Audio-visual integration of offset signals

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Accumulated evidence has shown that the perception of a visual object is altered by an auditory stimulus. This study investigated how the "offset" timing of an auditory stimulus would influence the perceived position of a moving visual object. A visual target moved smoothly in a horizontal direction and disappeared at an unpredictable position. Concurrently with the visual target, a pure-tone sound was continuously presented. The onset of the sound was temporally aligned with that of the visual target but the offset timing varied. The results showed that the perceived final position changed systematically with the temporal gap between the visual and sound offsets. This finding suggests that an offset of an auditory signal may signal changes of a visual object.

Key words: audio-visual integration, motion perception, mislocation

Information carried by different sensory channels is effortlessly and automatically integrated. Numerous studies have also shown that subjective visual experience can be dramatically altered by auditory signals (e.g., Shams, Kamitani, Thompson, & Shimojo, 2000). For example, Scheier, Nijwahan, Shimojo, (1999) have shown that visual temporal resolution can be either improved or degraded by sounds, depending on the temporal relationship. They showed that when two lights were turned on with a small temporal delay, the accuracy of temporal order judgment was better when one sound preceded, and another followed, the visual stimuli. In contrast, the subjects' performance became worse when two sounds were inserted between the two visual stimuli. This finding demonstrated that auditory signals can positively interact with the timing of visual stimuli. Whereas most of the previous studies have examined stimulus "onsets", less attention has been devoted to stimulus "offsets".

We therefore asked the question of whether an offset of auditory signal would alter visual perception. To address this question, we investigated how the offset timing of an auditory stimulus would influence the perceived offset position of a smoothly moving visual object.

Methods

Participants. Fourteen paid volunteers participated. All participants reported having normal hearing and normal, or corrected-to-normal, vision.

Apparatus and Stimuli. The participants were seated in front of a monitor in a quiet dark room, and were wearing headphones. The monitor background was split into two gray areas which were differentiated by the screen luminance: the upper area was brighter than the lower area (Figure 1). A white fixation cross was presented at 7 degrees under the center of screen. The target was a black disk (1 degree in diameter), which was 0.5 degrees above the boundary line of the background. The auditory

![Figure 1. Schematic representation of the stimulus. The arrow indicates the direction of the target's motion.](image-url)
stimulus was a continuous pure tone with a frequency of 1,000 Hz.

Procedure. The participant initiated each trial by pressing the space bar of a keyboard. The initial position of the target was 15 degrees away from the midpoint of the display. After a delay of 500 ms from the appearance of the target, it moved smoothly to the right, and disappeared at one of three random positions: either -0.3, 0, or 0.3 degrees from the display center. Concurrently with the visual target, a pure-tone sound was presented. The onset timing of the sound was temporally aligned with the onset of the target motion. The temporal delay between the target offset and the sound offset was either -120, -80, -40, 0, 40, 80, or 120 ms. After 200 ms from the target offset, a mouse cursor was presented at the center of the display. The participants were required to indicate the offset position as accurately as they could by using the mouse cursor. Each participant performed 210 trials.

Results

Figure 2 shows the mean mislocation of the target for each time difference between the sound offset and the visual offset. A positive value means that the offset position of the moving target was perceived as after the actual offset position. Analysis with a one-way ANOVA revealed a significant main effect \( F(6, 78) = 10.42, p < 0.001 \). Planned comparisons showed that when the sound offset was -120 ms the perceived termination position of the visual target was earlier than it was at a sound offset of 0 ms \( \bar{t}_{13} = 2.99, p < 0.01 \). Furthermore, when the sound termination was 120 ms after the target offset, the perceived target location was more advanced than it was at 0 ms \( \bar{t}_{13} = 2.54, p < 0.01 \).

Discussion

Our results clearly showed that the offset of an auditory stimulus influenced the perceived position at which a moving visual object disappeared. Specifically, when the offset timing of the concurrent sound was earlier than that of the visual target, the offset position of the target was perceived as before (i.e., earlier than) the actual offset position. In contrast, when the offset timing of the concurrent sound was later than that of the visual target, the offset position of the target was perceived as ahead of the actual location. These findings suggest that the offset of an auditory signal and that of a visual signal can also be integrated.

A phenomenon relevant to the present study is the temporal ventriloquism effect, in which the perceived timing of a visual stimulus is associated with that of the sound to which the visual stimulus is bound (Morein-Zamir, Soto-Faraco, & Kingstone, 2003; Vroomen & de Gelder, 2004). The present finding can be attributed to the offset timing of the visual target also being advanced or delayed, depending on the offset timing of the concurrent sound.

Whether this integration occurs in other modalities (e.g., vision and touch), and whether the effects depend on the spatial proximity of the stimulus, warrant further investigations.

References


![Figure 2](https://example.com/figure2.png) The mean mislocation for each temporal delay. Vertical bars indicate the standard error.