

Influence of eye fixation on the effects of visual and auditory cuing in sound localization

Beáta Tomoriová¹, Rudolf Andoga¹, Norbert Kopčo^{1,2}

¹ Perception and Cognition Lab, Technical University of Košice, Slovakia, ² Dept. of Cognitive and Neural Systems, Boston University

Background

Attention facilitates selection of objects, events, or spatial regions in complex scenes. Here, we investigate how the modality through which strategic spatial auditory attention is directed influences sound localization and whether the effect is influenced by eye fixation.

Experiment

Motivation

Few previous studies showed that in the task of sound localization directing attention by an auditory cue causes:

- Improvements in reaction times (Spence & Driver, 1994)
- Small (Sach et al., 2000) or no (Kopco et al., 2001) improvements in performance

Possible reasons for this lack of strong effects:

- tested SOAs too short to orient attention,
- modality through which attention is directed is important
- eye movements increased variance in responses, making results too noisy

Current study

Perform behavioral experiment to determine:

- whether attentional effects occur at longer SOAs
- whether attentional control is modality-dependent (visual vs. auditory cue)

Compare results of current experiment with preliminary experiment – here labeled as Experiment 1, where eyes were not fixated (Kopco, Tomoriová, Andoga, 2007) to determine possible effect of eye movements (Werner-Reiss et al., 2003).

Hypotheses

- Attention will affect performance by inducing biases in responses
- Effect of attention will be modality and eye-fixation dependent

Methods

Experiment 1

12 normal hearing subjects

Stimuli

- Target: broadband 2-ms click, simulated at one of 10 locations in virtual anechoic environment (Fig 1A)
- Auditory cue: 100-ms 2-kHz pure tone presented monaurally from L or R side
- Visual cue: left- or right-pointing arrow on a computer screen (Fig 1B)

Procedure

- 10 one-half hour sessions
- each session consists of 7 blocks, one per measurement type:
 - 2 modalities (auditory, visual) x 3 informativeness + no cue
- cue informativeness: cue correctly predicts target lateral side on 50%, 80%, or 100% of trials within a block
- one block contains 10 (locations) x 3 (SOAs) trials
- SOA: 0.4, 0.8, or 1.6 seconds

Setup

- subject seated in front of a computer (Fig 1A), surrounded by a semicircle with pictures of speakers
- perceived location entered using numeric keypad on computer

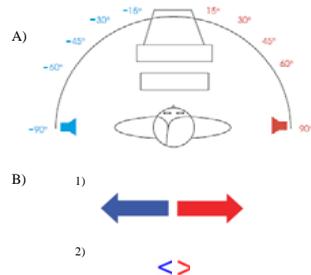


FIGURE 1 Experimental setup. A) Top view of a listener in the simulated environment. Numbers show simulated target locations. B) Sample arrows shown on a computer screen as a visual cue in 1) - experiment 1, 2) - experiment 2

Experiment 2

Similar to experiment 1, except

- eyes fixated to the center of the computer screen
- different (centered) visual cue (Fig 1B2)
- SOA 0.8 excluded

Results

Data collapsed across median plane and informativeness

FIGURE 2 Bias in responses induced by the cue. Across-subject mean and standard error in the difference between responses with and without cue.

Auditory and visual cuing shift perceived locations of auditory targets.

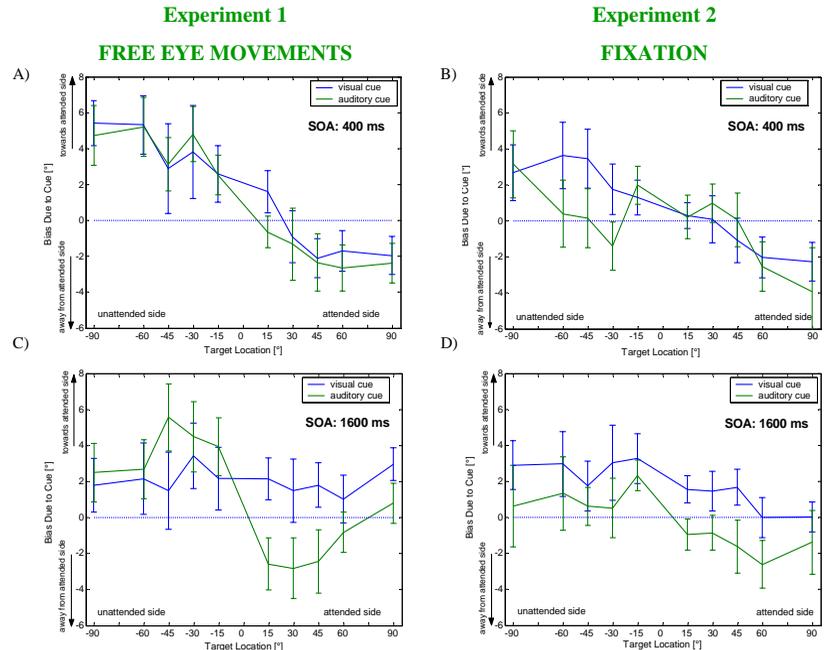
Experiment 1: Free eye movements (panels A and C)

Both cues attract targets presented from the unattended side.

Effects of auditory and visual cues for targets presented from cued side differ at longer SOA.

Experiment 2: Eyes fixated (panels B and D)

Eye fixation changed the visual cue bias negligibly (blue lines in panels A vs. B and C vs. D). However, it affected the auditory-cue bias (green lines).



Auditory Cue

- medial bias
- almost independent of SOA

Visual Cue

- at short SOA medial bias similar to auditory cue
- at large SOA, bias always towards the cued side

Auditory Cue

- negligible bias
- almost independent of SOA

Visual Cue

- at short SOA medial bias
- at large SOA, bias always towards the cued side

Conclusion & Discussion

Attentional cuing influenced sound localization by inducing biases in responses.

Effect was modality dependent, especially at longer SOA.

Eye fixation reduced the auditory cue bias almost to no-cue responses, but had just negligible effect on visual-cue bias. Possible explanations:

- keeping the eyes fixated requires concentration (attentional resources), reducing the resources available for processing and using the cue when it is from a different modality (i.e., auditory).
- processing of auditory cue might have been more difficult, because it was presented from a location (-90° or 90°) that differed from the fixation point (0°). Visual cues and fixation point were aligned at 0°.

References & Acknowledgement

1. Kopco, N, A Ler, and B Shinn-Cunningham (2001). "Effect of auditory cuing on azimuthal localization accuracy." JASA 109, 2377
2. Kopco, N, Tomoriová, B, Andoga, R. (2007) "Visual and auditory hemispheric cuing in horizontal sound localization (A)" J. Acoust. Soc. Am., 121, 3094
3. Sach, A.J, Hill, N.I, and Bailey P.J. (2000) Auditory spatial attention using interaural time differences. JEP:HPP. 26(2):717-729
4. Spence, C.J and Driver J (1994) Covert spatial orienting in audition: Exogenous and endogenous mechanisms. JEP:HPP. 20(3): 555-574.
5. Werner-Reiss, U, Kelly, K.A, Trause, A.S, Underhill, A.M and Groh, J.M. (2003). Eye position affects activity in primary auditory cortex of primates. Current Biology, 13:554-562.

Support: Slovak Science Grant Agency grants #1/3134/06