Absolute and relative localization strategies in expectation of a distractor sound

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Introduction

Various studies show that the position we attribute to a sound source with a specific interaural time/level difference is influenced by many other factors (Moore et al., 2004).

Shifts in perceived position can be elicited by other acoustic stimuli, such as:
- masker overlapping with target in time (Braasch et al., 2002),
- preceding stimulus - e.g., a prolonged adaptor (Carlile et al, 2001) or a transient distractor (Kopco et al., 2007).

In Kopco et al. (2007), shifts in localization responses were found not only in trials in which the target was preceded by *a priori*-known distractor, but, surprisingly, also in interleaved control trials in which target was presented alone (Fig. 1A). This latter shift was referred to as **"contextual plasticity"**.

A follow-up study of contextual plasticity showed that while the responses on baseline runs (with only no-distractor trials) tend to gradually drift towards the medial plane, the presence of context (consisting of trials with distractor) counteracts this drift (Tomoriova et al., 2010, Figure 1B). This suggests that even though the context biases responses relative to "normal localization", it might in fact improve localization (e.g., if distractor acts as an anchor for relative localization).

Current study tests the **hypothesis** that: Listeners use spatial information provided on the context trials by the distractor to improve their localization performance.

We analyzed whether presence of context:
- reduces bias in responses,
- reduces temporal drifts in respones,
- reduces standard deviations of responses,
- increases correlations of responses with actual target locations.

Methods

Data from two previous experiments were re-analyzed.

Setup (Fig.2)
- array of 8 (Exp1) or 7 (Exp2) loudspeakers with 11.25° separation
- one distractor, remaining speakers targets,
- 3 sp. arrangements (1 in Exp1, 2 in Exp2).

Stimuli
- target - 2-ms frozen noise burst,
- distractor - identical to target.

Task
Closed eyes.
Pointing to perceived location of target.

Experimental Procedure
Experiment consisted of 32-60 runs, each containing 189-259 trials.
Two types of runs (Figure 3):
- baseline, in which no plasticity was induced, contained only no-distractor trials,
- experimental, in which plasticity was induced, contained two randomly interleaved types of trials:
  - no-distractor trials: only target sound,
  - distractor trials (representing **context**): target preceded by distractor.

Experimental run consisted of pre-adaptation adaptation and post-adaptation part (dotted lines in Fig. 4). Distractor trials were presented only in adaptation part.

Experiment 1

- frontal distr. at edge of speaker array
- **proportion of distractor trials within distractor run varied between 50%, 75% or 90%** (fixed withi run).

Experiment 2

- frontal or lateral distr. in midle of array
- targets in distr. trials restricted to one of the **three context configurations** (fixed withi run, Fig. 2):
1) to the left of distractor
2) to the right of distractor
3) to both sides of distractor

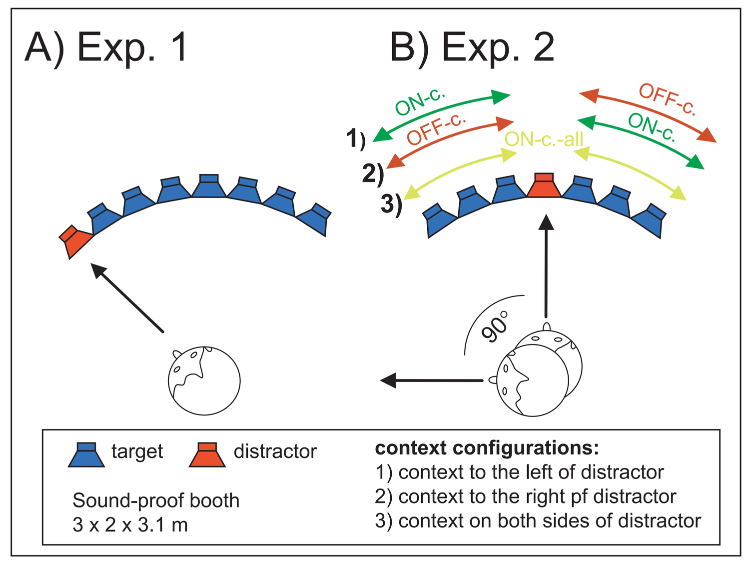


Figure 2 Experimental setup for Exp. 1 (panel A) and Exp. 2 (panel B)

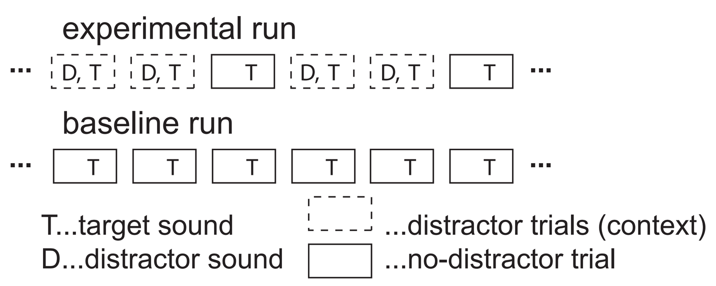


Figure 3 Example scheme of trial sequence for different types of runs

Data analysis

- **consider only no-distractor trials from all runs**.
- analyze differences between no-distractor trials in distractor runs and no-distractor (baseline) runs in terms of temporal drift/bias, standard deviations in responses, and correlation coefficients between responses and actual locations.

Exp2 data regrouped (Figure 2) into:
- ON-context (responses to targets from subregion in which context was presented)
- OFF context (responses to targets from subregion in which no context was presented)
- ON-context-all (responses to targets when context was presented on both sides off the distractor).

All graphs show across-subject mean and standard error of mean.

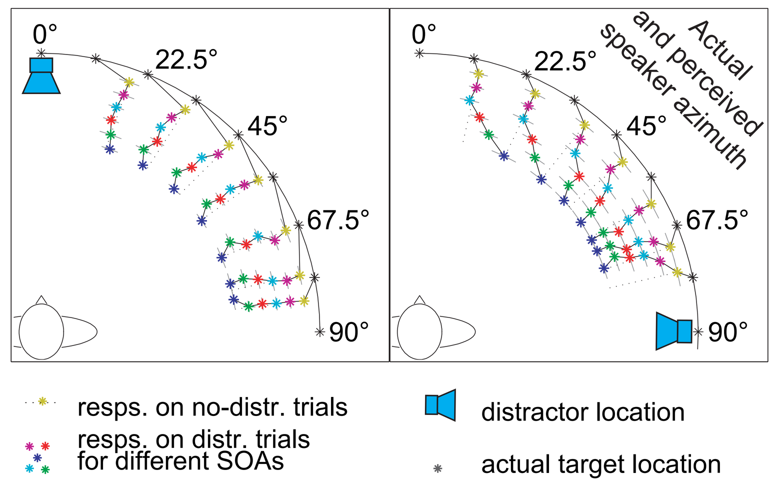
Notes:
Exp1 - 11 subjects; distractor-to-target onset asynchrony varied between 25, 100, and 400 ms
Exp2 - 8 subjects; distractor-to-target onset asynchrony fixed at 25 ms

Previous studies

Kopco et al. (2007)
Experiment consisted of trials in which the target was preceded by a distractor, randomly interleaved with trials in which only the target was presented.

Shifts were observed not only on trials with distractor, but also on no-distractor trials (compare yellow asterisks in left vs right panel of Fig. 1A).

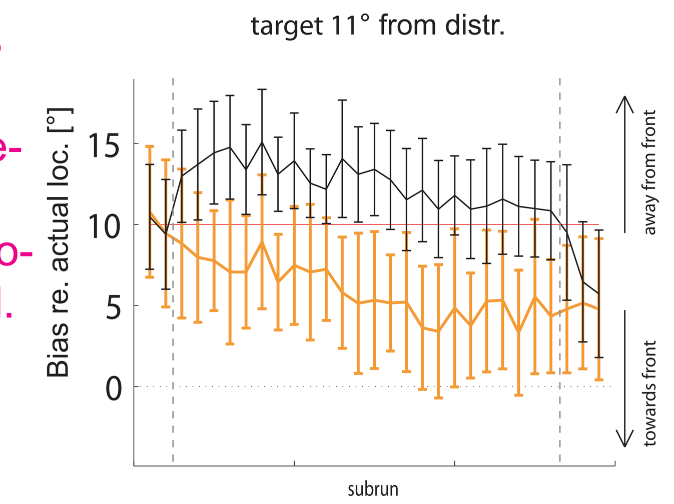
Figure 1A Mean responses on distractor and no-distractor trials from Kopco et al. (2007)



Tomoriova et al. (2010)
Design similar to Kopco et al. (2007). Baseline runs were included, consisting exclusively of no-distractor trials.

After initial bias in adaptation part, responses to targets with no distractors in distractor runs return to position observed at the beginning of the run, while responses in baseline runs gradually drift towards median plane (black line approaches red line in Figure 1B).

Figure 1B Temporal drifts of responses from Tomoriova et al. (2010)



Results

Temporal drifts

Baseline responses drift towards medial plane, especially for locations with initially large biases (large drift for Fig. 4 A and B3-4, similar to Fig. 1B, smaller for B2).

Responses in runs with no distractor spontaneously drift towards front.

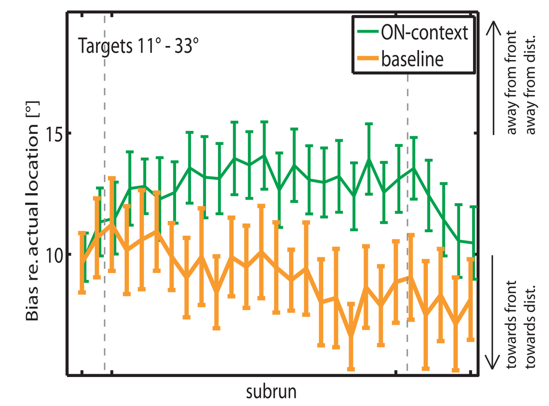
ON-context responses:
- biased (re. baseline) in direction away from distractor location (all panels of Fig. 4),
- drift towards the front smaller (A, B2, B3) or equal (B1, B4) to baseline.

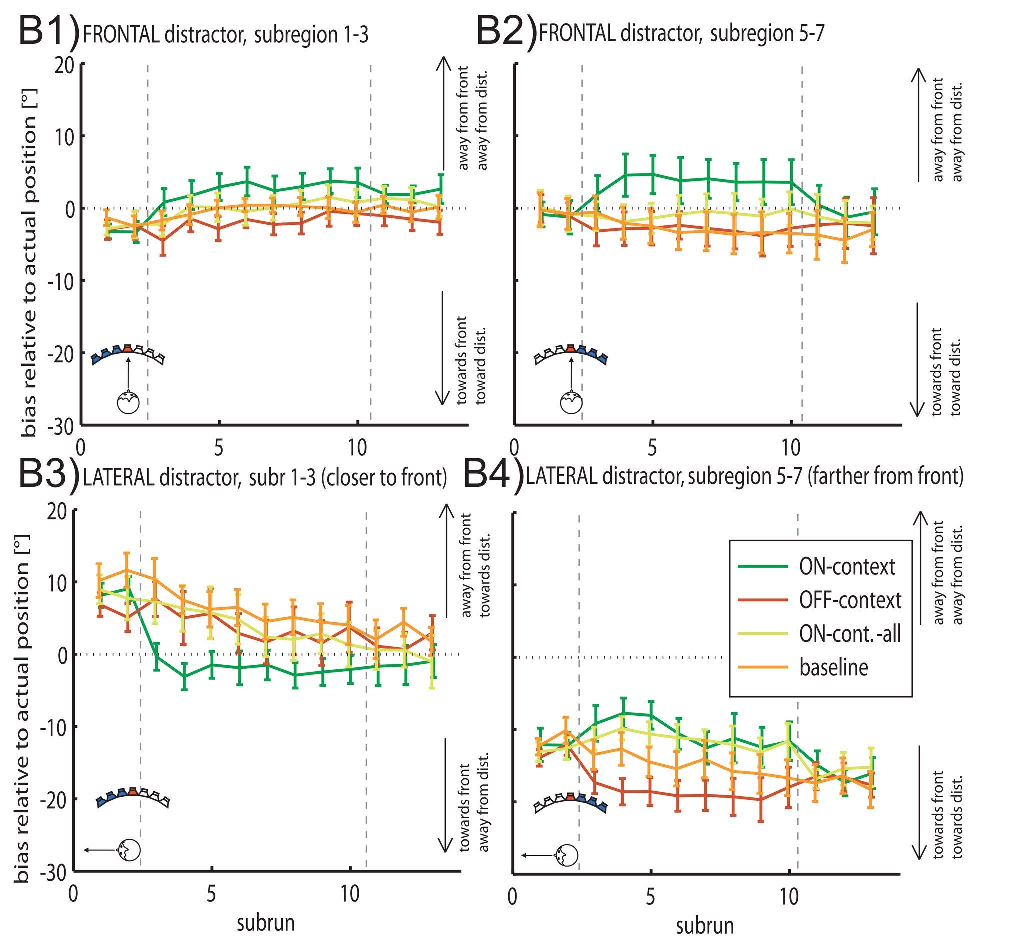
OFF-context and ON-context-all effects small.

Contextual bias doesn't always reduce bias due to temporal drift (observed in baseline runs).

Context tends to repulse responses away from distractor and decrease drift.

Figure 4 Temporal drift in responses re. actual target locations in Exp 1 (panel A) and Exp 2 (panels B1-4)





Standard deviations and correlations

Subregion behind interaural axis (Fig. 3B4) excluded from analysis because correlations very low (approx. 0.1). All 6 targets considered in analysis of Exp. 1. Triplets of targets to the left/right of distractor considered separately in analysis of Exp. 2.

Effect of context on std. devs:
- decrease, especially when percentage of distractor trials is large (Fig. 5A),
- decrease in ON-context,
- no change in ON-context-all and OFF-context (Fig. 5B).

Context reduced response variability in subregion in which it was presented. This effect grew with increasing percentage of distractor trials within a run.

Effect of context on corr. coefficients:
- negligible in Exp. 1 (Fig. 6A).
- improvement in Exp. 2 (Fig. 6B):
  - ON-context better than baseline,
  - ON-context-all and OFF-context slightly better than baseline.

Context improved consistency of responses in subregion in which it was presented, in particular when presented near distractor and on only one side of distractor.

Figure 5 Standard deviations in Exp 1 (panel A) and Exp 2 (panel B)

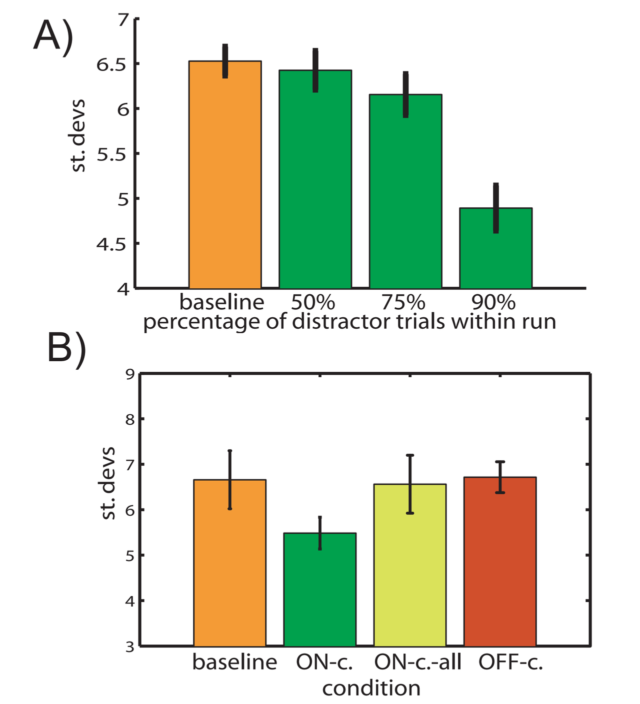
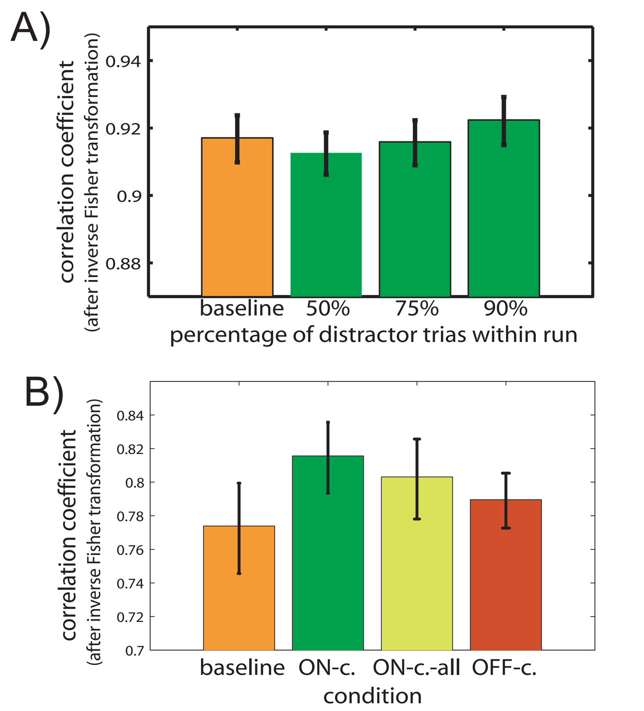


Figure 6 Correlation coefficients in Exp 1 (panel A) and Exp 2 (panel B)



Summary and Discussion

Context improved localization performance in several conditions and several measures:
- it did not always counteract drift in baseline (only "repulsed" responses from distractor),
- it often reduced drift in responses,
- it tended to reduce response variability,
- it increased consistency of responses in several conditions.

These improvements were mainly observed for ON-context data (small improvement was found when context was presented on both sides off the distractor) of Exp. 2.

Discussion
In current study target location computed:
1) based on absulte target ITD/ILD info,
2) based on relative info (ITDs/ILDs relative to distractor ITDs/ILDs, which acts as a stable anchor because it is repeatedly presented from fixed position),
3) combination of 1 & 2.

When there was no anchor (distractor), subjects used only absolute localization, which underwent spontaneous adaptation.
When distractor was present, subjects could combine absolute and relative localization info. Contextual plasticity might be a result of this combined computation, which initially induced bias in responses, but which provided more stable and more correlated mapping between stimulus and response locations.

Reasons why improvements were smaller in Exp. 1 might be:
- targets further from distractor were considered, for which the anchoring is weaker,
- contextual bias reduced response range (data not shown), causing lower correlations.

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