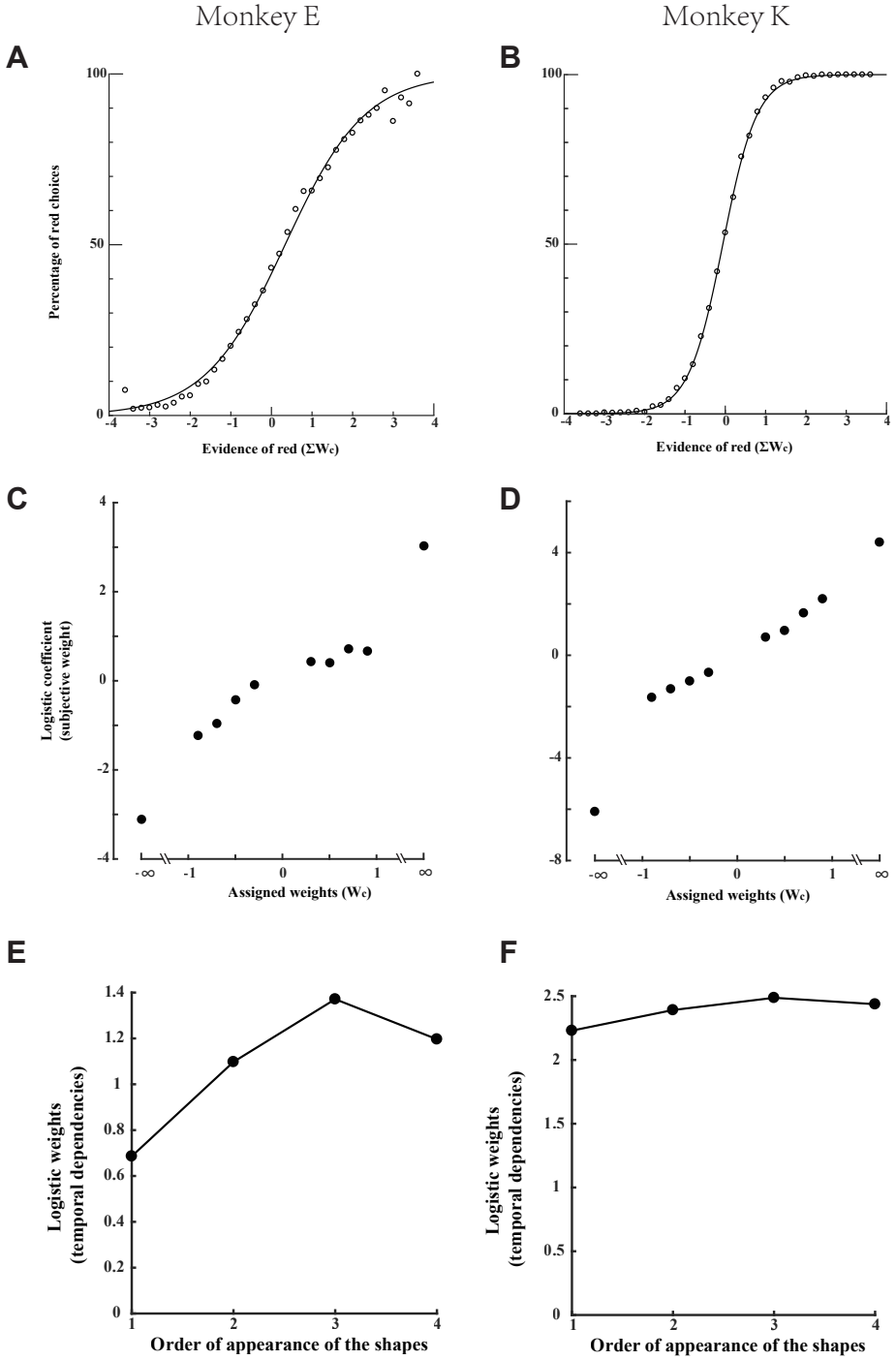


Figure S1. Individual monkey's performance. (A) and (B): Performance for monkey E and K. The percentage of red choices is plotted against the summed weights of the four shapes (open dots). The curve is a fitted logistic function. (C) and (D): Subjective weights for monkey E and K. We used a logistic regression to assess the effects of each shape on the monkeys' choice and plotted the coefficients (subjective weights) against the assigned weights. Positive subjective weights indicate a tendency to choose the red target. (E) and (F): Temporal weights for monkey E and K. We used a logistic regression to assess the effects of each epoch on the monkeys' choice. The fitted coefficients indicate dependency of the choice to the temporal order of the shapes.

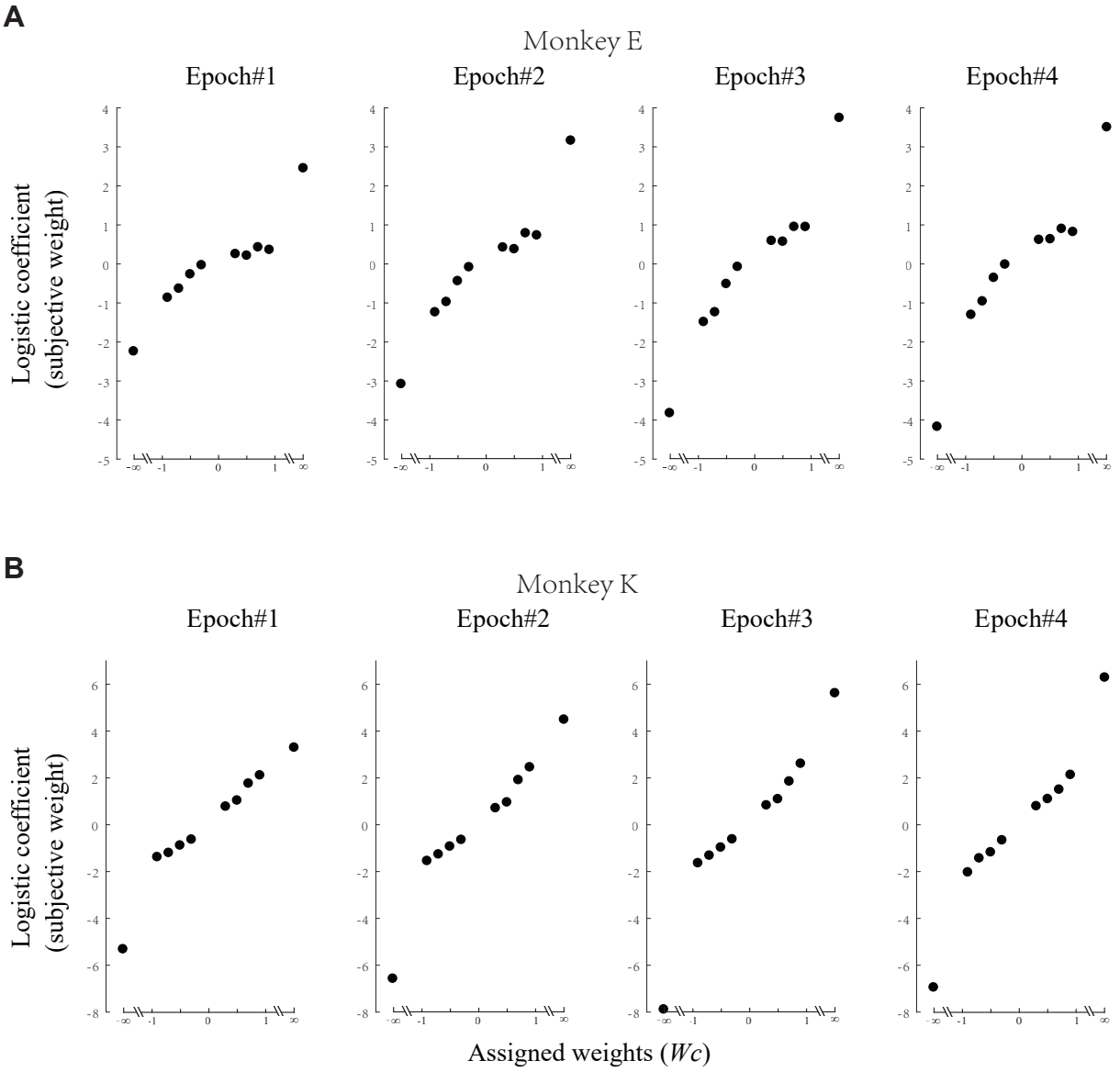


Figure S2. Subjective weights calculated separately for 4 different epochs. (A) monkey E. (B) monkey K. The subjective weights were calculated similarly as in Fig 1C. Instead of including 10 variables for each shape, we used 10×4=40 variables in this regression analysis, each corresponding to a particular shape appearing in a particular epoch.

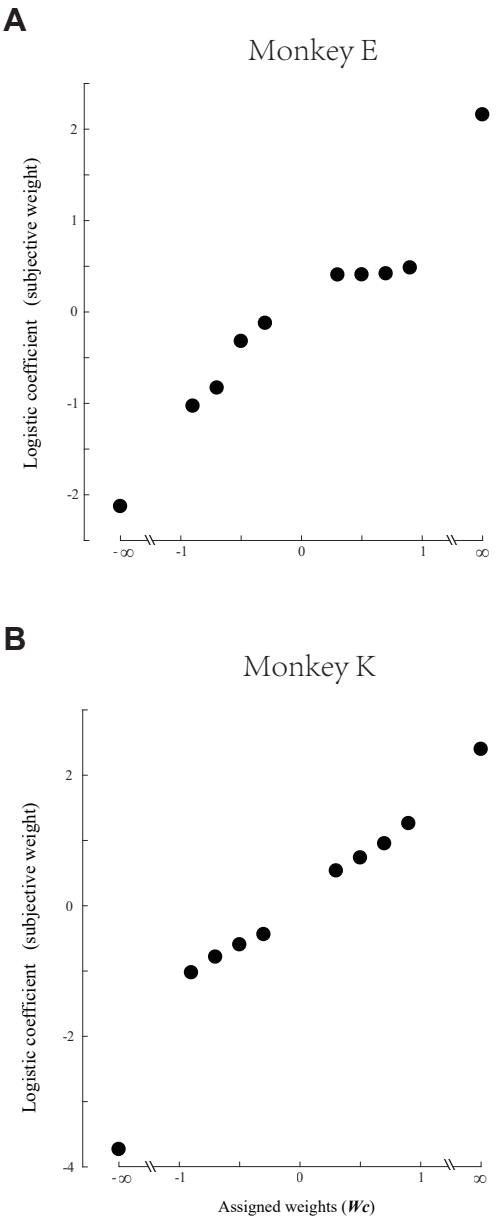


Figure S3. Subjective weights calculated from all trials with an infinitive-weight shape appearing in the 1st epoch. (A) monkey E. (B) monkey K. The analysis is the same as that of figure 1C, except that only the trials that started with an infinitive-weight shape are used. The subjective weights of the rest of the shapes are similar to those in Figure 1C, suggesting that the monkeys did not stop accumulating evidence after seeing an infinitive-weight shape.

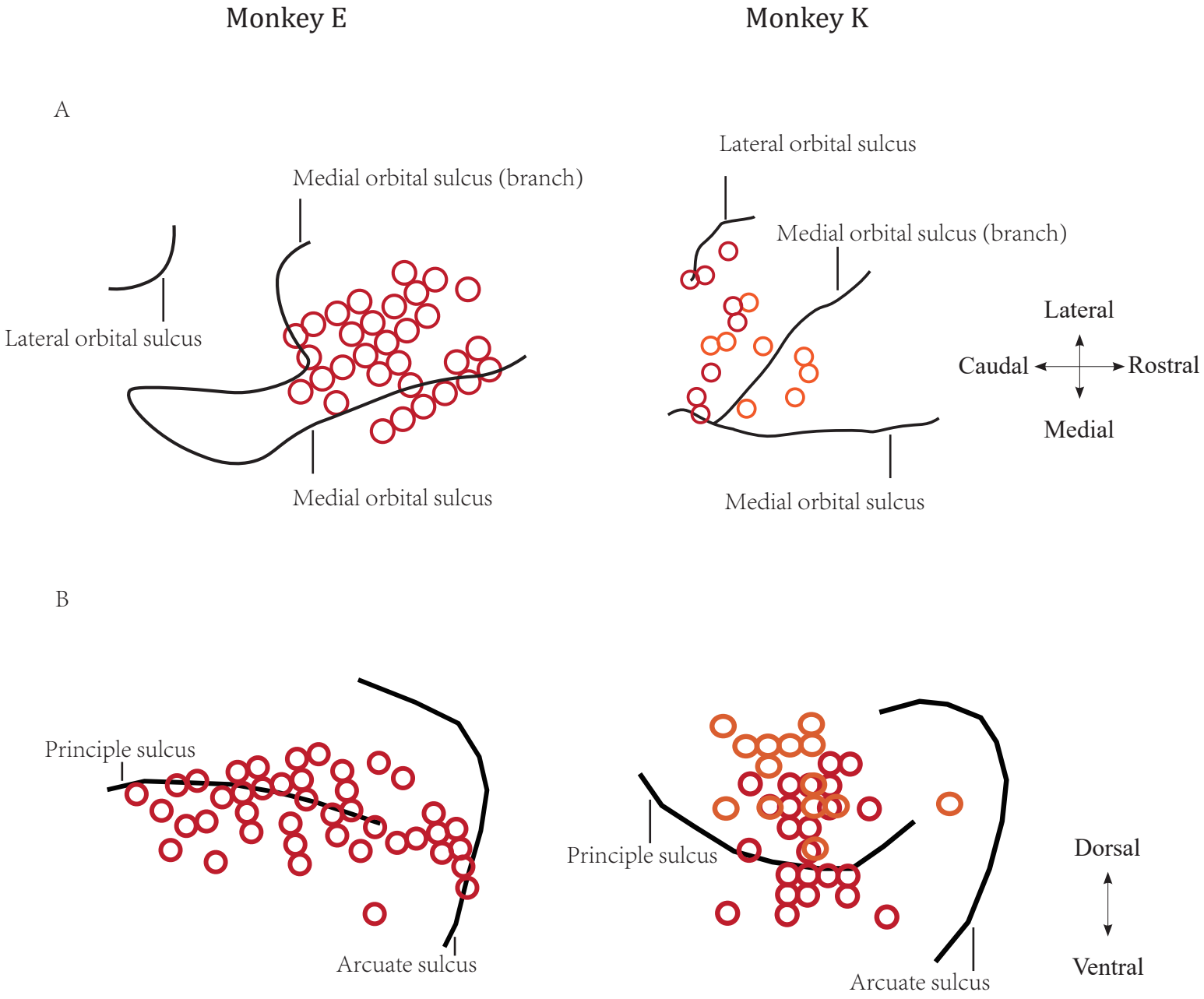


Figure S4. The recording sites in (A) the OFC and (B) the DLPFC. Left column: monkey E; right column: monkey K. Sulci are marked in the figure. The location of the recording chamber of Monkey K was moved once in the middle of the experiment. The orange circles indicate the recording sites after the movement of the chamber.

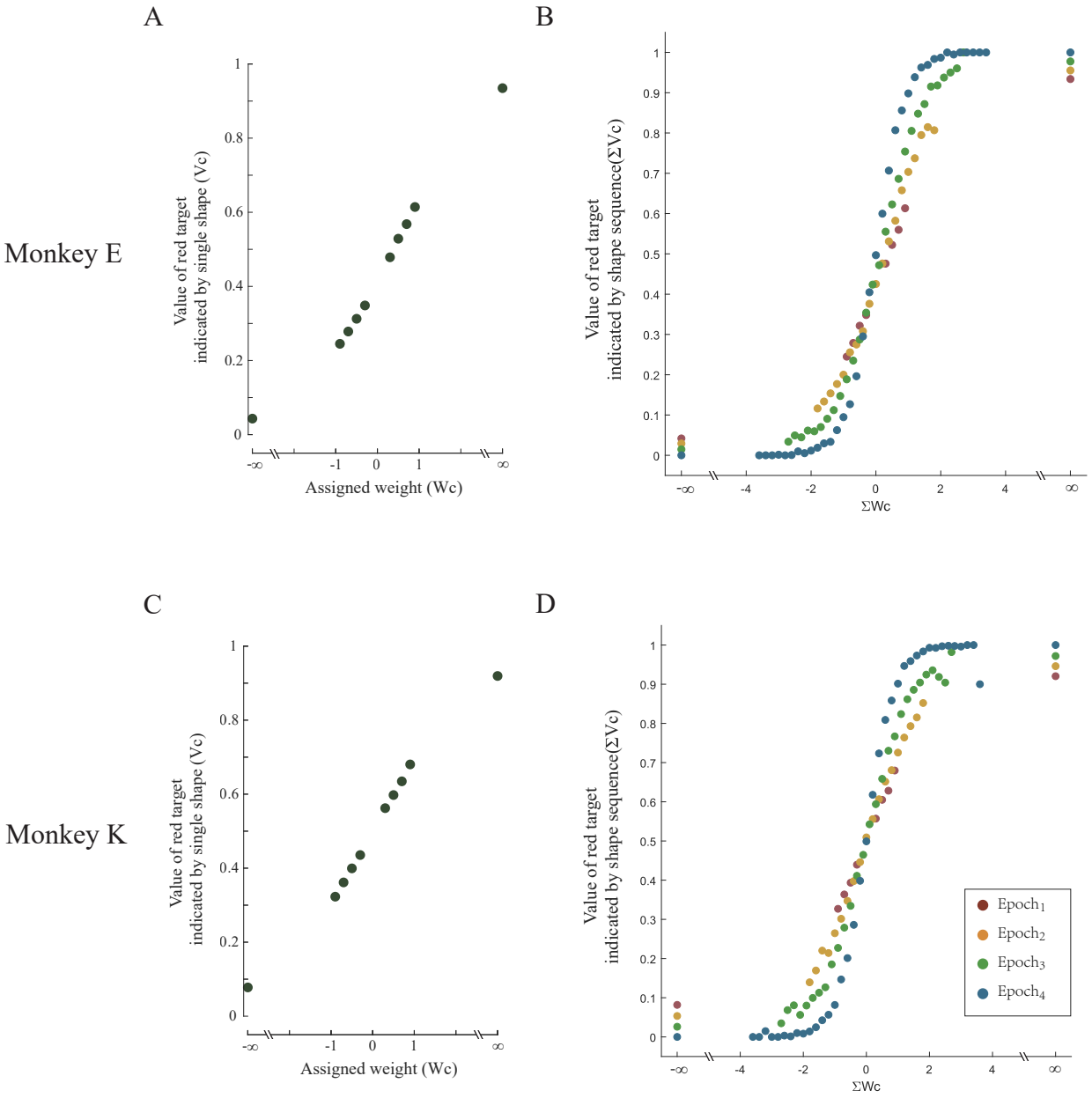


Figure S5. The value of the shapes is correlated with the assigned weight. (A-B) Values calculated using the trials of monkey E's recording sessions. (C-D) monkey K. (A) and (C): The average value of each shape is plotted against its assigned weight. (B) and (D): The value of the shape sequences is plotted against the corresponding sum weights.

The value of an individual shape in the stimulus domain (*Vc*) is defined as the average reward probability of the red target in all trials in which the shape appeared at least once. Replacing *Vc* with the value associated with the green target or the value difference between the two colors does not affect the explained variance analyses in Fig S14, S15, or S16.

The value of a sequence (*ΣVc*) is defined as the frequency of getting a reward in all red-choice trials with the sequence with identical *ΣWc.*

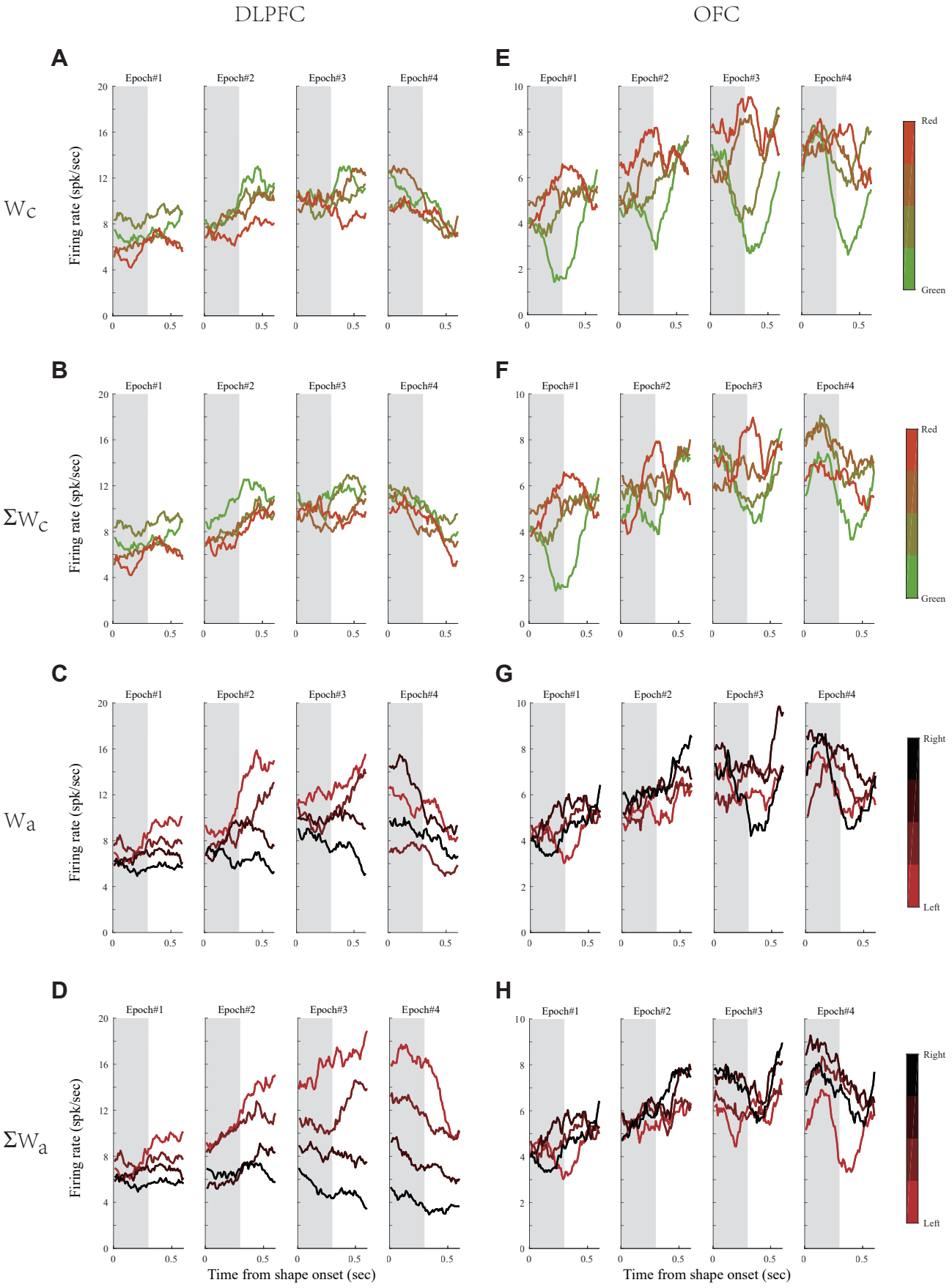


Figure S6. Responses of the two example neurons in Figure 2 sorted by different task variables. (A-D) The averaged activity of the DLPFC example neuron at different *Wc*, *ΣWc*, *Wa*, *and ΣWa* levels, respectively. (E-H) The averaged activity of the OFC neuron at different *Wc*, *ΣWc*, *Wa*, *ΣWa* levels, respectively. The color bar on the right of each row shows which target and how much the variable is favoring. The gray shades indicate the shape presentation period (300ms).

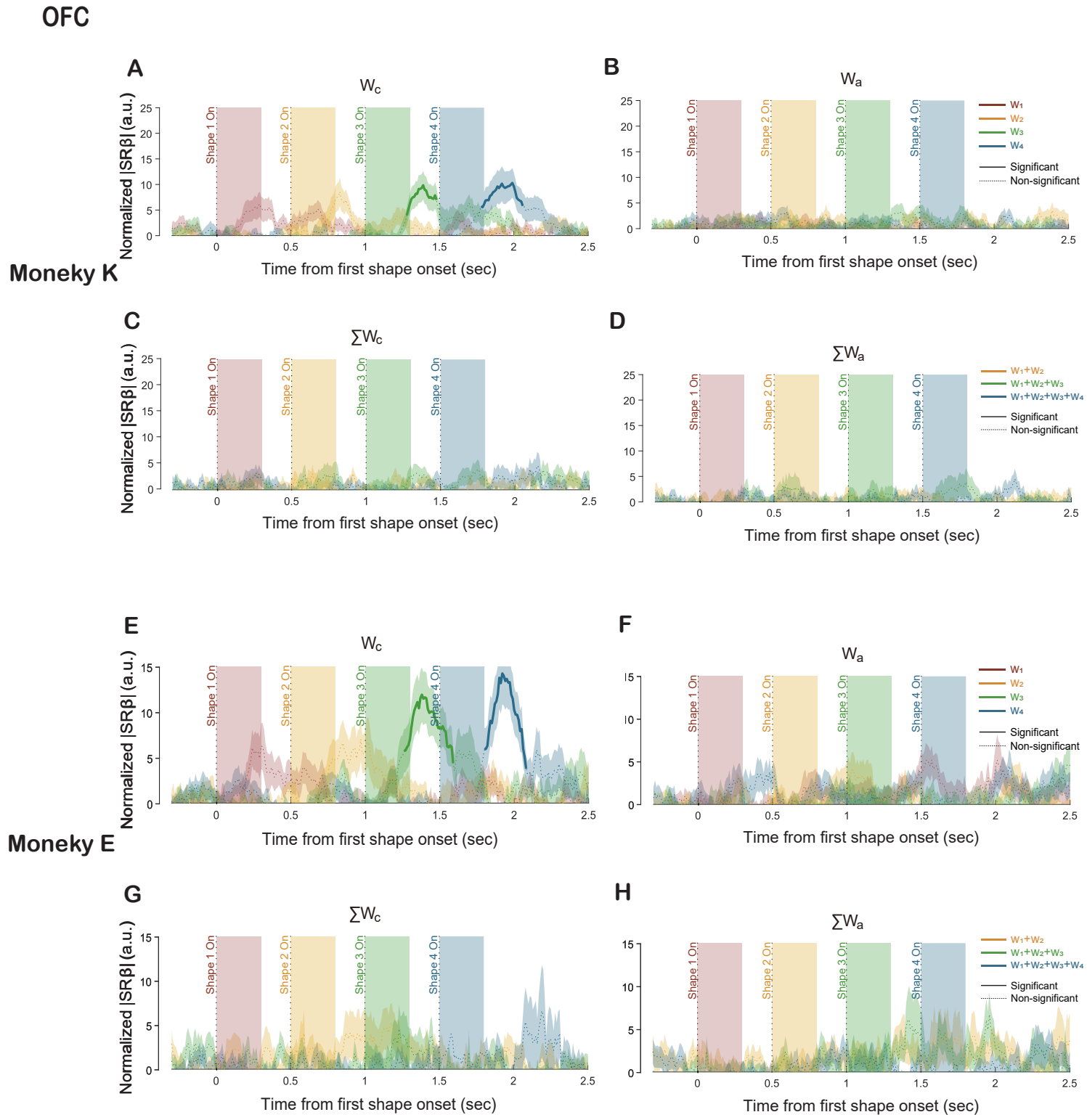


Figure S7. Representation of the shape weights in the OFC in monkeys K and E with LASSO. (A-D) Monkey K. The normalized $|SR\beta|$ of *Wc*, *Wa*, *ΣWc*, and *ΣWa* of the OFC neurons are plotted. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least consecutive 150 ms), and the dashed sections are not significant. Error bars indicate SEM. (E-H) Monkey E.

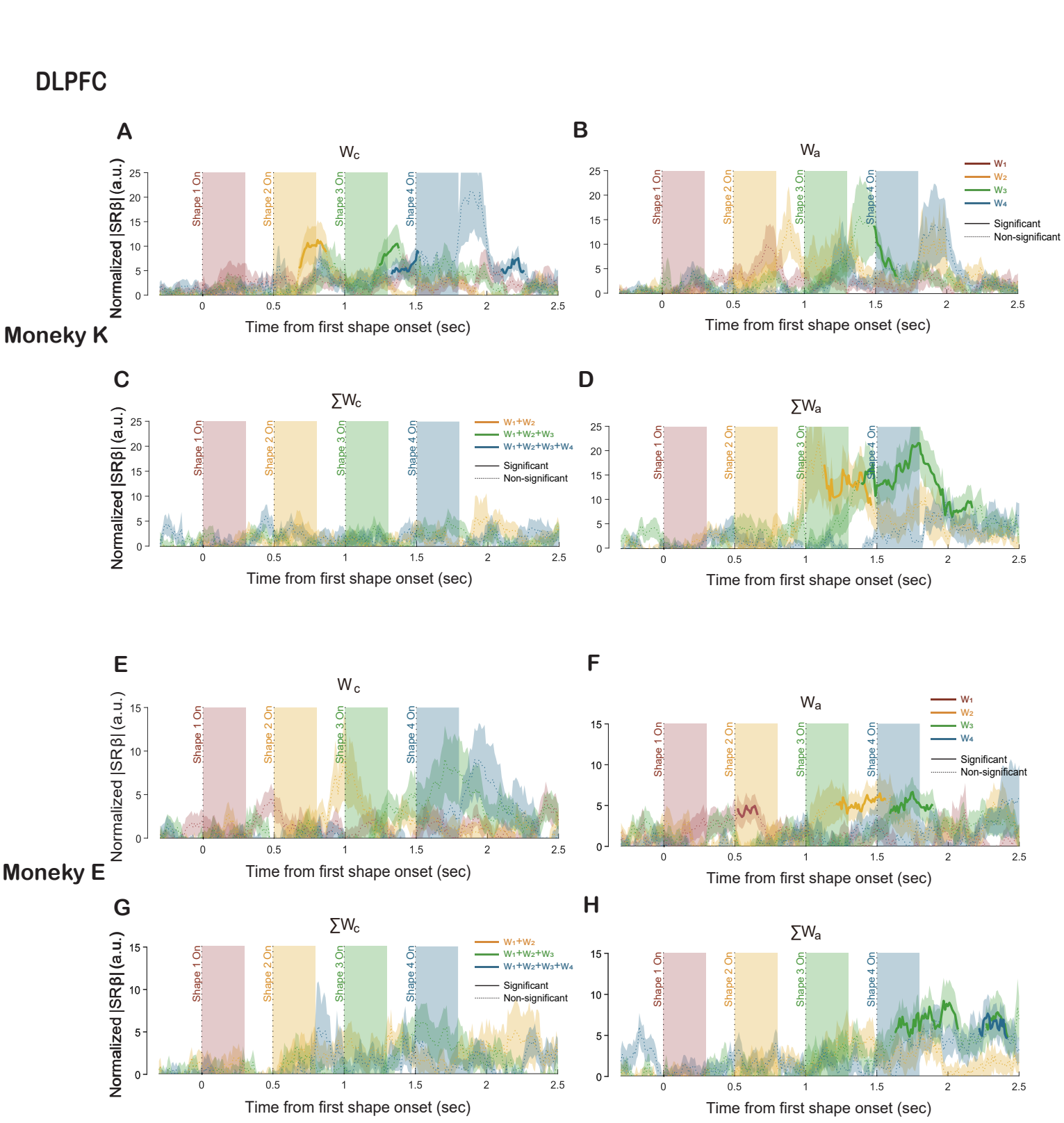


Figure S8. Representation of the shape weights in the DLPFC in monkeys K and E with LASSO. (A-D) Monkey K. The normalized $|SR\beta|$ of *Wc*, *Wa*, *ΣWc*, and *ΣWa* of the DLPFC neurons are plotted. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least consecutive 150 ms), and the dashed sections are not significant. Error bars indicate SEM. (E-H) Monkey E.

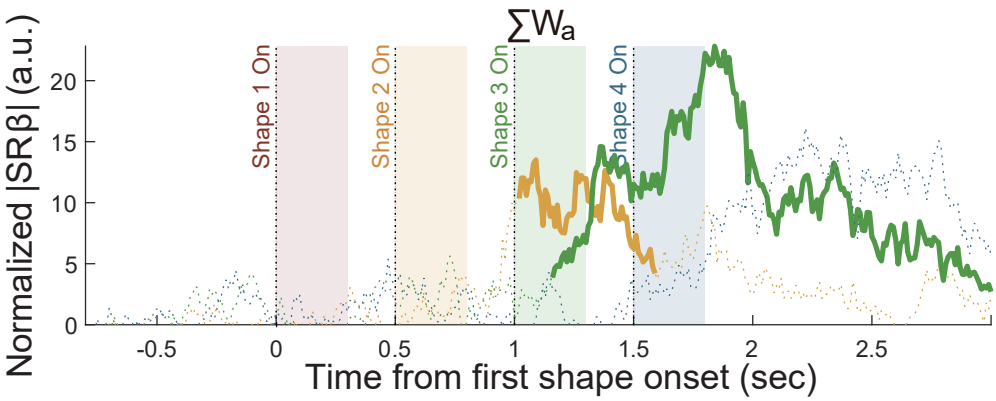


Figure S9. Representations of ΣWa in the DLPFC with regularization parameter optimized to late period. The conventions are identical to Figure 5B, except that we used the time window 1.8-2.5s to determine the regularization parameter of the LASSO algorithm.

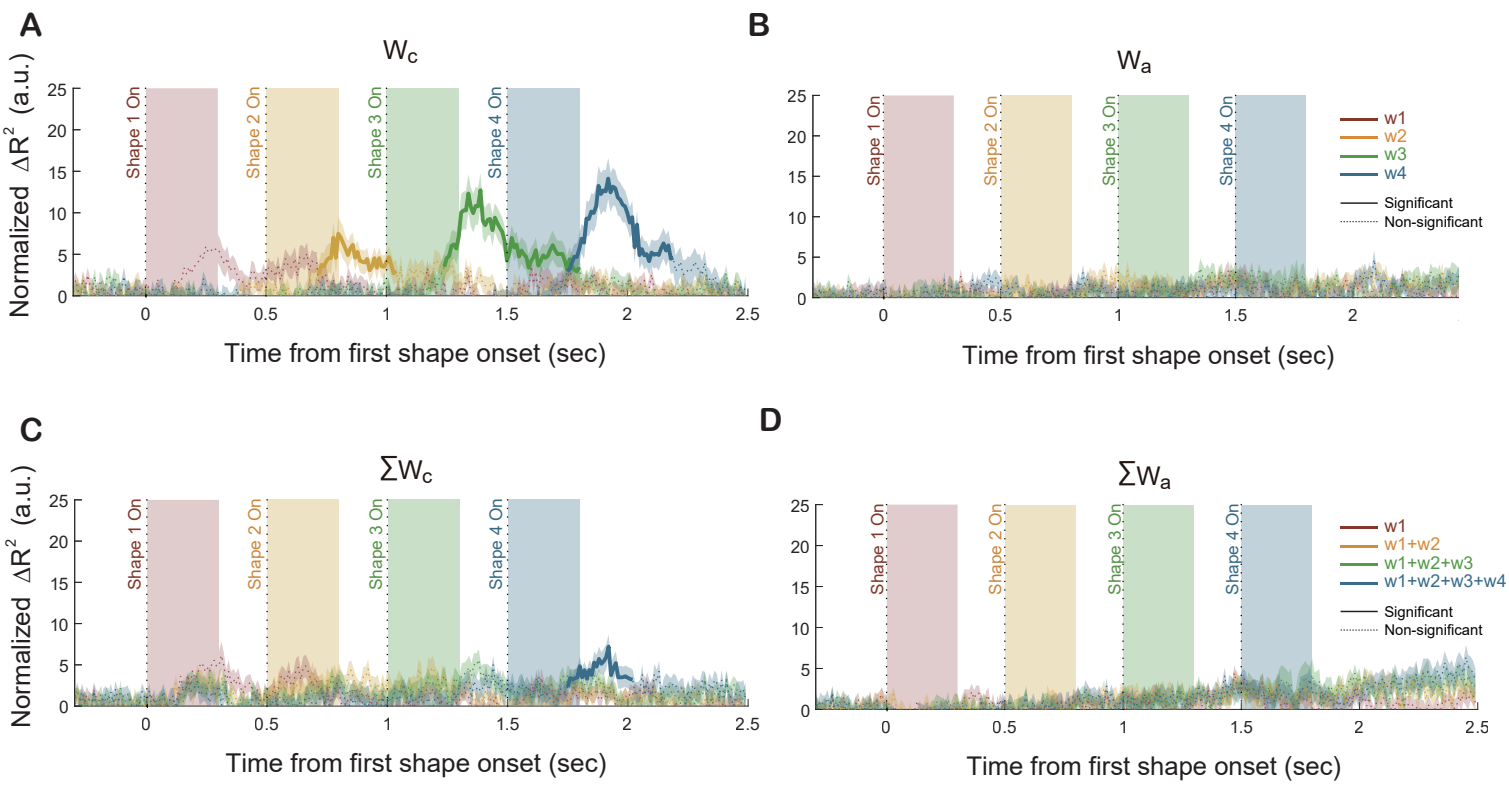


Figure S10. Representations of the single weights and the summed weights in the OFC of both monkeys. (A-D) The normalized explained variance of *Wc*, *Wa*, *ΣWc*, and *ΣWa* of the OFC neurons. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least consecutive 150ms), and the dashed sections are not significant. Error bars indicate SEM.

The regressions were separately performed on four variables for each shape epoch: single color weight (*Wc*), summed color weight (*ΣWc*), single action weight (*Wa*), and summed action weight (*ΣWa*). The single and summed weights were the same in the first epoch by definition. For each neuron, we convoluted its firing rate (FR) with a 200ms square wave at 10 ms steps. We then regressed the FR at each time step on the respective variable in epoch *i* (Factor *i*).

$$FR = \beta_i * Factor_i + \beta_0 \ . \qquad \text{(S1)}$$

Note that the regression covered the whole trial while the particular factor was only associated with the shape presented in epoch *i*. The results preceding the epoch *i* reflect the noise level, while the results following the epoch *i* reflect how sustained the encoding of the information was.

The normalized ΔR^2 was calculated similarly to the procedure described previously (Cai and Padoa-Schioppa, 2014). Briefly, to obtain the ΔR^2 for each neuron, we calculated the R^2 of the shuffled regression model in which the pairing of the FR and $Factor_i$ was shuffled. We then subtracted the shuffled R^2 from the R^2 of the regression model in Eq. S1. In order to convert ΔR^2 into a normalized Z-score, we shuffled the spike count in the baseline period (300 – 0 ms before the target onset) across all trials for 1000 times. We calculated the ΔR^2 for the shuffled samples and then obtained the distribution for the baseline ΔR^2_{bl}, whose mean and variance were used in calculating the Z-score. For each neuron and each factor *i*, the normalized ΔR^2 was:

$$norm\Delta R_i^2 = \frac{\Delta R_i^2 - mean(\Delta R_{bl}^2)}{\sigma_{\Delta R_{bl}^2}}, \qquad \text{(S2)}$$

where $mean(\Delta R_{bl}^2)$ and $\sigma_{\Delta R_{bl}^2}$ are the mean and the standard deviation of (ΔR_{bl}^2), respectively. Following the same procedure, we calculated the normalized population average of ΔR^2 by further normalizing the $norm\Delta R_i^2$:

$$pop\_norm\Delta R_i^2 = \sum norm\Delta R_i^2 / sqrt(N), \qquad \text{(S3)}$$

where N is the number of neurons. Thus, the population ΔR^2, at the chance level, has an expected value of 0 and a standard deviation of 1, and is comparable across different populations or brain areas.

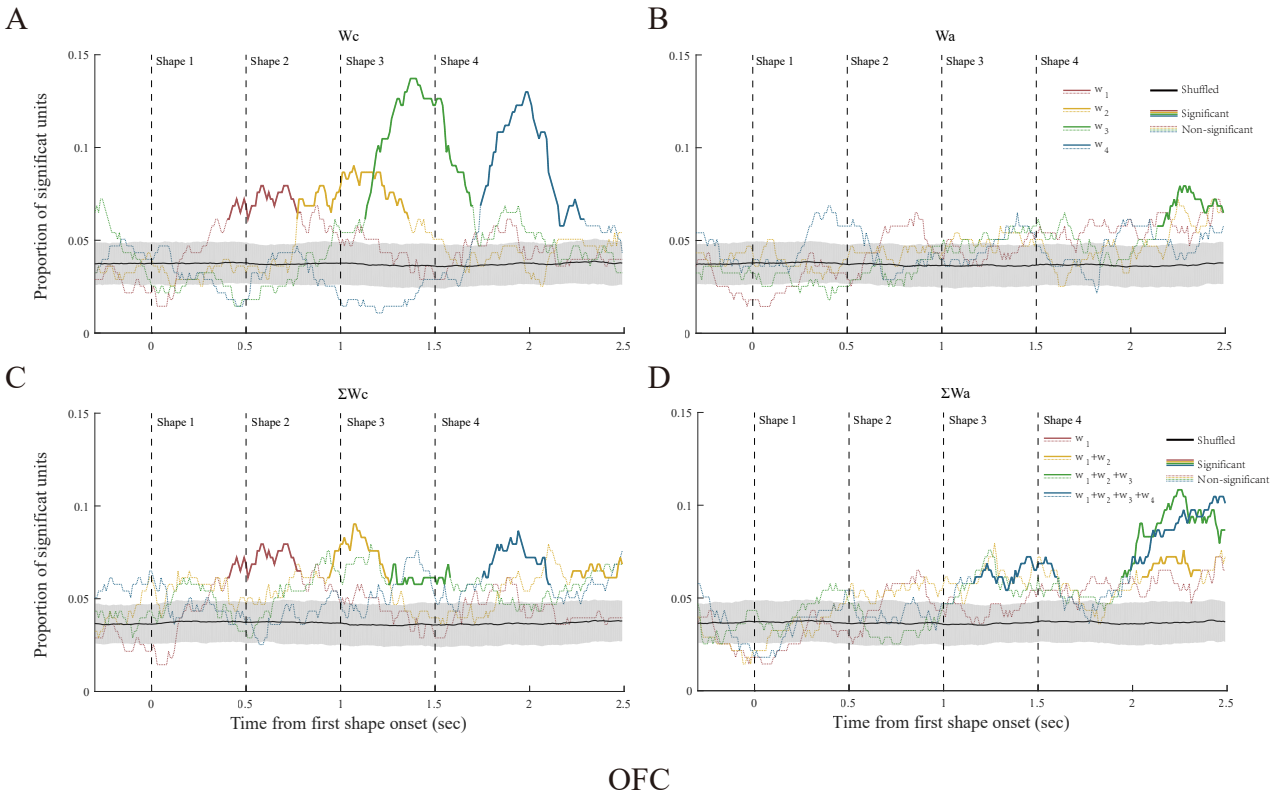


Figure S11. The proportion of neurons selective to the shape weights in the OFC. (A-D) The proportion of OFC neurons that are significantly tuned by *Wc*, *Wa*, $\sum Wc$, $\sum Wa$. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.05$ with multiple comparison corrections), and the dashed sections are not significant. The black solid horizontal lines represent the chance level and the gray shaded areas indicate the s.d. of the shuffled distribution.

The significance of a neuron's selectivity was determined as follows. We first applied the same linear regressions as those in Figure S10 at every time bin for the neuron. At each time bin, we applied the student's t-test with our multiple comparison correction procedure to determine its significance (see Methods). We determined the significance by testing whether the actual number of significant neurons was significantly different from the shuffled data at 95% confidence interval with multiple-comparison correction. The shuffled data were created as follows. For each neuron, we shuffled the trial labels and applied the same analysis described above to calculate the number of the neurons with significant tuning after the shuffle. This step was repeated for 100 times. We created a shuffled dataset for each variable in each epoch separately to determine its significance. Because the results from the four shuffled datasets largely overlapped, for illustration, we combined trials from the four shuffled data sets created from each epoch and plotted the mean and the 95% confidence interval from the combined shuffled data only.

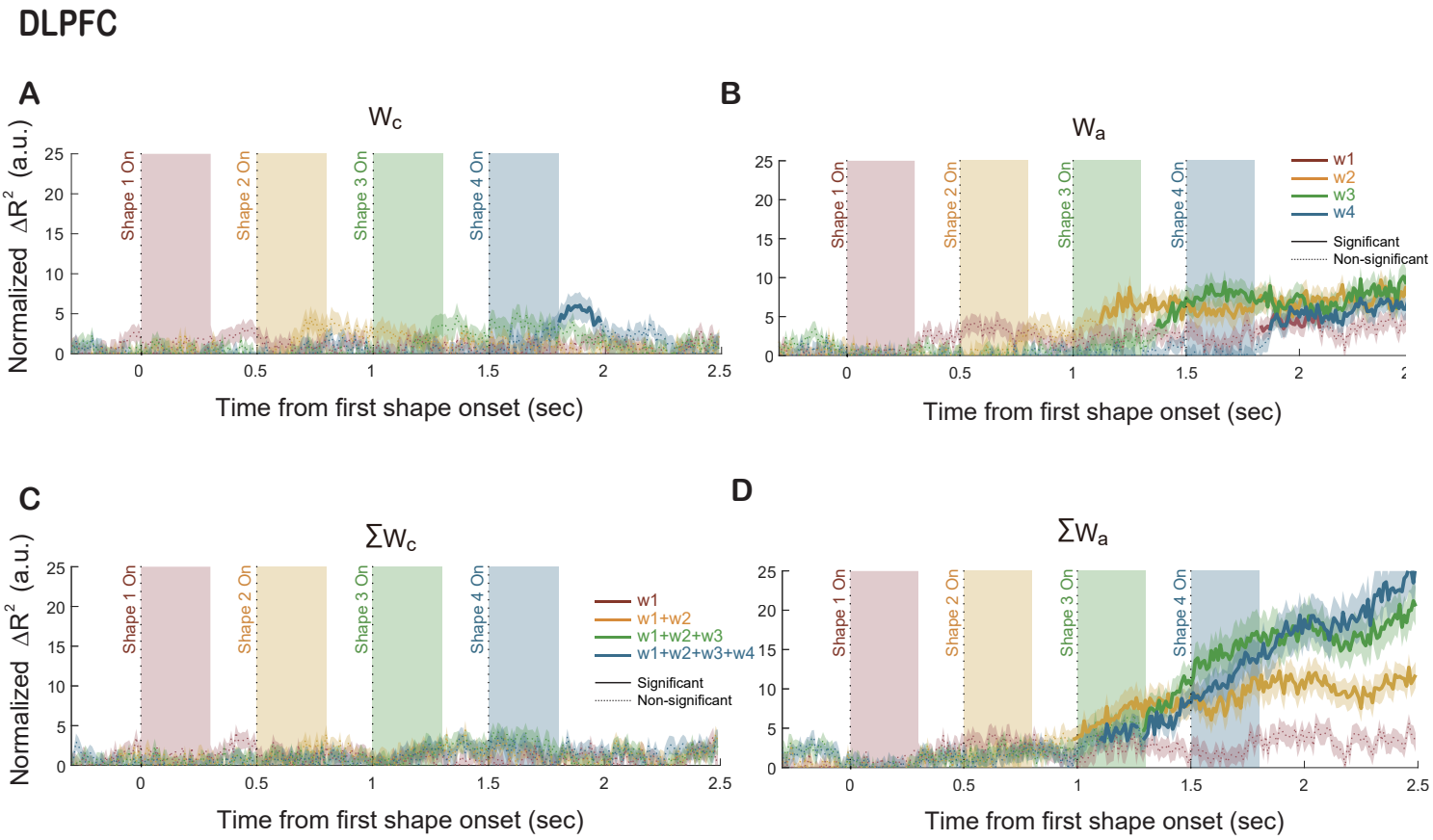
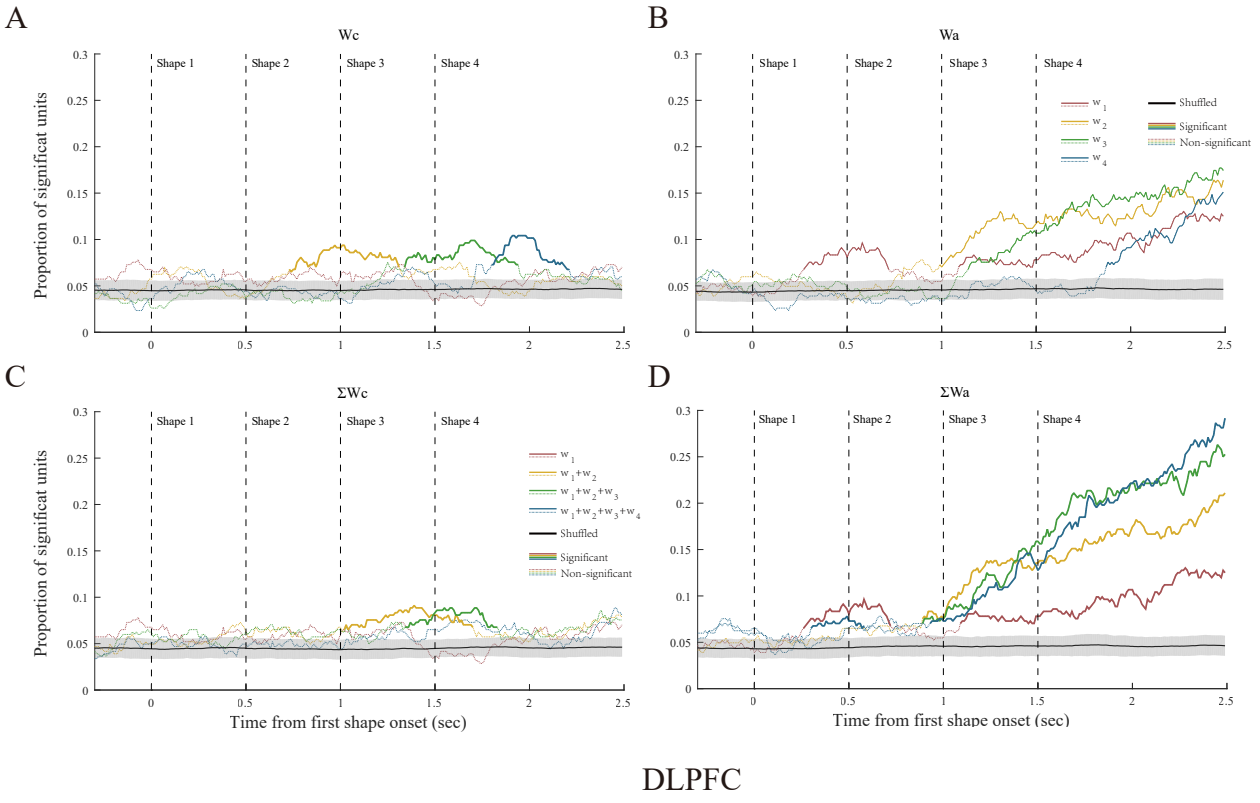


Figure S12. Representations of the single weights and the summed weights in the DLPFC of both monkeys. (A-D) The normalized explained variance of *Wc*, *Wa*, *ΣWc*, and *ΣWa* of the DLPFC neurons. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least consecutive 150ms), and the dashed sections are not significant. Error bars indicate SEM. Please refer to Figure S10's legend for the analysis details.



DLPFC

Figure S13. The proportion of neurons selective to the shape weights in the DLPFC. (A-D) The proportion of neurons that are significantly tuned by *Wc*, *Wa*, $\sum Wc$, $\sum Wa$ in the DLPFC. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.05$ with multiple comparison corrections), and the dashed sections are not significant. The black solid lines represent the chance level and the gray shaded areas indicate the s.d. of the shuffled distribution. Please refer to Figure S11's legend for the analysis details.

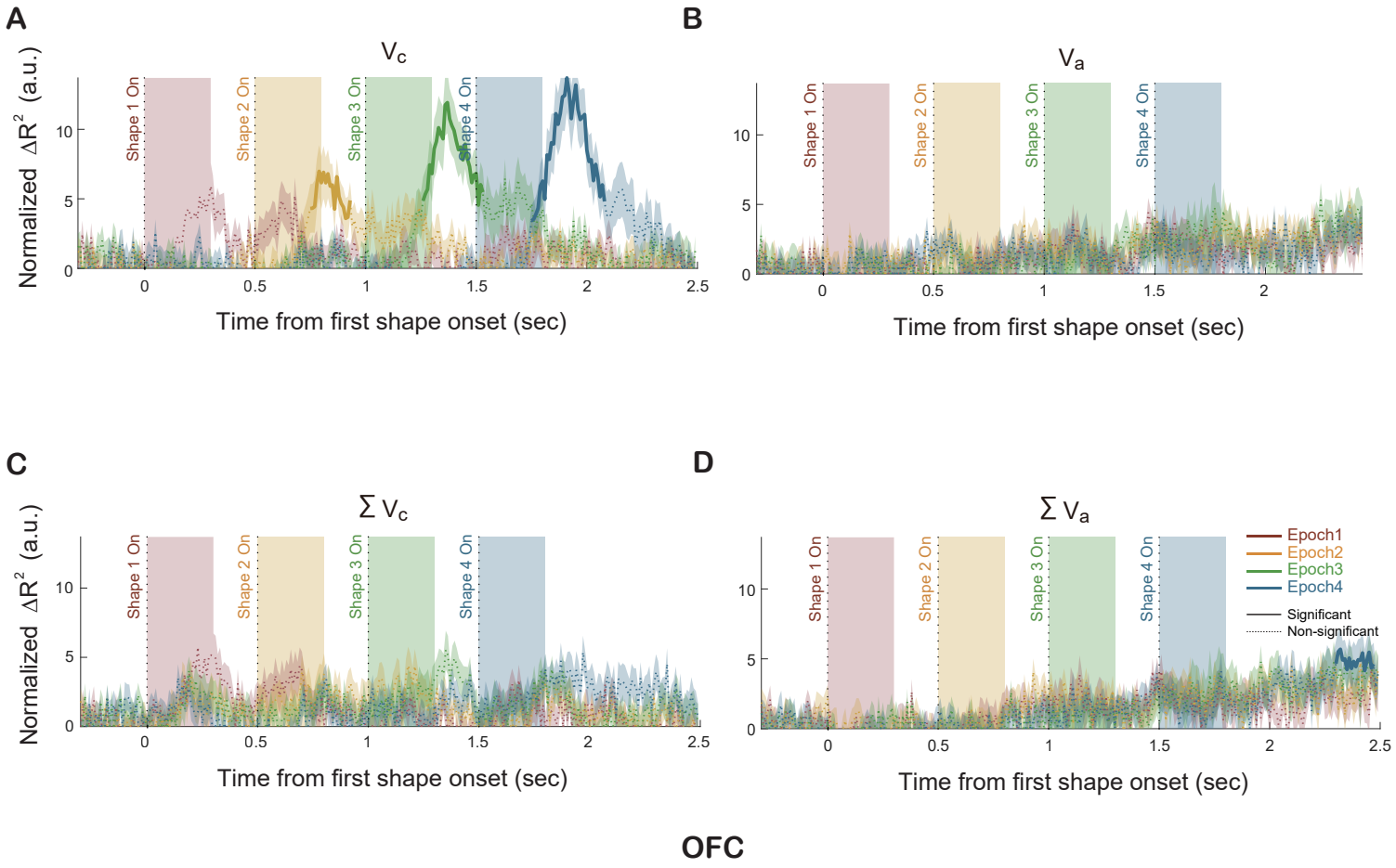


Figure S14. Representations of shape value in the OFC. (A-D) The normalized explained variance of *Vc*, *Va*, *ΣVc*, and *ΣVa* of the OFC neurons. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least continuous 150ms), and the dashed sections are not significant. The analyses were done in the same procedure as those in Figure S10. *Va* and *ΣVa* were determined in similar procedure to those in Figure S5, but the reward probabilities were computed for the left target.

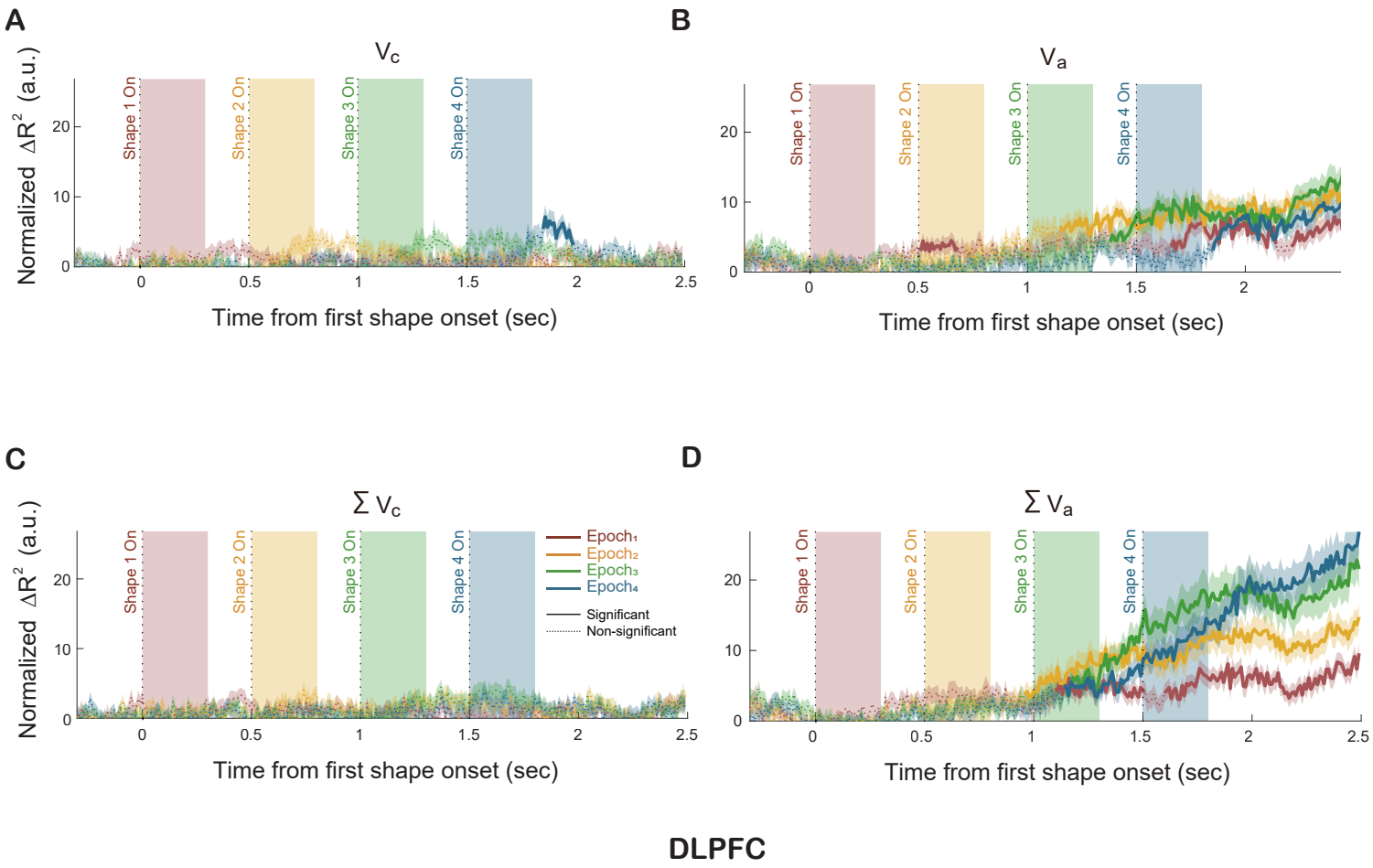


Figure S15. Representations of shape value in the DLPFC. (A-D) The normalized explained variance of *Vc*, *Va*, *ΣVc*, and *ΣVa* of the DLPFC neurons. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least continuous 150ms), and the dashed sections are not significant.

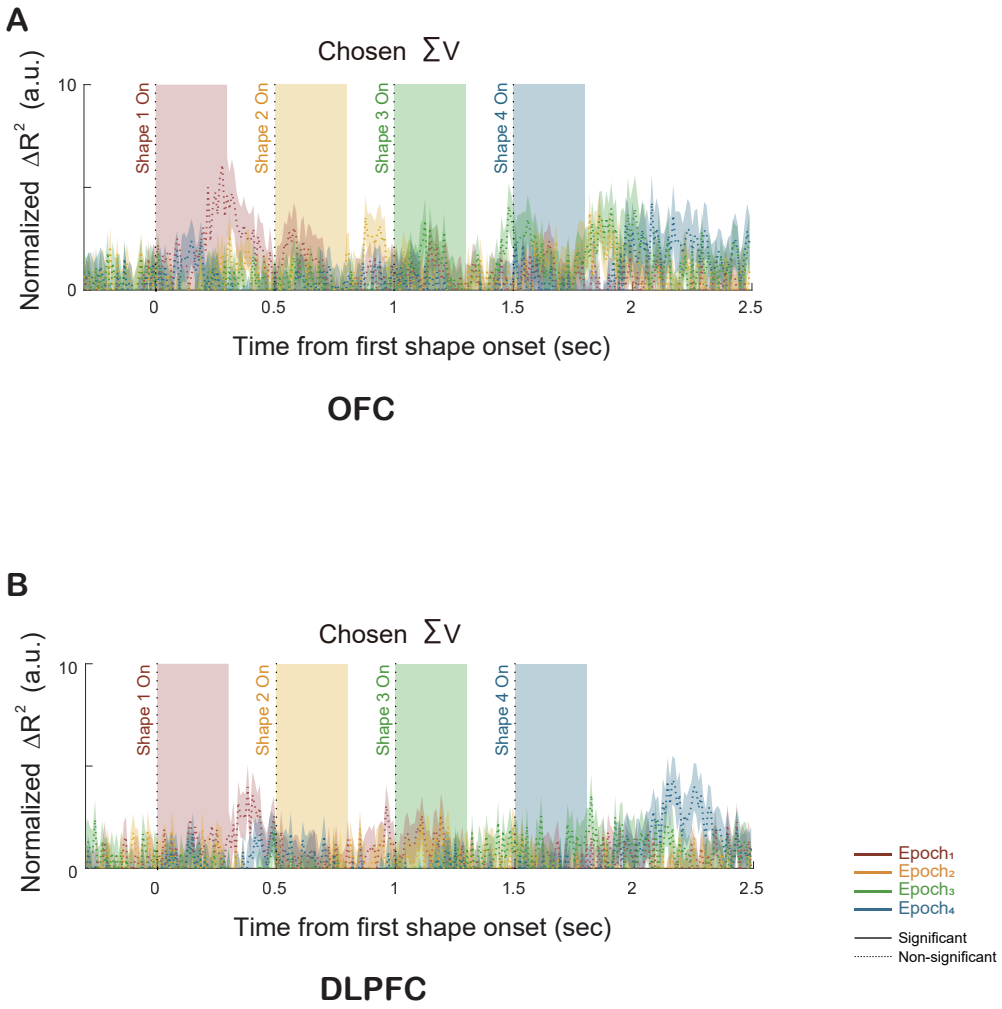


Figure S16. Representations of the chosen values in (A) the OFC and (B) the DLPFC. The normalized explained variance of the chosen value of the observed sequence is plotted. The red, yellow, green, and blue traces indicate the 1st, 2nd, 3rd, and 4th epoch, respectively. The solid sections of each trace indicate significance ($p<0.01$ for at least continuous 150ms), and the dashed sections are not significant. The chosen value is the value of the choice with a higher probability, given the evidence provided by the shape sequence until the particular epoch.

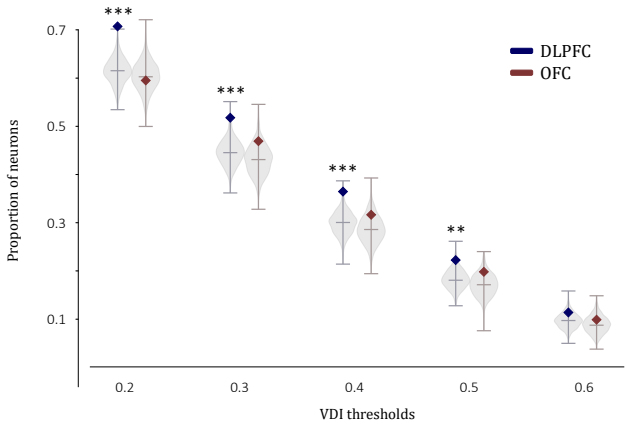


Figure S17. The proportions of neurons with VDI larger than certain criteria, in the DLPFC (blue) and the OFC (red), plotted against the criteria. The dots indicate the actual proportion under each criterion. The violin plots indicate the distribution of the shuffled data, with the contour indicating the kernel density estimation of the distribution. Only the DLPFC have neurons with VDIs over a range of criteria significantly more than expected from chance. ***/** indicate actual proportion larger than 99%/95% of the shuffle distribution. We estimated the distribution of the shuffled data by shuffling the spatial configuration 1000 times and computing the VDIs.