Contextual Shifts in Sound Localization Induced by an *a priori*-known Distractor

Beata Tomoriova, Rudolf Andoga and Norbert Kopco
Technical University of Kosice, Slovakia

Introduction

Background

Accuracy of sound localization depends on:
- temporal and spectral structure of targets,
- spatial arrangement of targets,
- acoustics of the environment (reverb),
- mechanisms of binaural and spatial processing in the brain, ...

Previous study of horizontal sound localization with a preceding distractor found biases in localization responses even on trials on which the target was not preceded by a distractor (Kopco et al., 2007; see Figure 1A).
➔ Localization is also affected by the **context** defined by the non-target sounds, the listener's task and a priori information.

This contextual effect has quick build-up and decay, and depends on the frequency with which distractors are presented (Kopco et al., 2009; see Figure 1B).

Current study

Measure the dependence of the **contextual plasticity** on distractor characteristics such as:
- distractor-target similarity (Exp. 1),
- distractor-target order (distractor either preceded or followed the target) to determine whether the plasticity is driven by bottom-up or top-down processes (Exp. 2).

Hypotheses
Experiment 1:
1. target-distractor similarity is important ➔ dissimilar distractor less effective
2. perceptual grouping is important ➔ plasticity stronger if streaming makes task more difficult

Experiment 2:
Absence of contextual plasticity when target precedes distractor ➔ strategy important; otherwise processing automatic (adaptation)

Methods

Setup
Array of 8 loudspeakers (Fig.2)
- 11.25° separation
- 7 target loudspeakers
- 1 distractor loudspeaker (always in front)

Task
Point to the perceived location of the target sound.

Two types of trials (randomly interleaved):
- no-distractor trials: only target sounds,
- distractor trials: target and distractor stim. (represent the context to induce the adaptive changes in no-distr. localization).

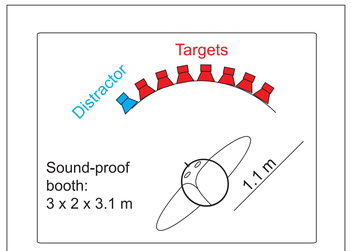


Figure 2 Experimental setup

Experiment 1

Stimuli
- target - 2-ms frozen noise burst,
- distractor (preceding the target) can be:
  1) identical to target: "1-click"
  2) train of eight clicks (each identical to target) with 125-ms inter-click-interval: "8-click",
  3) noise with the same duration and energy as the whole 8-click train,
- distractor-to-target interval fixed at 23 ms.

Experimental Procedure
- 8 normal-hearing subjects,
- 4 sessions, each of 7 runs,
- distractor type fixed within a run,
- run consists of:
  - pre-adaptation (2 sub-runs),
  - adaptation (20 sub-runs),
  - post-adaptation (3 subruns).
- pre- and post-adaptation parts contain only no-distractor trials (only the target is presented),
- on 75% of trials in the adaptation part, the target is preceded by frontal distractor,
- one "baseline" run in each session, where no adaptation was induced (contained just no-distractor trials) - used as a reference for estimation of the contextual effect),
- subjects changed orientation after each run.

Experiment 2

Stimuli
- target - 2-ms frozen noise burst,
- distractor - identical to target (can precede or follow the target)
- distractor-to-target (or target-to-distractor) onset asynchrony fixed at 400 ms.

Experimental Procedure
- 6 normal-hearing subjects,
- same design as in Experiment 1 except:
- distractor-target order fixed within a run,
- run consists of 203 trials (2+24+3 subruns)

Data analysis

To estimate effect of the context, consider no-distractor trials from all runs.
Analyze differences between distractor runs and no-distractor (baseline) runs.
Plot across-subject mean and standard error.

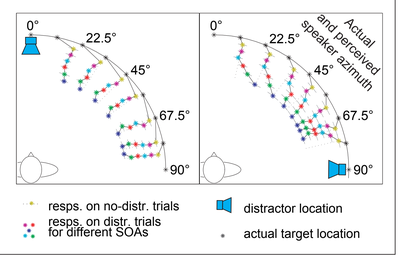
Previous studies

Kopco et al. (2007) (Figure 1A)

Experiment consisted of trials with target preceded by distractor, randomly interleaved with trials with no distractor.

Biases were found not just in distractor trials, but also in no-distractor trials (compare yellow stars in left and right part of Fig. 1).

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

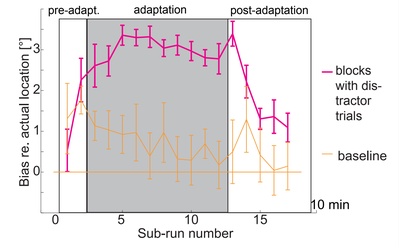


Kopco et al. (2009) (Figure 1B)

Measured the size of plasticity by comparing biases for no-distracor trials in distractor runs re. no-distractor baseline run. Studied temporal profile of adaptation.

Found fast build-up and decay (2-3 minutes).

Figure 1B Build-up and decay of contextual adaptation from Kopco et al. (2009) study.



Results

Dependance of contextual adaptation on distractor spectro-temporal characteristics (Experiment 1)

All responses slightly biased towards middle of the response range (Figure 3A).

Responses in distractor runs biased re. no-distractor baseline in direction away from distractor location (Figure 3B).

Contextual biases are larger for targets near the distractor.

Contextual bias is (Figure 3B, 4):
- largest shifts for 8-click,
- reduced for 1-click,
- smallest for noise;
- dependent on location for 1-click and 8-click;
- independent of location for noise.

Contextual biases depend on spectro-temporal similarity between stimuli and on their perceptual separation.

Figure 3 A) Bias in responses re. actual target locations, B) Bias in responses re. no-distr baseline

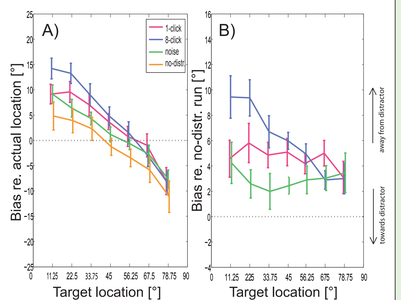
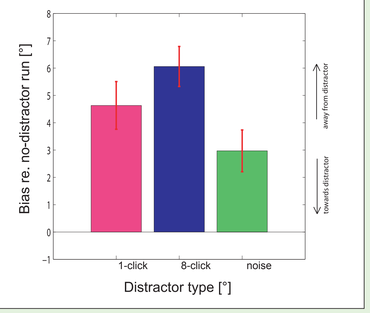


Figure 4 Bias re. no-distractor-only baseline averaged across target locations



Automatic vs. strategic mechanisms (Experiment 2)

Abbreviations and labeling in figures:
TD - runs where target precedes the distractor.
DT - runs where distractor precedes the target
—— no-distr. trials
- - - distr. trials

No-dist. biases (Figure 6A)
- dependent of target location (similar to Exp. 1),
- independent of distractor-target order,

Effect similar for distractor trial biases.

Contextual biases do not depend on whether distractor preceded or followed the target in inducing trials.

Responses to frontal (but not to lateral) targets change over time (Figure 6B, 7):
- responses gradually more biased towards the front (i.e. towards distractor),
- independent on type of run, even in baseline run.

Context results in bias away from distractor.

Responses change over time even in baseline runs. Contextual bias is in opposite direction to these spontaneous changes.

Figure 6 A) Biases re. no-distractor baseline. B) Difference in biases re. actual target location before and after the adaptation.

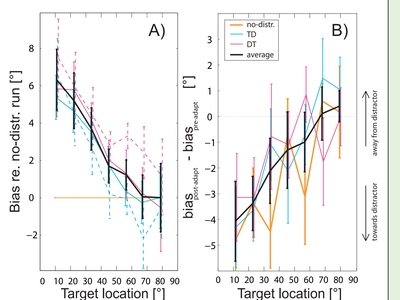
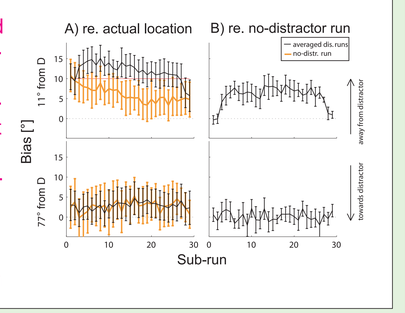


Figure 7 Build-up and decay of adaptation for targets locations closest and farthest from distractor A) re. actual location, B) re. baseline run



Summary and Discussion

Contextual plasticity
- depends on the spectro-temporal characteristics of distractor,
- is strongest for 8-click distractor and weakest for noise distractor,
- does not depend on distractor-target temporal order.

No-distractor trial responses to frontal targets gradually drift towards the midline (distractor location) during experimental run, even in no-distractor runs.

Discussion

Contextual bias is
- strong when target and distractor are similar (1-click),
- weak when they are dissimilar (noise vs. click),
- likely to be influenced by perceptual grouping (large effect for 8-click),
- not determined primarily by the distractor energy (equal for 8-click and noise),
- unlikely to be due to a simple change in strategy (occurs independently of target-distractor temporal order),
- likely to be a result of some automated change in processing,
- too quick to be due to short-term bottom-up adaptation.

Hypothetical mechanism:
There are 3 possible strategies to determine target location: 1) based on absolute ITD/ILD information, 2) based on relative information (re. the known location of distractor/anchor), 3) combination of 1&2.
When there is no distractor, the only available infomation is absolute.

No-distractor runs suggest that "absolute" localization undergoes adapation (Fig. 7).
When the targets are interleaved with a priori known distractors, both absolute and relative information is available. Contextual plasticity might be a result of combined computation, which initially induces additional bias, but later results in correction of the spontaneous adaptations in absolute localization (Fig. 7).

References
- N Kopčo, V Best, and BG Shinn-Cunningham (2007). Sound localization with a preceding distractor, Journal of the Acoustical Society of America, 121, 420-432.
- N Kopčo, B Tomoriova, R Andoga, and M Barto (2009). Temporal characteristics of Task-Dependent Contextual Shifts in Sound Localization, ARO Meeting, Abs #1019.