Mechanisms of contextual plasticity in localization of click sounds with a preceding distractor

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Introduction

First arriving click sound from a priori known position influences perceived position of the lagging click sound (Distractor-Target) for stimulus onset asynchrony (SOA) 25-400ms (Kopčo et al.,2007) = Effect of preceding distractor

In addition, another effect was observed: responses on interleaved control trials (Target-only) were unexpectedly biased = Contextual plasticity

Goal of the study: Examine and identify neural mechanisms of contextual plasticity (CP) and additionally extend the knowledge of the effect of preceding distractor (EOPD) by manipulating temporal, statistical, and streaming properties of the contextual stimuli.

Candidate mechanisms of CP

1. Precedence effect buildup and breakdown causes increase or decrease of the echo threshold after different contextual stimuli on the scale of 1-10 seconds (Freyman, 1991; Keen & Freyman, 2009)
2. Adaptation after prolonged tone adaptor causes frequency specific shift in perceived location away from adaptor (Kashino & Nishida, 1998)
3. Attention related effect increase intelligibility of target sounds at expected locations and the effect varies with the amount of expectation (Kidd, Arbogast, Mason, & Gallun, 2005; Kitterick, Bailey, & Summerfield, 2010). Distracotr may act as anchor providing additional 'relative' cues.
4. Perceptual organization of streaming sequences changes after contextual buildup (Snyder & Weintraub, 2013)

Hypotheses

1. The buildup process is related to the "amount of presented context". As echo threshold rises with number of clicks (Freyman, 1991), more Distractor-Target trials should increase CP.
2. CP should lead to enhanced perceptual segregation of stimuli, distractor may act as anchor - with additional relative cues. We may observe decrease in localization variance
3. If CP is affected by perceptual organization of stimuli, more streaming in Distractor-Target stimuli (8-click distractor) should increase CP.
4. If CP is related to adaptation, noise distractor should lead to CP, spatial specific decrease in localization variance might be observed.
5. If we are trying to direct attention away from expected location of distractor, SOA might affect CP because SOA affects separability of target vs. distractor. This may persist to Target-only trials
6. EOPD will vary with SOA, not with frequency. Different distractors may interact with EOPD due to filter ringing or interactions on binarual processor

Methods

Two localization experiments.

Setup
- Array of 8 loudspeakers with 11.25° separation
- One distractor, remaining speakers targets

Stimuli
- Target-only trials: no-distractor trials: (2ms frozen noise)
- Distractor-Target trials: target preceded by distractor from medial plane (representing context)

o condition fixed in a run

Experiment 1
- SOA 25-400ms
- Frequency of Distractor-Target trials – 50-90% in a run
- Distractor: single click

Experiment 2
- Fixed SOA=25ms, frequency = 75%
- Three distractors:

o single click

o 8-click train with SOA=125ms

o noise with identical RMS and duration as 8-click

Task
- Closed eyes.
- Pointing to perceived location of target in self-paced manner

Experimental Procedure
- Experiment consisted of 60 runs, each containing 189/175 trials.

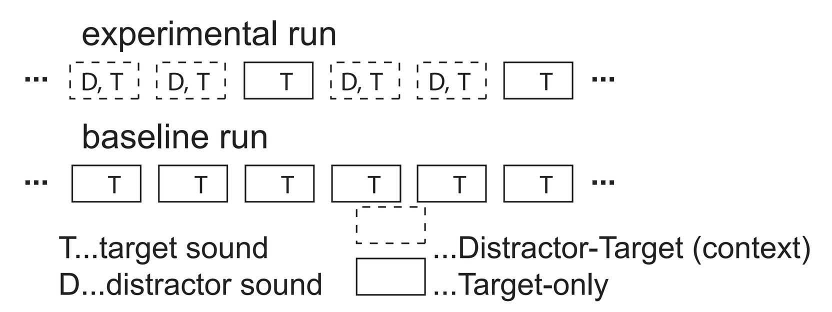


Figure 1 - Schematics of experimental procedure.

Figure 5 - Standard deviations computed within subject, experimental run, trial type, and target loudspeaker. Data were averaged across speakers, conditions, and subjects afterwards. Subpanels show data separately for Distractor-Target and Target-only trials as a function of SOA on x-axis for different frequencies of Distractor-Target trials.

Results - Raw data and baseline

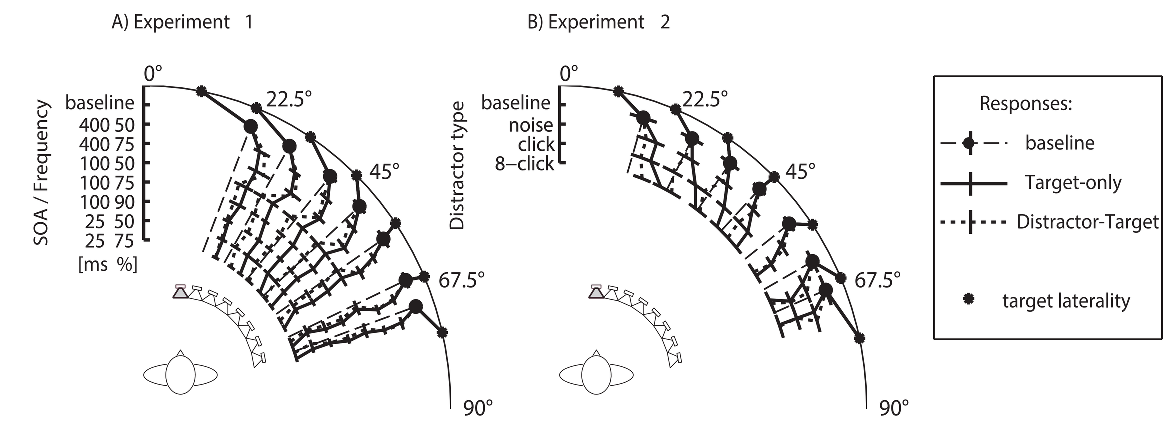


Figure 2 - Experimental configuration and mean across subject responses in different experimental conditions. Further graphs were computed as a difference in using these data except Fig. 5.

Baseline - compression of the response range in both experiments due to the response method can lead into underestimation of observed effects

Results - Contextual plasticity

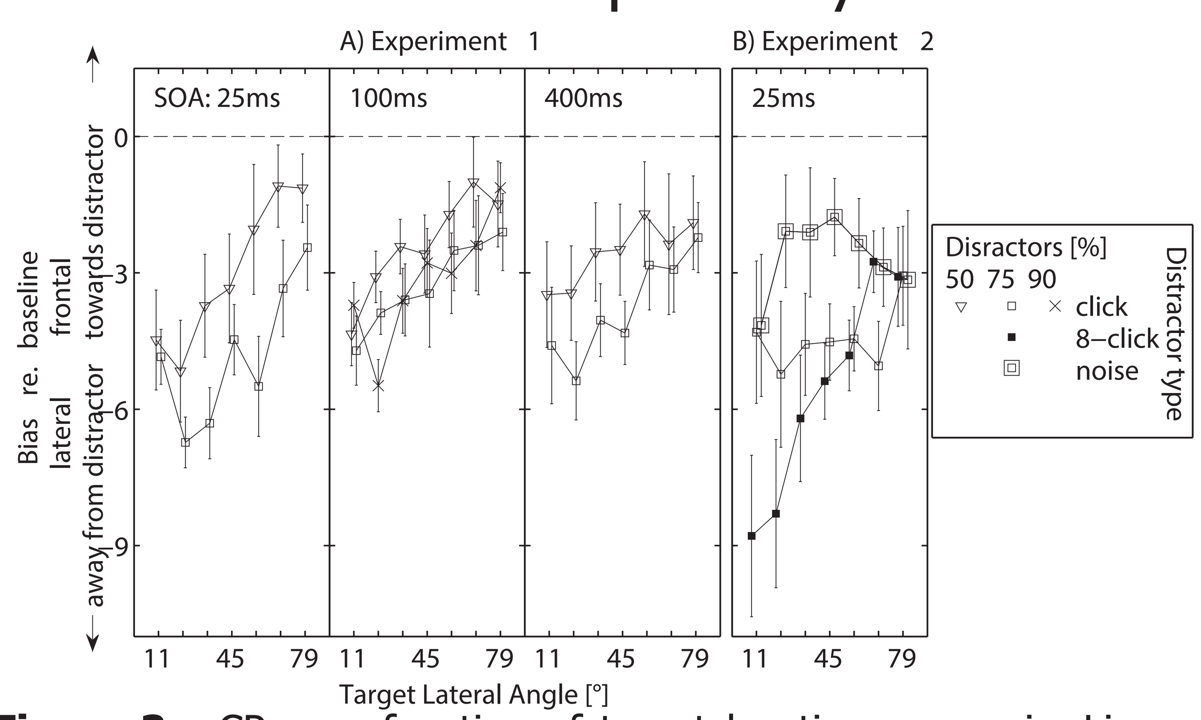


Figure 3 - CP as a function of target location on x-axis. Line markers and subpanels distinguish conditions with various SOA and frequency of Distractor-Target trials (Exp 1) and type of distractor (Exp 2). Direction of the induced shift is away from distractor. Error-bars are SEMs. Open squares in Exp1 and Exp2 had identical conditions.

Biases
- CP decreases with target laterality
- CP increases with increasing frequency of Distractor-Target trials
- CP increase at shortest SOA only at closest target locations
- 8-click increases CP mostly at the closest target locations
- noise distractor decreases CP (but CP is still present)

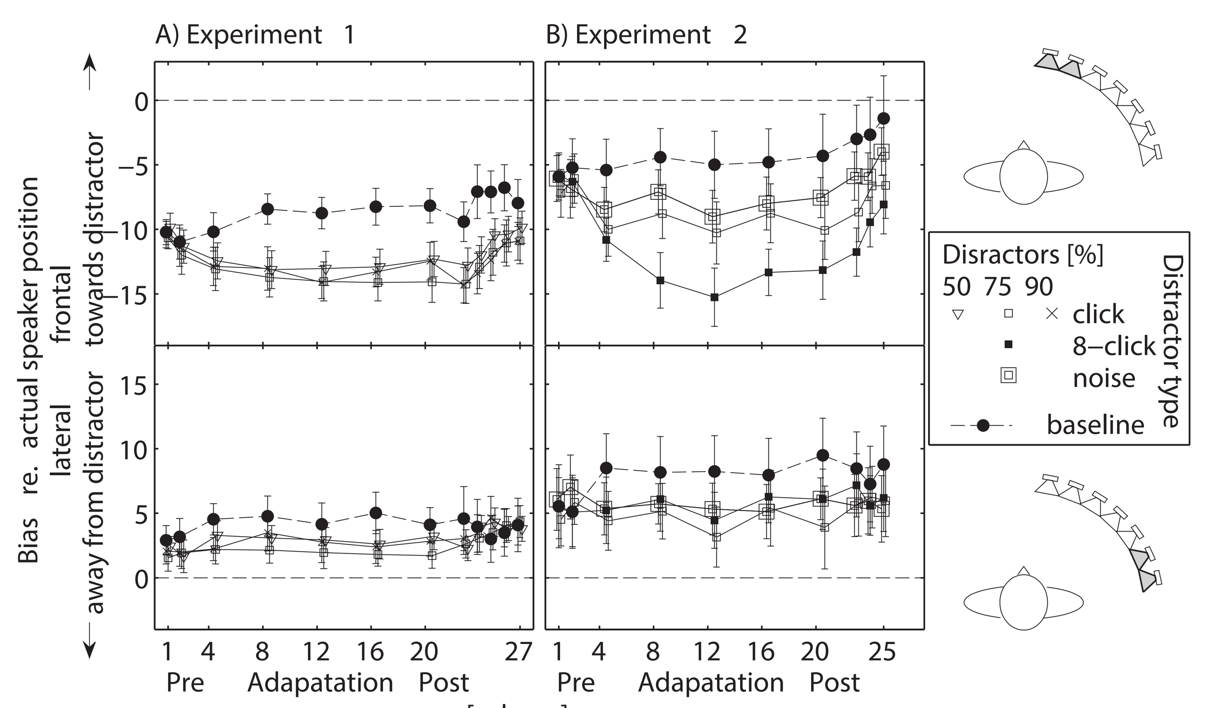
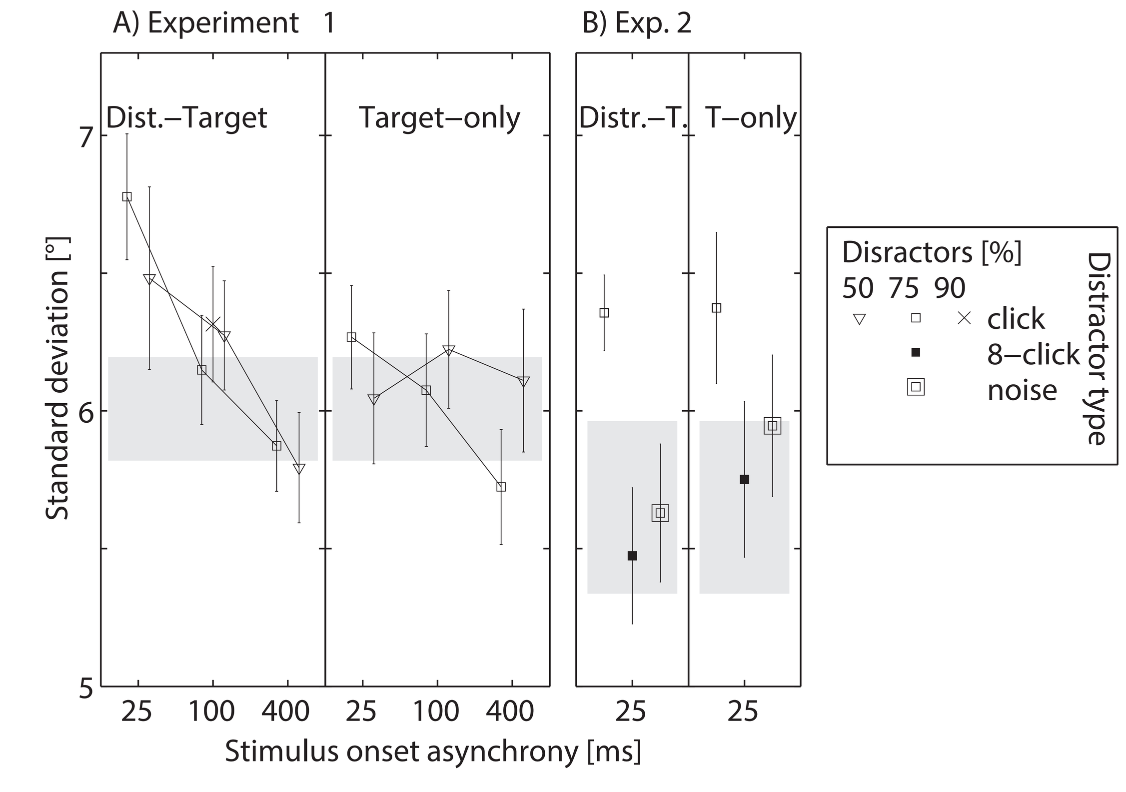


Figure 4 - Temporal profile of localization bias within one experimental run averaged across 2 left most and 2 rightmost target locations (top vs. bottom). CP is a difference of baseline (dashed-lines) and Target-only responses (solid lines). For Exp 1 lines are averaged across SOA, in Exp 2 data are averaged across distractor-type.

Temporal profile - Figure 4
- CP builds-up within 2-10 subruns (14-70 trials)
- CP decays within 5 subruns (35trials) but only at closer locations and during 8-click it does not reach baseline (3 subruns 21 trials post-adaptation in Exp2)
- baseline spontaneously drift which increases CP



Standard deviations - see Figure 5
- Immediate Distractor increases variability at shortest SOA and the variability increases with SOA, there might be a small decrease at SOA=400ms under baseline
- Immediate 8-click and noise distractor decreases variability at compared to single click
- some of the increased variability might be adapted into Target-only data but only at short SOA, the result is consistent across experiments (compare single-click in Target-only) across experiments

Results - Effect of preceding distractor

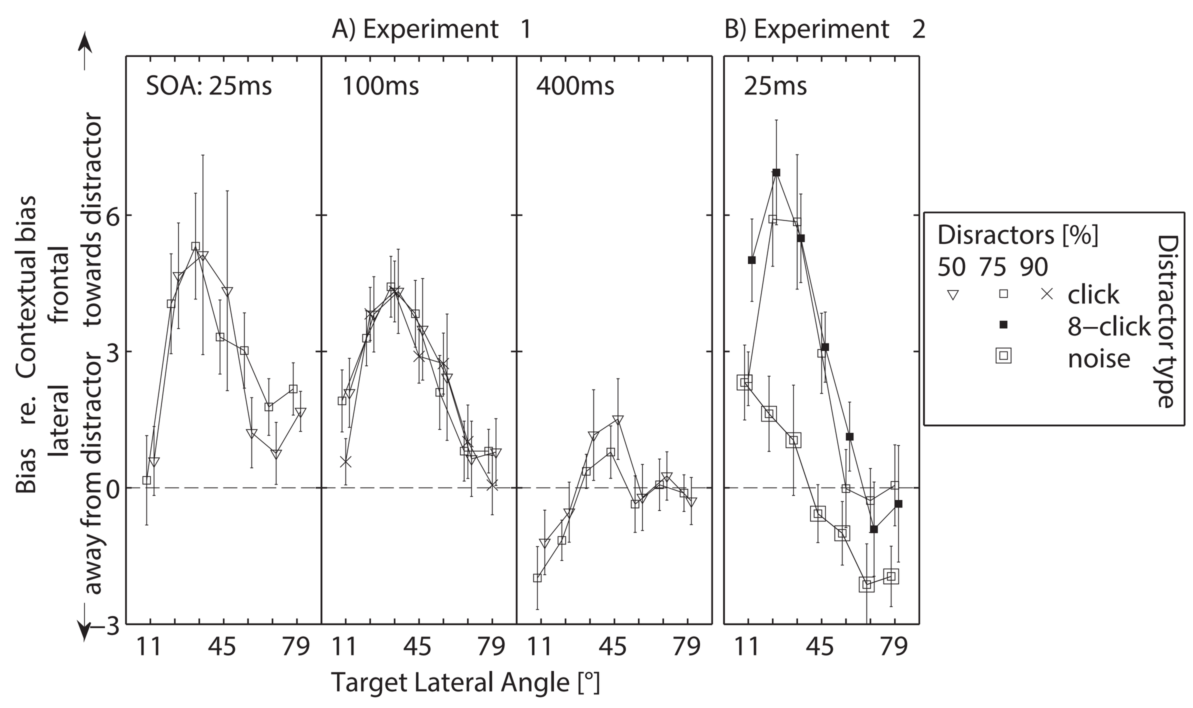


Figure 6 - Effect of preceding distractor as a function of target laterality on x-axis. For Exp 1 subpanels represent different SOA, line markers frequency of Distractor-Target trials. In Exp1 line markers denote distractor types.

Effect of preceding distractor
- average magnitude around 3°
- varies with SOA and target laterality.
- strongest at 22°-45°
- small increase at the end of response range
- 8-click distractor is the same as single-click
- noise distractor creates linear effect form +2° (11°) to -2° (79°)

Discussion

Current findings are consistent with (Kopčo et al., 2007)
- CP is caused in direction away from distractor
- magnitudes and shapes of EOPD are comparable
- variability is increased after immediate distractor

Hypotheses evaluation

1. Confirmed. CP varies with the number of contextual trials.
2. Rejected. Current data do not show decrease on localization variance possibly due to high variability of response methods.
3. Confirmed. CP increases after increasing streaming of contextual stimuli
4. Confirmed. CP might be influenced by similar process as observed in adaptation paradigms, however, no decrease in variance was observed.
5. Partially confirmed. SOA has only modest effect on CP.
6. Confirmed. EOPD varies with SOA, noise distractor decreases EOPD possibly due to different activations of auditory filter or dissimilarity of distractor from target.

None of the potential mechanisms of CP could be ruled out, however, from previous literature it is not known how these mechanisms relate to each other, however, it is clear that temporal integration of spatial perception extends scale of seconds which should be incorporated in auditory models.

EOPD is a different mechanism most likely explainable with peripheral processing and current models should be tested whether they can explain observed shifts in perception.

References and Acknowledgements

Freyman, R. L. (1991). Dynamic processes in the precedence effect. The Journal of the Acoustical Society of America, 90(2), 874. doi:10.1121/1.401955

Kashino, M., & Nishida, S. (1998). Adaptation in the processing of interaural time differences revealed by the auditory localization aftereffect. The Journal of the Acoustical Society of America, 103(6), 3597. doi:10.1121/1.423064

Keen, R., & Freyman, R. L. (2009). Release and re-buildup of listeners' models of auditory space. The Journal of the Acoustical Society of America, 125(5), 3243–52. doi:10.1121/1.3097472

Kidd, G., Arbogast, T. L., Mason, C. R., & Gallun, F. J. (2005). The advantage of knowing where to listen. J Acoust Soc Am, 118(6), 3804–15. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16419825

Kitterick, P. T., Bailey, P. J., & Summerfield, a Q. (2010). Benefits of knowing who, where, and when in multi-talker listening. The Journal of the Acoustical Society of America, 127(4), 2498–508. doi:10.1121/1.3327507

Snyder, J. S., & Weintraub, D. M. (2013). Loss and persistence of implicit memory for sound: evidence from auditory stream segregation context effects. Attention, Perception & Psychophysics, 75(5), 1059–74. doi:10.3758/s13414-013-0460-y

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