

METHODS

Two experiments

Exp 1 compares effects of visual and auditory cues with different information values and at different SOAs when eye-movement not restricted

Exp 2 looks only at the effect of the visual cue at the longest SOAs, comparing behavior when subjects are fixating vs. not fixating.

Experimental Procedure

11 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)

Experimental conditions

- 7 different types of measurement:
2 (cue modalities) x 3 (cue informativeness) + no cue
- cue modality: auditory or visual
- cue informativeness: cue is valid (i.e., correctly predicts target lateral side) on 100%, 80%, or 50% of trials within a block
- type of measurement fixed within a block
- one block contains 10 (locations) x 3 (SOAs) trials (no-cue block has only 10 trials)
- SOA: 0.4, 0.8, or 1.6 seconds

Experiment

- 10 one-half hour sessions
- each session consists of 7 blocks, each measuring performance in one measurement type

One trial

- subject informed about cue modality, informativeness, and SOA

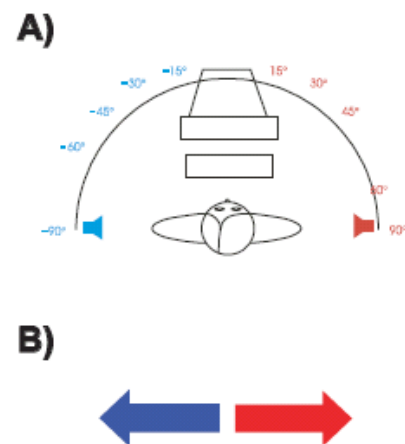


FIGURE 1 Experimental setup. **A)** Top view of a listener in the simulated environment. Numbers show simulated target locations. **B)** Sample arrows shown on a computer screen as a visual cue.

- presentation of stimulus
- perceived location entered using numeric keypad on computer

Data Analysis

- collapse data across median plane
- bin data by location, cue type (modality, Informativeness, valid/invalid), SOA, subject
- compute mean and standard deviation in responses for each bin
- compute across-subject mean and standard error of the mean

RESULTS: MEAN RESPONSES (EXP1)

FIGURE Bias in responses induced by the cue. Across-subject $m+SE$ in the difference between responses with and without cue. Data collapsed so that cue is always on right.

AUDITORY CUE

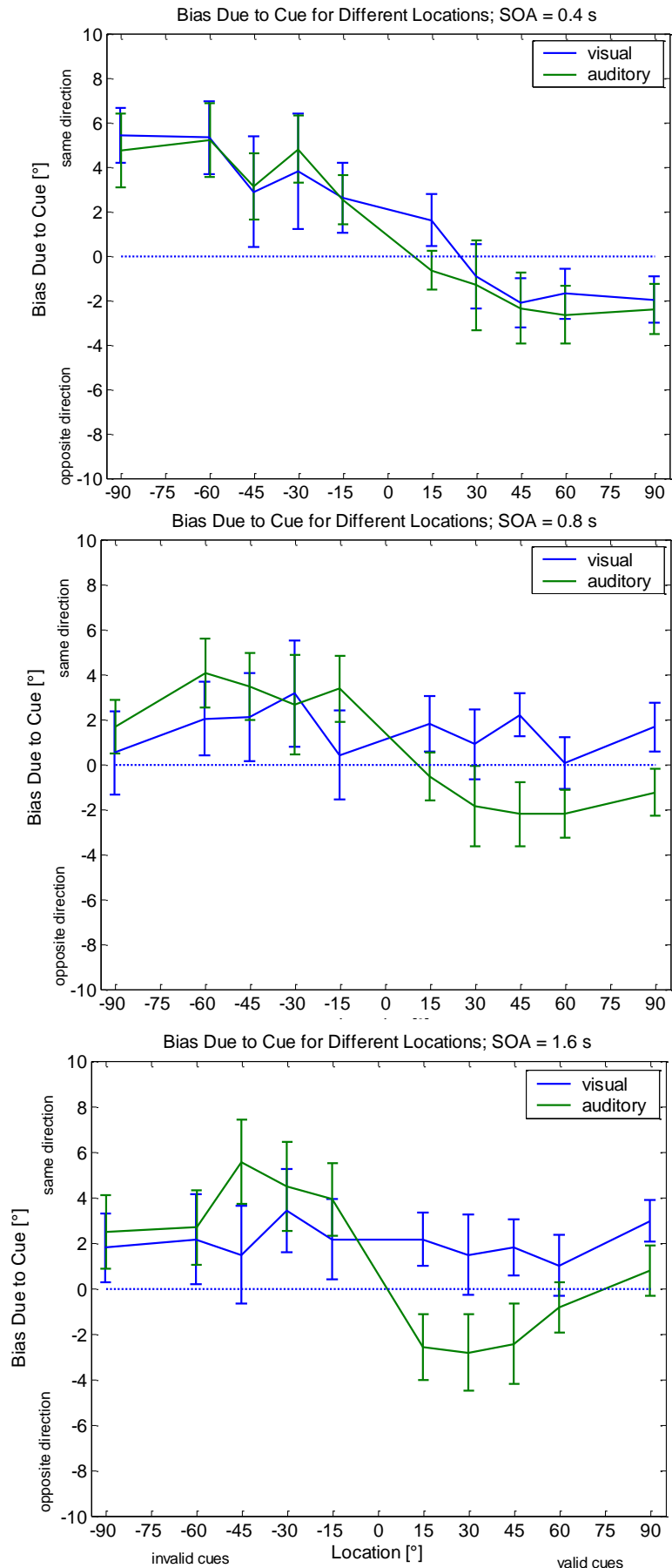
- causes a combination of:
 - a) medial bias
 - b) bias towards attended side (rightward shift)
- independent of SOA

VISUAL CUE

- at short SOA medial bias similar to auditory cue
- at larger SOAs, bias always towards the cued side (right)

Summary

Independent of cue modality or SOA, cue attracts targets presented from the unattended side.
 Auditory cue repulses targets from attended side.
 Effect of visual cue on ipsilateral targets reverses at larger SOA, possibly due to eye movements.



RESULTS: MEAN RESPONSES (EXP2)

FIGURE Effect of fixation on the bias in responses induced by a visual cue at SOA 1600ms.

Without fixation:

- bias towards cued side as in Exp 1

With fixation:

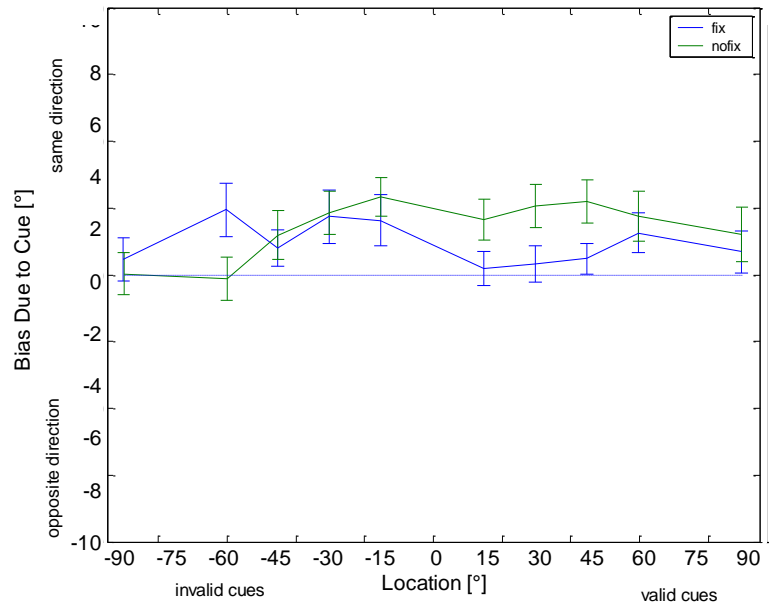
- bias on cued side reduced

Summary

Bias on unattended side independent of eye fixation.

Bias on attended side in Exp 1 was due to eye movement.

But, even with eyes fixating the (no) bias on attended side is different from auditory cue.

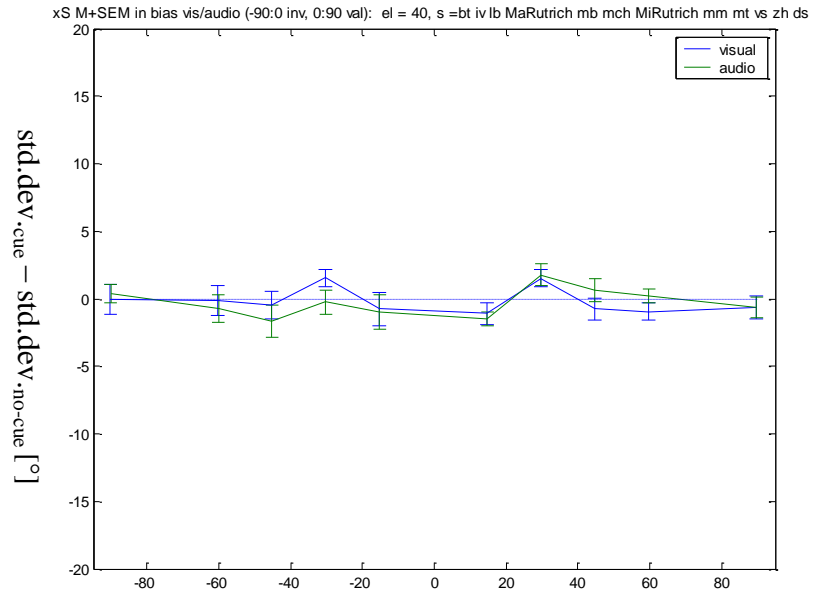


RESULTS: STD. DEVIATIONS

EXP 1

FIGURE Effect of fixation on the std.dev. in response induced by a visual and auditory cue at 1600 ms

Very small effect of visual or auditory cue.



EXP 2

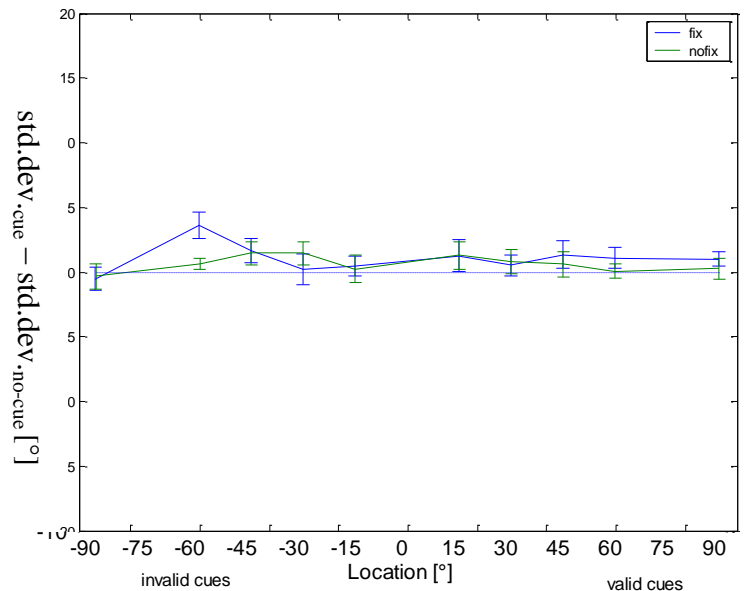
FIGURE Effect of fixation on the std.dev. in responses induced by a visual cue at SOA 1600ms.

Without fixation:

- no consistent effect (or a weak increase on unattended side), similar to Exp 1

With fixation:

- increase on the unattended side at -60° (one-way ANOVA, $p < 0.05$)



Summary

Spatial cuing never improves performance in terms of std.dev.

Focusing attention increases variability in responses on unattended side.

DISCUSSION AND CONCLUSIONS

Attentional cuing influences auditory localization by:

- inducing biases
 - affecting variability in responses
- at cue-to-target stimulus onset asynchronies of up to 1600 ms

The effect of cuing is modality dependent:

Auditory cue

- induces bias that is a combination of:
 - bias toward attended side
 - medial bias
- has no consistent effect on std. dev. in responses

Visual cue

- **has effect that has covert and overt components (distinguished by fixation):**
 - independent of fixation, on unattended side responses always biased towards attended side (similar to auditory cue)
 - on attended side, lateral bias if eyes move, no bias if they don't (both different from auditory cue)
 - increases variability in responses on the unattended side, when covert (no eye movement)

No effect of cue information value

- **subjects always use the same strategy.**
- **Given the large SOAs, all effects are likely due to exogenous attention.**