Passively-induced Contextual Plasticity in Sound Localization in Real and Virtual Environments

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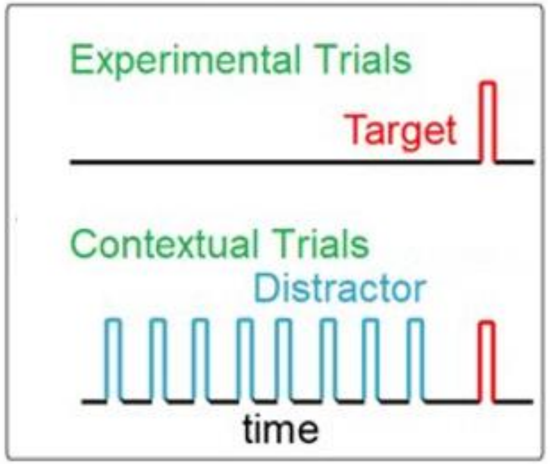
Introduction

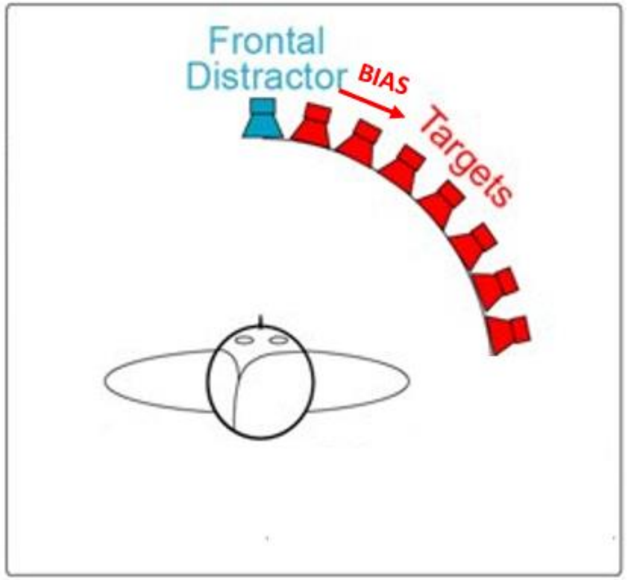


Various **adaptive** effects are observed:

- Localization **aftereffects** (Thurlow & Jack, 1973; Carlile et al., 2001; Dingle et al., 2012)
- **Precedence** effect **build-up** (Freyman et al., 1991; Djelani and Blauert, 2001)

Contextual plasticity, CP (Kopčo et al., 2007, 2015, 2017, Hládek et al., 2017)

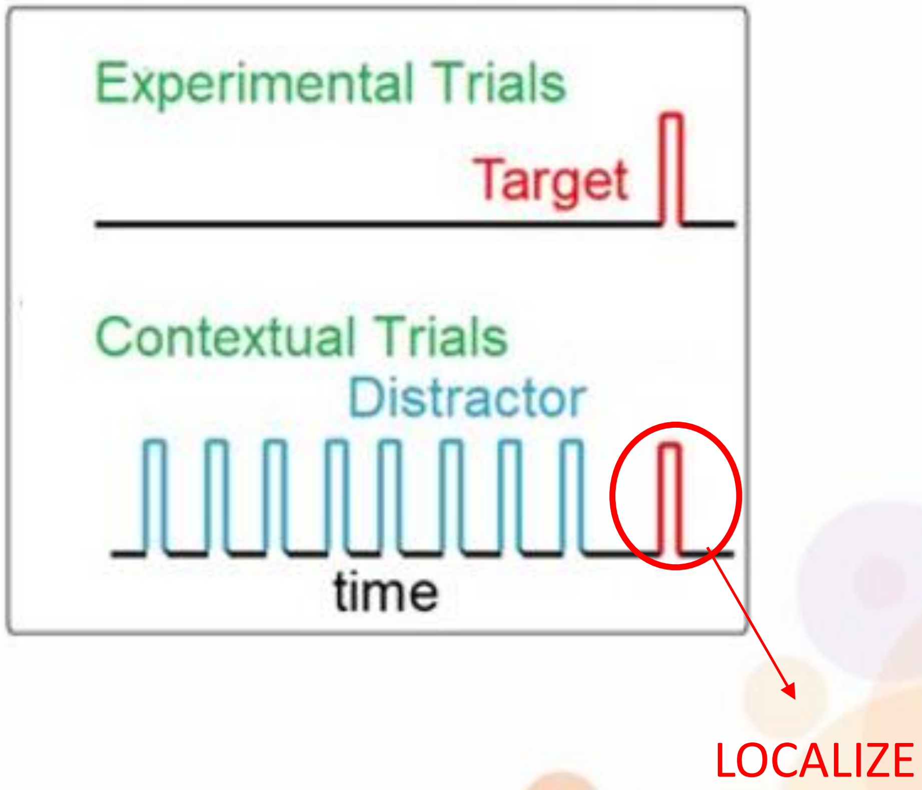
- observed as biases in localization of **click target** stimuli, interleaved with ***contextual*** **distractor-target trials**, the same clicks are preceded by **fixed-location distractor**



Introduction

Contextual plasticity, CP (Kopčo et al., 2007, 2015, 2017, Hládek et al., 2017)

- reported in **real reverberant** and **anechoic environments**
- context was an **active task**
- listener supposed to **localize targets presented after a preceding DISTRACTOR**



Experimental Questions

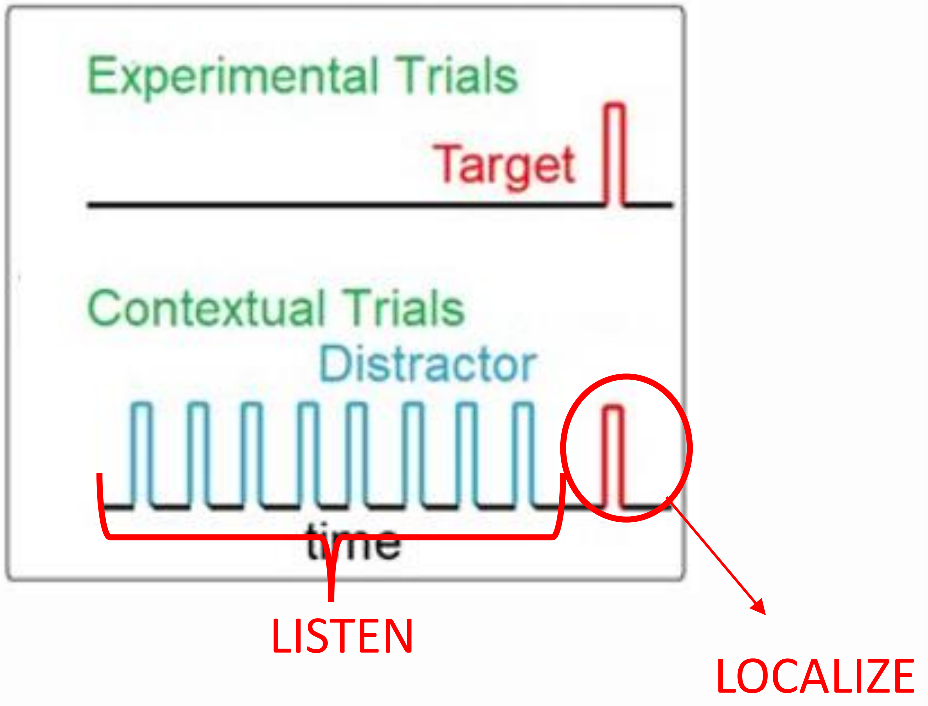
Experiment 1

- Is CP, measured in a real room, dependent on engagement of the subject in an **active localization task** on the contextual trials?

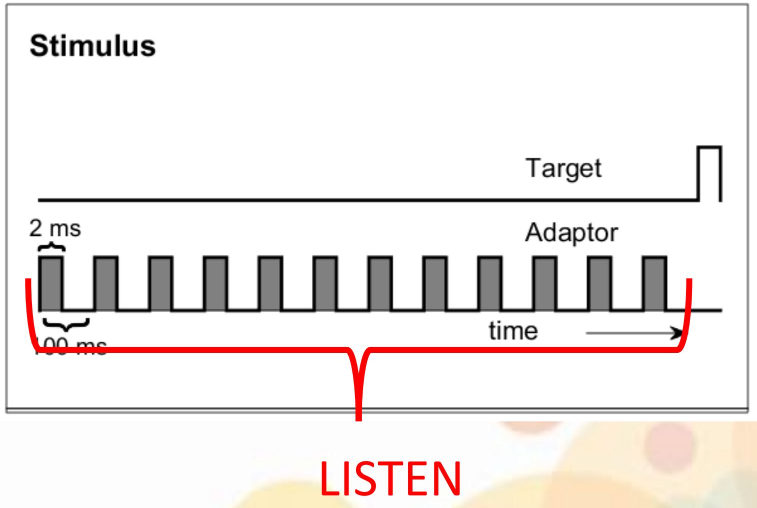
Experiment 2

- Is CP also **observed in virtual environments, both reverberant and anechoic**?

Previous studies:



Current experiments:



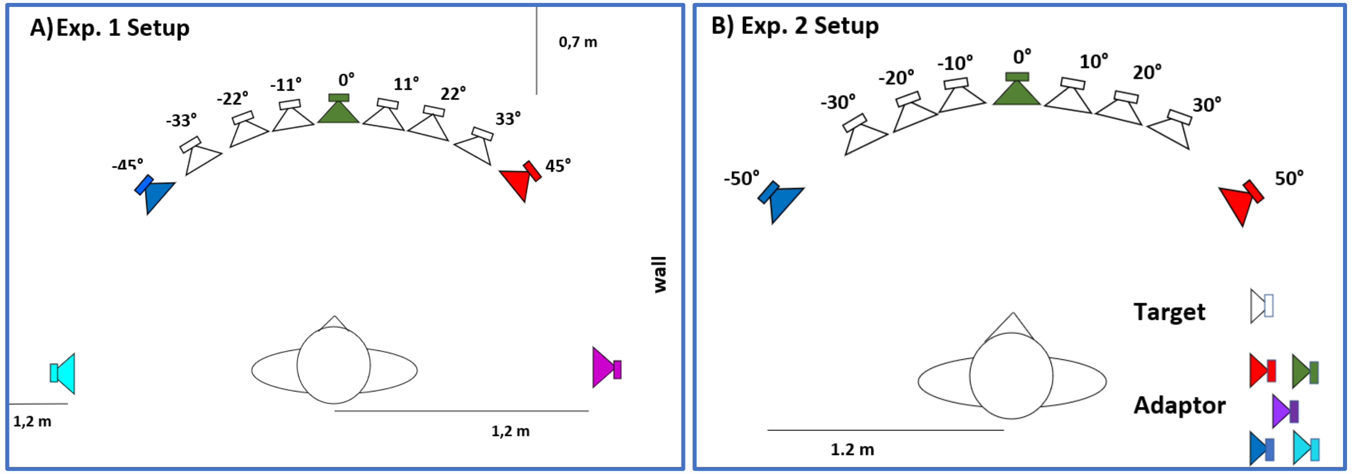
Experimental Setup and Stimuli

Experiment 1 (panel A)

- real midsize reverberant room, 6 targets speakers, 5 adaptor speakers

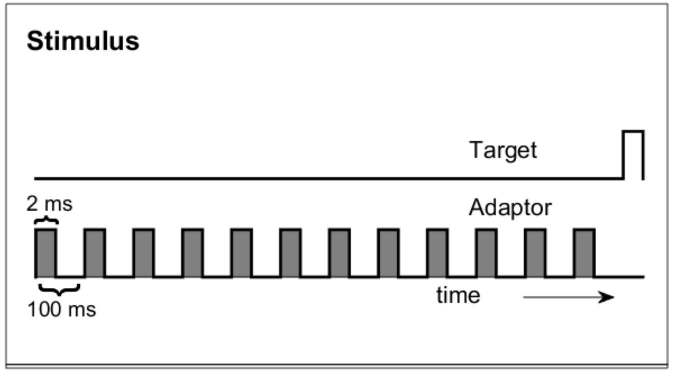
Experiment 2 (panel B)

- virtual midsize reverberant or anechoic room, 6 targets speakers, 3 adaptor speakers



Stimuli

- Target (T): 2-ms frozen noise click
- Adaptor (A): train of 12 such clicks presented at rate of 10/sec



Experimental Methods

One run

- divided into parts
  - pre-adaptation (target-only, 2 subruns),
  - adaptation (target or adaptor in a ratio 1:1, 14 subruns)
  - post-adaptation (target only, 3 subruns)
- adaptor position fixed throughout the contextual run (silent in baseline).

One session

- one run for each adaptor position + baseline (no adaptor presented)

Hypotheses, Predictions and Evaluation

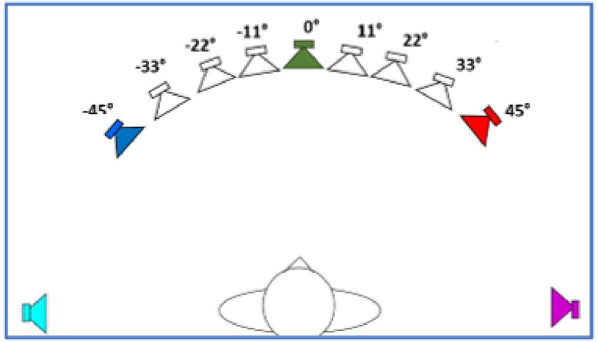
Experiment 1

- HYPOTHESIS H1: **If CP is caused by adaptation to the distractors/adaptors, independent of their role in the listener's task, then it will be observed when the listener only passively listens to the context.**

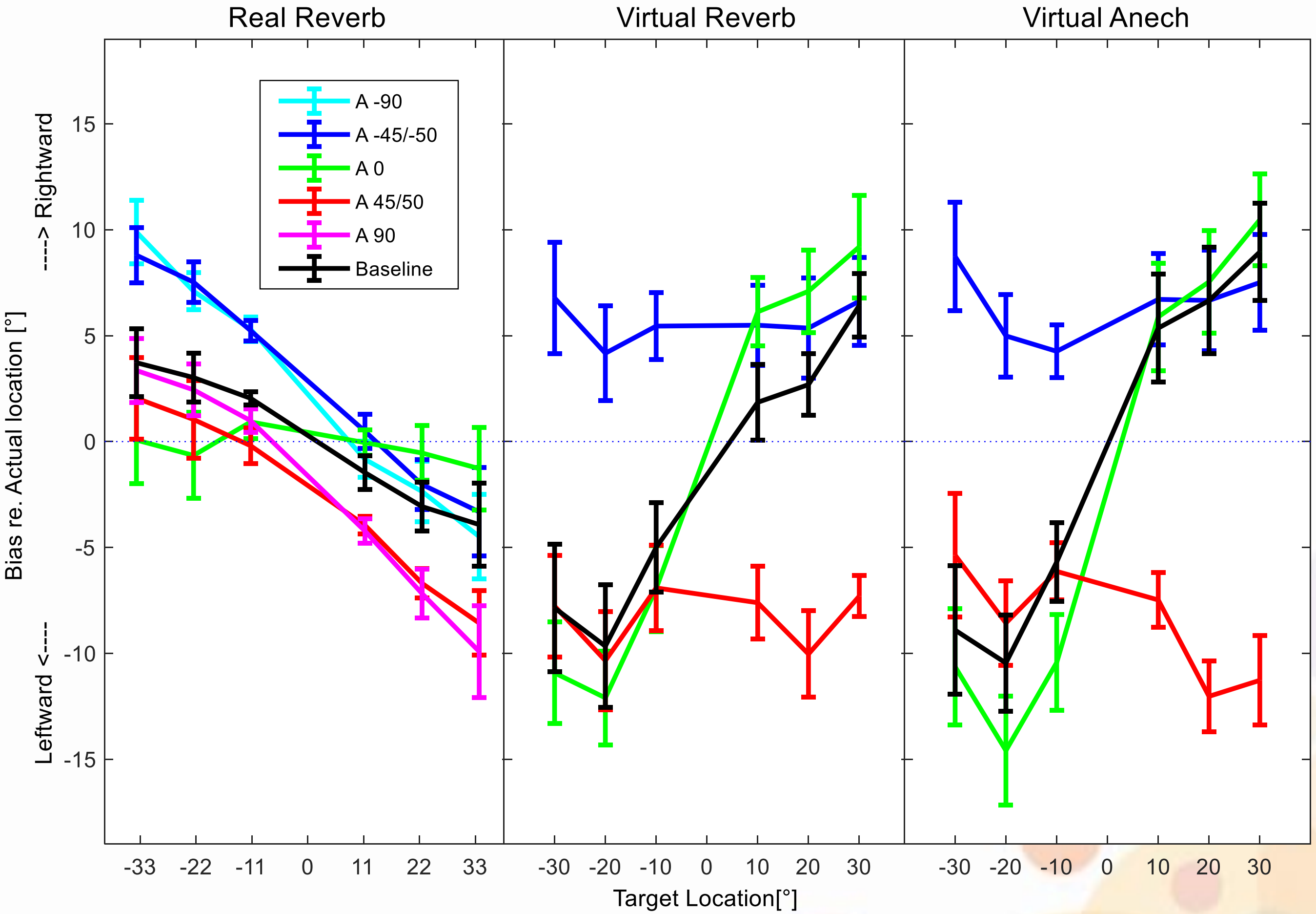
Experiment 2

- HYPOTHESIS H2**: CP might be observed in virtual environment, and it would be stronger than in Exp. 1 (real environment), as no anchoring of stimuli as objects in real world is available to calibrate perception.**

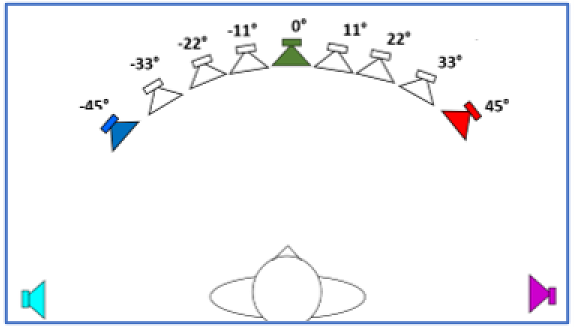
Results: Bias



- in baseline, show compression in real and expansion in virtual environments
- depend strongly on adaptor location
  - Exp. 1: A x T ($p < 0.001$)
  - Exp. 2: A x T x Env. ($p < 0.001$)



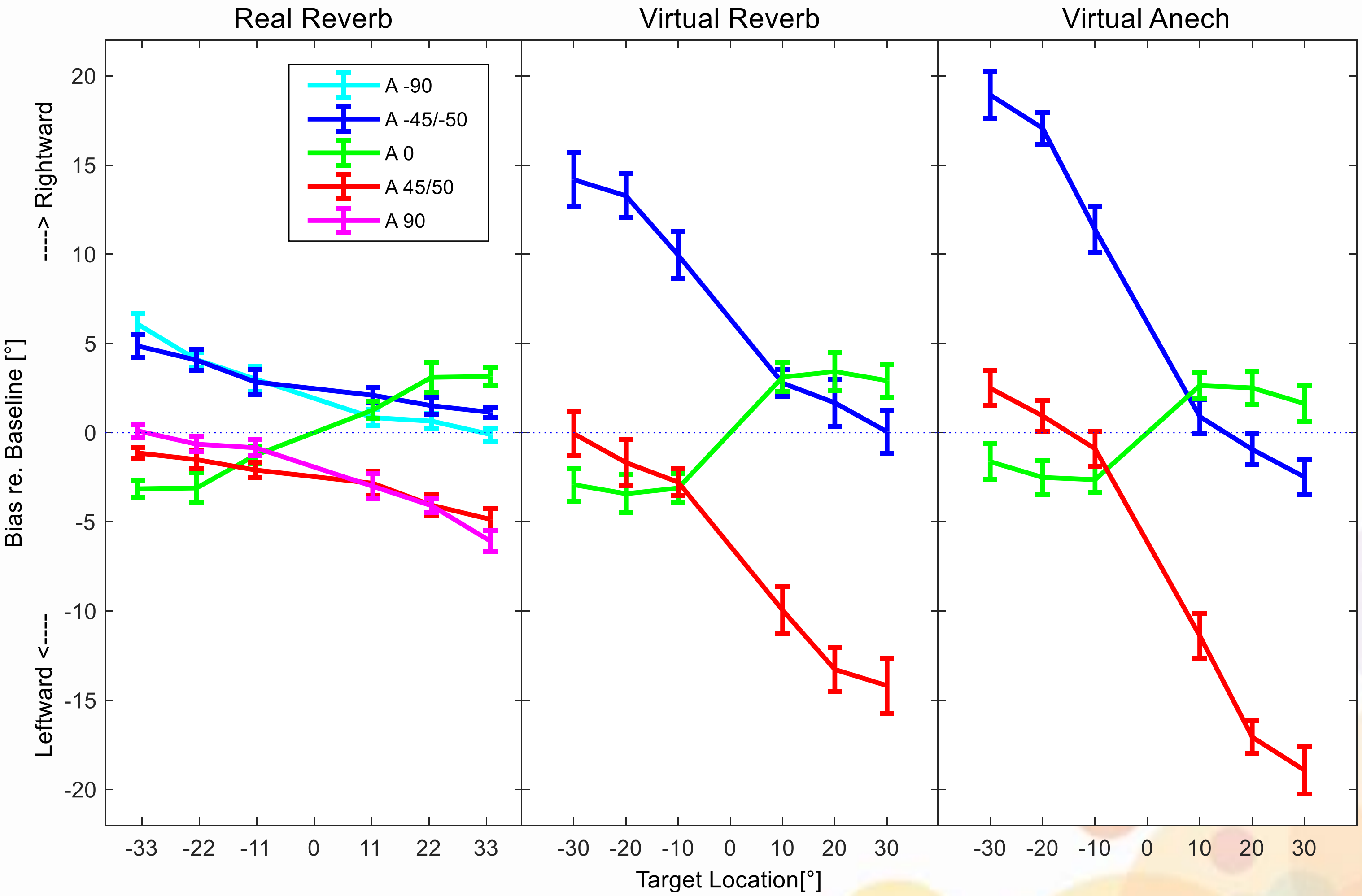
Results: Bias



Biases re. Baseline

(data mirrored assuming left-right symmetry)

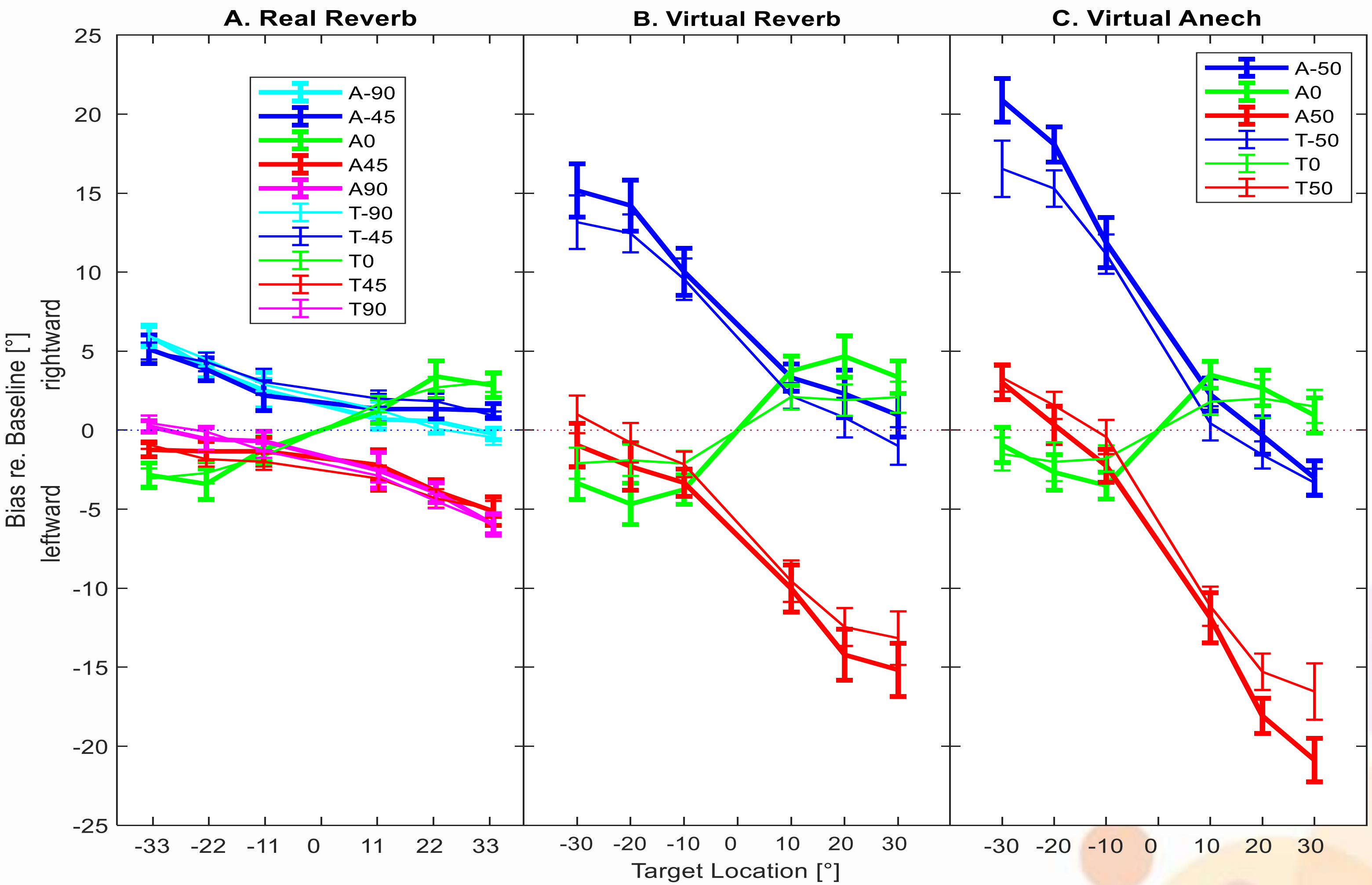
- away from adaptor
- stronger for lateral adaptors than frontal
- stronger in virtual than real environment
- stronger in virtual anecho than in virtual reverberant
- **contextual bias induced by adaptors**



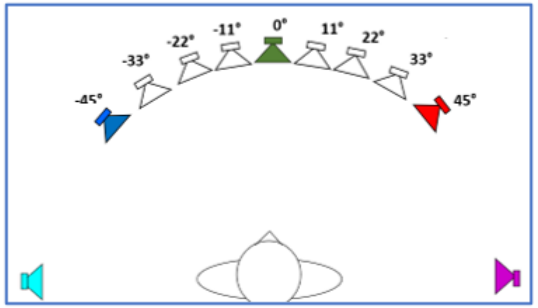
Results: Bias Dynamics on a Short-Time Scale

Effect of immediately preceding trial type (Adaptor or Target) on target localization:

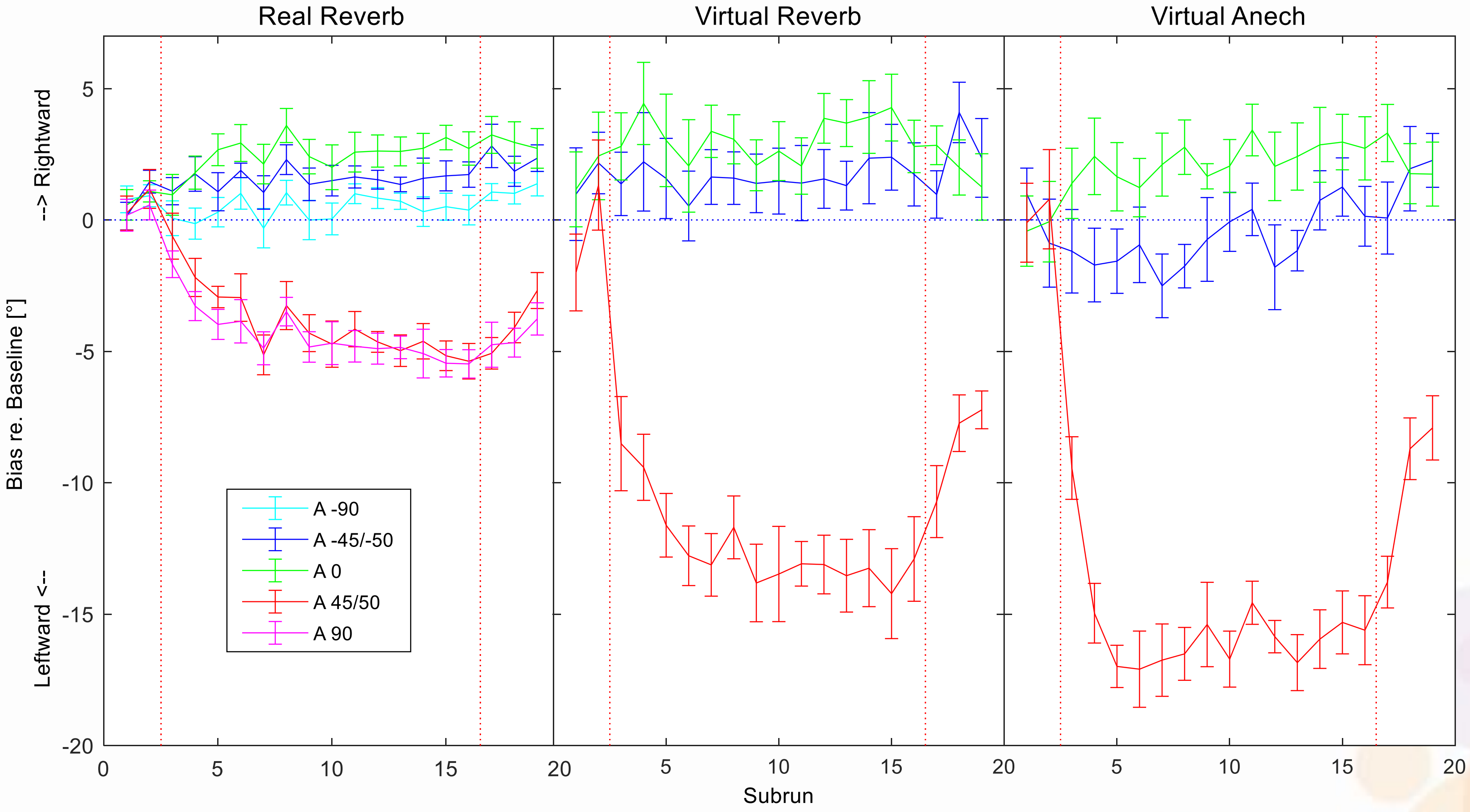
- no effect in real reverberant env. ($p > 0.09$, panel A),
- **bias larger for trials preceded by adaptor** in both **virtual environments** and both adaptor locations ($p < 0.05$, panels B & C)
- quick adaptation - 5 sec



Results: Build-up of Bias



- duration **12 minutes**
- very slow for the frontal adaptor in all environments
- ipsilateral adaptor:
  - fastest in virtual anech
  - slower in virtual reverb
  - slowest in real reverb
- no clear pattern for contralateral adaptor



Mechanism of CP

Two candidate mechanisms have been proposed to explain adaptation phenomena similar to CP:

- **fatigue due to extended activation** reduces responses in spatial channels near adaptor location (Carlile et al., 2001)
- spatial representation **adapts to improve source separation** at the cost of introducing localization biases (Lingner et al., 2018)

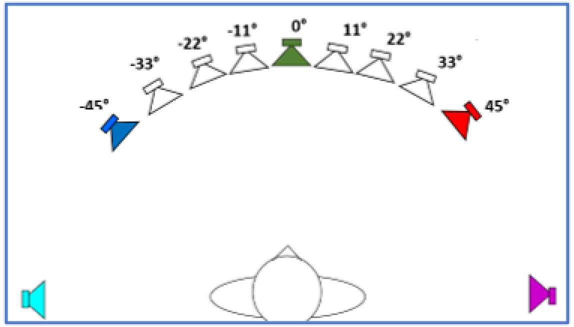
Predictions for location discrimination performance after adaptation:

- **worse for targets** near adaptor (vs. far from adaptor) (Carlile et al., 2001)
- **better for targets** near adaptor (Lingner et al., 2018)

Predictions about mechanism underlying CP:

- HYPOTHESIS H3: **Localization discrimination will be worse for target near adaptor (Carlile),** as suggested by previous CP results

Correlation and Std. Dev. Analysis Methods



- Only later portion of adaptation parts considered

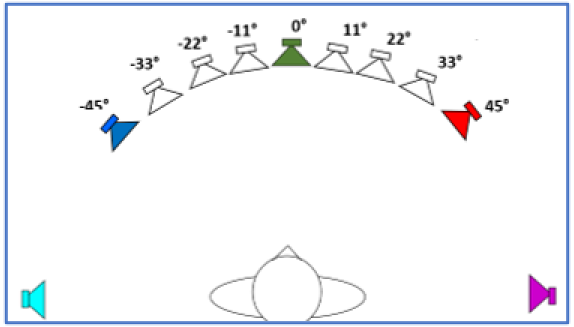
Pearson's Correlation Coefficient:

- Targets divided into triplets of 3 right-most (RT) and 3 left-most targets (LT)
- Responses for each triplet correlated with real positions within a run
- Results combined across left-right symmetric positions (-90° LT, +90° RT)

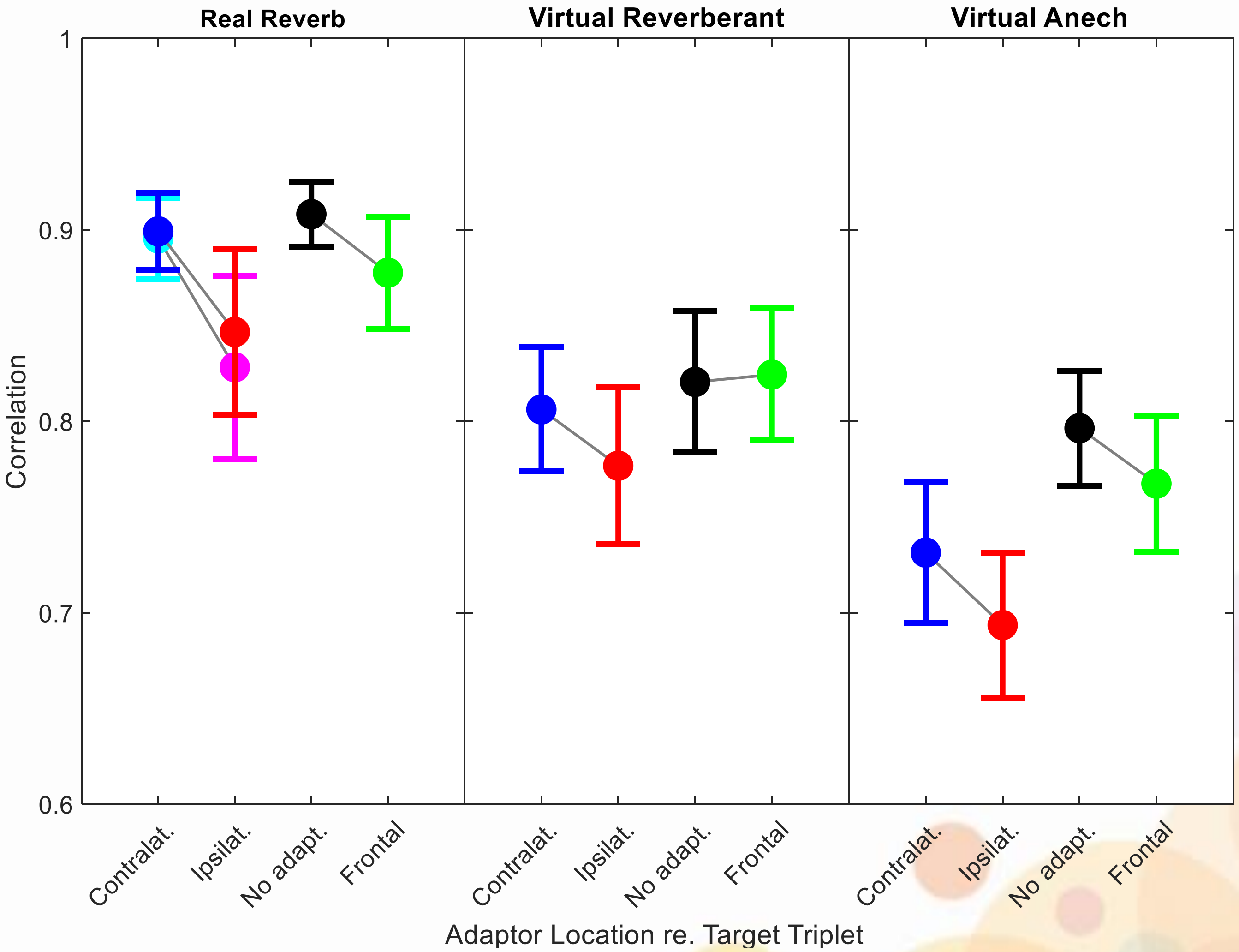
Variance:

- Std. dev. computed separately for each combination of session, target, run and subject; then averaged
- Results combined across left-right symmetric conditions

Results: Pearson’s r

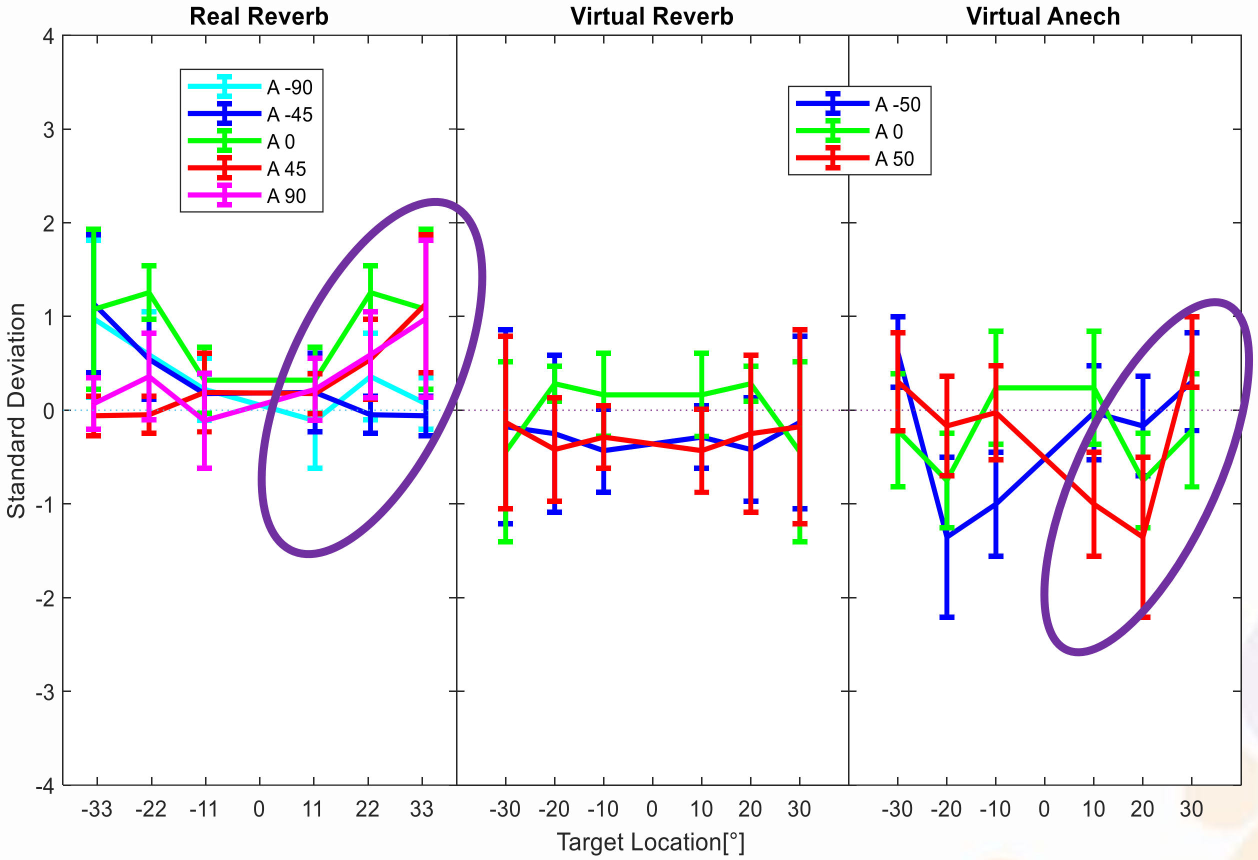


- better for targets far (contralateral) than near (ipsilateral) re. lateral adaptor ($p < 0.0001$)
- better without than with frontal adaptor ($p < 0.005$)
- **consistent with Carlile’s model**



Results: Standard Deviations

- increases for target triplet near adaptor in real reverberant ($p < 0.05$)
- no significant effect in virtual reverberant
- trend for effect in virtual anech, such that standard deviation increases near adaptor and decreases further away ($p = 0.09$)
- **more consistent with Carlile's model**



Conclusions and Discussion

- Hypothesis H1: If CP is caused by adaptation to the distractors/adaptors, independent of their role in the listener's task, then it will be observed when the listener only passively listens to the context.

CONCLUSION: **Passive exposure to adaptors is sufficient to induce CP**

- slightly stronger bias in active task
- future experiment with active vs. passive task

Conclusions and Discussion

- Hypothesis H2**:** CP might be observed in virtual environment, and it would be stronger than in Exp. 1 (real environment), as no anchoring of stimuli objects in real world is available to calibrate perception.

CONCLUSION: **CP observed in virtual environment in Exp.2. and it is much stronger and faster in virtual than real environment. CP slightly stronger in anechoic than reverberant virtual environment.**

- less certainty about the virtual environment
- using relative vs. absolute localization strategies, interpreting adaptor as an anchor and responding relatively to it

Conclusions and Discussion

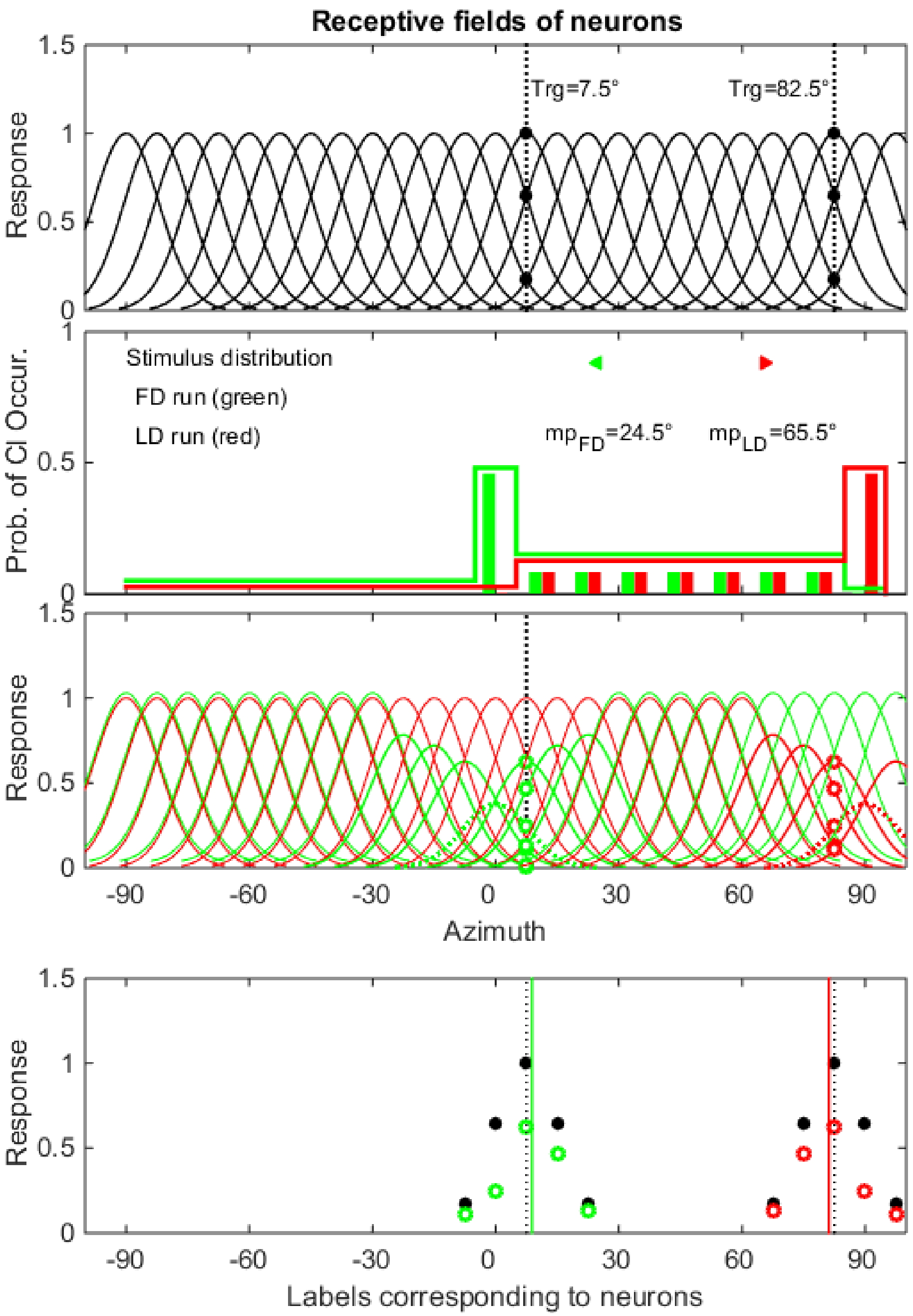
- HYPOTHESIS H3: Localization discrimination will be worse for target near adaptor (Carlile), as suggested by previous CP results.

CONCLUSION: **Both stimulus-response correlation and response standard deviations increase near adaptor -> localization discrimination after adaptation is worse for target near adaptor** (Carlile et al., 2001)

In virtual anechoic environment st.d. has some tendency to improve for targets not immediately neighboring the adaptor (Lingner et al., 2018):

- expansion of space even in baseline
- rapid adaptation to preceding trial type
- lower overall accuracy in terms of correlation

THANK YOU FOR YOUR ATTENTION



Receptive fields of neurons
Trg=7.5°
Trg=82.5°
Response
Stimulus distribution
FD run (green)
LD run (red)
mpFD=24.5°
mpLD=65.5°
Prob. of CI Occur.
Response
Azimuth
Response
Labels corresponding to neurons