Radial Bias Pilot 1

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Contents

1 Experiment Description of Pilot 1

To compare discriminability for radial motion directions compared to tangential motion directions with 1D drifting gratings at 8 polar angle locations at 7 deg eccentricity. A total of 4 motion directions will be per location, 2 radial (inwards and outwards) and 2 tangential.

1.1 Parameters

Eccentricity from central fixation: 7 degrees
Locations tested (polar angle relative to fixation): 0-315 degrees in 45 degree increments
Stimulus: sine wave gratings w/ 0.4 deg sigma gaussian mask
Stimulus spatial frequency: 1 c/deg
Stimulus drift speed: 8 deg/s
Stimulus contrast: 50% contrast per grating + gaussian mask

Stimulus aperature diameter: 2.5 deg
Black circular aperature was put onto screen to avoid perceptual artifacts from screen edges
Aborts trials that have breaks in fixation during stimulus presentation (stimulus_start - 300 ms TO stimulus_end)
Number of subjects: 5

1.2 Subject Instructions

For each of the following trials, a fixation dot will appear on the screen. A drifting pattern will appear at some distance from the center. Your task is to determine whether the pattern is drifting clockwise or counterclockwise relative to the reference.
Please remain fixated on the dot throughout the trials.
Press the RIGHT ARROW for clockwise direction.
Press the LEFT ARROW for counterclockwise direction.

1.3 Experimental Design

The pilot uses a 2AFC paradigm, within a block each trial includes a drifting grating presented at 1 of 4 possible positions, while the subject maintains fixation at the central dot. A method of constant stimuli is used which is set based on the performance of the training session (see Methods). The angular values added to the internal reference frame is chosen at random from the following constants [-8, -4, -2, -1, -0.5, 0.5, 1, 2, 4, 8] – logarithmic spacing from 0.5 to 8. The observer must determine whether the direction of motion if clockwise or counterclockwise relative to the internal reference. The sequence of each trial for the 4 motion standards (specific to diagonal locations) at one location is depicted below:

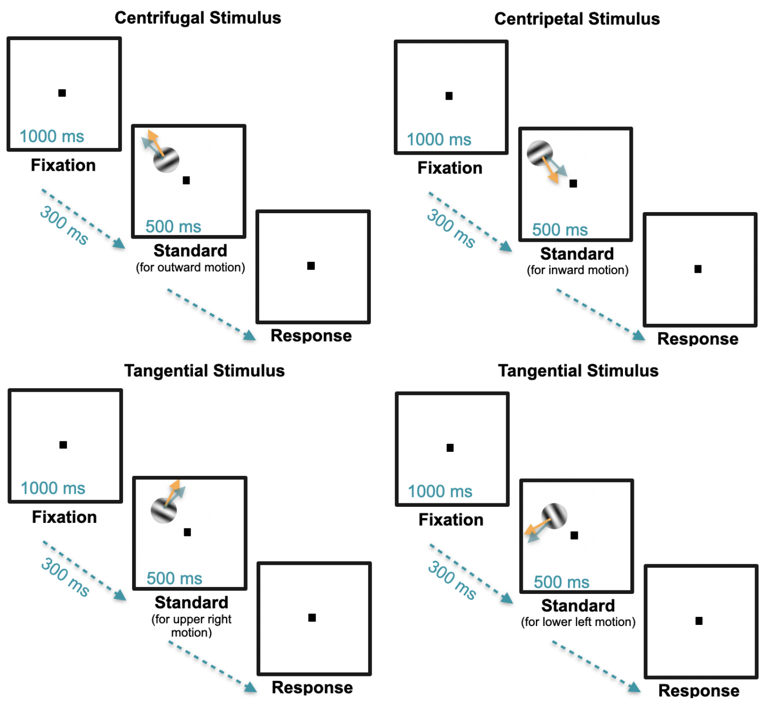
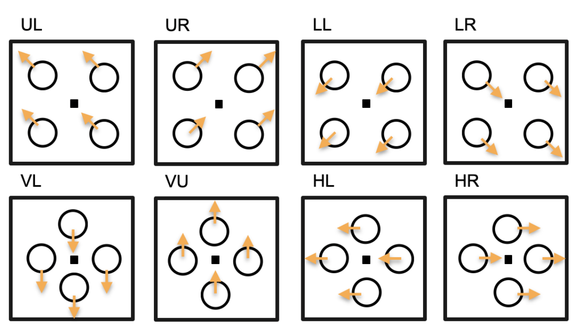


Figure 1: Blue arrow represents the internal reference, the orange arrow represents an example of the direction at which the stimulus is presented (can be clockwise or counterclockwise to the blue arrow.

1.4 Block sequence

Four blocks were run, and each block corresponded to 1 of the 4 conditions being tested (tangential lower left motion, tangential upper right motion, radial upper left motion, radial lower right motion). The internal reference frames for each block is shown below:



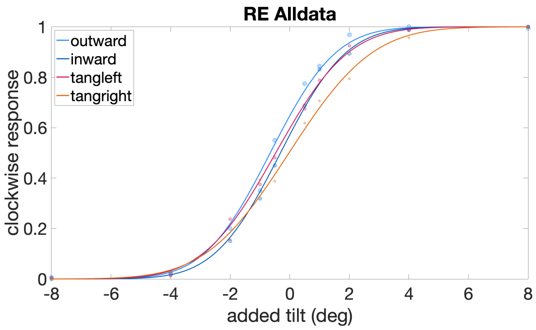
Prior to the actual experiment, the "standard" motion direction corresponding to that specific block will be showed to the observer to use as an internal reference. Then a training session is conducted to determine how much tilt is required to meet 75% accuracy with staircase procedure (MLPest), and to allow subject to practice task with feedback. The estimated angular value to add/subtract to the standard to achieve 75% performance of the clockwise/counterclockwise will be used to determine constants. For this pilot, constants [-8, -4, -2, -1, -0.5, 0.5, 1, 2, 4, 8] were chosen for all 8 blocks. Note positive and negative values for clockwise v. counterclockwise tilt.
Each block contained 4 locations x 5 tilt values x 2 (clock v cc) x 20 repetitions = 800 trials. There

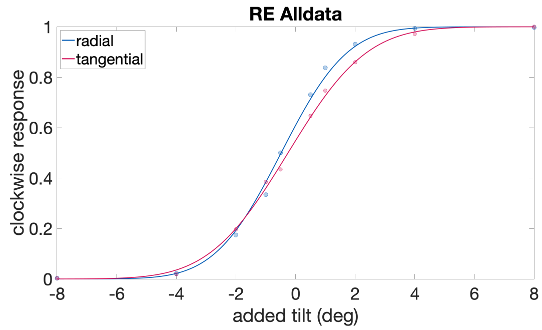
are 8 blocks * 800 trials = 6400 total trials (3200 tang, 1600 radial-in, 1600 radial-out). Each full-block takes 45 min; all 8 blocks took 360 min.
Example sequence of blocks for RE

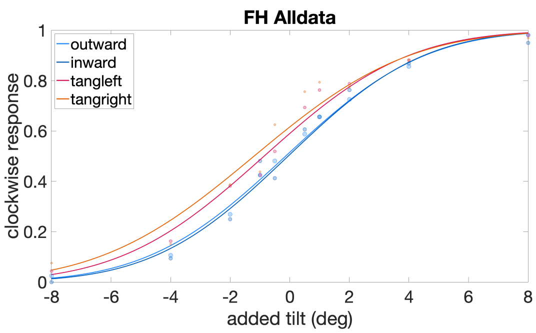
1. diag-UL [angles: +- 0.5, 1, 2, 4, 8] (45 min)
2. card-HR [angles: +- 0.5, 1, 2, 4, 8] (45 min)
3. diag-LR [angles: +- 0.5, 1, 2, 4, 8] (45 min)
4. card-VL [angles: +- 0.5, 1, 2, 4, 8] (45 min)
5. diag-UR [angles: +- 0.5, 1, 2, 4, 8] (45 min)
6. card-HL [angles: +- 0.5, 1, 2, 4, 8] (45 min)
7. diag-LL [angles: +- 0.5, 1, 2, 4, 8] (45 min)
8. card-VU [angles: +- 0.5, 1, 2, 4, 8] (45 min)

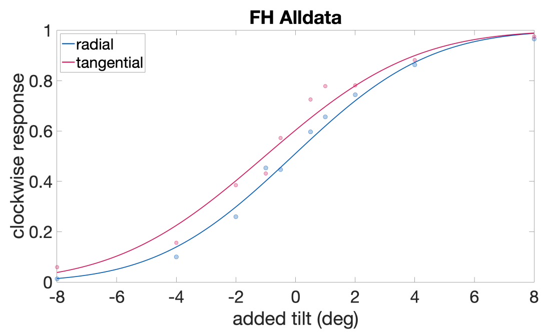
2 Subject Data (Relative motion)

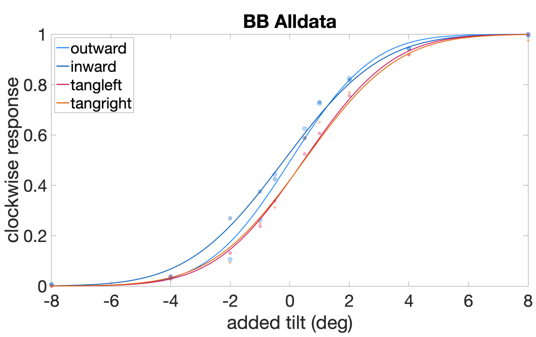
2.1 Psychometric Fits

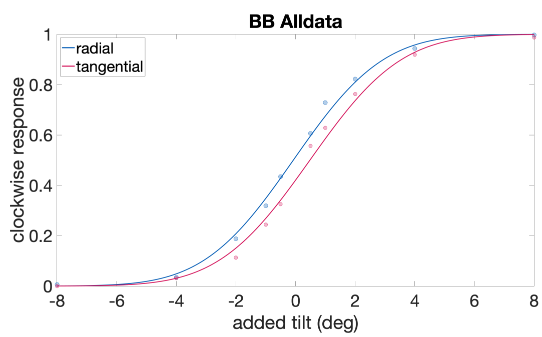


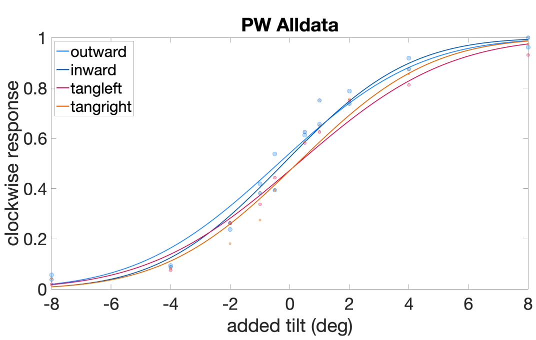


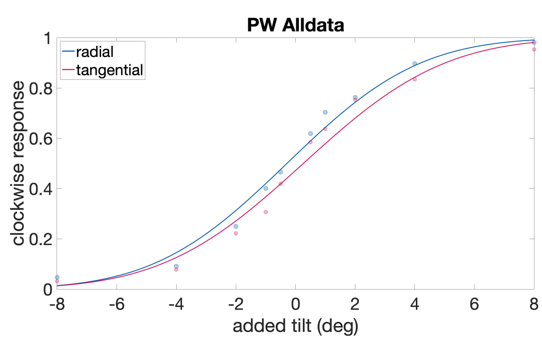












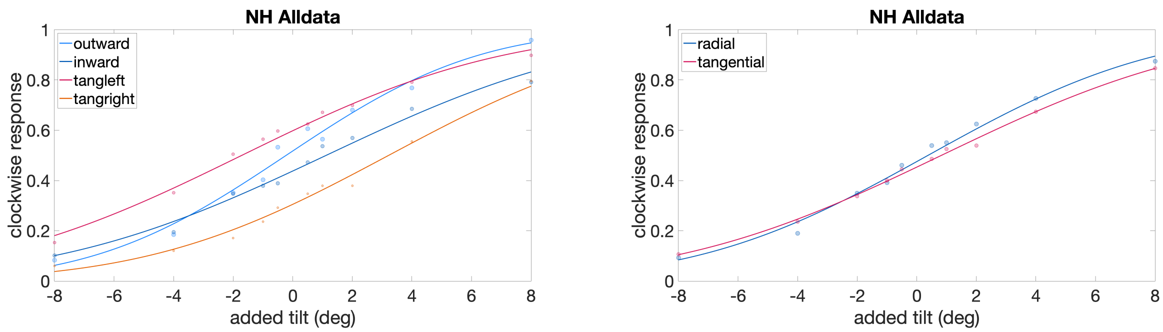


Figure 2: LEFT: 270 trials per point. RIGHT: Each point is 540 trials.

2.2 Sensitivity Polar Plots: Relative Motion

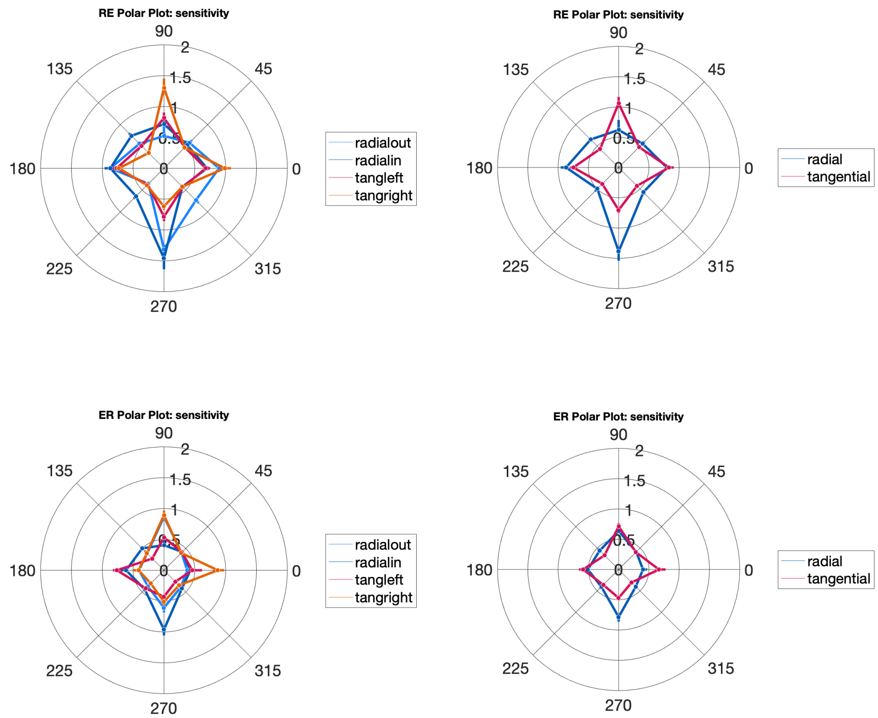
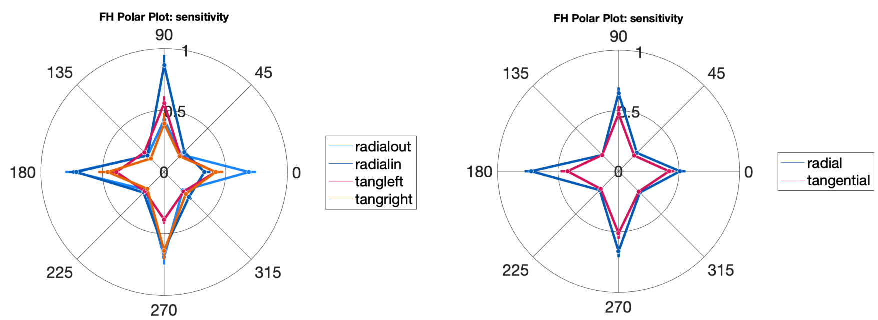


Figure 3: Same subject (RE) but at half distance.



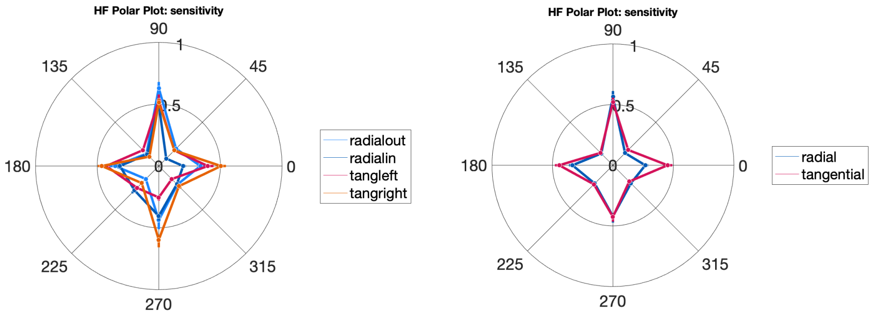


Figure 4: Same subject (FH) but at half distance.

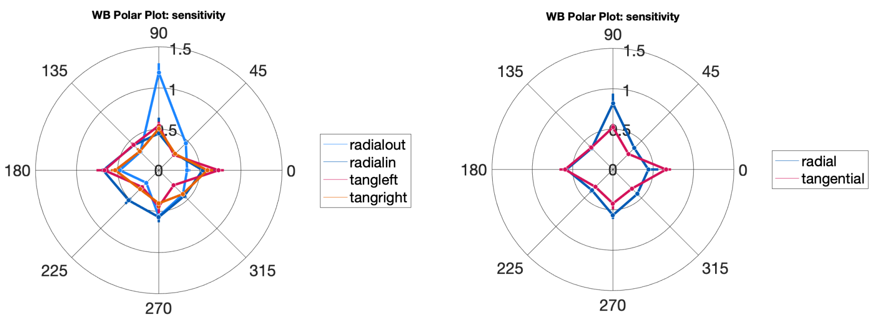


Figure 5: Same subject (BB) but at half distance.

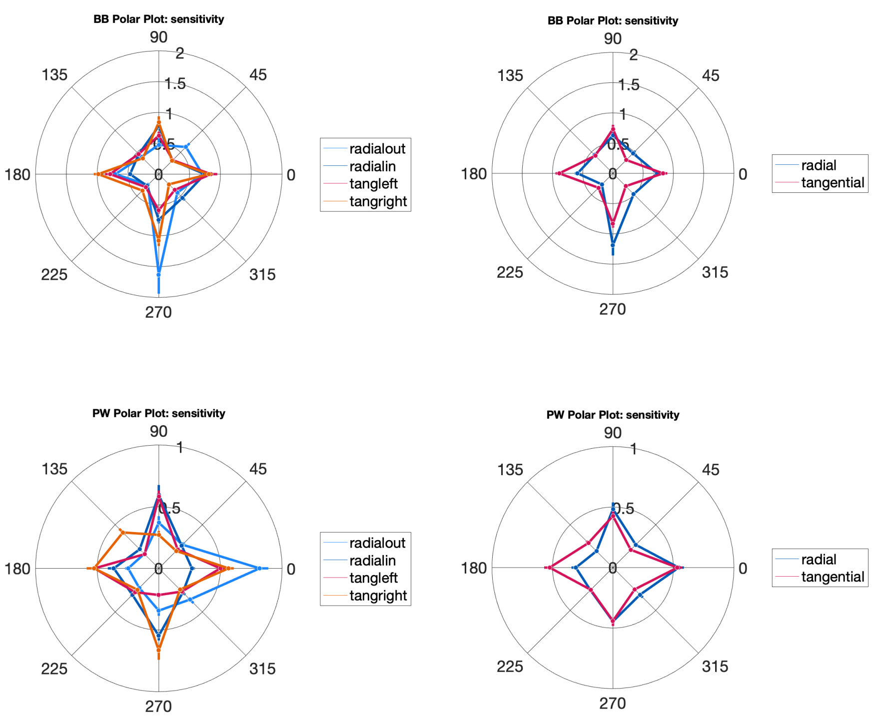


Figure 6: LEFT: 20 trials per point. RIGHT: 40 trials per point. 68% CI from 1000 bootstraps.

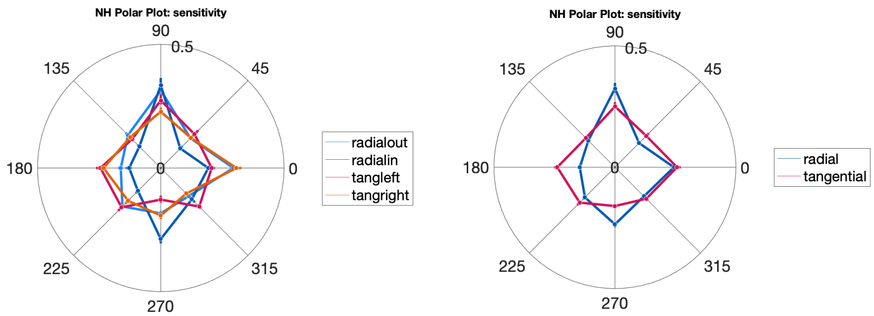


Figure 7: LEFT: 27 trials per point. RIGHT: 54 trials per point. 68% CI from 1000 bootstraps.

2.3 Bias (absv) Polar Plots: Relative Motion

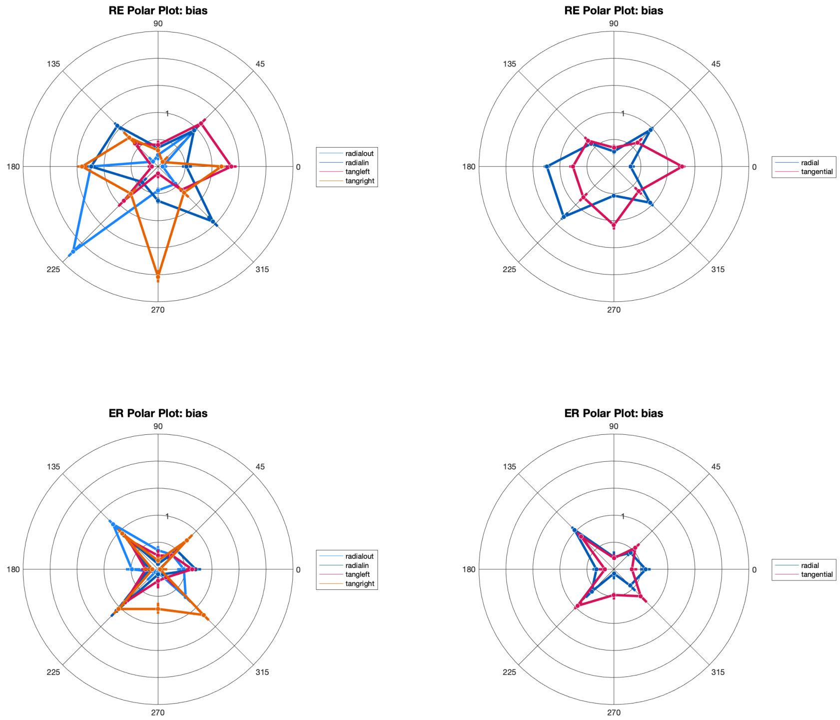
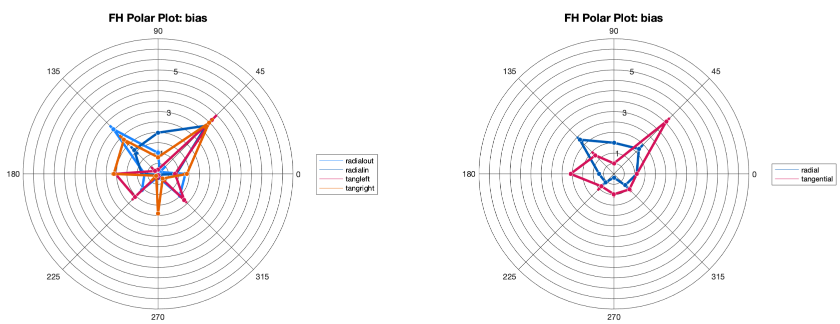


Figure 8: Same subject (RE) but at half distance.



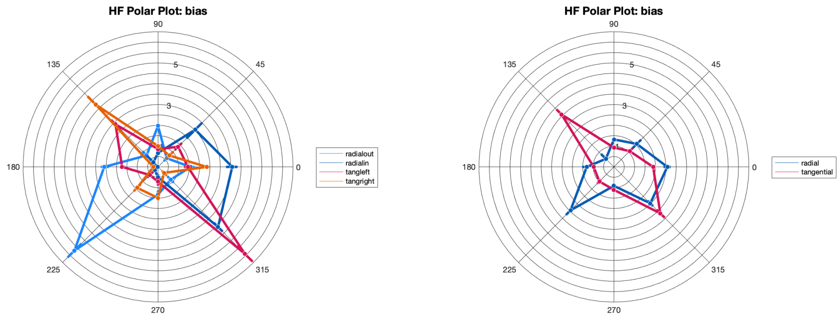


Figure 9: Same subject (FH) but at half distance.

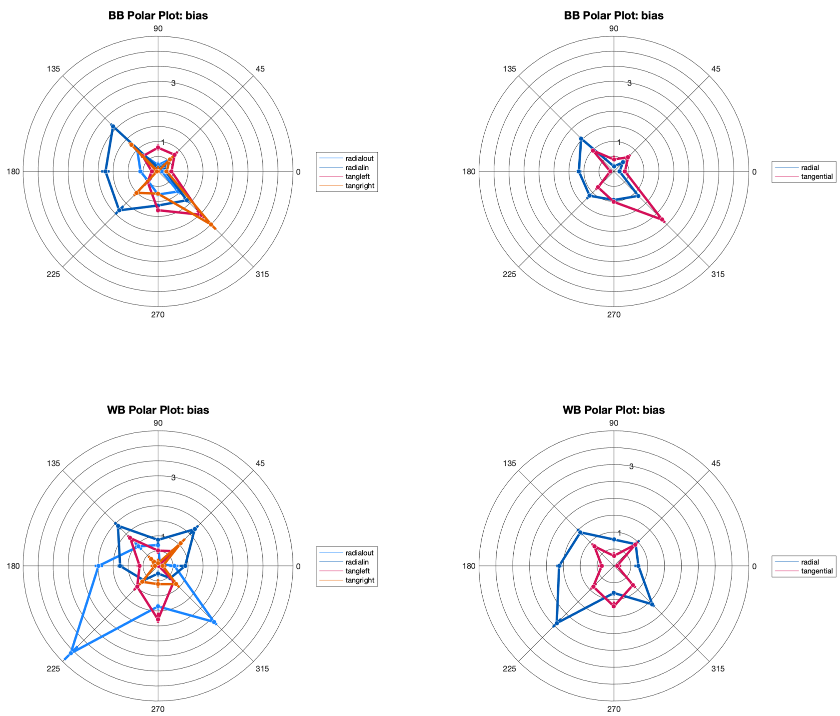


Figure 10: Same subject (BB) but at half distance.

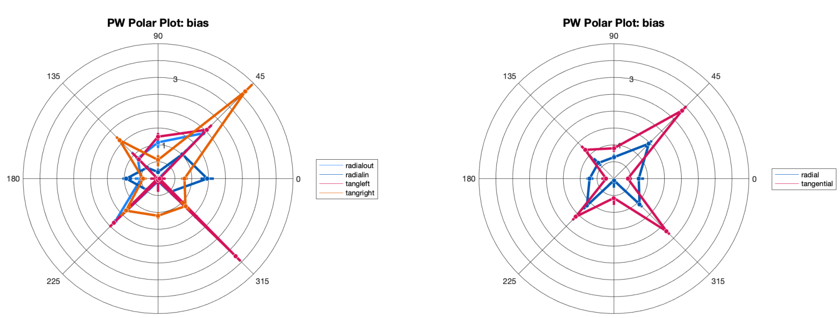


Figure 11: LEFT: 20 trials per point. RIGHT: 40 trials per point. 68% CI from 1000 bootstraps.

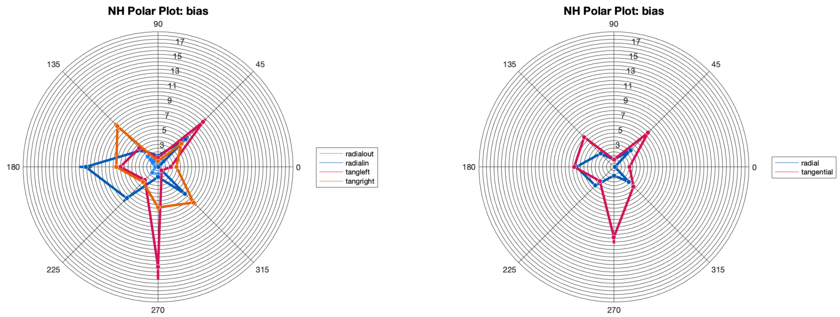


Figure 12: LEFT: 27 trials per point. RIGHT: 54 trials per point. 68% CI from 1000 bootstraps.

3 Subject Data (Absolute motion)

3.1 Sensitivity Vector Plots: Absolute Motion

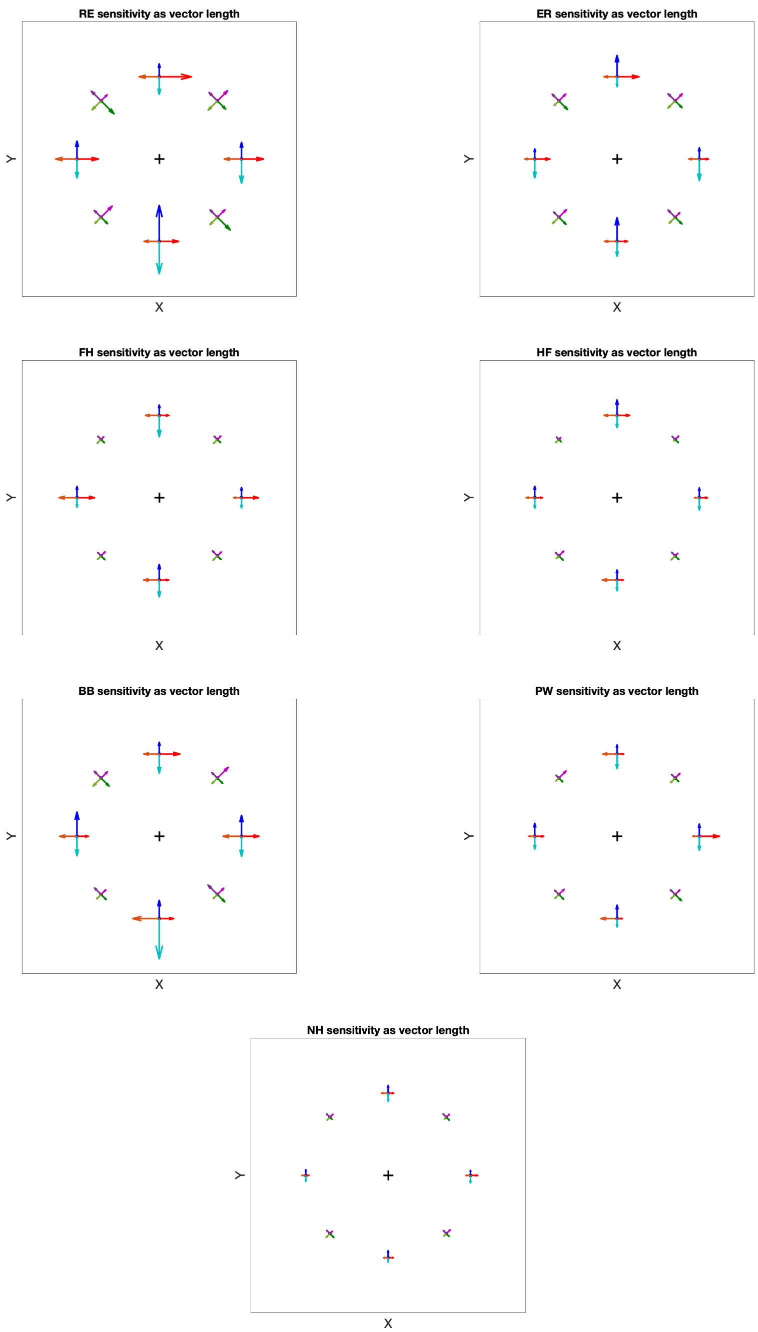


Figure 13: Vector direction corresponds to direction of drift; magnitude corresponds to sensitivity.

4 Subject Data (Across Datasets)

4.1 Sensitivity Polar Plots: Original vs Switched Condition

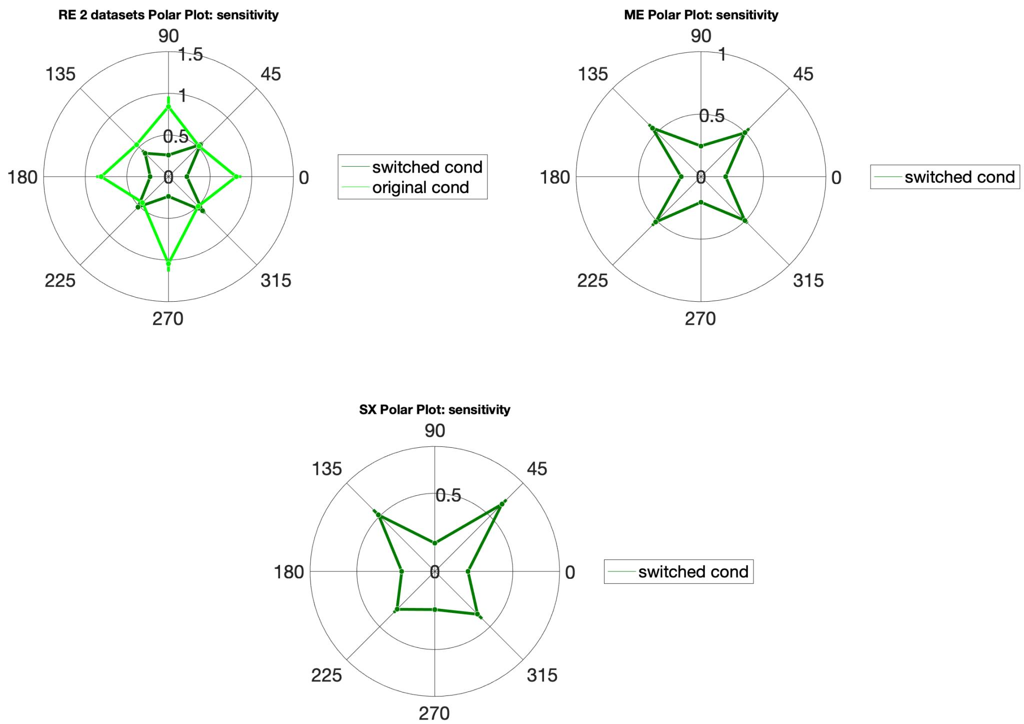


Figure 14: Comparison of two datasets (original vs switched condition) per subject. Each point represents data collapsed across 4 conditions.

4.2 Sensitivity Polar Plots: Cardinal vs Oblique Condition

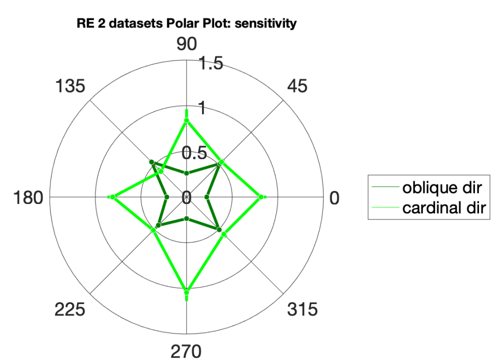


Figure 15: Same as above but plotted in terms of cardinality across datasets.

4.3 Sensitivity Vector Plots

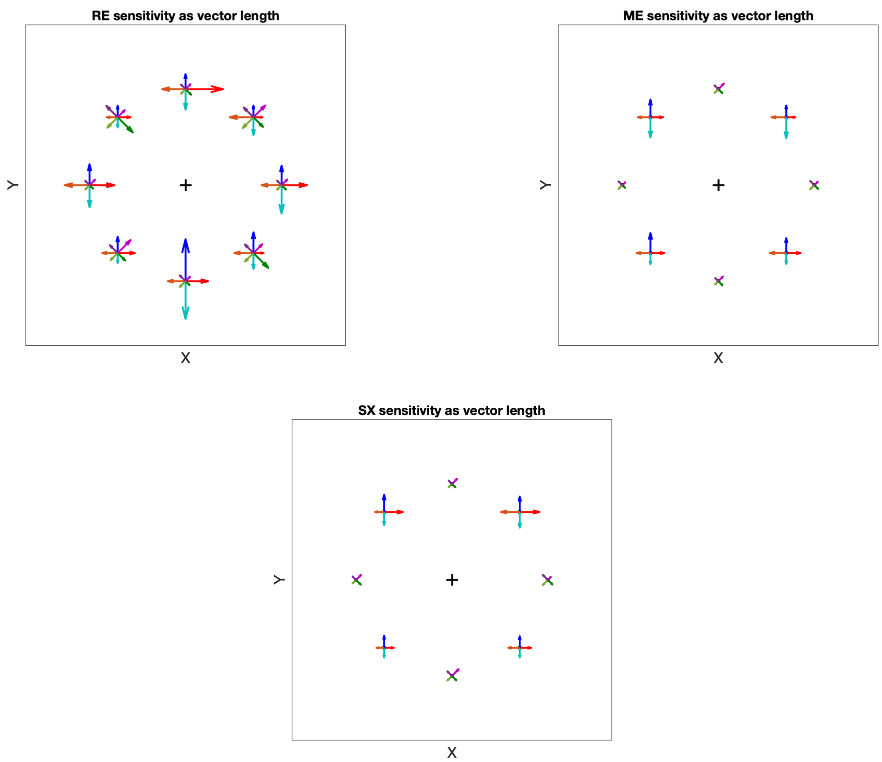


Figure 16: Same as above but plotted in terms of vector length.

5 Group Data (Relative motion)

5.1 Sensitivity Polar Plots: Relative Motion

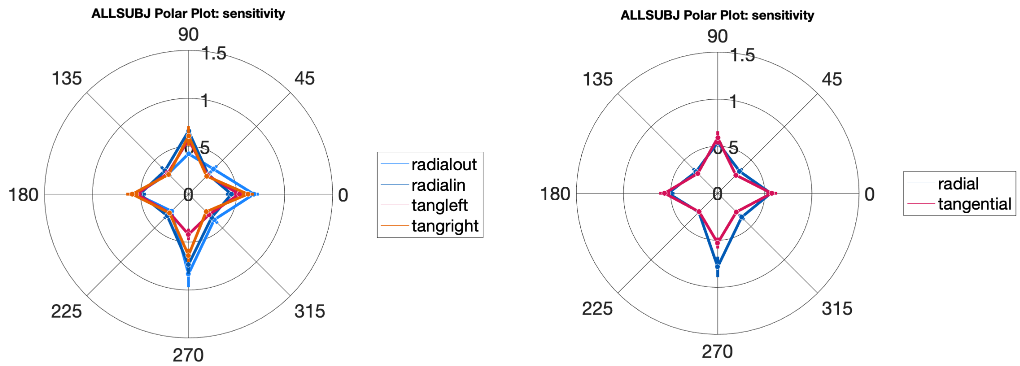


Figure 17: LEFT: 600 trials per point. RIGHT: Each point is 1200 trials. Error bars represent SEM across subjects.

5.2 Z-score Sensitivity Polar Plots: Relative Motion

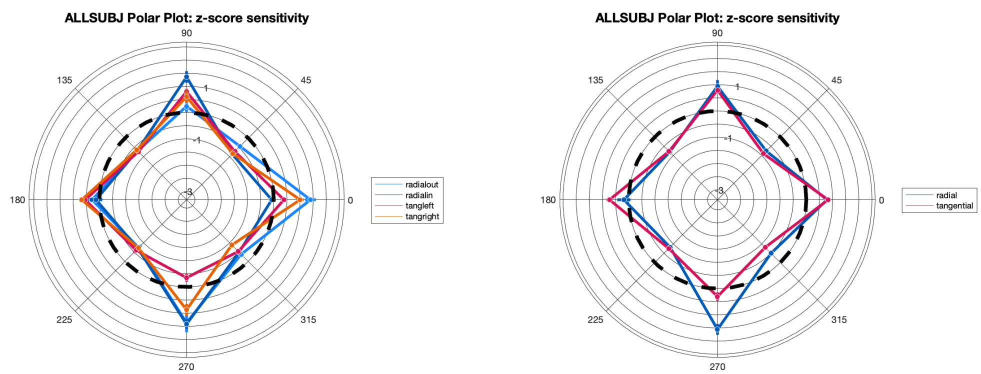
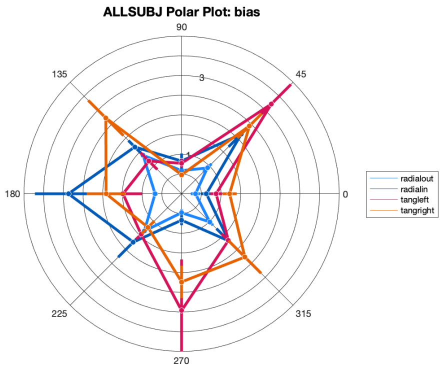
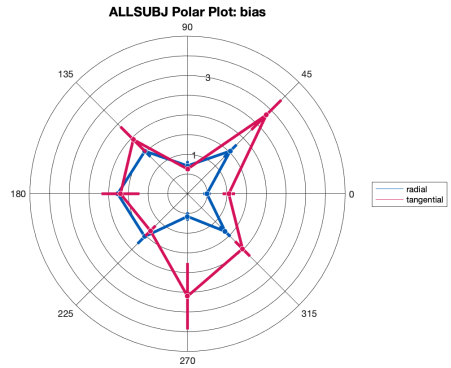


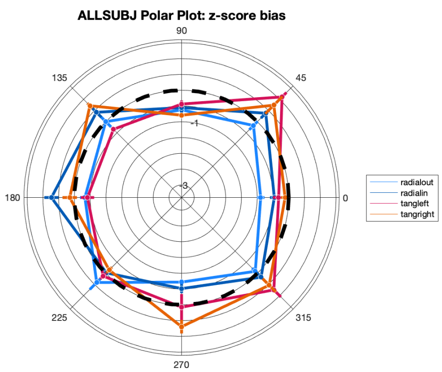
Figure 18: LEFT: 600 trials per point. RIGHT: Each point is 1200 trials. Error bars represent SEM across subject z-scores.

5.3 Bias (Abs) Polar Plots: Relative Motion





5.4 Z-score Bias Polar Plots: Relative Motion



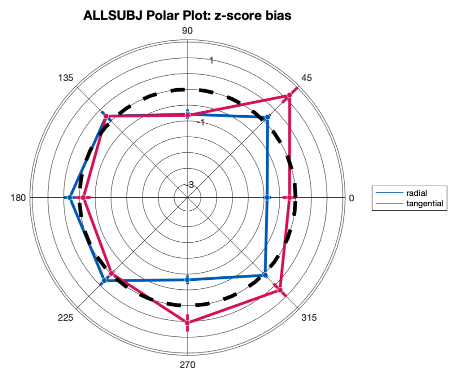


Figure 19: I think these aren't useful since the dashed line no longer indicates no bias (just mean).

6 Group Data (Absolute motion)

6.1 Sensitivity Polar Plots: Absolute Motion

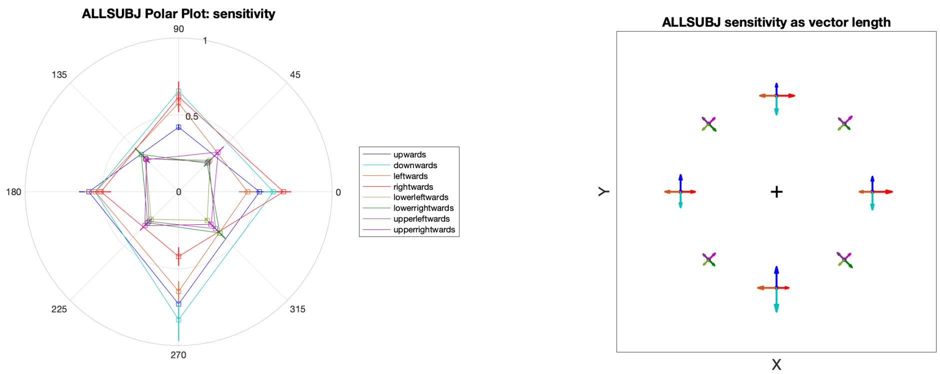


Figure 20: LEFT: Polar plots of average sensitivity, CIs represent SEM. RIGHT: Vector plots of average sensitivity.

6.2 Bias Polar Plots: Absolute Motion

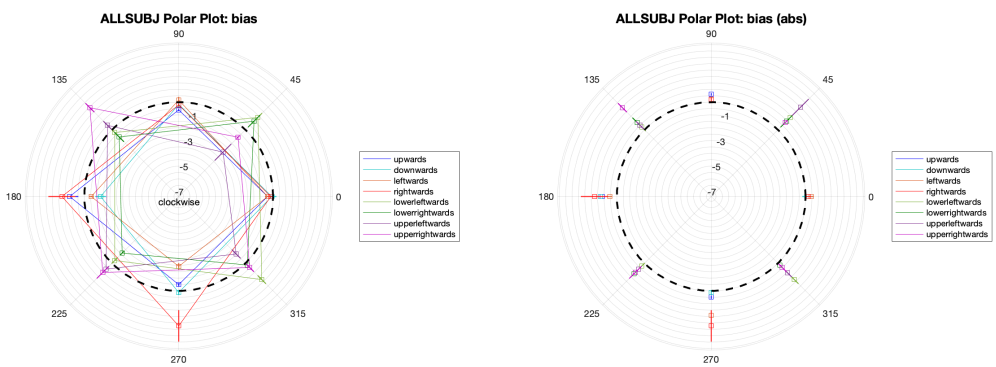
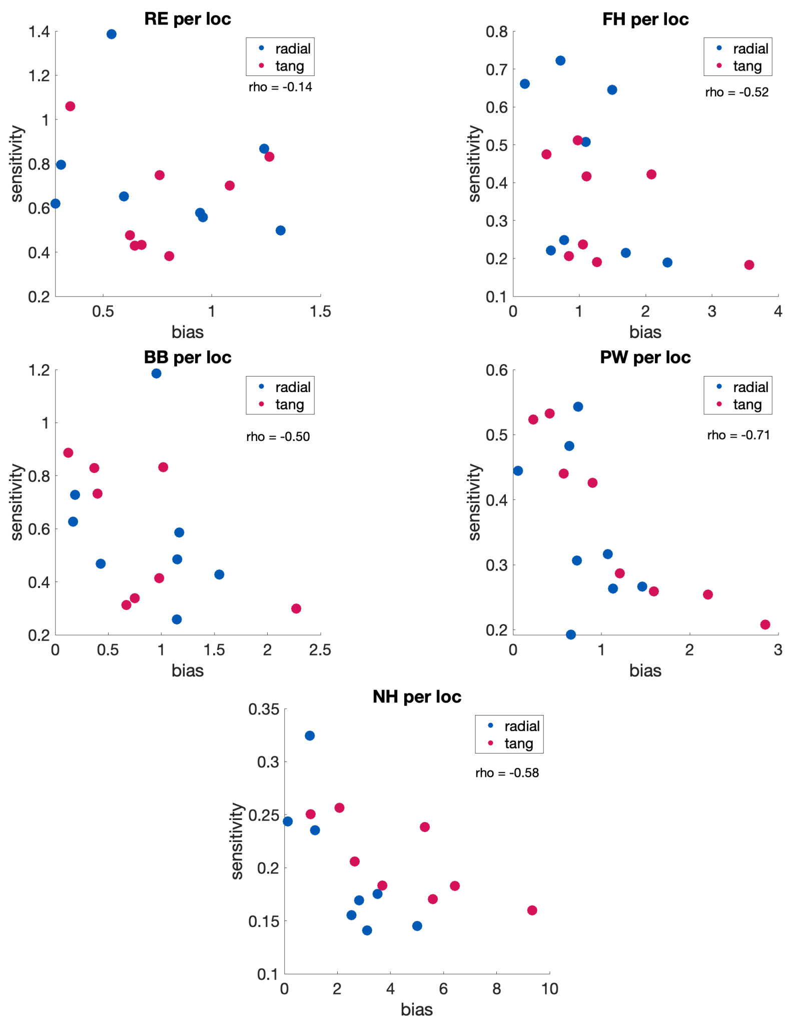


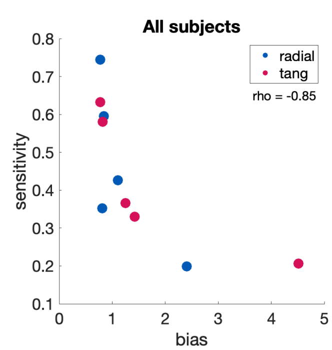
Figure 21: LEFT: Polar plots of bias. RIGHT: Polar plots of average abs(bias).

7 Bias vs Sensitivity

7.1 Individual Plots (each location)

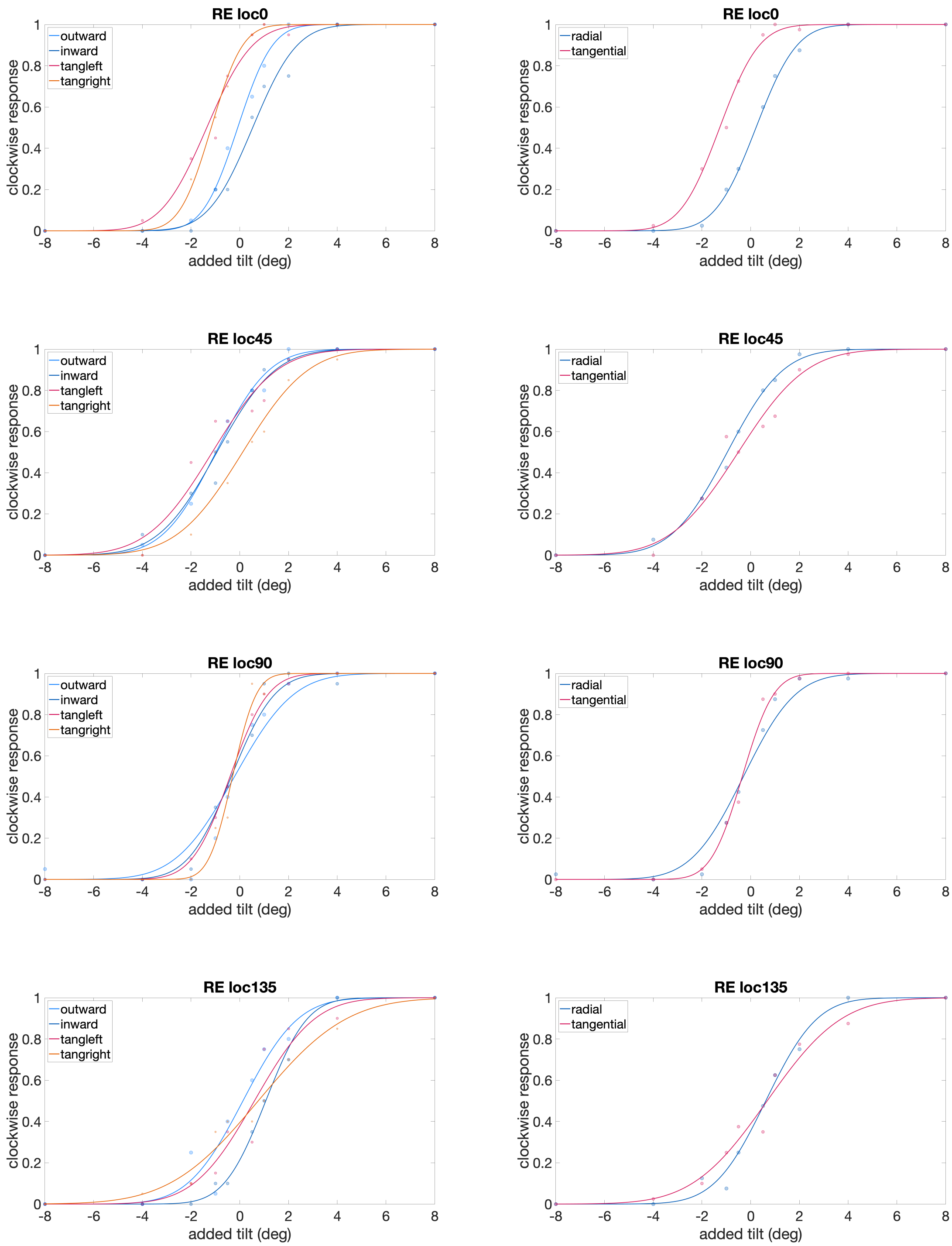


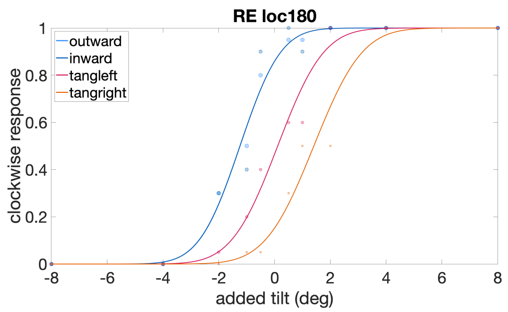
7.2 All subjects Plot (mean across locations)

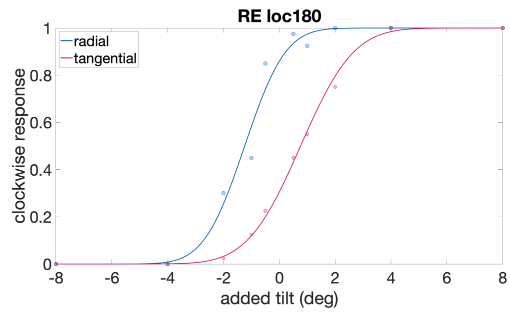


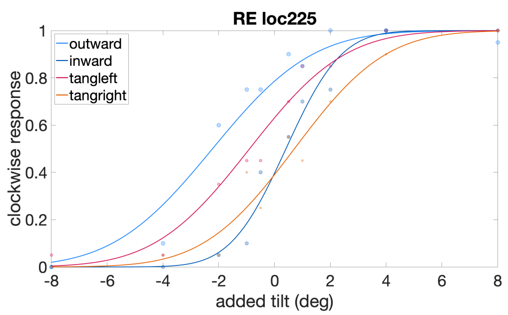
8 Supplementary Images: PFs per location

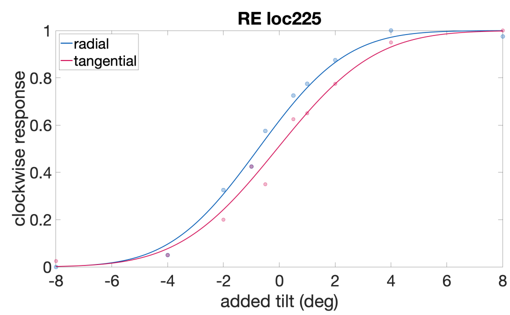
8.1 RE PFs Per Location

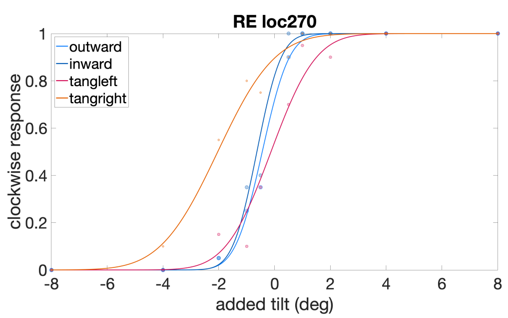


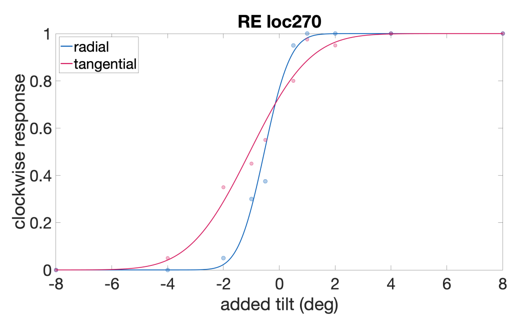

RE loc180
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

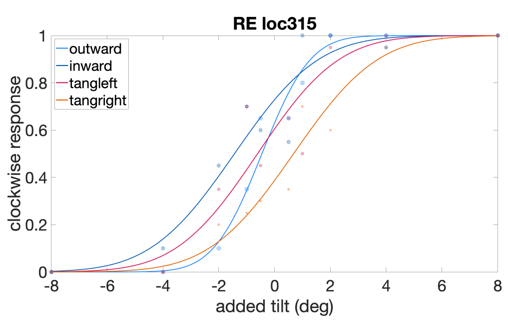

RE loc180
radial
tangential
clockwise response
added tilt (deg)

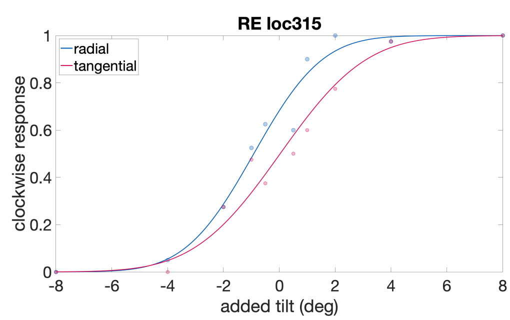

RE loc225
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)


RE loc225
radial
tangential
clockwise response
added tilt (deg)


RE loc270
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

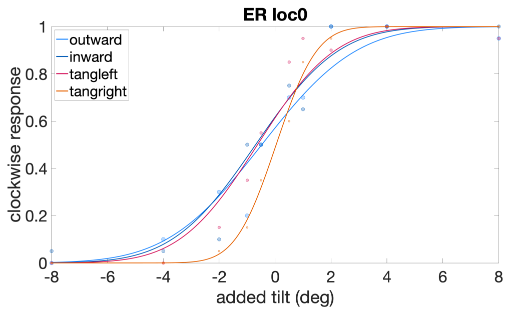

RE loc270
radial
tangential
clockwise response
added tilt (deg)

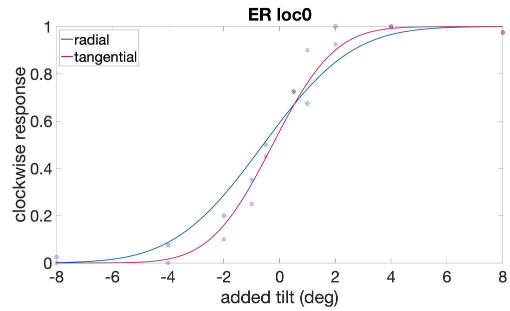

RE loc315
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

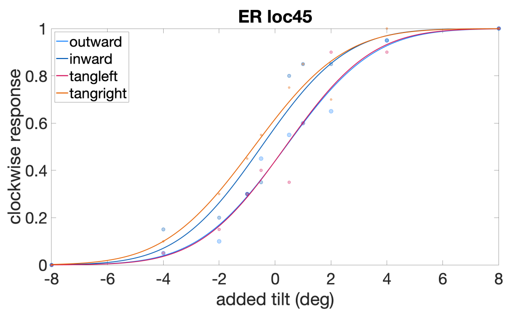

RE loc315
radial
tangential
clockwise response
added tilt (deg)

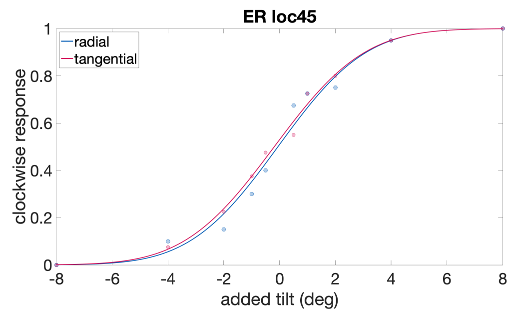
9 Supplementary Images: PFs per location

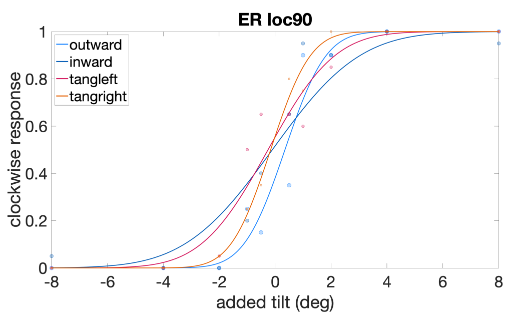
9.1 RE PFs Per Location (at half distance)

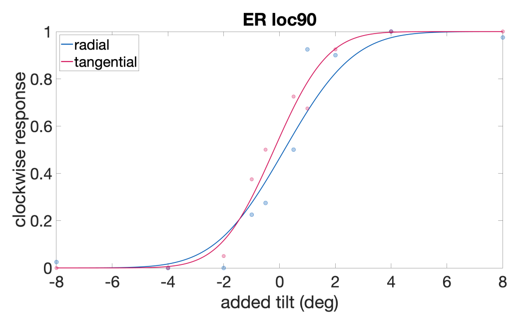


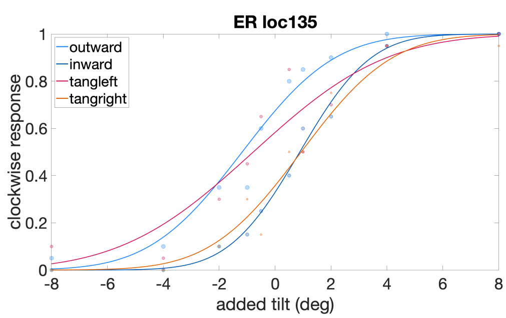


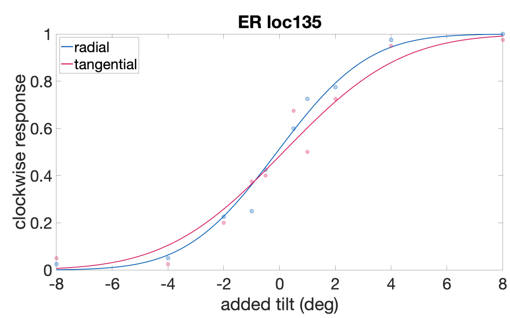


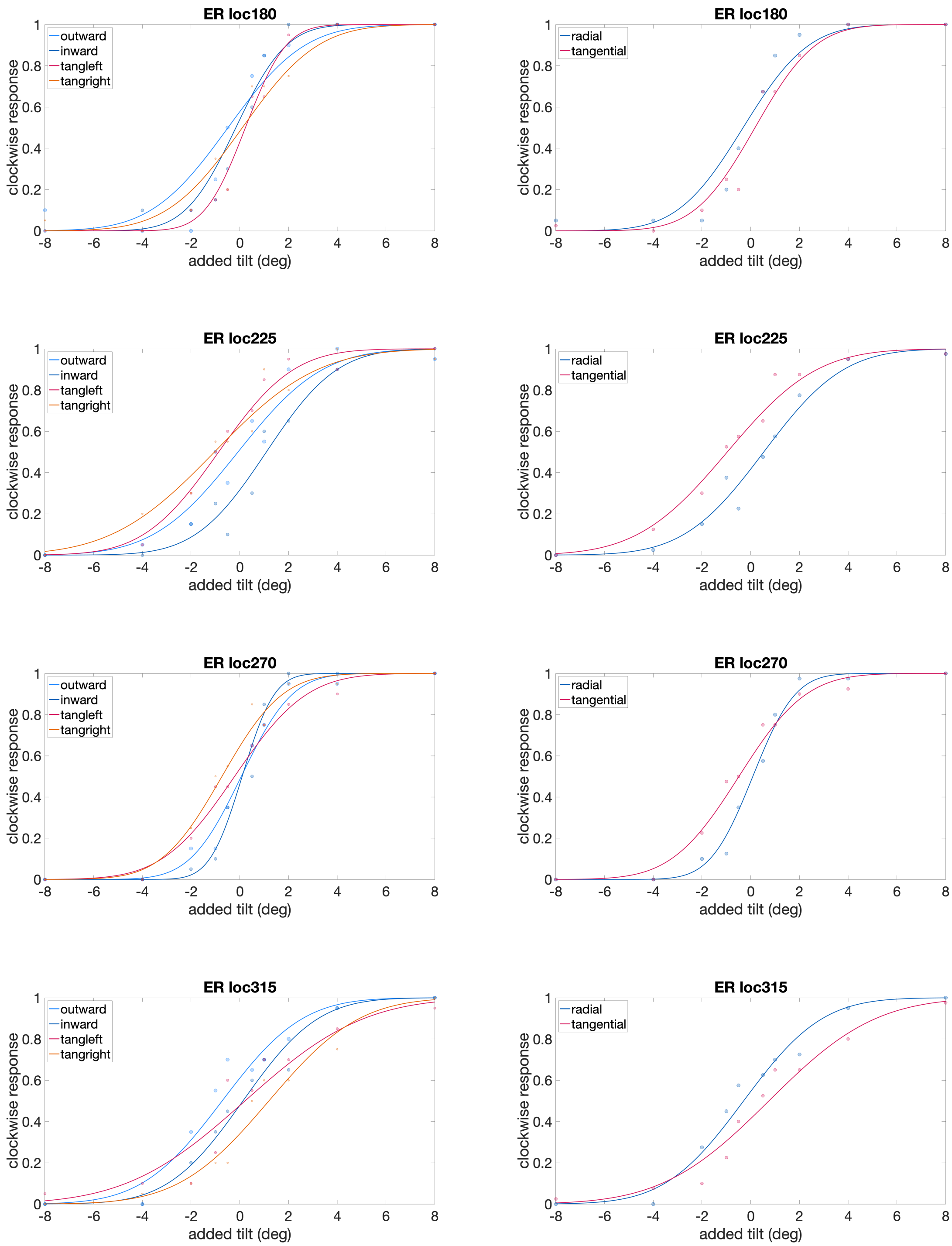




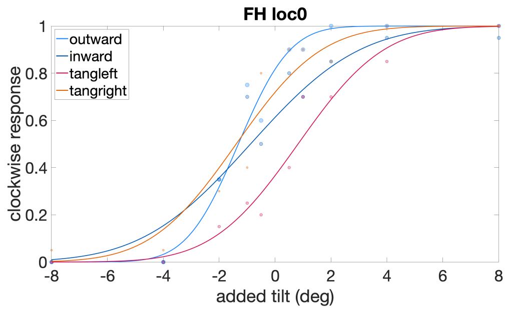


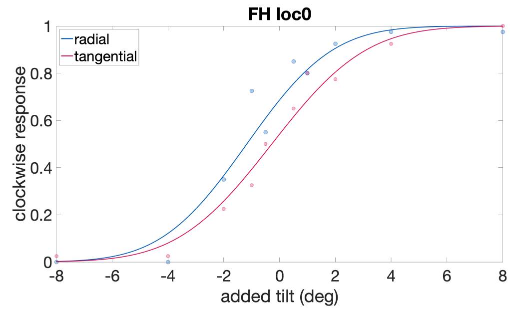


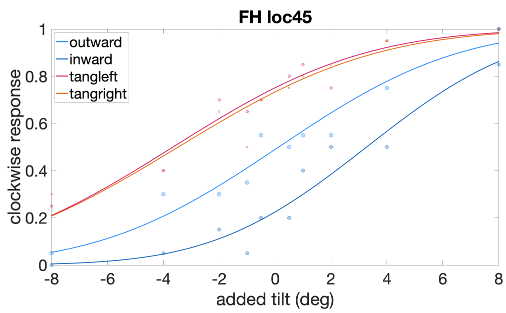


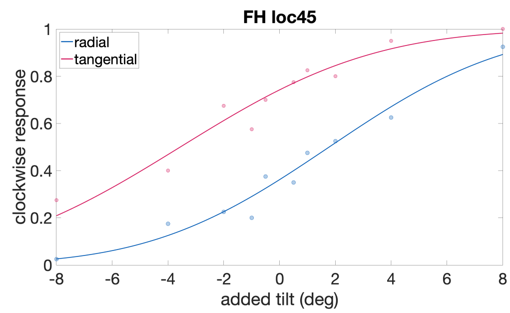

ER loc180
outward
inward
tangleft
tangright
radial
tangential
clockwise response
added tilt (deg)
ER loc225
ER loc270
ER loc315

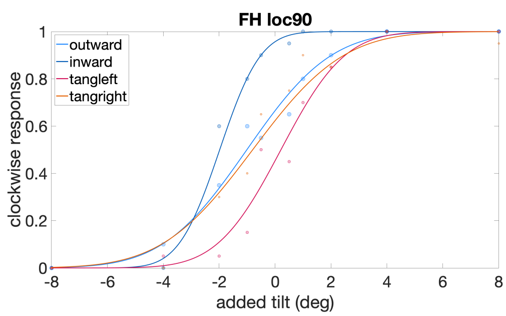
9.2 FH PFs Per Location

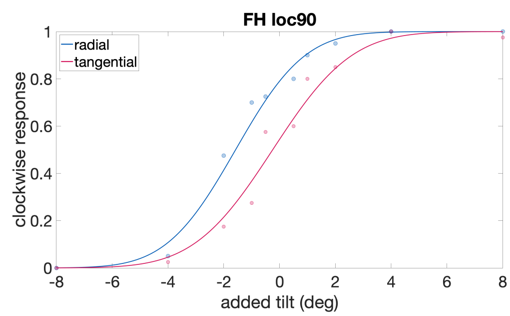


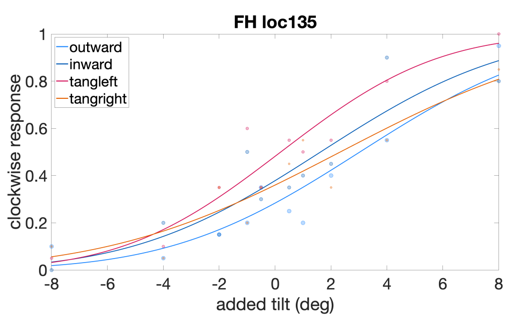


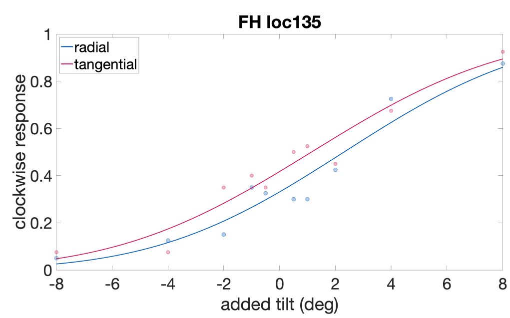


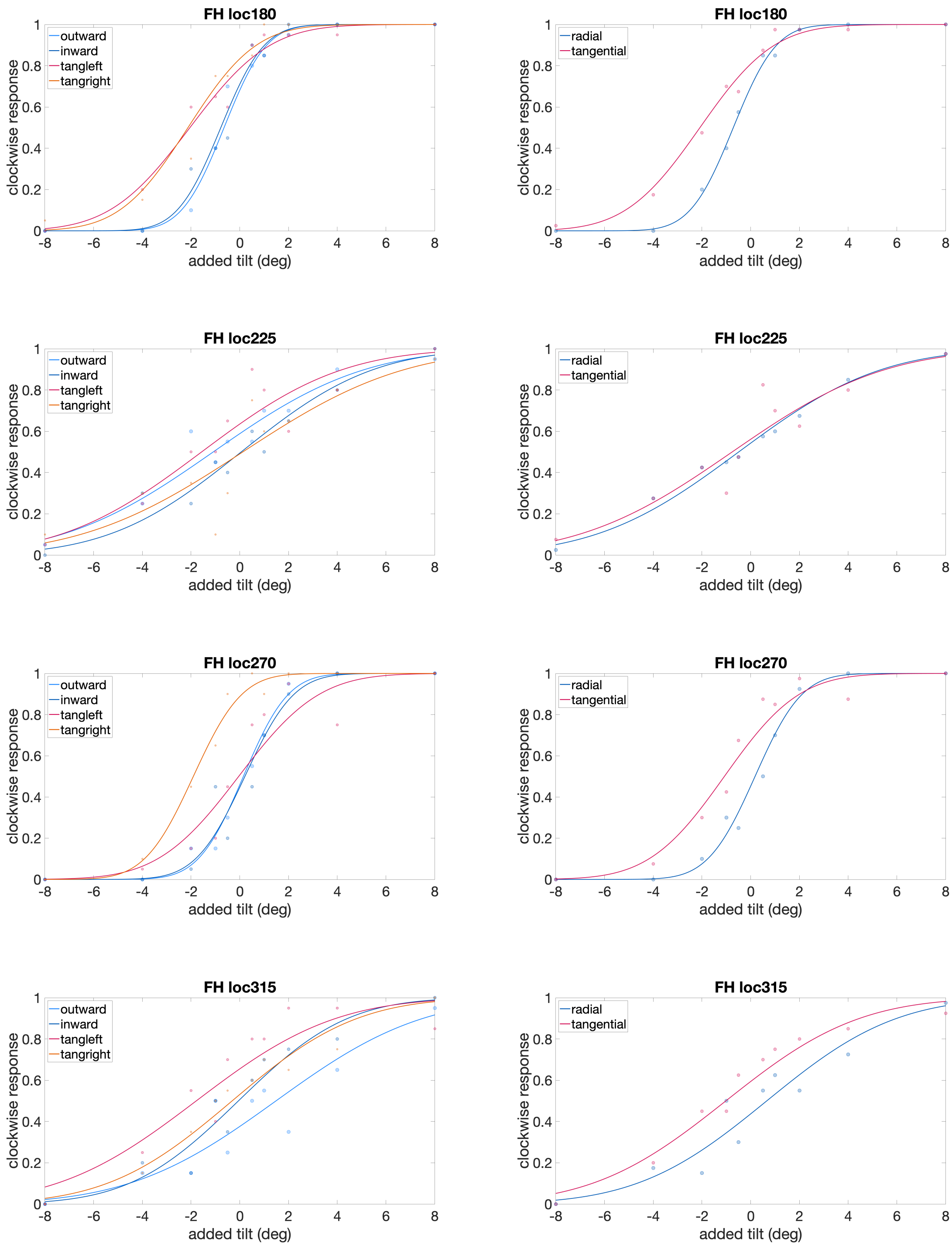




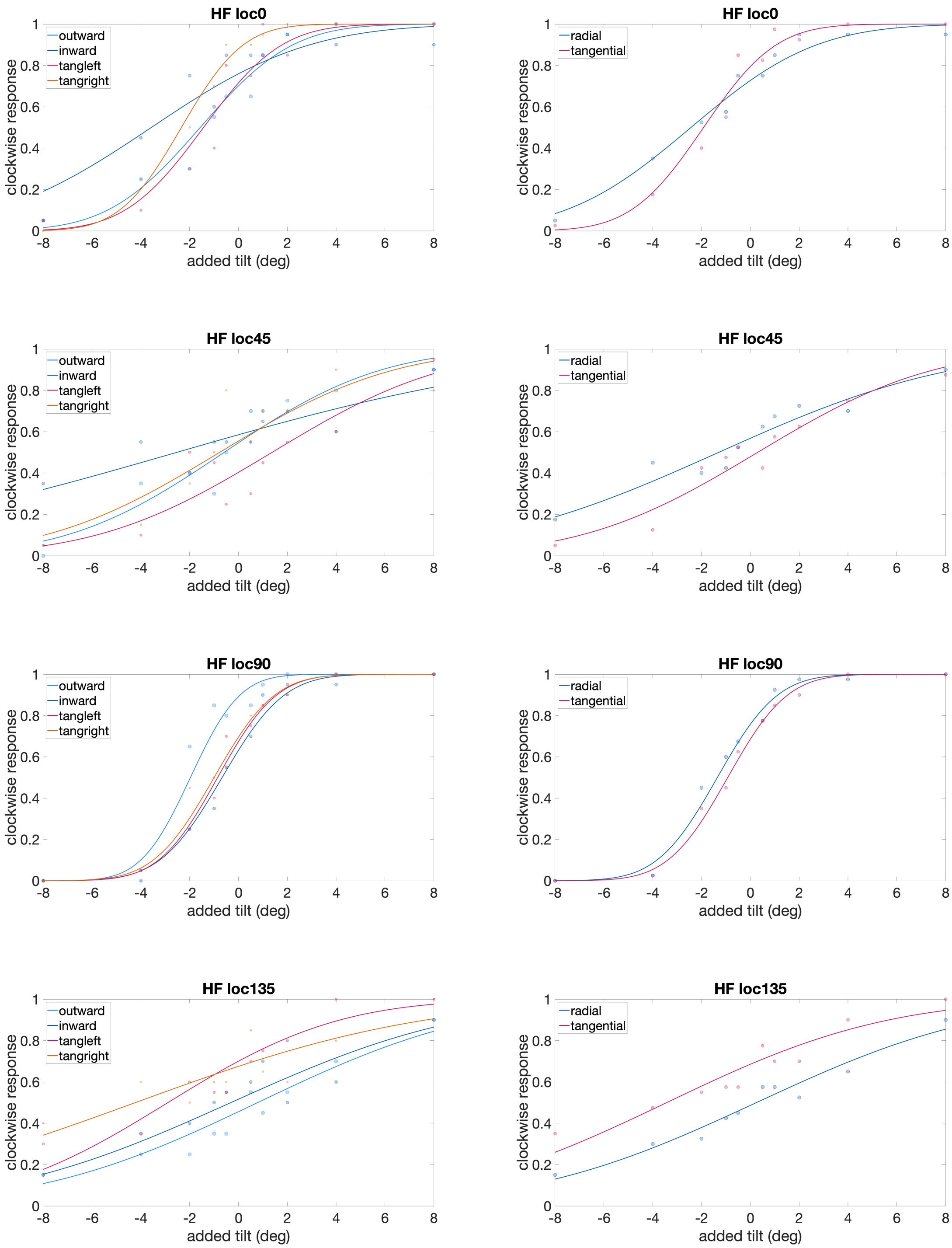


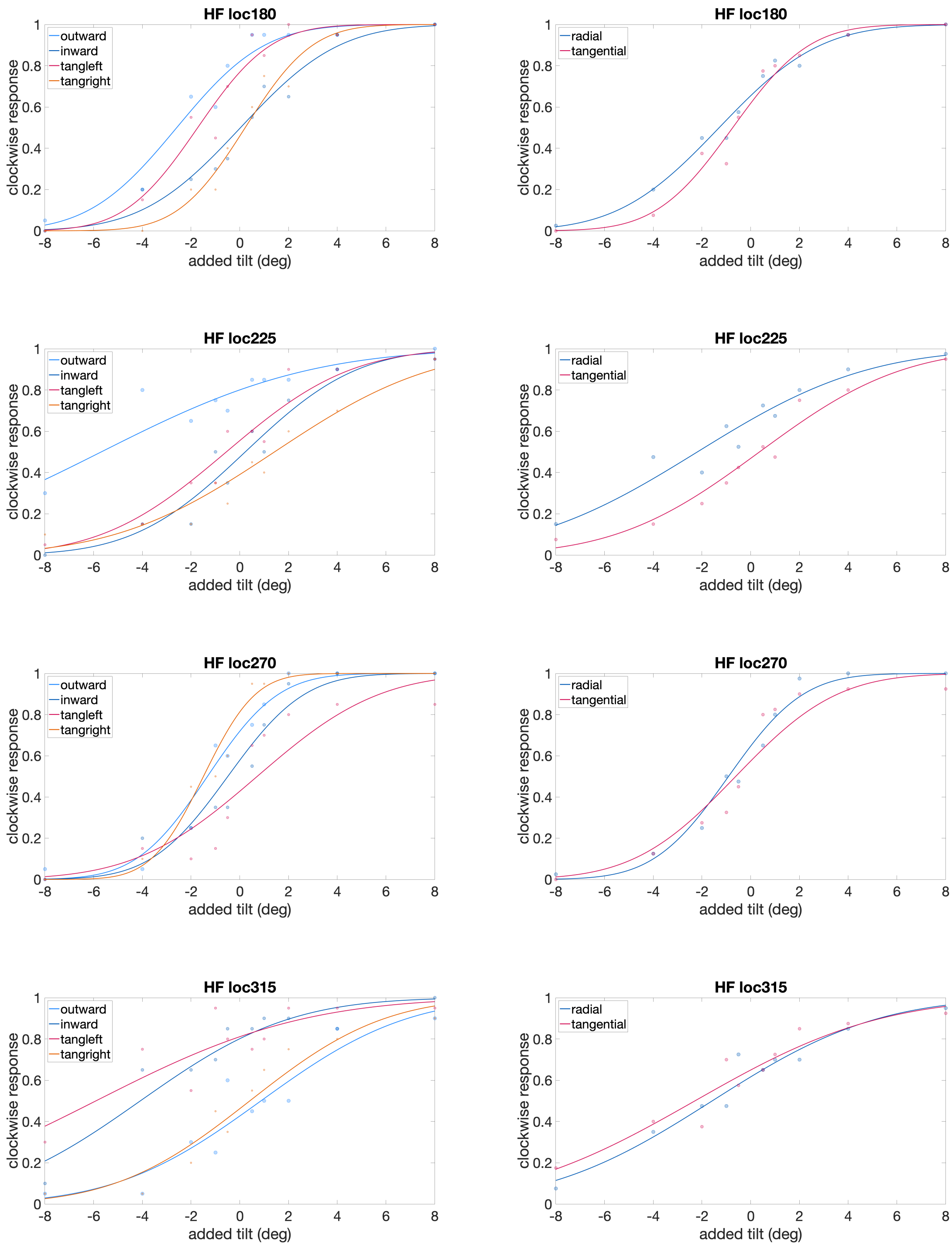




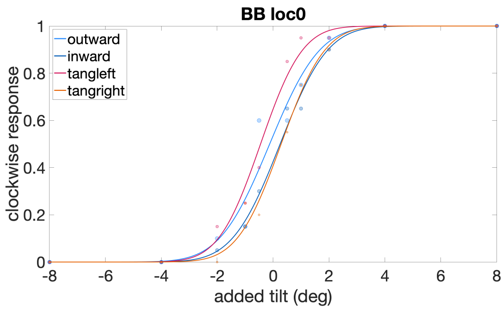

FH loc180
outward
inward
tangleft
tangright
radial
tangential
FH loc225
FH loc270
FH loc315
clockwise response
added tilt (deg)
0
0.2
0.4
0.6
0.8
1
-8
-6
-4
-2
0
2
4
6
8

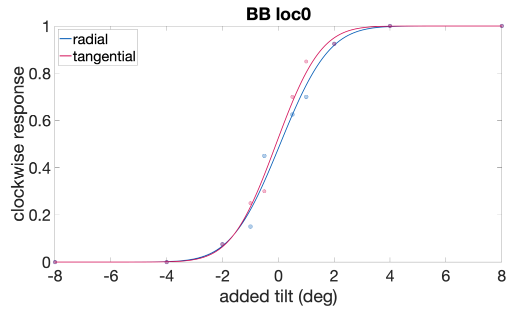
9.3 FH PFs Per Location (at half distance)

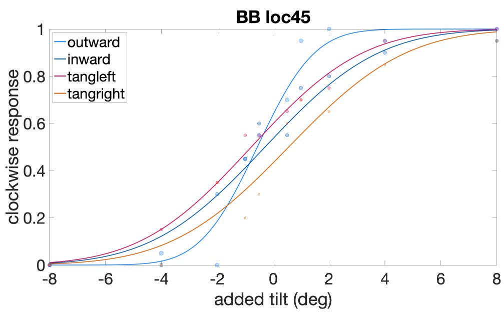


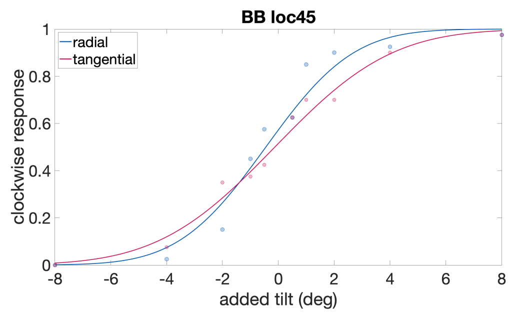

HF loc180
outward
inward
tangleft
tangright
radial
tangential
HF loc225
HF loc270
HF loc315
clockwise response
added tilt (deg)
-8 -6 -4 -2 0 2 4 6 8
0 0.2 0.4 0.6 0.8 1

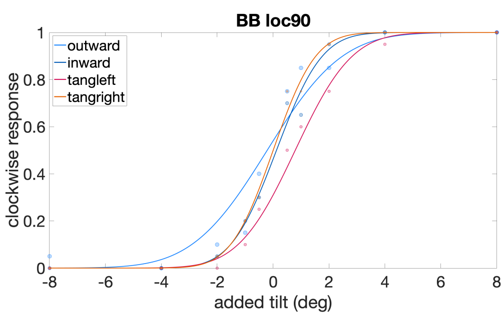
9.4 BB PFs Per Location

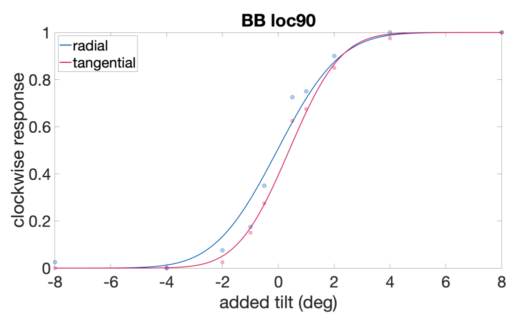


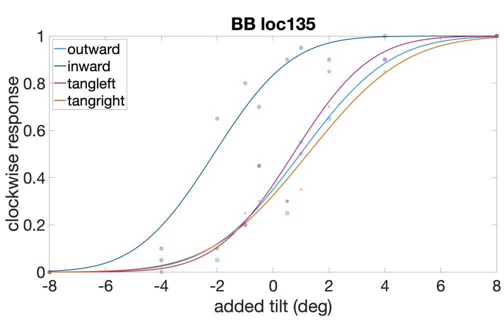


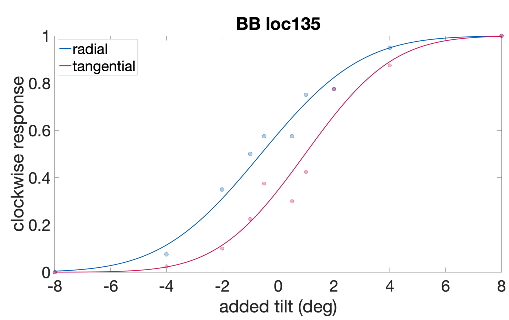


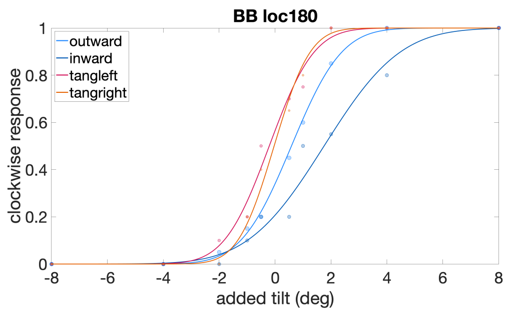


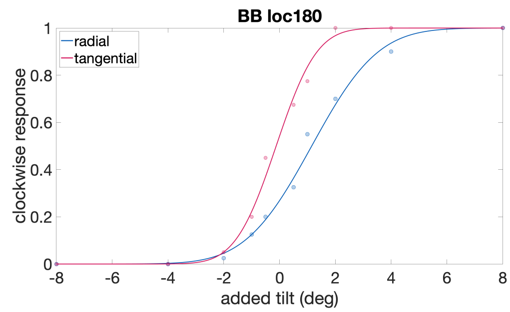


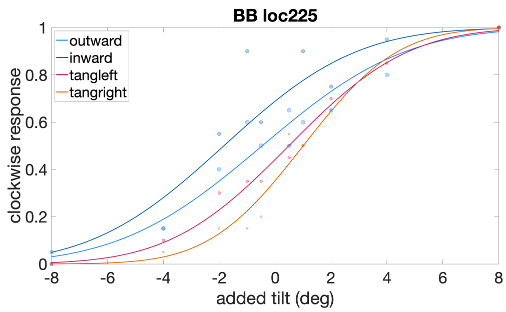


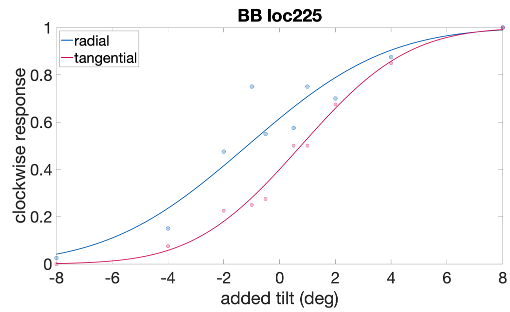


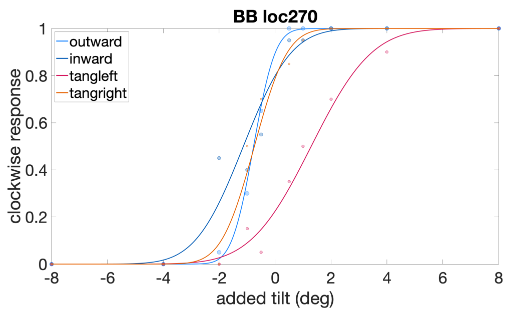


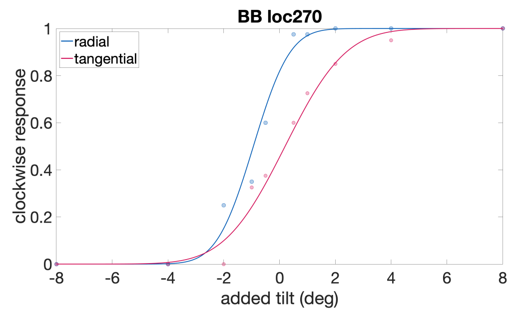

BB loc180
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

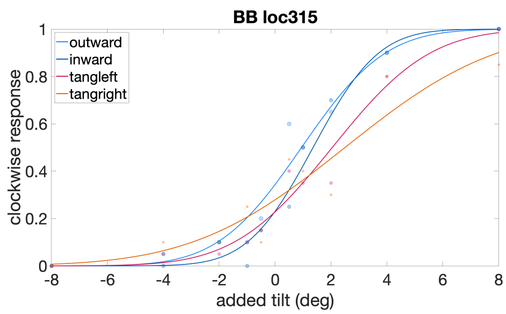

BB loc180
radial
tangential
clockwise response
added tilt (deg)

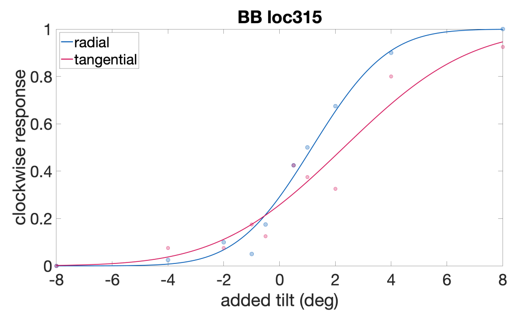

BB loc225
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)


BB loc225
radial
tangential
clockwise response
added tilt (deg)

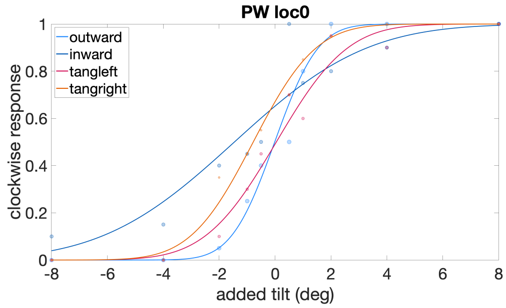

BB loc270
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

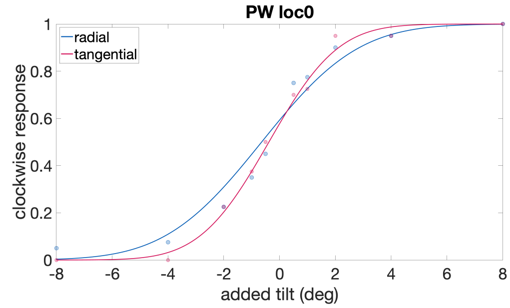

BB loc270
radial
tangential
clockwise response
added tilt (deg)

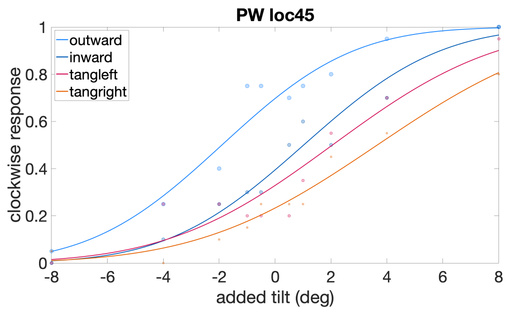

BB loc315
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

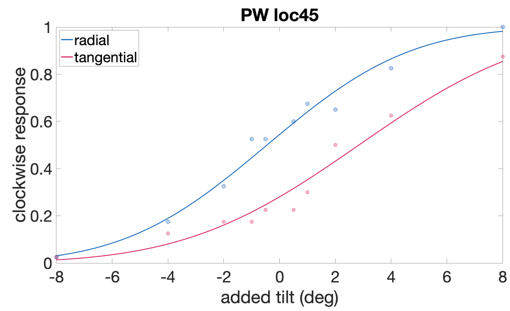

BB loc315
radial
tangential
clockwise response
added tilt (deg)

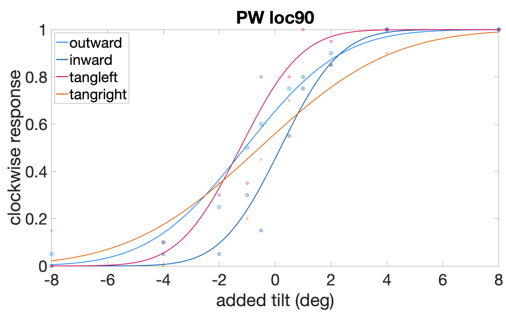
9.5 PW PFs Per Location

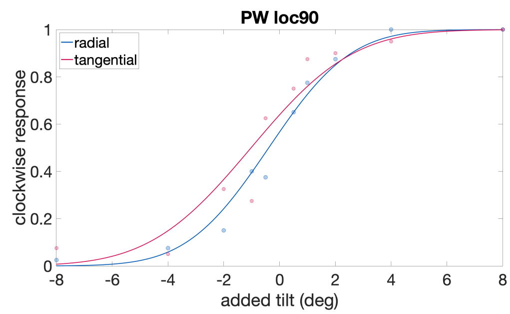


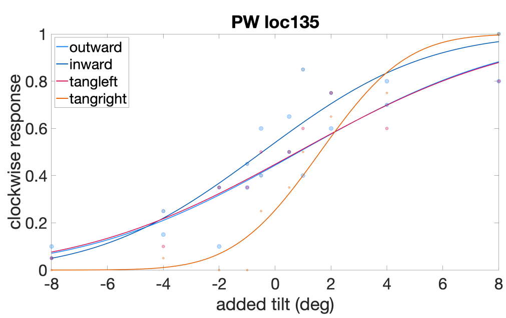


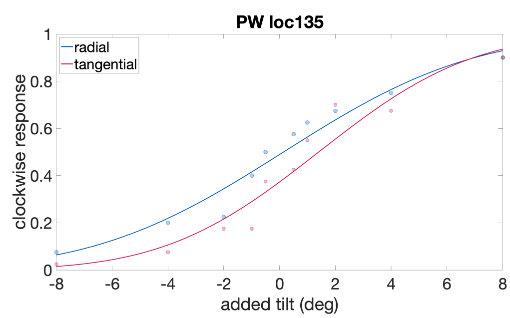


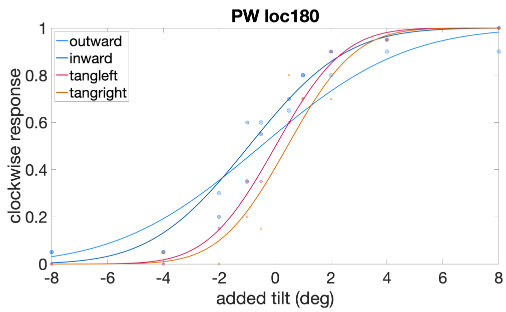


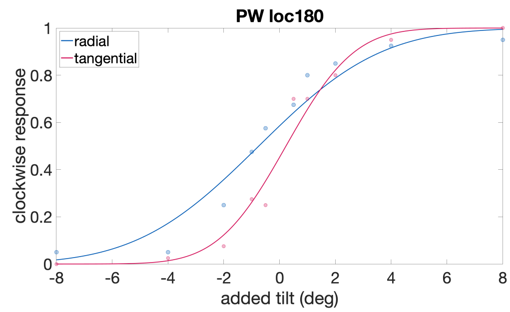


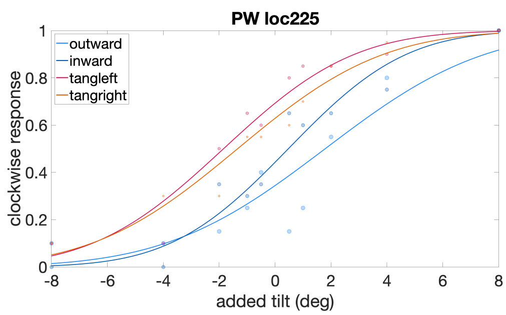


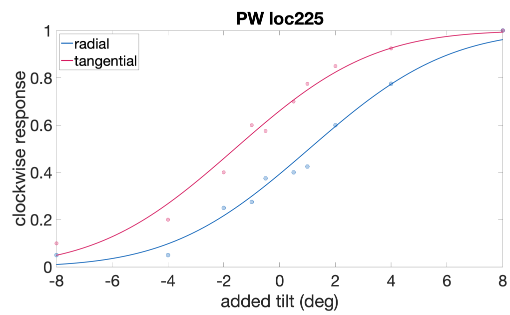


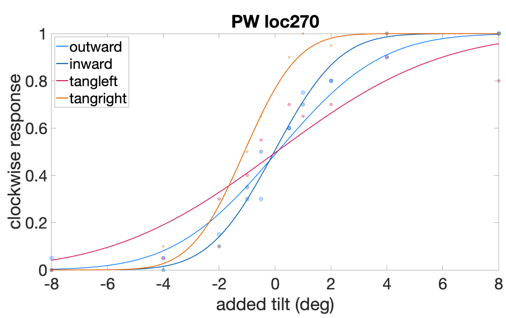


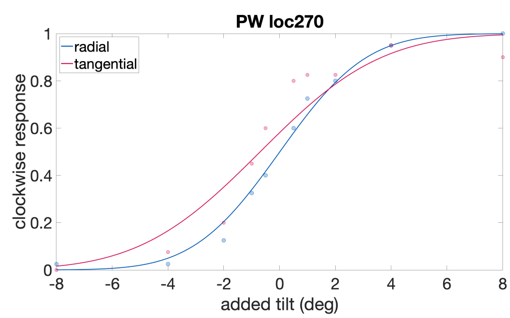

PW loc180
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

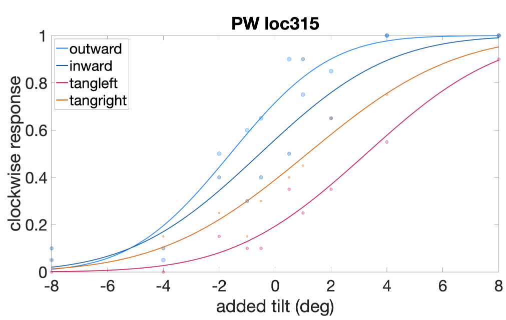

PW loc180
radial
tangential
clockwise response
added tilt (deg)

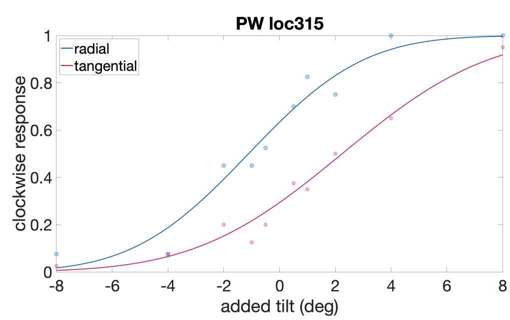

PW loc225
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)


PW loc225
radial
tangential
clockwise response
added tilt (deg)

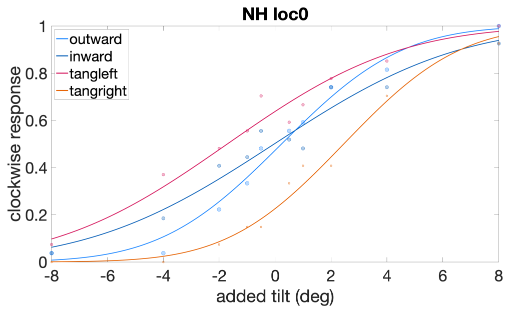

PW loc270
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

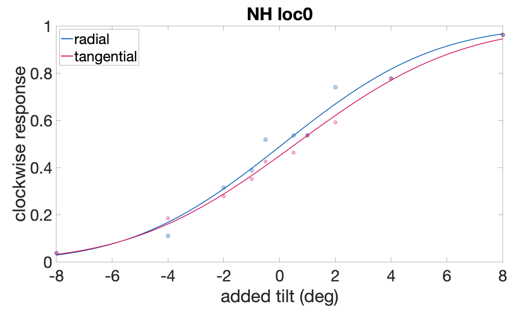

PW loc270
radial
tangential
clockwise response
added tilt (deg)

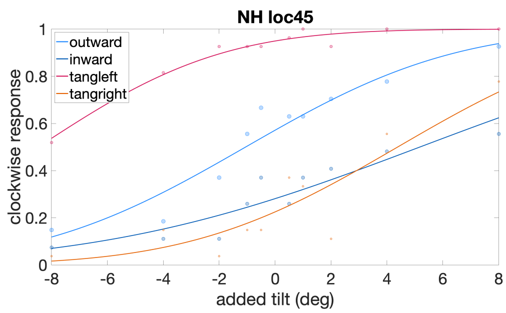

PW loc315
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)

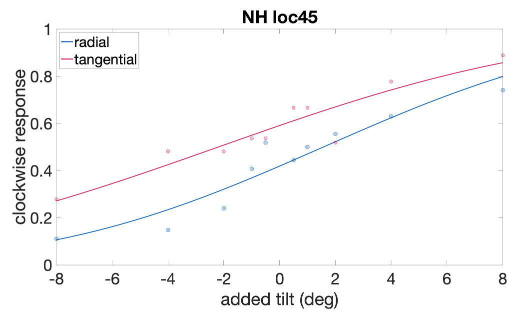

PW loc315
radial
tangential
clockwise response
added tilt (deg)

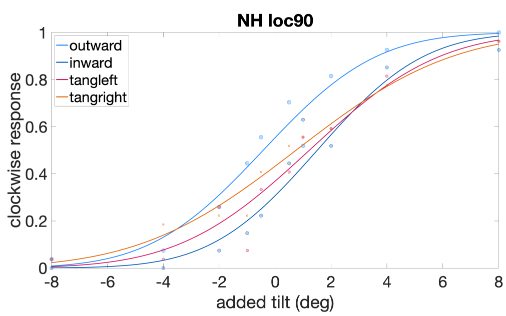
9.6 NH PFs Per Location

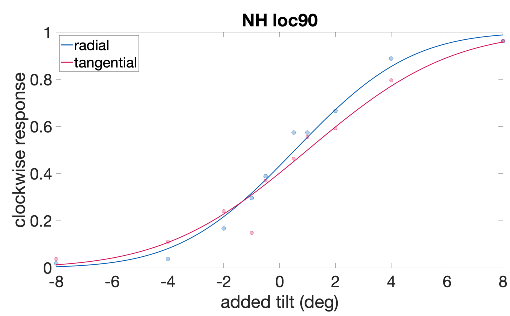


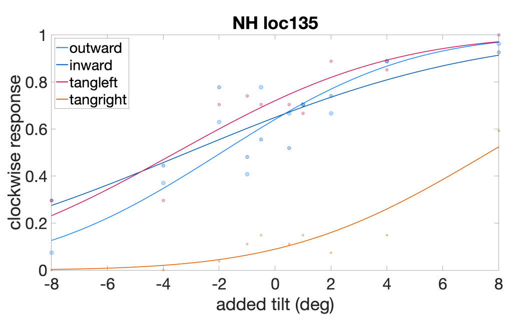


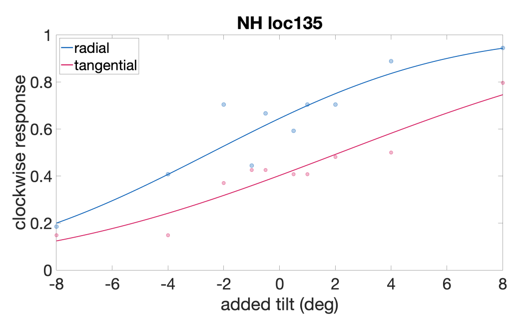


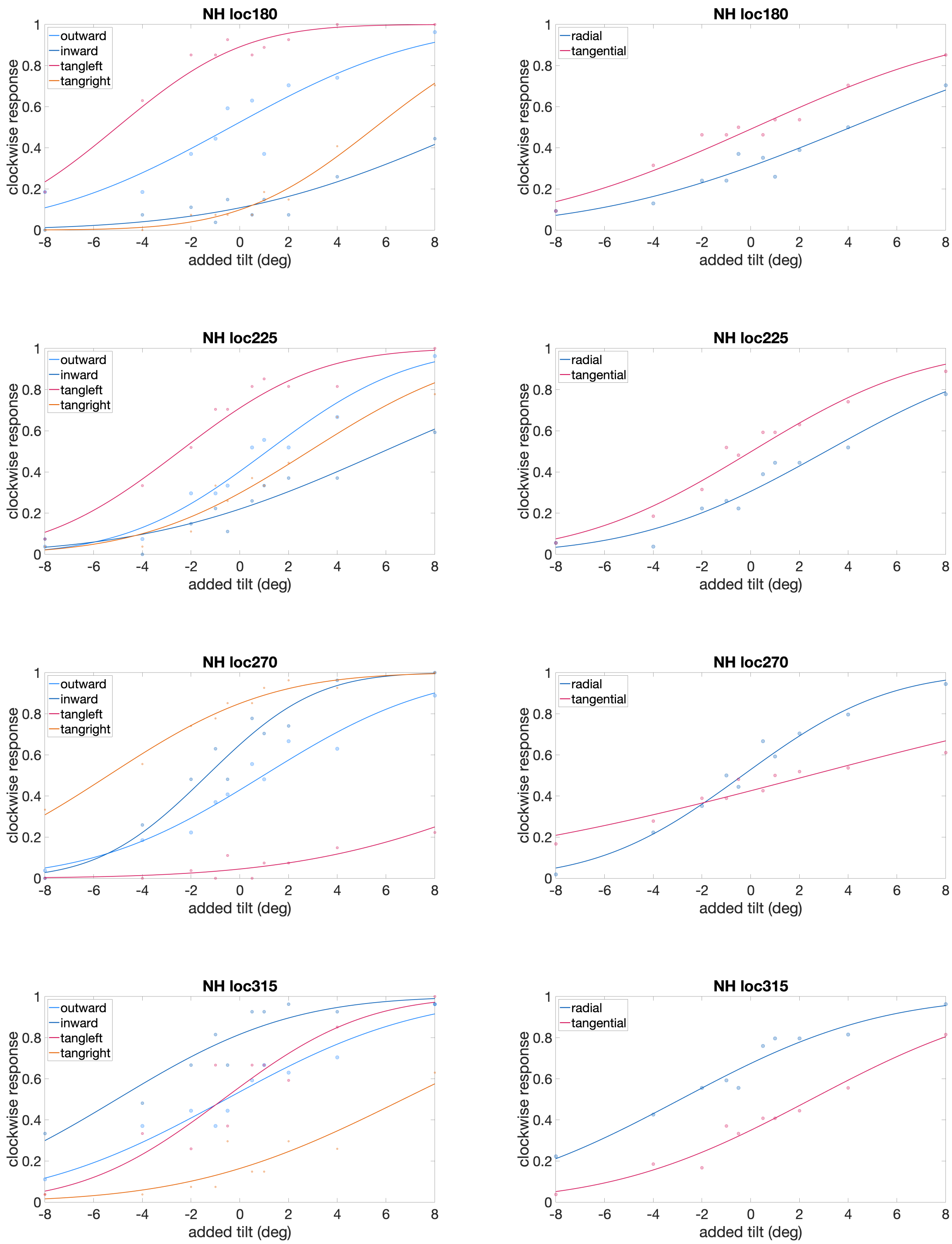











NH loc180
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)
NH loc180
radial
tangential
clockwise response
added tilt (deg)
NH loc225
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)
NH loc225
radial
tangential
clockwise response
added tilt (deg)
NH loc270
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)
NH loc270
radial
tangential
clockwise response
added tilt (deg)
NH loc315
outward
inward
tangleft
tangright
clockwise response
added tilt (deg)
NH loc315
radial
tangential
clockwise response
added tilt (deg)

10 Supplementary Images: Subject Cartesian Line Plots

10.1 Sensitivity Cartesian Line Plots: Relative Motion

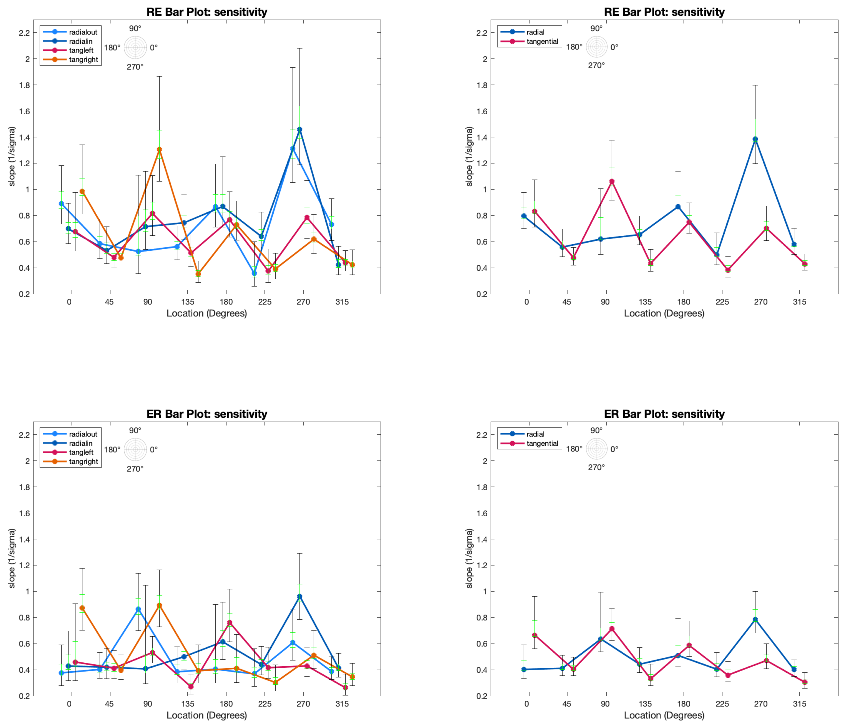
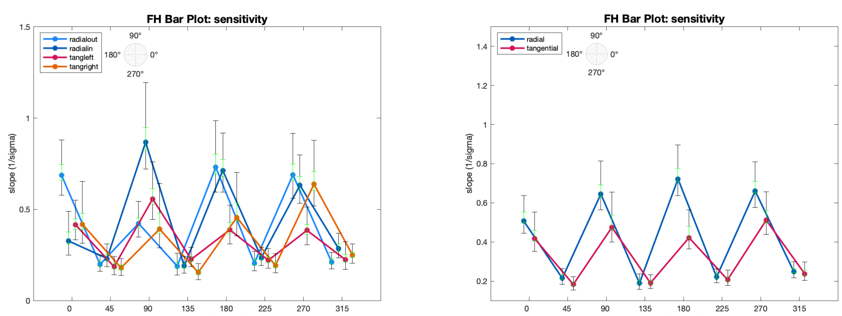


Figure 22: Same subject (RE) but at half distance.



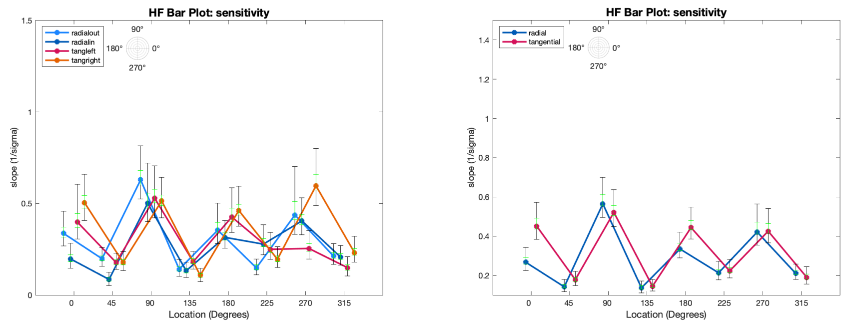


Figure 23: Same subject (FH) but at half distance.

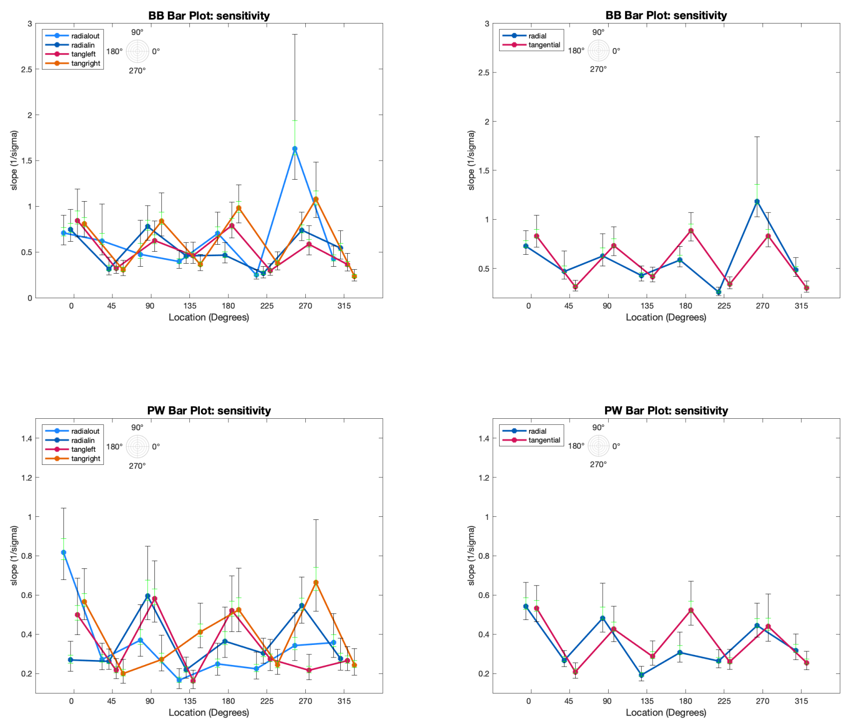


Figure 24: LEFT: 200 trials per point. RIGHT: 400 trials per point. 95% CI from 1000 bootstraps.

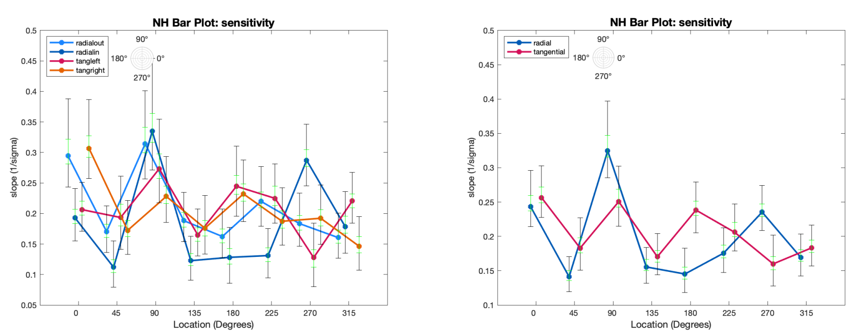


Figure 25: LEFT: 270 trials per point. RIGHT: 540 trials per point. 95% CI from 1000 bootstraps.

10.2 Bias Cartesian Line Plots: Relative Motion

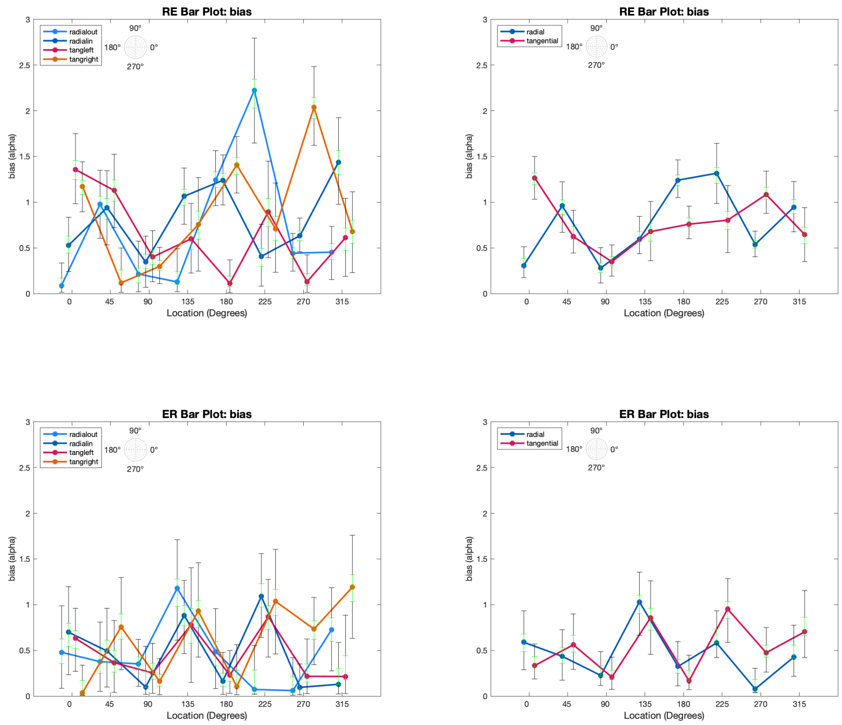
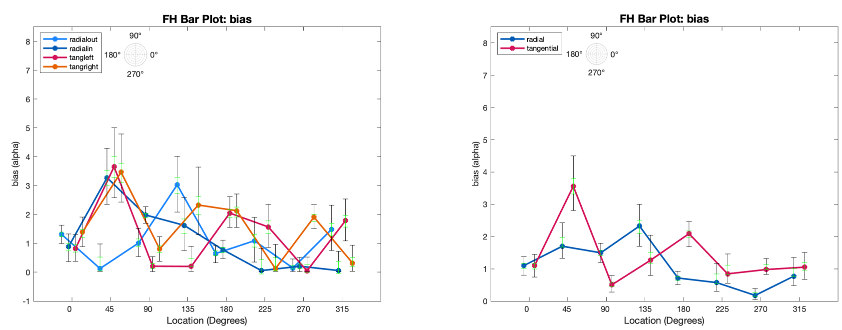


Figure 26: Same subject (RE) but at half distance.



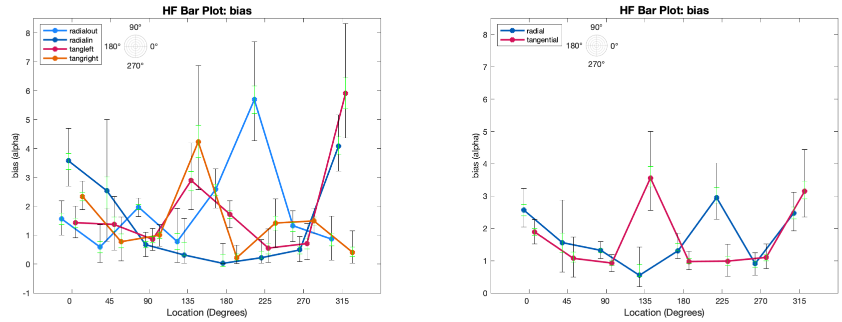


Figure 27: Same subject (FH) but at half distance.

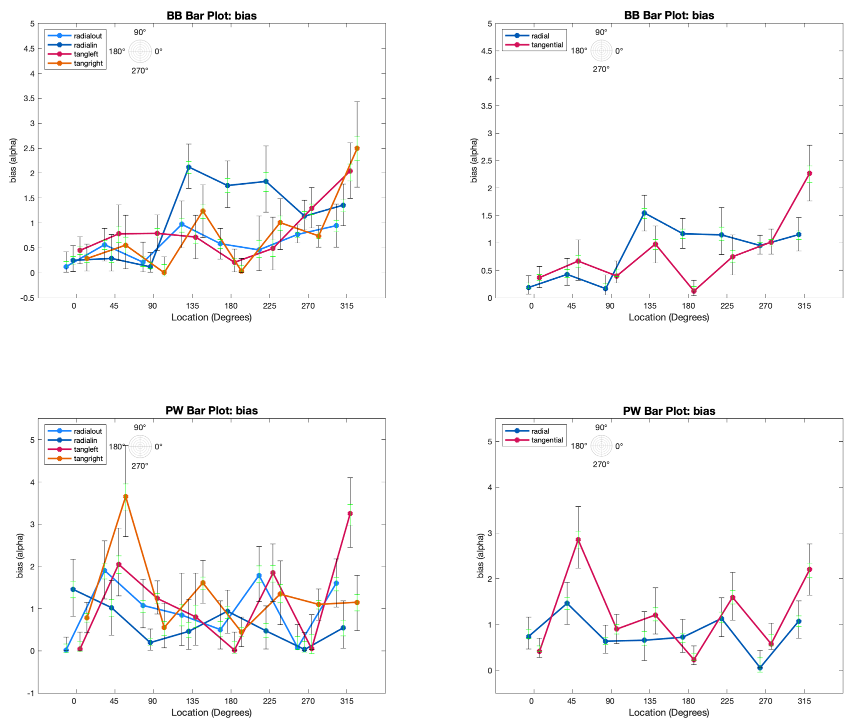


Figure 28: LEFT: 200 trials per point. RIGHT: 400 trials per point. 95% CI from 1000 bootstraps.

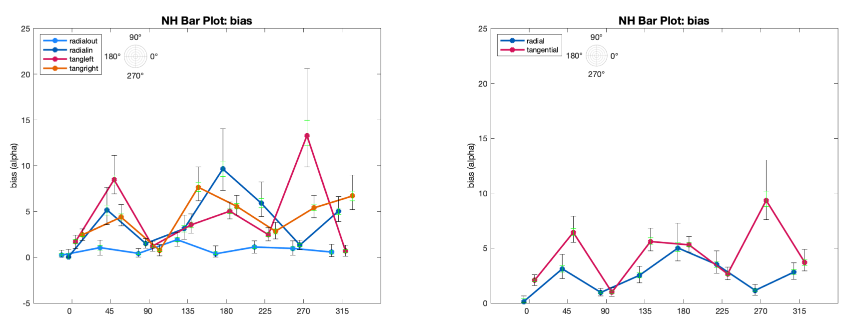
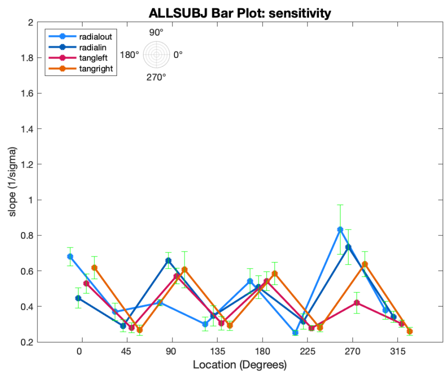
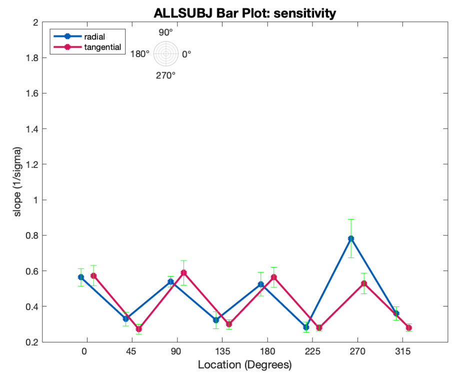


Figure 29: LEFT: 270 trials per point. RIGHT: 540 trials per point. 95% CI from 1000 bootstraps.

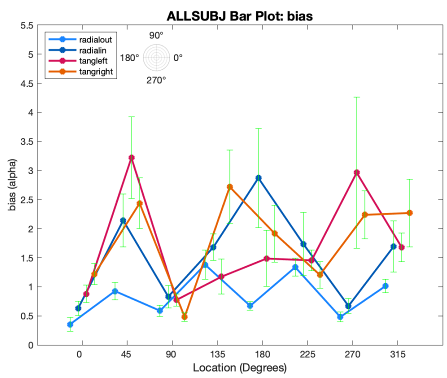
11 Supplementary Images: Group Cartesian Line Plots

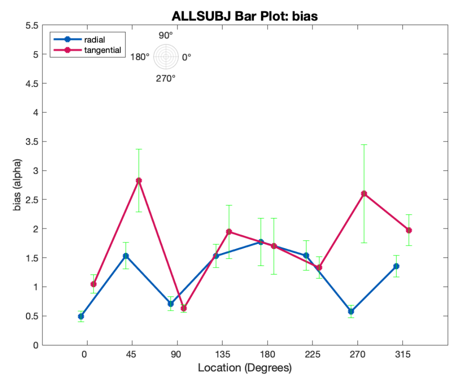
11.1 Sensitivity Cartesian Line Plots: Relative Motion





11.2 Bias Cartesian Line Plots: Relative Motion





12 Current Goals

1. Several papers demontrate that sensitivity to radial orientations is greater than tangential orientations; similarly, radial direction bias is reported for moving dot stimuli. But orientation and motion direction is always orthogonal with 1D drifting gratings. Is sensitivity greater for radial motion or radial orientations w/ 1D drifting gratings? If the radial sensitivity is greater in respect to motion direction, then the radial orientation effect is weaker than the radial motion effects (or visa versa).

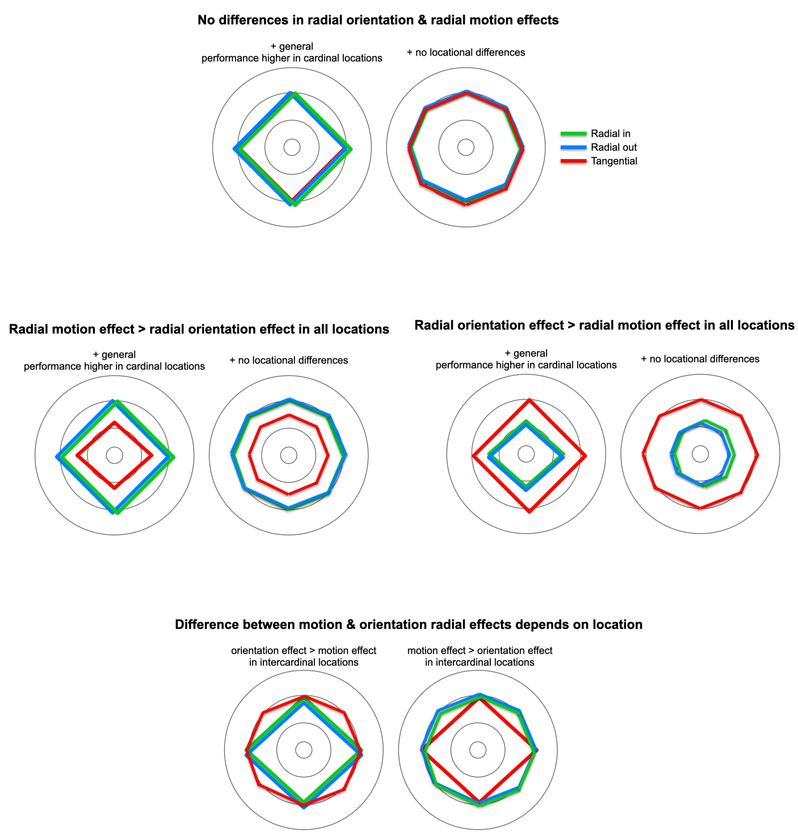
   - Interesting because the reported effects seem at odds, physiologically. Component neurons generally respond to motion that is orthogonal to their preferred orientation.
   - So far, data points to radial bias in respect to motion domain (conflict w/ Hong).

2. Is sensitivity generally greater in cardinal locations compared to non-cardinal locations?

   - Note: if sensitivity is higher in cardinal locations, this could be due to the location or due to the feature of the stimulus (cardinality in orientation/motion).

3. Is the difference in radial and tangential sensitivity more pronounced in non-cardinal locations compared to cardinal locations?

   - Note: Cardinal bias might enhance sensitivity disproportionately for orientation, which minimizes radial bias differences on the cardinal axes.



13 Incorporating fMRI

13.1 Goals

- Better understand the topography of MT; Compare cortical surface area dedicated to upper vs. lower vertical meridian (and visual field generally)
- Compare BOLD magnitude for different motion directions (radial vs. tangential) in lower vertical meridian separately in V1, MT, and MST;
- Within MT, MST, V1, which motion directions (inward, outward, tangential) have the highest decoding accuracy?

13.2 Runs needed

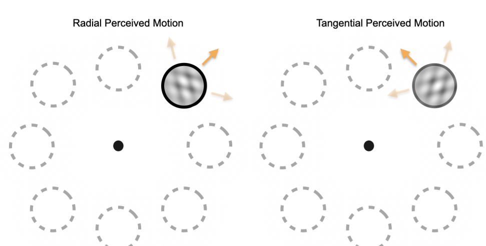
1. MT+ functional localizer (moving vs. static stimuli); static
2. Way to map retinotopy of MT, MST, and V1 (Huk et al., 2002 and Amano et al., 2009)

13.3 Inverted Encoding Model

- Can we predict what stimulus was shown – radial vs. tangential?
  - Use stimulus to map channel responses for each motion direction, and use as weights to reconstruct signal
  - First create encoding model by using basis functions for each motion direction
  - Then, for each ROI voxel, for each trial, calculate channel weights for each basis function ("forward model")
  - Fit to testing data on different trials/runs to reconstruct population-level stimulus representation
  - We would expect better decoding for radial motion directions in lower vertical meridian

14 Extending to Plaid Stimuli

1. How does this extend to plaid stimuli? Does the bias apply to the component motion direction or the perceived motion direction?



120 deg angle between component gratings
Comparing these 2 conditions controls for radial orientation bias and extends findings to 2D motion

15 Supplemental Questions

1. Is there an HVA or VMA present for any/all of the conditions? (SF in design matters in this case)

2. Is there a difference in sensitivity to radial-inward vs. radial-outwards motion?

   - So far, there doesn't seem to be a difference at 7 deg eccentricity.

3. Maybe abandon question about how these biases change w/ eccentricity.

16 Updates

- Design Related
  - Fixed code for running multiple experimental conditions (update code in exp room)
- Analysis Related
  - Made all same-subject plots same axes
  - Updated bias calculations throughout report
  - Talked to Mike: why bias apparent given feedback? Repulsion from prior possible. Fix for NH is ok.
  - Mike: also, why not testing HVA, VMA?
  - Additional 1/3 data for NH, added to all plots.
  - Added 1 more subject at half-viewing distance (BB)
  - Added 1 more subject at switch (ME), and will also run on original
- Other improvements
  - Corrected absvalue bias plots, and now using 68 CIs
  - Fixed axes for same subject data
  - Grant copy of materials from BB and Erica Shultz (aim 1- first project, aim 2- fmri, aim 3- computational model)
- For discussion
  - Is bias higher for off-cardinal locations? Seems to be lower at LVM and radial in general. Look into Albright 1989
  - Reasoning for LVF radial bias? (Edwards/Badcok 1993, Von Helmholtz 1909/1962)
  - fMRI design
  - Plaid design
  - Reference repulsion/attraction
  - Results Section for paper
  - Eye tracker in RM 956
    - Afp server not compatible with PC? – currently backing up data on my GDrive
    - CRT monitor calibration.

17 To Do

- Feedback for Analysis
  - Plot bias vs sensitivity in a scatter plot (Each subject is a dot for mean across locations – radial vs tang); and all dots w/o mean on one graph
  - Plot actual bias (not abs) for all locations and all conditions on histogram to see if normal or binomial, per subject (no systematic pattern).
  - Compute average sensitivity for HVA and VMA

- Refit all data with cg in CumNormFitYN_cg (not just NH)
- Add dotted lines to PF plots (horizontal at 50 & vertical at 0)
- Create function to download data, run and create figures
- Progress on paper
- Create branching logic for possible mechanisms
- Create a table of r-squared values (per fit)
- Create an addition average sensitivity by z-score (use norm function), and SEM would be of the weighted average.
- IGNORE: Can also use precision-weighted average, goodness of fit, or likelihood to weight subjects for average plots
- IGNORE: Can even normalize (z-score?), or subtract/divide by mean, average, and then add/multiply by mean (to make error bars relative across subjects)
- Do I need to fix CIs for 2 condition?
- Can try adding 6 random data points each of the 4 conditions at each tilt value to see if plots significantly change
- Plot TangRight Sensitivity against TangLeft Senstivity; then on top RadialIn vs RadialOut in a different color
- Add CIs to bar plots per condition of sensitivity/bias across all locations
- *Update PF functions for cardinal/oblique separately
- Create bar plots of sensitivity/bias within (first/second half) per block and across blocks
- Check in with Nina about the Eyelink File
- LATER: fit linear mixed effects model to include condition (radial/tang) and location as covariates – should see effects for both. Can also do conditions (radialin, radialout, tangright, tangleft).

• Feedback for Experiment Design

  - *Equally distribute difficulty levels and clock/counterclockwise within each block?
  - *Explore 2-up 1-down converging staircases as method to compute slope and bias for my purposes (try this on myself)
  - *Print thank you message before saving eyelink data (last trial)
  - *Ensure speed is the same across locations (Billy & Jon both mention some seem faster)
  - *Billy also reported that LL radial motion seemed more clockwise – double check that CRT monitor does not cause issues with stretching

• Feedback for Presentation/Other

  - Type up instructions for experiment
  - Latex file – any way to generate in parent folder?
  - Can let subjects rotate keyboard when right/left if more intuitive for subject
  - Table for now: If we want to capture polar angle differences, might need to increase SF? (confirmed in other exp around 6 cpd, 6 deg ecc)
  - Double check sigma of gaussian for reporting purposes (and at what eccentricity contrast drops below 1 perc)

18 Questions from ECVP Attendees

- Where would you expect these asymmetries to stem from in the brain?
- How does this relate to the HVA and VMA findings?
- If relating the findings to natural scene statistics, why use "unnaturalistic" stimuli? Why gratings, when orientation is a confound?
- Results would lend great support to being an interaction of the 2 anisotropies, if you found radial and tangential difference in the 225 degree location.
- Would be interesting to see how the changes in parameters relate to the original subjects plots (on an individual basis).

19 Software to Cite

- PsychToolbox Extensions (Brainard, 1997; Pelli, 1997; Kleiner et al, 2007)
- Prins, N & Kingdom, F. A. A. (2018) Applying the Model-Comparison Approach to Test Specific Research Hypotheses in Psychophysical Research Using the Palamedes Toolbox. Frontiers in Psychology, 9:1250. doi: 10.3389/fpsyg.2018.01250