

Supplemental test: LMM S1

In LMM S1, we tested whether participants' response was influenced by the mean of the distribution, the distance between the mean and the mode of the distribution, or the starting direction of the responding bar. Since the starting direction of the responding bar varied trial by trial, this linear mixed effect model was fitted at the single-trial level. The dependent variable in this model is the angle difference between the participant's response and the mean direction in each trial. The positive value represents that the response is clockwise to the mean.

LMM S1 includes five fixed-effects and three random-effects terms.

Fixed effects:

- (1) the mean direction of the motion distribution,
- (2) the Mean-Mode angle difference, with a positive value representing that the mode is clockwise to the mean. Please note that this parameterization took the clockwise-counterclockwise into account,
- (3) the interaction between (1) and (2),
- (4) the start orientation of the responding bar relative to the mean direction, with a positive value representing that the start direction is clockwise to the mean
- (5) intercept.

Random effects:

- (1) the Mean-Mode angle difference, with a positive value representing that the mode is clockwise to the mean
- (2) the start direction of the responding bar relative to the mean direction, with a positive value representing that the start direction is clockwise to the mean
- (3) intercept

In this model, we treated the mean direction as a 36-level categorical variable rather than a continuous variable. This was simply because the direction was in circular space, and there was no point in expecting a linear effect associated with a periodic variable. We did not treat the mean direction and its associated interaction terms as random effects, because including as many as 70 random effects would make the model fail to converge.

There were a main effect of the mean direction ($F(35, 10752.1) = 13.08, p < 0.001$) and a main effect of the Mean-Mode angle difference ($F(1, 15) = 1864.3, p < 0.001$). The starting direction did not have a significant influence on the participant's response ($F(1, 15.3) = 1.4, p = 0.26$). Besides, there was a significant interaction between the mean direction and the Mean-Mode angle difference ($F(35, 10749) = 4.89, p < 0.001$).

Supplemental test: LMM S2

In LMM S1, we tested whether participant's response variability would be influenced by the mean of the distribution, the absolute Mean-Mode distance, and the clockwise/counterclockwise relationship between the mean and the mode. In this LMM, we did not consider the 0 Mean-Mode distance level, so that the clockwise/counterclockwise relationship variable could have a clear implication. The dependent variable in this model is the standard deviation of the participant's response.

LMM S2 includes eight fixed-effects and four random-effects terms.

Fixed effects:

- (1) the mean direction of the motion distribution,
- (2) the absolute Mean-Mode distance.
- (3) the clockwise/counterclockwise relationship between the mean and the mode
- (4) the interaction between (1) and (2)
- (5) the interaction between (1) and (3)
- (6) the interaction between (2) and (3)
- (7) the interaction between (1), (2), and (3)
- (8) intercept

Random effects:

- (1) the absolute Mean-Mode distance
- (2) the clockwise/counterclockwise relationship between the mean and the mode
- (3) the interaction between (1) and (2)
- (4) intercept

For similar reasons that we stated above for LMM S1, we did not include the mean direction of the motion distribution and its associated interaction terms as random factors.

There was a main effect of absolute Mean-Mode distance ($F(1, 15.09) = 690, p < 0.001$). The mean direction did not have an effect on participant's response variability ($F(35, 2670) = 0.74, p = 0.85$). The interaction between the mean direction and the absolute Mean-Mode distance was not significant ($F(35, 2670.13) = 1.255, p = 0.144$).

Supplemental test: LMM S3

The training length of 9 participants in the Mean-feedback group (2304 trials) was slightly smaller than that of the remaining 19 participants (2448 trials), which raised the possibility that any differences in learning effects between the two groups might come from the different training lengths. In LMM S3, we tested how participants' towards-mode metric changed trial by trial. This single-trial-level LMM would allow us to evaluate the learning effects per trial and thus make participants with different training lengths comparable.

In LMM S3, the towards-mode metric was regressed against eight fixed effects and four random effects.

Fixed effects:

- (1) the number of finished training trials
- (2) the absolute Mean-Mode distance
- (3) the feedback group
- (4) the interaction between (1) and (2)
- (5) the interaction between (1) and (3)
- (6) the interaction between (2) and (3)
- (7) the interaction between (1), (2), and (3)
- (8) intercept

Random effects:

- (1) the number of finished training trials
- (2) the absolute Mean-Mode distance
- (3) the interaction between (1) and (2)
- (4) Intercept

Participants' towards-mode metric was larger for larger Mean-Mode distance (i.e., $27.5 > 17.5$, $F(1,33.15) = 264.09$, $p < 0.001$). Meanwhile, towards-mode metric increased with increasing experimental sessions ($F(1,26.11) = 6.67$, $p = 0.015$). The increase of towards-mode metric across experimental sessions was larger at the trained 27.5 than at the untrained 17.5 Mean-Mode distance level (interaction $F(1, 30.97) = 5.77$, $p = 0.022$), which echoed our finding in Experiment 1 that participants' towards-mode metric scaled with the Mean-Mode distance. No other significant result was observed.

All these statistical conclusions were the same as those of the session-level analysis in the main text.