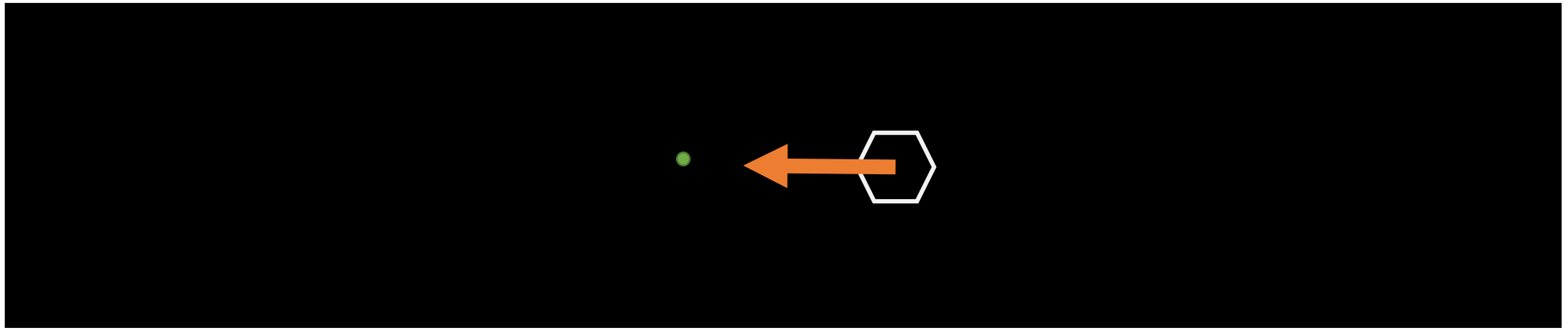
Modeling the reference frame of the ventriloquism aftereffect

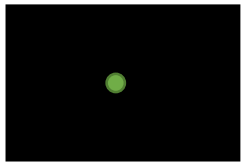
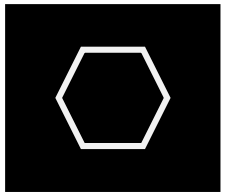
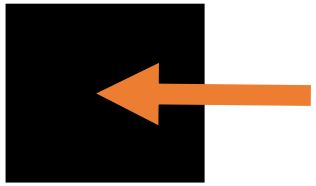
Ing. Peter Lokša, PhD.

co-author: doc. Norbert Kopčo PhD.

Perception and cognition lab: PCL.UPJS.SK

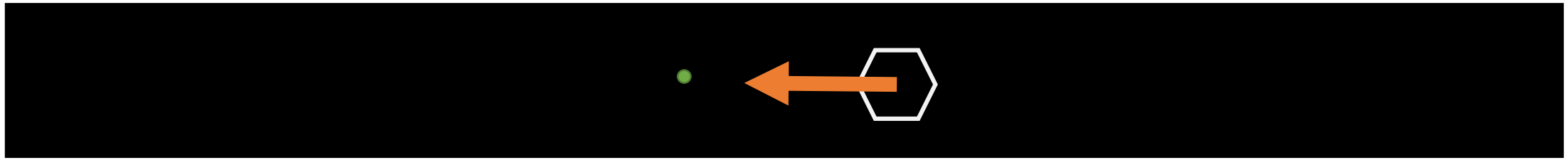
What is Ventriloquism Effect (VE)?



- Visual stimulus - 
- Auditory stimulus - 
- Perceived stimulus location - 

Ventriloquism aftereffect (VAE)

many times:



afterwards:

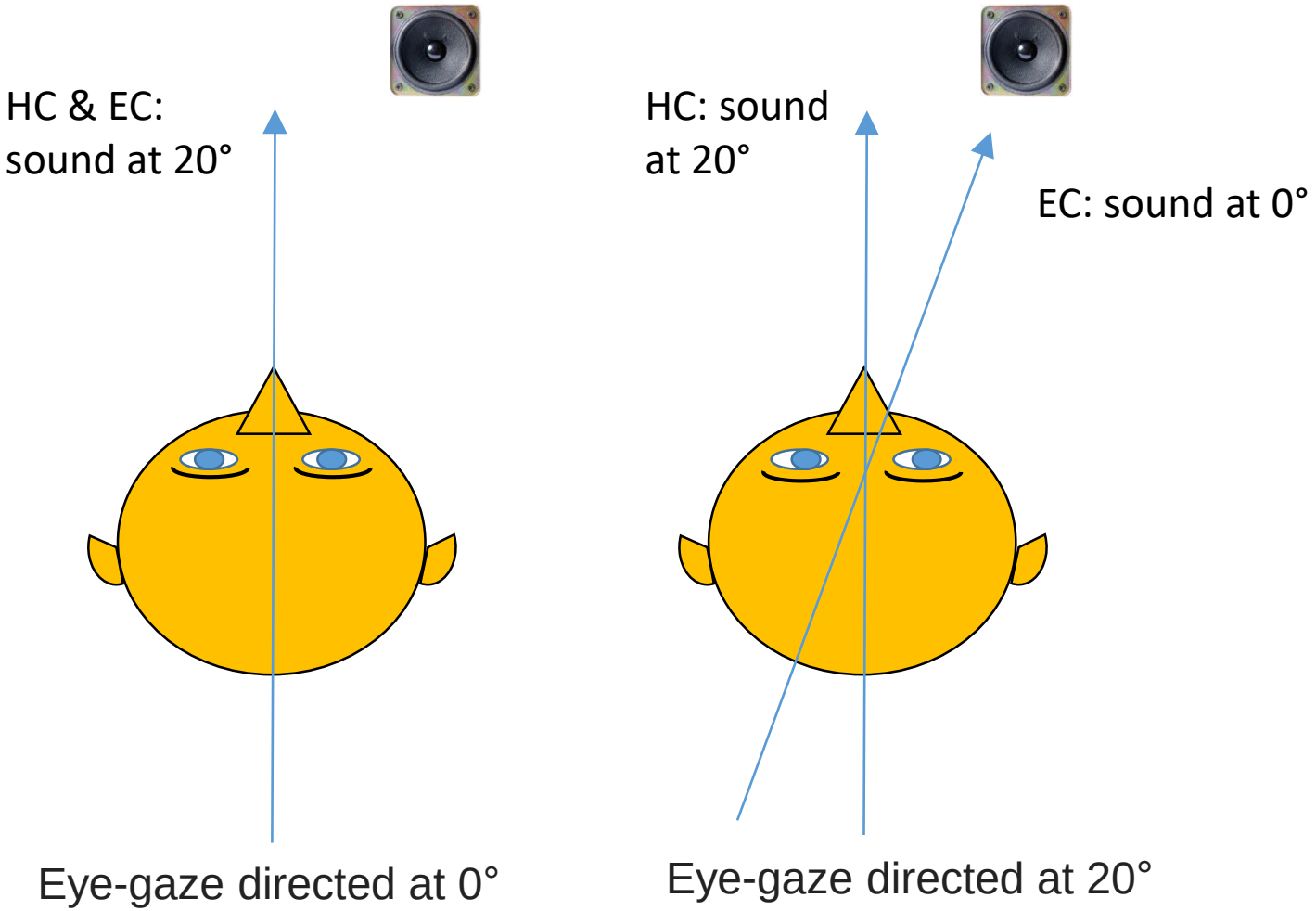
What is the reference frame of the Ventriloquism Aftereffect?

Ref. frame of spatial representation in
- hearing: head-centered (HC)
- vision: eye-centered (EC)

Which RF is used in VAE?

Studies performed:
Kopco et al. (2009) – central VAE inducement – mixed RF
Kopco et al. (2019) – peripheral VAE inducement – HC RF

Modeling performed to assess RF:
AV-aligned data
VAE data



Basic Design of Exp. 1 & 2

1. Pre-adaptation baseline: Measure auditory saccade accuracy

2. Adaptation phase: Present combined visual-auditory stimuli, with visual location shifted

3. Compare auditory saccade accuracy pre- and post-adaptation

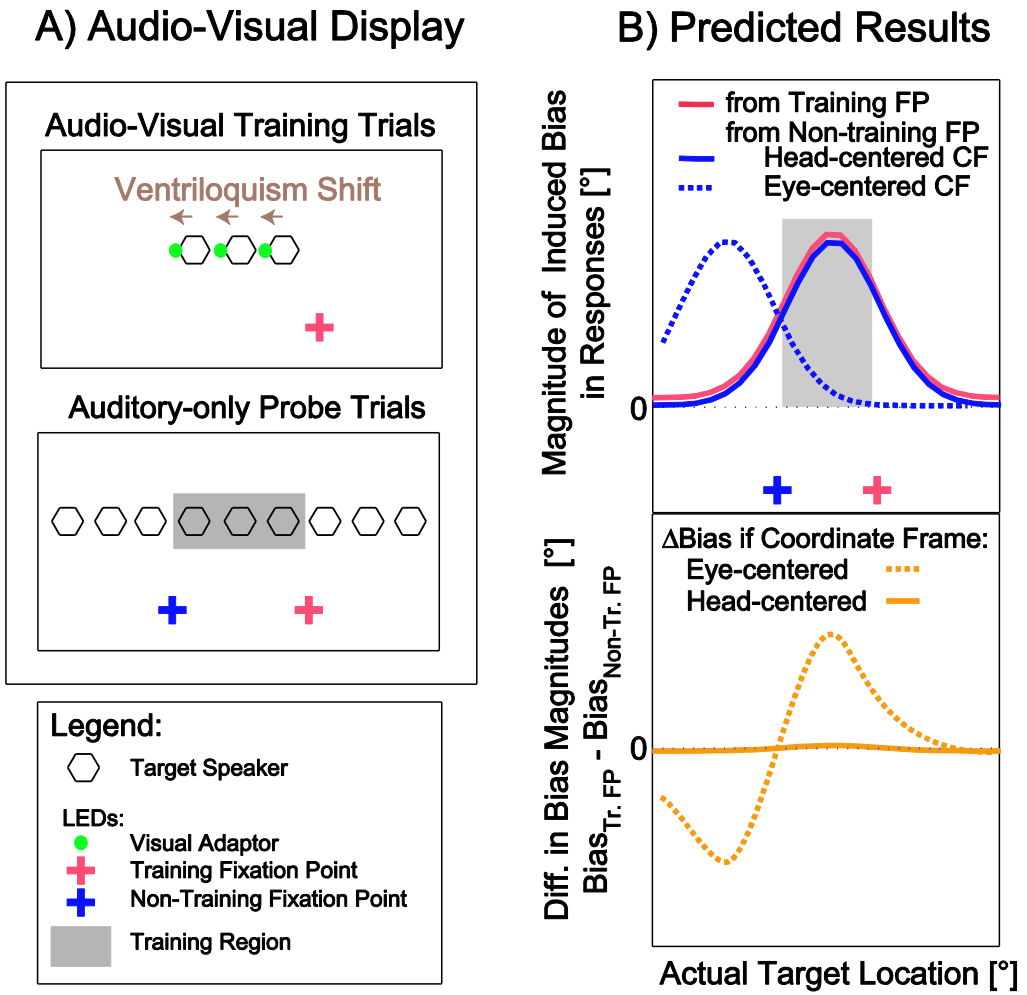
Methods of Experiment 1: central training

1. Training with audiovisual stimuli presented in the central region while fixating on the right +.
2. Testing: Auditory-only stimuli from 9 loudspeakers while fixating one of two FPs + or +.

Predictions:

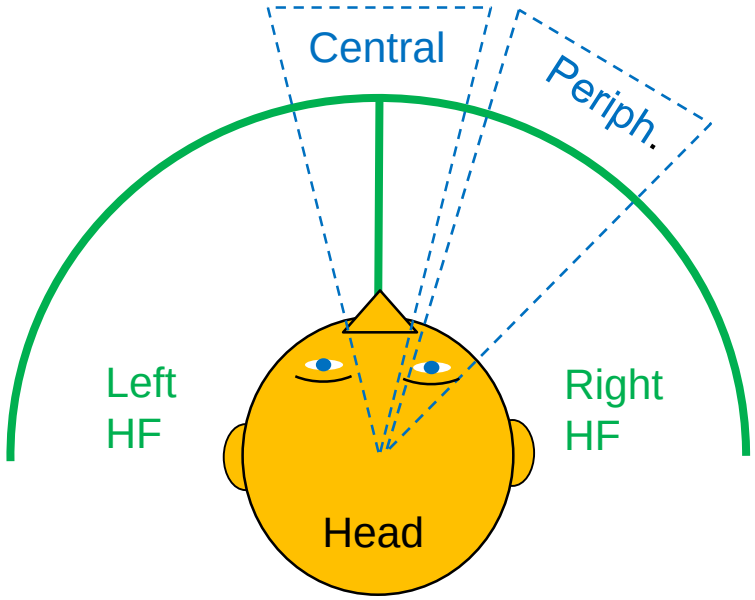
- Locally induced VAE from +.
- When fixation shifts to +, VAE:
  - stays the same → RF of VAE is head-centered,
  - shifts with fixation → RF of VAE is eye-centered,
  - changes in a different way → RF is mixed.

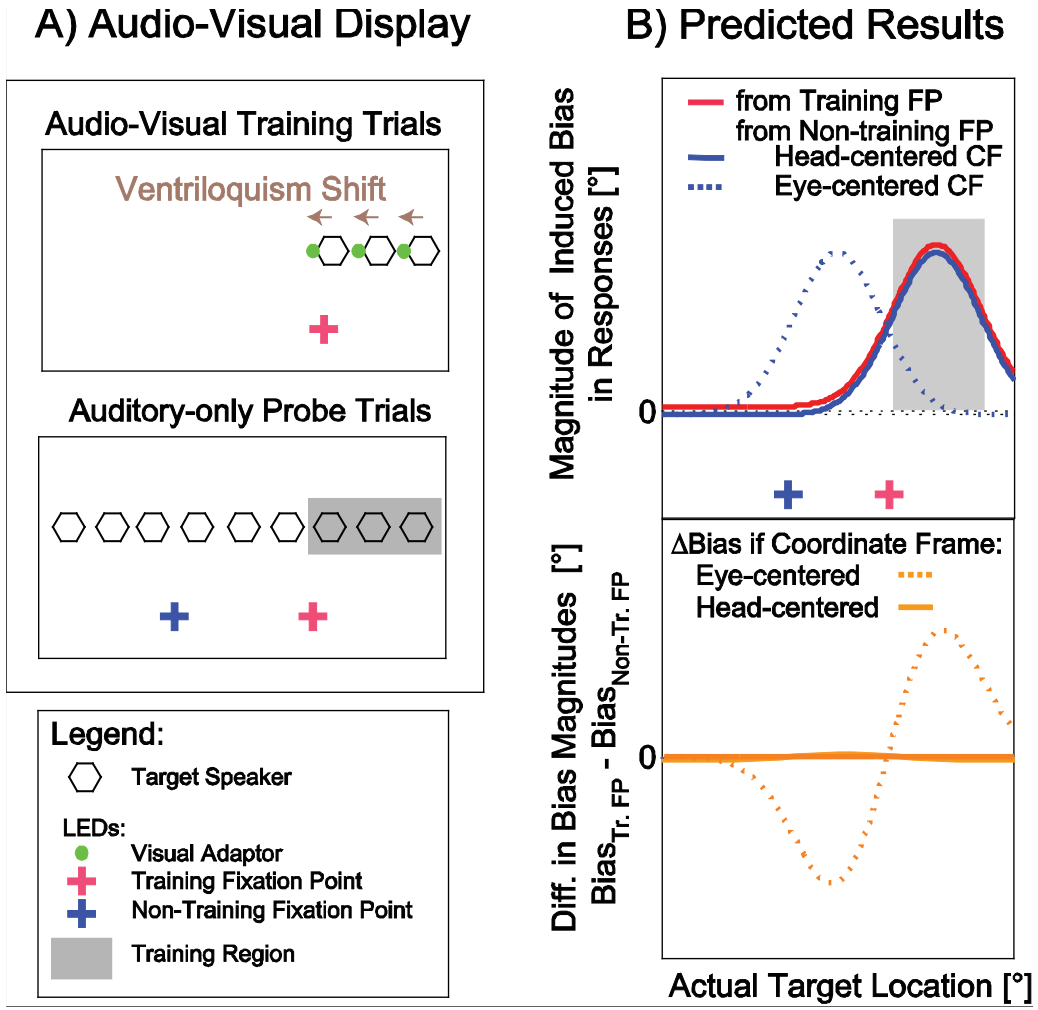
Predictions evaluated directly by computing difference + - +.



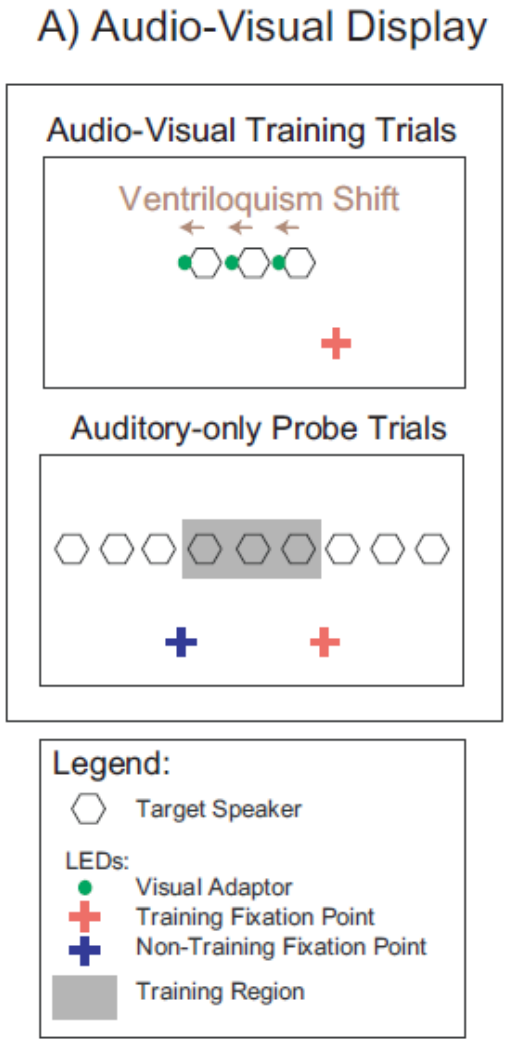
Methods of Experiment 2: peripheral training

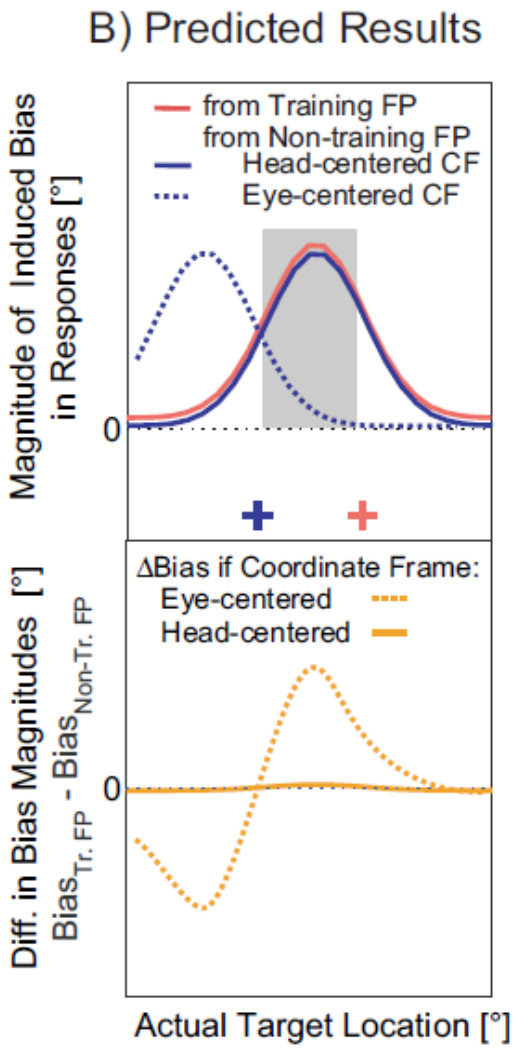
- All methods the same as experiment 1, except training region shifted to periphery
- Expected that the results might be different, in particular since auditory space might have hemisphere-specific representation

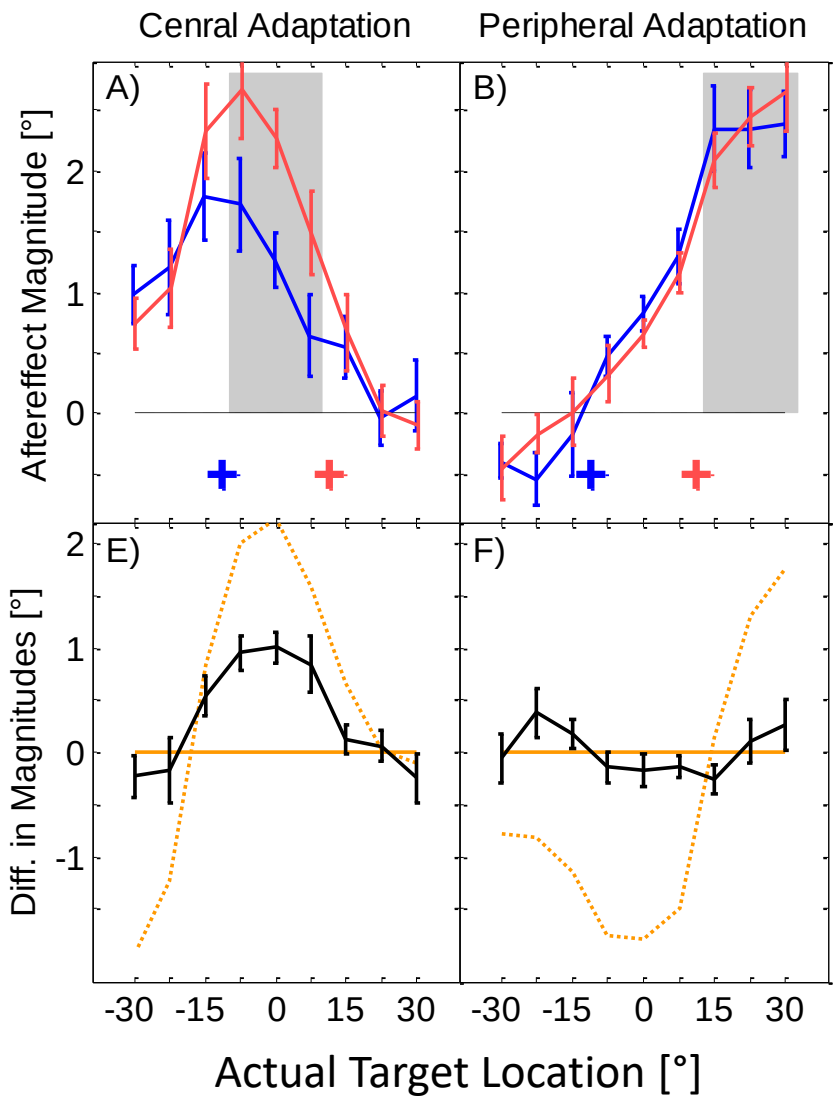




Results of Experiments: Ref. Frame of VAE



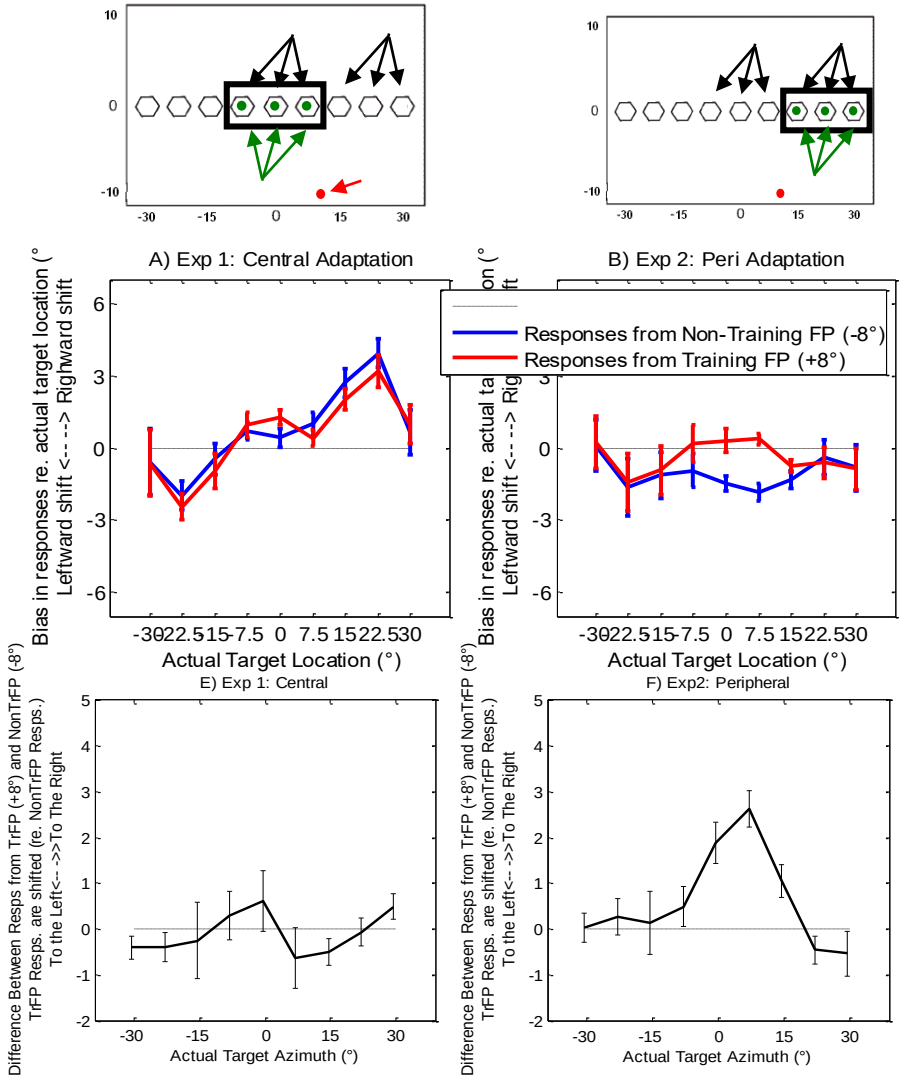




RFs differ for central vs. peripheral experiments (7 subjects):

- Central – mixed RF
- Peripheral – mostly head-centered RF

Results of experiments: AV-aligned baseline



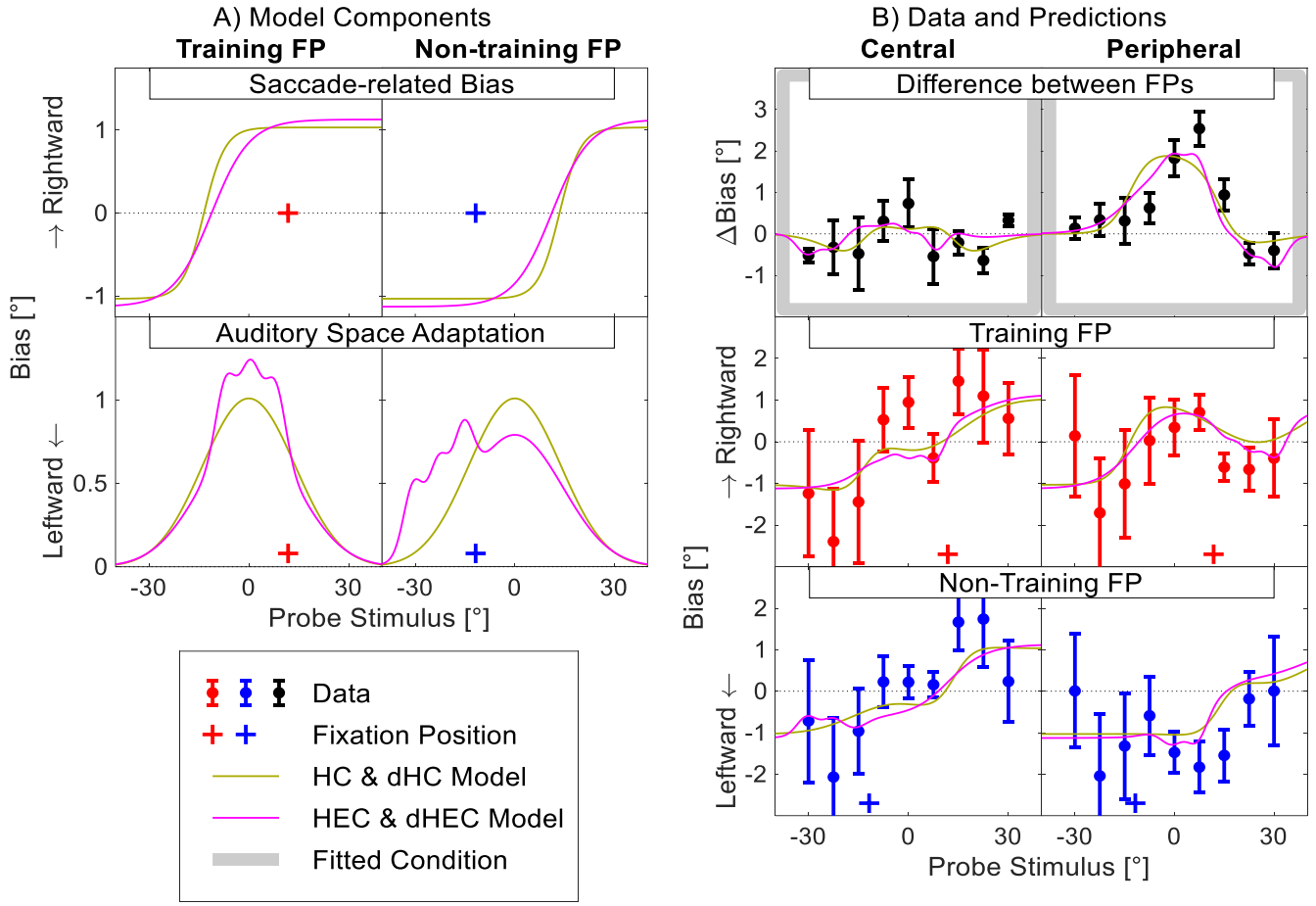
Central Experiment:
- slight expansion outside training region,
- independent of FP.

Peripheral Experiment:
- FP-dependent shift in the central region.

AV signals presented within one hemisphere cause hemisphere-specific adaptation, dependent on hemisphere of FP.

Results of modeling of AV-aligned data

- HC model is sufficient.
- This model could also fit 3 different subsets of all data separately (different versions and values).
- However, it could not fit aftereffect data well enough, and thus, all data weren't also fitted well.



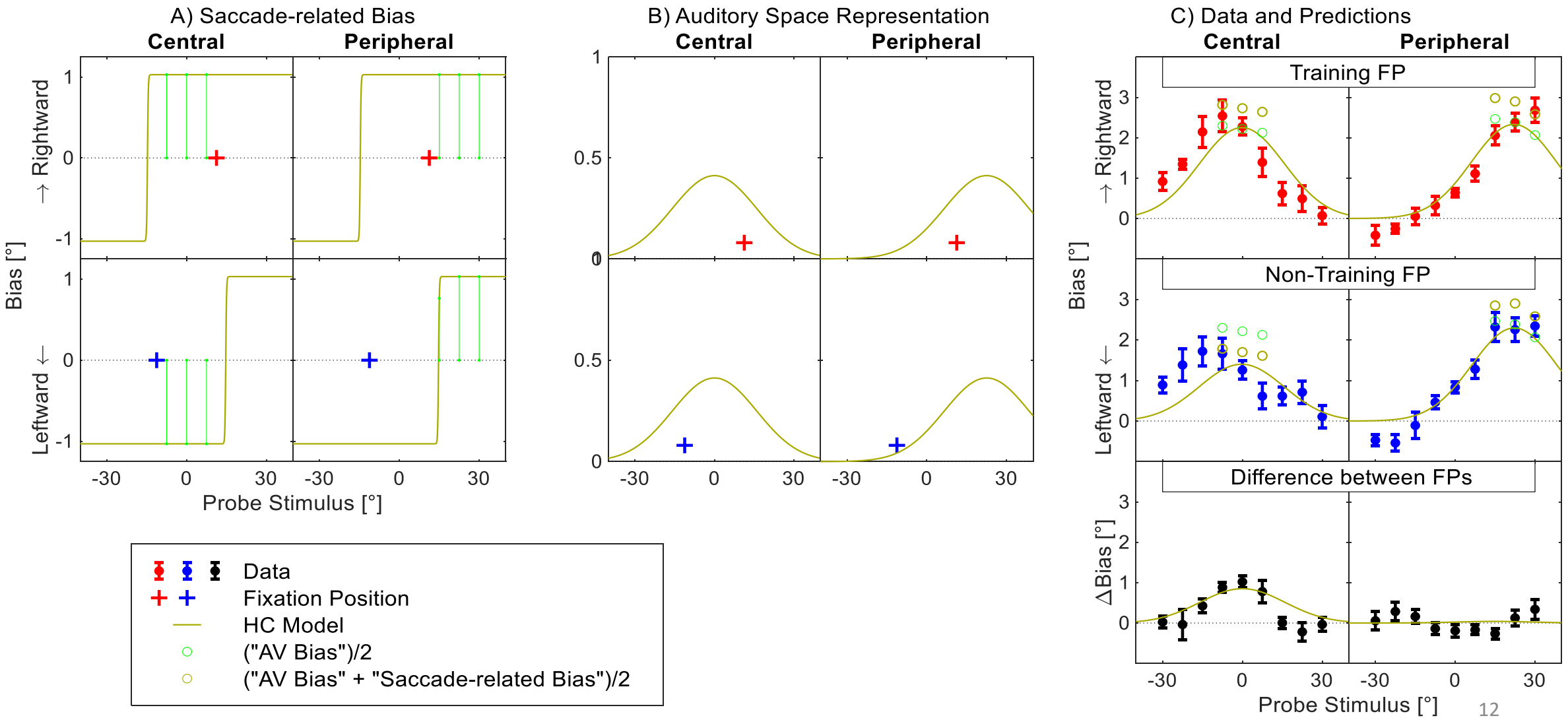
Modeling – goals:

Propose a computational model that can describe the aftereffect data.

Based on the evaluation of different versions of the model, we are proposing following questions:

- Can a basic version of (HC) the training-region-specific model of saccade-related EC bias with auditory space representation explain the differences in RFs based on the aftereffect data, both central and peripheral?
- Is it necessary that EC component is also considered, and thus that the RF is indeed mixed?
- Is FP-dependent attenuation helpful in explaining our aftereffect data?

Results


A) Saccade-related Bias
Central
Peripheral
→ Rightward
Leftward ←
Bias [°]
Probe Stimulus [°]
B) Auditory Space Representation
Central
Peripheral
C) Data and Predictions
Central
Peripheral
Training FP
Non-Training FP
Difference between FPs
→ Rightward
Leftward ←
Bias [°]
ΔBias [°]
Probe Stimulus [°]
Data
Fixation Position
HC Model
("AV Bias")/2
("AV Bias" + "Saccade-related Bias")/2

Conclusions and discussion

Modeling concluded that:

- HC version of the training-region-specific model fits our aftereffect data well.
- Versions of the model with the EC component has very slight contribution to the fitness of the model, which means we don't need EC component of auditory space representation to explain our data or to explain that our aftereffect data was apparently mixed.
- The versions of the model with the d parameter provided no contribution at all in comparison with the ones where this parameter absented. This means the FP-dependent attenuation is not required to describe the reference frame of the ventriloquism aftereffect.

HC version of our model can describe the phenomena observed in Kopco et al. (2009; 2019), and suggests that:

- auditory spatial representation adapted by Ventriloquism is uniform, using a HC RF.

However:

- Our training-region-specific model cannot explain our AV-aligned data.

Future steps:

- Try to combine the current model with the model for AV aligned data.
- Experimentally test saccade-related EC bias.
- Incorporate the model to Auditory Modeling Toolbox in Matlab.

Thanks for your attention.

This work was supported by EU Danube Region Strategy & The Slovak Research and Development Agency DS-FR-19-0025