Footstep sounds increase sensitivity to point-light walking when visual cues are weak

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Introduction

• The Superior Temporal Sulcus (STS) is involved in the visual analysis of human action and multisensory integration. 1,2,3
• MRI BOLD signal in STS displays Inverse Effectiveness; BOLD responses to AV stimuli are greater when unimodal stimulus strength is weak. 4,5,6
• We examined if the influence of meaningfully related sounds on visual sensitivity to human motion varies as a function of the strength of the visual signal.
• The results indicate that meaningfully related sound cues aid in the visual analysis of human action when visual cues are weak.

Inverse Effectiveness and Multisensory Integration

• Some multisensory neurons display Inverse Effectiveness. 7,8,9
• Neural responses to multimodal stimuli are greater when the most effective unimodal stimulus on its own produces a weak response.
• Studies suggest that the effect of auditory cues on visual processing is greater when the visual signal is relatively weak. 10,11

The Superior Temporal Sulcus

• Is involved in the visual analysis of human action and multisensory integration. 1,2,3
• (MR) BOLD signal in STS displays Inverse Effectiveness. 4,5,6

Multisensory Action Perception

• The integration of meaningfully related audiovisual cues aids human action perception. Observers are more sensitive to human motion when paired with meaningfully related sounds. 12,13
• Does perceptual sensitivity to meaningfully related audiovisual displays vary as a function of the strength of the visual signal, as suggested by the Inverse Effectiveness rule?

Rationale & Predictions

1) Meaningful sound cues enhance visual sensitivity to point-light actions.
2) Multisensory processes follow the Inverse Effectiveness rule.
3) Therefore, the benefit for meaningful sounds on sensitivity to human actions should depend upon the relative strength of the visual signal.

Experiment 1

Research Question

• Does the integration of meaningfully related auditory and visual human action displays follow the Inverse Effectiveness rule?

Hypothesis

• Heard footsteps will increase detection sensitivity only when the visual stimulus is relatively weak.

Methods

• Between-subjects design: 3 conditions
• 60 participants
• 20 silent (vision only control)
• 20 1000Hz tones (meaningfully unrelated)
• 20 footprint sounds (meaningfully related)
• Person detection task
• ½ movies – coherent point-light walker + mask
• ½ movies – scrambled point-light walker + mask
• Movie duration: 3000ms
• Sounds presented over speakers
• Sounds temporally coincident with walker’s footsteps

Results

• One way ANOVA revealed main effect of sound, F(2,57) = 7.107, p = .002.
• Post-Hoc T-tests indicate that sensitivity was greater for footprint than for tone (p = .039) and silent displays (p = .002). No difference between tone and silent displays (p = .806).
• Internal analysis of sensitivity data (D’) obtained percent correct for each movie presented in silence (range 33-100%).
• Split movies into two groups based on visual difficulty; median split (high and low).
• 2 x 3 mixed measures ANOVA revealed a main effect of sound (p < .000), difficulty (p < .000) and a sound x difficulty interaction (p = .020).
• Post-Hoc T-tests indicate footprint sounds improved visual sensitivity only for visually hard movies. Footstep > silent, p = .003; footsteps > tone p = .115.

Discussion

• The relative strength of the visual signal impacted the degree to which meaningfully related sounds impacted sensitivity to human movement.
• Footstep sounds increased sensitivity to masked point-light walking motion displays that were difficult to perceive in silence.
• Footstep sounds had no effect on displays that were easy to perceive in silence.
• Results support the hypothesis that the integration of meaningfully related auditory and visual action cues follows the Inverse Effectiveness rule.
• These results dovetail with neuroimaging studies wherein STS BOLD stimuli to audiovisual stimuli displays Inverse Effectiveness.
• Not all multisensory processes adhere strictly to the Inverse Effectiveness rule.
• Relationship between neural Inverse Effectiveness and perceptual outcomes is not entirely clear.
• Future work should examine how signal strength impacts integration using a wider range of relative signal strengths.

References


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