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EFFECT OF CUING ON SOUND LOCALIZATION ACCURACY IN A ROOM

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1. ABSTRACT

A previous study of auditory attention examined how auditory localization accuracy in an ordinary room is affected when a test stimulus is preceded by an auditory cue from either the correct or opposite hemifield (Kopčo et al., 2001, see Fig 1). Results suggested that the auditory cue does not improve localization accuracy, even when the cue is always informative. In fact, the presence of a preceding cue from either +90° or –90° azimuth caused a consistent localization bias of the test stimulus (causing the test stimulus to be heard more towards the midline) for cue-test delays as long as 300 ms. In the current study, these findings are extended to determine how the azimuthal position of the cue stimulus affects localization bias. Acoustic analysis examines the extent to which localization bias can be explained by the reverberation in the room (which has a broadband T60 of roughly 450 ms), as opposed to perceptual effects (e.g., Carlile et al., 2001).

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2. MOTIVATION

PREVIOUS RESULTS

Sach et al. (2000): interaural time difference (ITD) cuing improves ITD discrimination

Spence and Driver (1994): in cued localization study, reduced reaction time (no front/back accuracy improvement)

Kashino & Nashida (1998), Carlile et al. (2001): repulsion of a later sound by a preceding cue.

Kopčo et al (2001): a cue preceding a target by 300 ms
- increases localization error
- causes bias towards median plane (see Figure 1)

Results were roughly insensitive to
- whether or not cue indicated correct hemifield
- cue & target stimulus type (click vs. burst)
- stimulus-onset asynchrony (SOA; 50 ms vs. 300 ms)

Two hypotheses for cause:
1) room-acoustics
2) bottom-up perceptual factors

Other studies have found either repulsion (Hartung and Braasch, 1999) or attraction (Good, 1994) of a target when presented simulataneously with a masker.

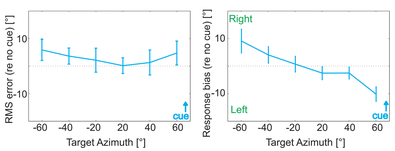


FIGURE 1 Results of Kopčo et al (2001). The effect of cue on localization error (left) and localization bias (right) as a function of target azimuth for cue at 90°

CURRENT STUDY

Replicate Kopčo et al (2001) with new cue positions (+/-45°) and SOAs (0, 300, 700 ms).

HYPOTHESES

For 90°-cue, results should replicate Kopčo et al. (2001)

For 45°-cue
- midline symmetry would imply effects due to acoustics
- non-symmetrical results would suggest perceptual factors

Expect "informative" and "non-informative" results to be the same (i.e., no effect of whether or not cue indicated correct hemifield)

For simultaneous sources, may see repulsion (Hartung and Braasch, 1999) or attraction (Good, 1994).

3. METHODS

EXPERIMENTAL PROCEDURES

Six normal-hearing subjects (2F, 4M)

Targets in frontal horizontal plane uniformly distributed between +/- 90°

Cues at +/- 90°, +/- 45° (fixed within run)

Cue sound: 20-ms noise burst, Target: 2-ms click

Stimulus onset asynchrony (SOA): 0, 300, 700 ms

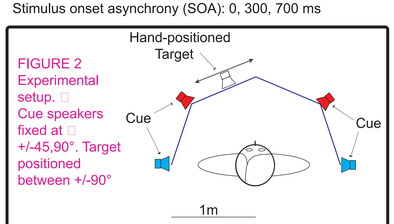


FIGURE 2 Experimental setup. Cue speakers fixed at +/-45,90°. Target positioned between +/-90°

Three cue conditions varying % trials w/ cue on target side
- no cue (0%)
- 50% of trials (no information in cue)
- 100% (informative cue)

Runs blocked by cue condition x cue position x SOA
- eight one-hour sessions per subject
- session = 12 36-trial runs (random order)

Minimum of 120 trials / subject-condition
- distributed randomly in azimuth (-90° to +90°)

Performed in center of quiet room (5 m x 4 m; T_{60}=500ms) [T_{60} was 700 ms in Kopčo et al. (2001)]

DATA ANALYSIS

Assume left/right symmetry (collapse + and - cue locations)

Trials divided into three azimuthal bins

(0° - 30°) (30°- 60°) (60° - 90°)

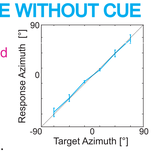
Calculate across-subject mean and st. dev. in:
- RMS error
- mean signed error (bias)

4. RESULTS - SOA>0

A. PERFORMANCE WITHOUT CUE

FIGURE 3 Across-subject mean and std. dev. in perceived target azimuth without any cue.

Without cue, performance is accurate.



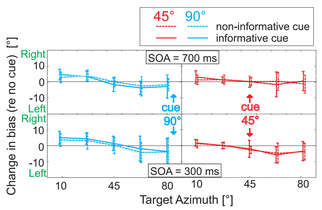


FIGURE 4 Mean change in response bias with cue (compared to no cue condition). Error-bars show across-subject standard deviation. Informative and non-informative cues cause identical change in bias.

B. STRATEGIC CONTROL

Cue biases perceived target azimuth (Figure 4)

Informative and non-informative cues yield identical bias (i.e., no conscious attention effect)

Informative and non-informative cues yield same RMS error (not shown)

Data for informative and non-informative cue are collapsed in subsequent analysis

C. CHANGE IN RMS ERROR DUE TO CUE

The cue either improves accuracy or has no effect.

(Subject S6 fell asleep during the task, and performed differently from other subjects. S6's data was excluded from solid line analysis)

Improvement due to cue is
- largest near the cue
- stronger for 45°-cue
- weaker for 90°-cue
- independent of SOA (Figure 5a vs. 5b)
- opposite results of Kopčo et al. (2001; Figure 5c) where cue increased error

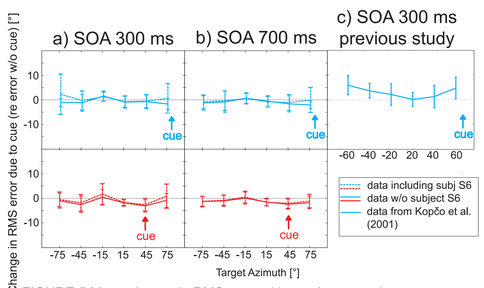


FIGURE 5 Mean change in RMS error with cue (compared to no cue condition). Error-bars show across-subject standard deviation.

D. CHANGE IN BIAS DUE TO CUE

The cue alters bias (by as much as 5°).

The bias due to cue is
- weak for many positions
- cue-position dependent
- stronger for 90°-cue
- weaker for 45°-cue (opposite RMS error, Fig 5)
- asymmetric with respect to midline (0°)

For 45°-cue, depends on SOA (Figure 6a vs. 6b), but not for 90°-cue

Results hold also with subject S6 included.

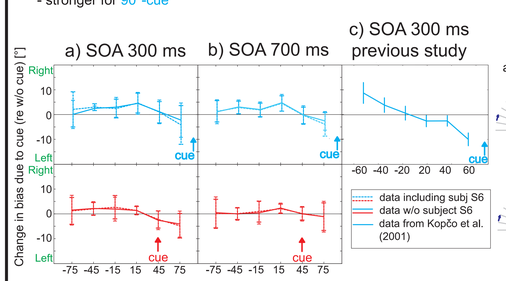


FIGURE 6 Mean change in bias with cue (compared to no cue condition). Error-bars show across-subject standard deviation.

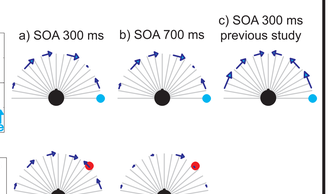


FIGURE 7 Cartoon illustrating the bias caused by the cue (filled circles show cue position).

5. DISCUSSION - SOA>0

COMMENT ONE

Bottom-up auditory processing causes localization of a target to be influenced by a preceding cue.

Reverberation influences this bottom-up processing, and differs between Kopčo et al. (2001) and the current study.

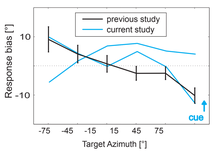
COMMENT TWO

Subject differences are large, and only 3 subjects were tested in Kopčo et al. (2001).

Among the current 6 subjects, some subjects show results very comparable to Kopčo et al. (2001).

Figure 8 compares the previous data to hand-selected subgroups of the current subjects.

FIGURE 8 Response bias in Kopčo et al. (2001) and for two hand-picked groups of subjects from the current study



6. RESULTS - SIMULTANEOUS PRESENTATION (SOA=0)

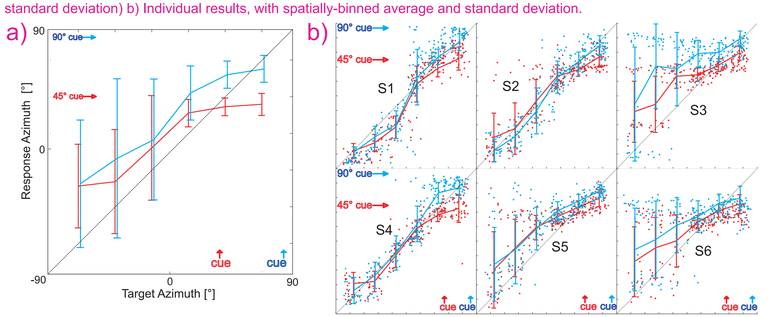
RESULTS

- When presented simultaneously with target, the cue acts as an distractor.
- Inter-subject variance is very large.
- For all subjects, the cue attracts nearby sources (in the same hemifield).
- Some subjects cannot localize the target in the hemifield contralateral to the cue (S3, S5, S6)

DISCUSSION

- The task with SOA=0 is much more difficult than SOA>0.
- Some Ss may not even be able to detect the target.
- Results opposite to Braasch and Hartung (2002), who reported repulsion of target by distractor (nonsimultaneous onsets)

FIGURE 9 Response azimuth as a function of target azimuth for simultaneous target and cue. a) Across-subject mean (+- standard deviation) b) Individual results, with spatially-binned average and standard deviation.



7. CONCLUSIONS

In a room, a cue preceding a target by 300 to 700 ms
- has an effect that varies strongly from subject to subject and from room to room
- can improve localization accuracy by 3° near the cue
- can introduce response bias of up to 5°, attracting distant targets and repulsing near sources
- causes an effect that is cue-position dependent (unlike in Kopčo et al., 2001)

The effects are
- likely due to acoustic and perceptual factors, but not to attentional processing
- present for almost all conditions, with the weakest effect in response bias for 45° cue and 700 ms SOA

Simultaneous presentation of cue and target
- makes the task much more challenging, increasing the inter- and within-subject variance
- can attract target, consistent with Good (1994), but opposite Braasch and Hartung (2002)

8. REFERENCES

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