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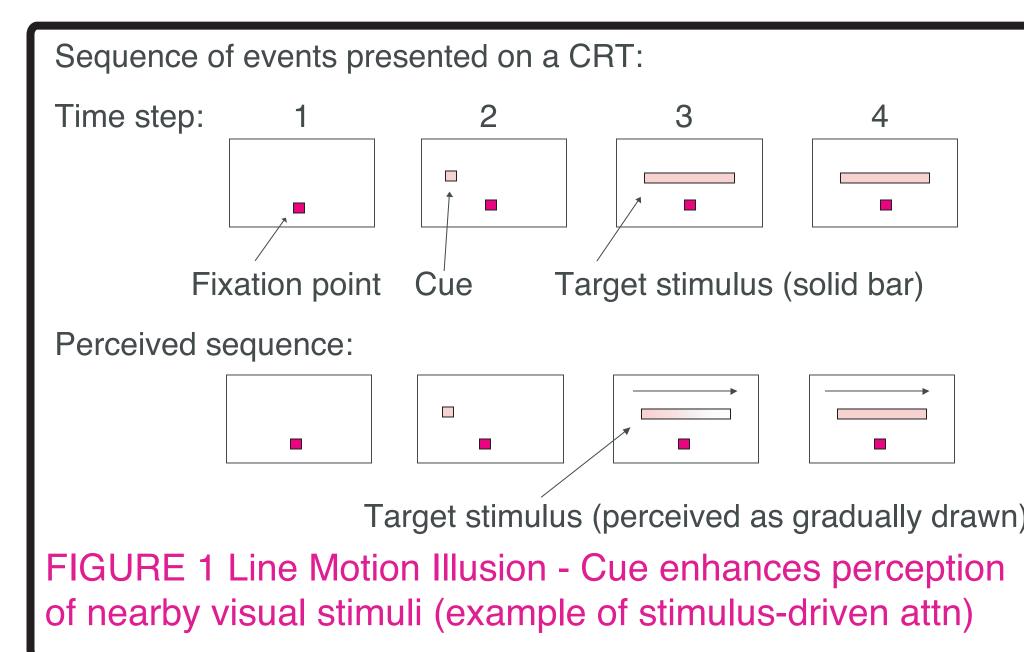
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EFFECT OF AUDITORY CUING ON AZIMUTHAL LOCALIZATION ACCURACY ¹Hearing Research Center, ²Departments of Cognitive and Neural Systems and ³Biomedical Engineering, Boston University

1. INTRODUCTION

Attention facilitates selection of objects, events, or spatial regions in complex scenes

The Line Motion Illusion iillustrates stimulus-driven attentional modulation in vision (Shimojo et al., 1992)



2. MOTIVATION

Spence and Driver (1994) cued localization task

- studied exogenous (involuntary, stimulus-driven, automatic) vs. endogenous (voluntary, goal-driven, strategic) attention
- cuing caused
- significant reduction of RT
- no increase in localization accuracy when speakers were at positions precluding any attentional modulation due to binaural processing
- task was position identification, insensitive to small changes in perceived source position

CURRENT STUDY

Measure azimuthal localization while varying probability that cue conveys information

SPATIAL AUDITORY ATTENTION

Part of "cocktail party effect" (Cherry, 1953; Moray, 1959). Very few cuing studies of auditory attention

- Early cuing studies (Posner, 1978; Scharf et al, 1987; Buchtel and Butter, 1988; Klein et al., 1987) found no effect in simple detection tasks
- Posner (1978) hypothesized detection does not depend on spatial representation
- Later cuing localization studies (Rhodes, 1987) show cuing affects reaction time (RT); may be response priming
- Spence and Driver (1994) showed RT effect in cued localization, but not detection
- Sach et al. (2000) showed that interaural time difference (ITD) cuing improves ITD discrimination.
- Arbogast et al. (2000) found decreased error rate and RT in a cued pattern identification task.
- stimulus-onset asynchronies (SOA; gap between cue and target stimulus)
- (both may modulate relative strength of exogenous and endogenous attention)

HYPOTHESES

Exo- and/or endogenous attention will **improve** localization accuracy near cued locations (valid trials)

- experiment relies on binaural processing, which is
- sensitive to attentional modulation (Sach et al., 2000)
- task provides sensitive measure of localization bias
- Effect will be larger for long SOA than short SOA
- exogenous effects for long and short SOA
- endogenous effects only for long SOA

Little effect on or decrease in accuracy for invalid trials (cue contralateral to target)

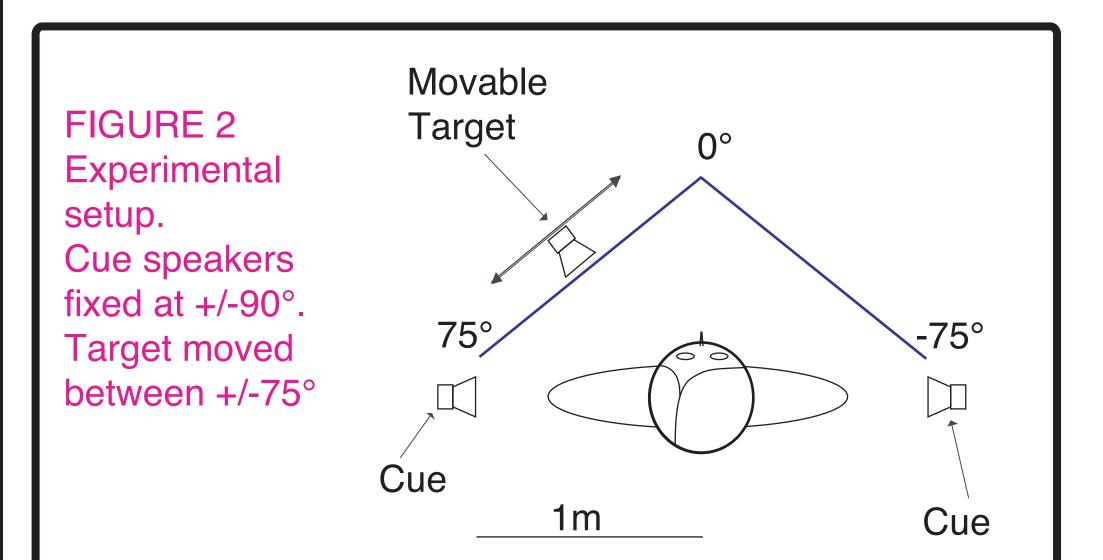
3. METHODS

EXPERIMENTAL PROCEDURES

Three normal-hearing subjects (1F, 2M) Sources in frontal horizontal plane Cues at +/- 90°

All combinations of

- cue: 2-ms click or 20-ms noise burst
- target: 2-ms click or 90-ms noise burst
- short (50 ms) and long (300 ms) SOA



- four cue conditions varying % trials w/cue on target side -- no cue (0%)
- -- 50% of trials (no information in cue; exogenous)
- -- 75% (cue usually informative; exo- and endogenous)
- -- 100% (cue always informative; exo- and endogenous)

Runs blocked by cue condition

- three two-hour sessions (cue conditions)+ one 1/2-hour session (no-cue condition)

- each session comprised of 30-trial runs (random order) Minimum of 60 trials / subject-condition - distributed randomly in azimuth $(-75^{\circ} \text{ to } +75^{\circ})$

Performed in center of quiet room (5 m x 9 m; T_{60} =450ms)

DATA ANALYSIS

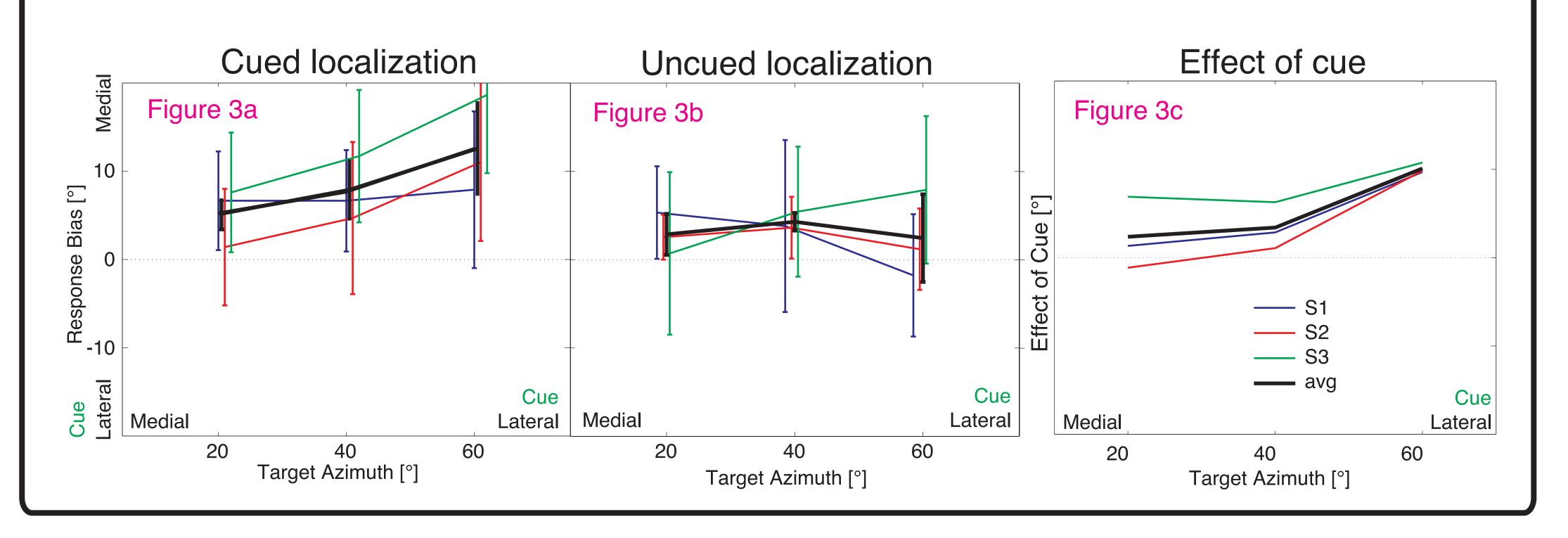
Collapsed across target side for each condition Trials divided into three azimuthal bins (0° - 30°) (30° - 50°) (50° - 75°)

Evaluated signed error (difference between actual and perceived source position) both mean and st. dev.,

4. EFFECT OF CUING (300 ms SOA; 100% VALID)

Figure 3 compares localization error in cued (Fig 3a) and uncued (Fig 3b) conditions a sample condition. These panels plot the difference between the actual and perceived target position as a function of target position. Individual subject results are shown in color (with standard deviation bars). The black line shows the across subject mean (with acrosssubject standard deviation). Panel c plots the difference of cued and uncued localization error for each subject (colors) and the across-subject average (black)

The condition shown is the 100% valid cue condition with SOA = 300 ms, using a noise-burst cue and click target.



5. EFFECT OF SOA, CUE AND TARGET TYPE (100% VALID)

Figure 4 shows cued localization bias. Mean and standard deviation for individual subjects are shown in color. Black lines show across-subject mean and standard deviation for both the cued (solid) and the no-cue (dashed) conditions.

Figure 5 shows the effect of the cue on localization bias. Individual results are shown in color; across subject average is in black.

Both figures have a similar layout. Figs 4a and 5a show SOA=50 ms; 4b and 5b show SOA=300 ms. In Fig 4 and 5, the top (panels a_1 , a_2 , b_1 , and b_2) and bottom (panels a_3 , a_{4} , b_{3} , and b_{4}) rows shows click-cue and burst-cue conditions, respectively. Columns show data from click-(panels a_1 , a_3 , b_1 , and b_3) or burst- (panels a_2 , a_4 , b_2 , and b_{Δ}) target conditions.

Of the parameters, SOA has the largest influence.

SOA:

- 50ms (Fig 5a): cue causes small medial bias, independent of target azimuth
- 300ms (Fig 5b): effect increases as target cue separation decreases
- Target type:
- click is always more influenced than noise burst

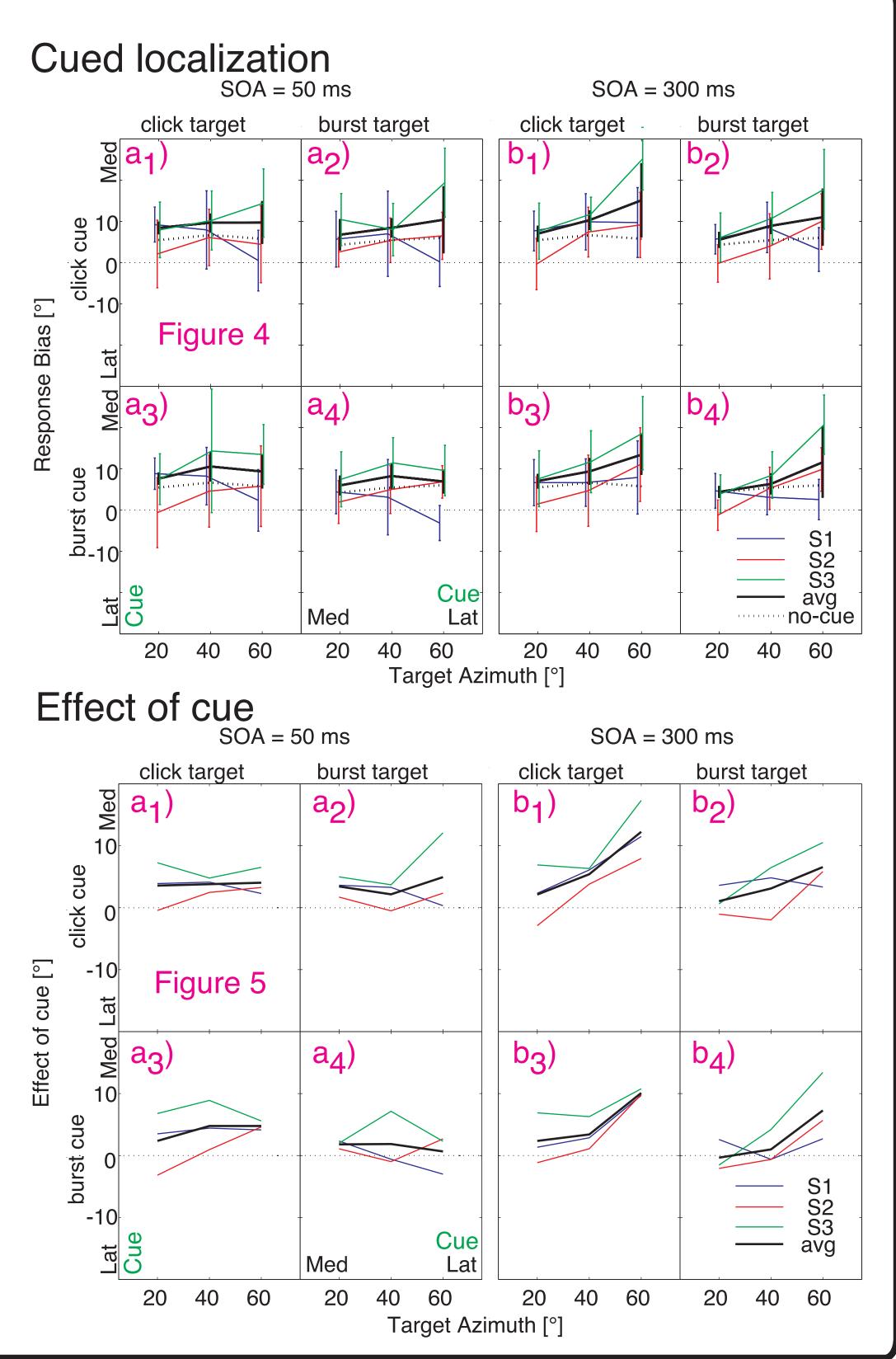
Cue type:

- no influence on the size of the cuing effect.
- ANOVA also showed significant two-way interactions between azimuthal bin and SOA and azimuthal bin and target type.

Inter- and intra-subject variability is large and similar magnitude for cued and uncued localization

- In cued localization, responses are biased towards median plane, which is away from the cue (Fig 3a).
- Bias increases as target cue distance decreases (Fig 3a). In uncued localization, medial bias also occurs, but is of smaller magnitude than in cued localization (Fig 3b).
- For each subject, the difference between mean cued and uncued bias is positive (Fig 3c).

The effect of the cue is to bias the perceived target location away from the cue location (i.e., to repulse the target).



6. EXOGENOUS VS. **ENDOGENOUS ATTENTION**

- Overall, results do not depend strongly on the percentage of valid versus invalid trials.
- There is no clear effect of endogenous (voluntary) attention.
- Plotted in this way, the cue effect is generally positive, regardless of cue condition
- ipsi targets are repulsed by the cue
- contra targets are attracted by the cue
- Stimulus type matters
- click-50ms-burst condition shows no cuing effect
- large and complex cuing effects on click targets at 50-ms SOA

 100% valid (cu 75%, valid (cu 50%, valid (cu 75%, invalid (cu 50%, invalid (cu

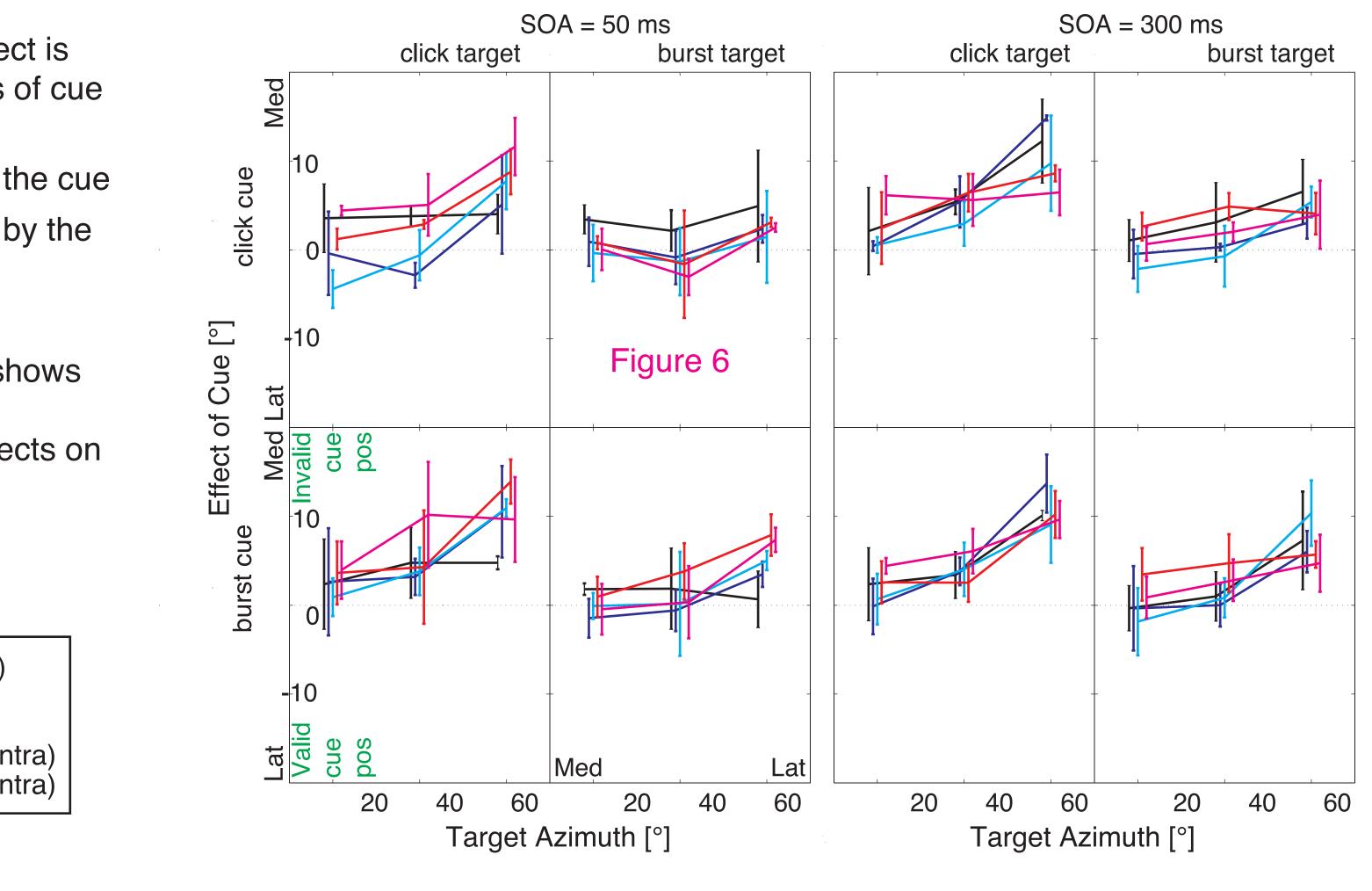
7. CONCLUSIONS

- perceived target location.
- response variance.
- For cues at extreme azimuths, ipsilateral targets are repulsed and contralateral targets attracted by the cue.
- perceived target location (e.g., Good, 1994)
- Possible explanations include:
- Mondor & Zatorre, 1995)

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cue ipsi) ue ipsi) ue ipsi) (cue contra) (cue contra) Figure 6 plots the effect of the cue on localization for different percentages of valid/invalid trials (panel layouts as in Figures 4 and 5). Cue conditions are represented by different lines (averaged across subjects; error bars show across-subject standard deviations). Note that all valid results (dark colors) and all invalid results (red colors) are nearly indistinguishable, independent of the cue condition.



A cue preceding a target stimulus by even 300 ms influences

Cuing causes bias in perceived location but no change in

- results are opposite to previous (simulataneous) masked localization studies where the masker attracts the

- an attention-like mechanism with an inverse difference-ofgaussians profile (as opposed to gradient distribution,

- simple collapsing of perceived target location towards median plane when target preceded by any cue

- acoustical interaction of cue and target due to room

reverberation (T_{60} =450ms, SOA<=300ms)

Effect of cue on localization:

- strongly influenced by location of target, SOA, and stimulus type
- not influenced by the cue type
- more cue/target positions needed to understand the spatial parameters that influence perception

Attention:

- stimulus-driven changes in performance are observed that may be related to exogenous attention mechanism
- however, these effects cause localization performance to become WORSE (not better) as target nears cue, opposite to most "attentional" phenomena
- no effect of endogenous attention observed

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