Trial-to-trial Contextual Adaptation in Sound Localization

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Abstract

Contextual plasticity (CP) is a localization aftereffect occurring on the time scale of seconds to minutes. It has been observed as a bias in horizontal sound localization of click target stimuli presented alone, when interleaved with contextual adapter-target trials in which the adapter was at a fixed location while the target location varied. The observed bias is always away from the contextual adapter location. This was confirmed for both real and virtual environments, for 1-click target sounds presented from different azimuths and interleaved with a 12-click adapter presented from a fixed position (Linková et al., 2022).

In the current study, we investigated the short-term dynamics of the adaptation by analyzing the effect of the stimulus immediately preceding a given target. Because the adapter is in a fixed position and contains more energy than the target, it was expected to induce stronger biases. The results confirmed this expectation, but only in a virtual environment, while a small opposite trend was observed in a real environment. These results illustrate complex interactions between environ-mental factors and stimuli in spatial auditory plasticity.

1 Introduction

The adaptation induced by preceding stimulation has been studied by many authors. E.g., Freyman et al. (1991) examined the precedence buildup induced by repeated presentation of 'lead-lag' stimulus pairs. Other studies looked for the auditory localization aftereffect induced by prolonged presentation of an adapter (Carlile et al. (2001); Phillips and Hall (2005); Thurlow and Jack (1973)). The latter studies typically used a long continuous adapter immediately followed by a target. They observed a repulsion by the adapter, i.e., biases in the perceived target locations away from the adapter location. Kopčo et al. (2007) described a related effect, CP, in which a repeated presentation of a short 1-click distractor affects target localization in a reverberant and anechoic room. Recent CP studies showed that CP can be induced by passive listening in both real and virtual environments (Linková et al. (2022); Piková (2018)). In the current study we examined the short-term dynamics of CP by analyzing the influence of the immediately preceding trial on the localization of the subsequent target stimulus

2 Methods

Data from two experiments of Linková et al. (2022) were used. The target (T) was a 2-ms noise burst (click). The adapter (A) was a click train consisting of 12 such clicks. Six target locations were used, $\pm 33, \pm 22, \pm 11°$. Adapter locations were fixed within a block at $0, \pm 45$, or $\pm 90°$in Exp. 1 and 0 or $\pm 50°$in Exp. 2 (setup in Fig. 1). Baseline blocks contained no adapters. Subjects - 8 in Exp. 1, real reverberant (RRE), and 9 in Exp. 2, virtual reverberant (VRE), anechoic (VAE) environment - responded by using a numerical keypad while seated with their heads supported by a headrest.

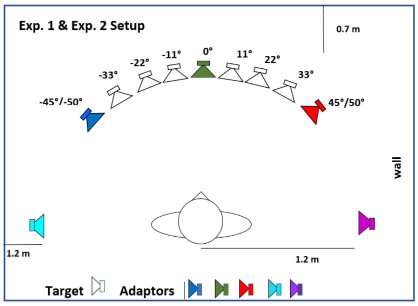

Fig. 1: Setup of experiments.

3 Results

We analyzed the biases in target responses separately for targets in adapter-target (AT) and target-target (TT) trial pairs. Fig.2 shows, for the three environments, the biases in responses (re. no-adapter baseline) as a function of target location after mirror-flipping the data assuming left-right symmetry in the effects. The thick line shows the deviations in AT and the thin line shows the deviations in TT data, with line color corresponding to different adapter locations. Because of the mirror-flip-ping, the red data are identical to blue after rotating around 0°, and green data are also symmetrical around (0, 0).

Overall, the pattern of results is consistent across the environments and adapter locations. There are biases away from the adapter that decrease with separation between adapter and target (e.g., blue lines decrease from left to right; green lines are positive on the right-hand side). The immediately preceding stimulus has a modulator effect, mainly in virtual environments.

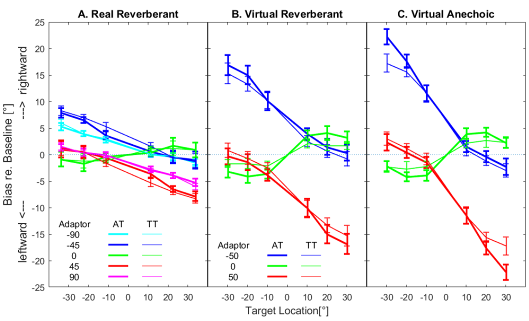

Fig. 2: Deviations in responses to target (T) relative to the baseline according to the previous type of target (TT) or adapter stimulus (AT).

The strongest effect of preceding trial is for the lateral adapter and nearby targets in VAE, where the difference between AT and TT data is 5°(blue lines at $-30°$). Similar, but weaker effects are also observed in VRE and for the medial adapter (green lines). On the other hand, in RRE, the immediately preceding A causes, if anything, a smaller CP, only observed for the 45°A and targets at $\pm 11°$. These results were confirmed by two ANOVAs in all environments. In ANOVA performed on virtual-environment data, the following interactions with the type of preceding stimulus were significant: *adapter x previous stimulus*: F(2, 16)=7.56, p=0.005, *environment x previous stimulus*: F(1, 8) =5.76, p=0.043, *target x previous stimulus*: F(2, 16)=5.10, p=0.02, *adapter x target x previous stimulus*: F(2, 16)=0.36, p = 0.703, *target x environment x previous stimulus*: F(4, 32)=4.41, p=0.006. In ANOVA performed on RRE data were significant *adapter*: F(4, 28) =38.42, p=0.00, *target*: F(2, 14) =6.57, p=0.009, *adapter x target*: F(8, 56) =5.45, p=0.00, *adapter x target x previous stimulus*: F(8, 56) =3.13, p=0.005.

Evaluation of standard deviations (SD) showed a complex pattern in RRE, while no significant effect was observed in VAE or VRE (data not shown). In RRE, SDs tended to be significantly higher when the previous stimulus was T vs. when it was A. However, that pattern only held for central targets and not for peripheral. ANOVA performed on the RRE data found significant main effect of the *previous trial type*: F(1, 7)=16.02, p=0.005, and *adapter*: F(4, 28)=4.17, p=0.009, a significant interaction *previous trial x target*: F(2, 14)=9.21, p=0.0028, and a nearly significant interaction: *previous trial x adapter*: F(4, 28)=2.60, p=0.058.

4 Discussion and conclusion

The results showed that the adapter affected target localization even in the short term. The biases increased immediately after A presentation in a virtual environment. This could be caused by the subjects' uncertainty in the localization of the stimuli, as a consequence of which the subjects responded mainly relatively with respect to the adapter which acted as an anchor. In terms of SD, the immediately preceding stimuli only affected responses in real environment. Again, it is likely that the 12 clicks of the A helped to stabilize spatial perception, making the responses to the subsequent T were more stable. On the contrary, if a target consisting of one click only was played from a varying location, the listener's spatial perception did not stabilize, and thus the variability in locating the subsequent target was high. These results show that CP has a fast component, observable on the time scale of several seconds, sup-porting the idea that CP is likely caused at least partially by a short-term suppression in spatial representation.

Acknowledgement

Work supported by VEGA 1/0350/22.

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