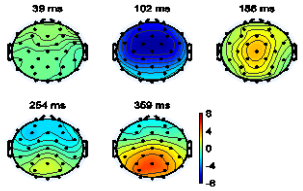


FIG 3: Topographic distribution of grand average potentials at P1, N1, P2, N2, P3 re. onset of target T1.

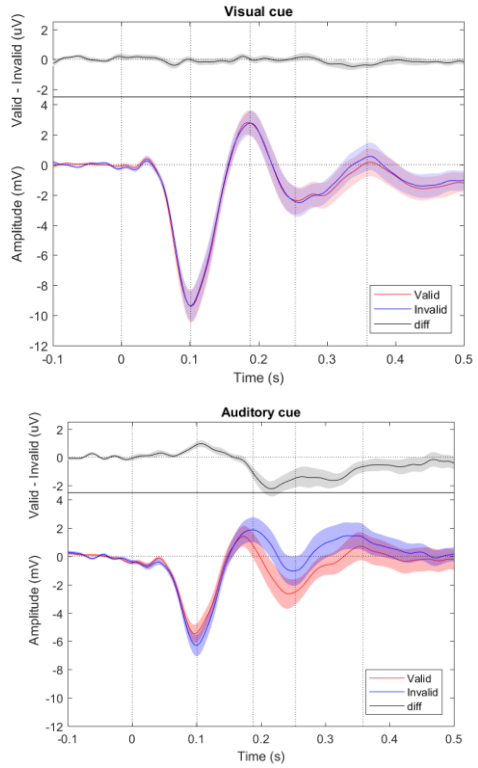


FIG 4: Cue-modality-specific and cue-validity-specific responses averaged across electrodes Cz, Fc1, Fc2, Fz. Vertical dotted lines indicate timing of components P1, N1, P2.

3.2 Analysis of Event Related Potentials

Maxima and minima of grand averaged potentials (FIG. 3) are referenced to the onset of target T1.

ERP analysis revealed that Target N1 after visual cue is much larger than after auditory cue ($p<0.001$).
Within N1 and P2 components; validity of auditory cue modulates target N1 and P2; which is smaller for valid cue ($p = 0.03 - 0.001$). Auditory cue ERPs also differs 200-300ms post-T1 (100-200ms post-T2) ($p<0.001$).

4 Conclusion

The results confirm that stimulus-driven automatic spatial attention influences auditory spatial discrimination.
An invalid auditory cue, presented from an incongruent location, had a detrimental effect on performance Invalid cue acts as a distractor (while valid cue has a small effect), while no effect of visual cues was found.
We found target N1 after visual cue much larger than after auditory cue. This effect is likely a result of spatially-specific adaptation, and not attention.
We found that auditory ERP differs strongly 200-300ms post-T1 (100-200ms post-T2). This is likely a correlate of behavioral interaction modality x validity.

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