

Supplementary Information for

Mixed-Selective Organization of Reach and Grasp in the Primate Fronto-Parietal Network

1 Alireza Fathian,^{1,2} Sebastian J. Lehmann,^{1,3} Jonathan A. Michaels,^{1,4} and Hansjörg Scherberger^{1,2,5,6,*}

2 ¹Neurobiology Laboratory, Deutsches Primatenzentrum GmbH, Göttingen, Germany

3 ²Department of Biology and Psychology, University of Göttingen, Göttingen, Germany

4 ³Department of Physiology and Pharmacology, Western University, London, ON, Canada

5 ⁴School of Kinesiology and Health Science, York University, Toronto ON, Canada

6 ⁵Senior author

7 ⁶Lead contact

8 *Correspondence: hscherb@gwdg.de

9

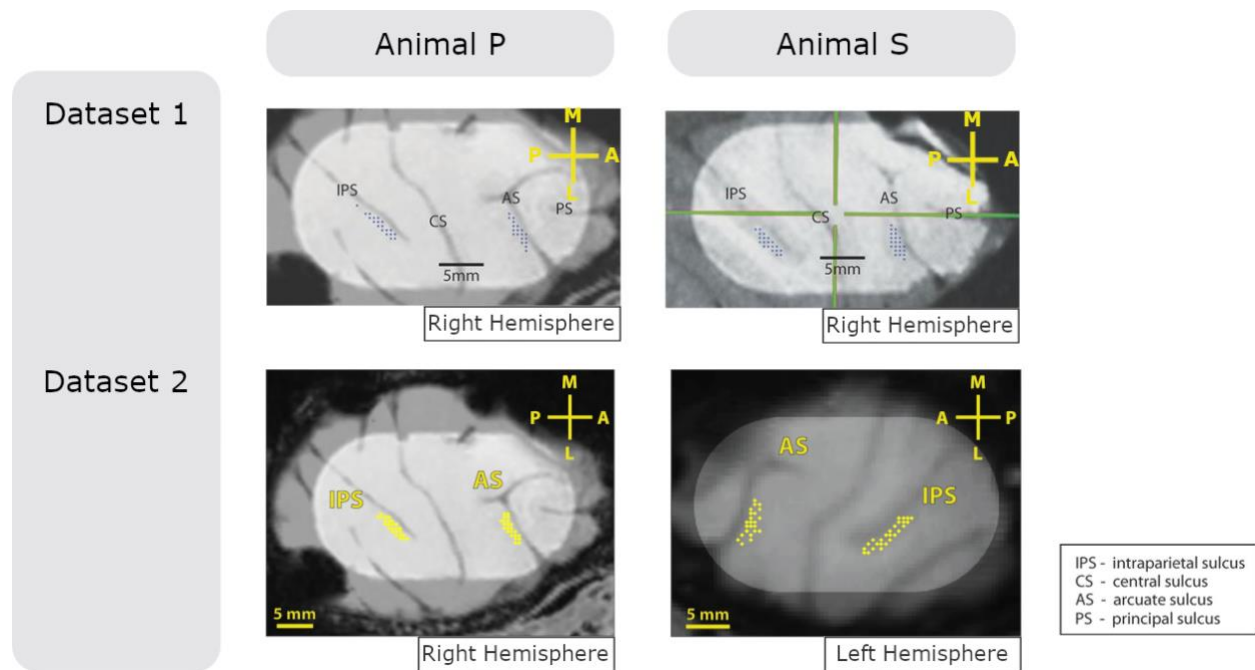


Figure S1. Recording locations for monkey P and S overlaid on a structural MRI. The illuminated oval marks the outline of the recording chamber. The cross shows the medial (M), lateral (L), anterior (A), and posterior (P) directions. Images for dataset 1 and dataset 2 are reproduced from Lehmann et al. (2013) and Michaels et al. (2018), respectively.

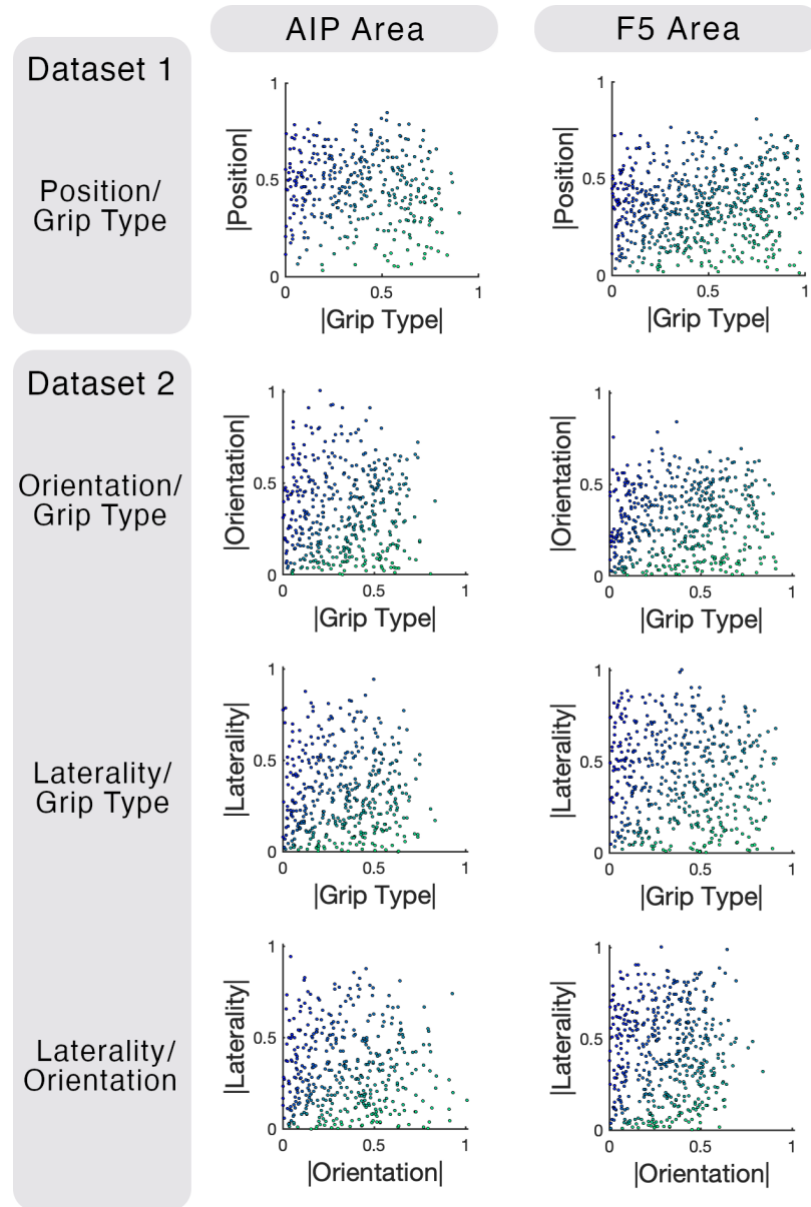


Figure S2. Neural activity cannot be categorized by selectivity. Scatter plots illustrate the contribution of AIP and F5 neurons, respectively, to different pairs of task parameters, with each point representing a neuron. The top row (Dataset 1) shows position vs. grip type, while the remaining rows (Dataset 2) depict orientation vs. grip type, laterality vs. grip type, and orientation vs. laterality, respectively.

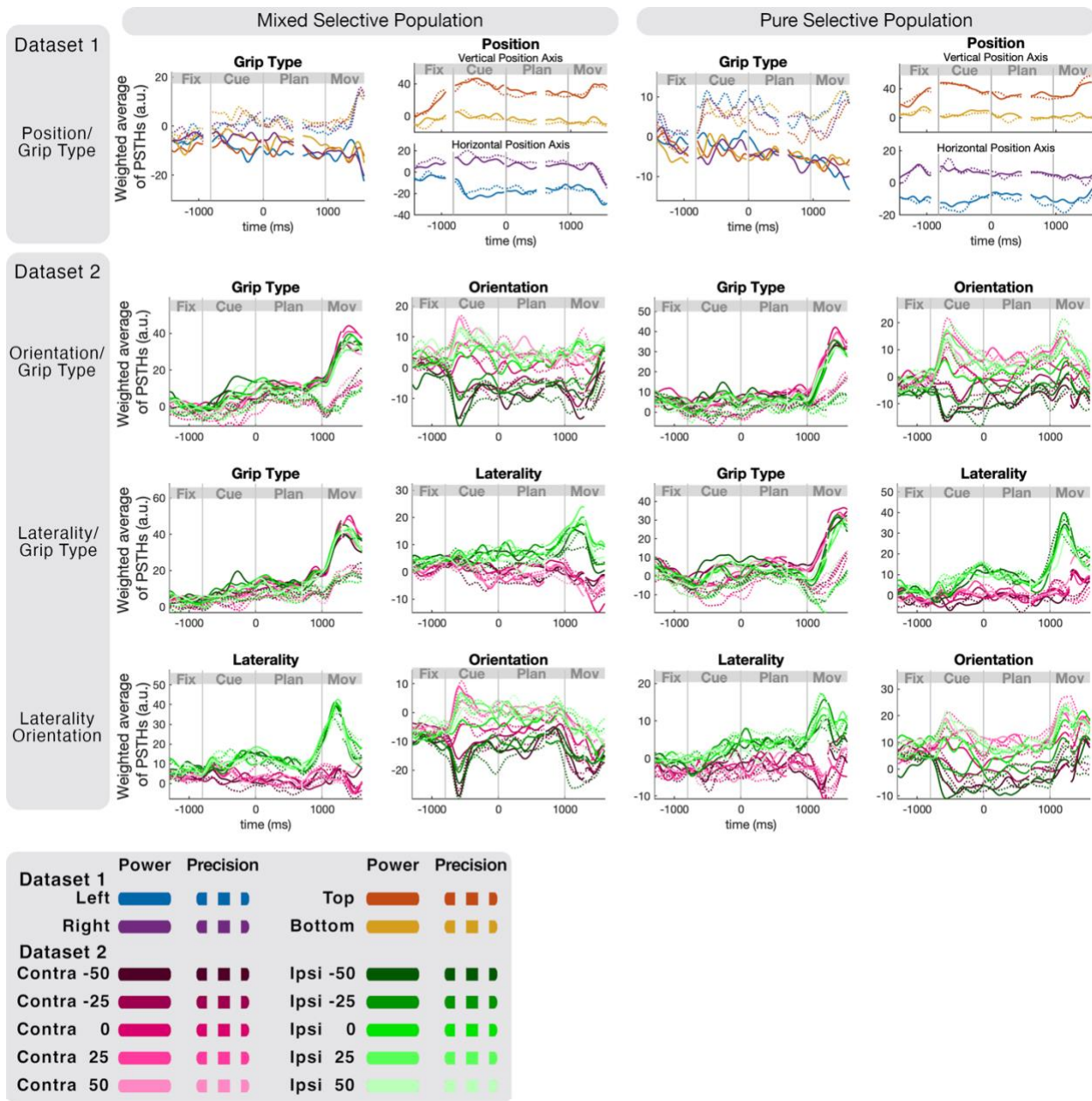


Figure S3. Task parameters are extractable from both mixed and pure selective populations in the AIP area. Weighted averages of peri-stimulus time histograms (PSTHs), using regression coefficients as weights, reveal parameter-specific population responses. Each row shows the population responses for two groups of pure and mixed selective neurons categorized based on the Mixed Selectivity Index (MSI) corresponding to a parameter pair. The top row (Dataset 1) shows position vs. grip type, while the remaining rows (Dataset 2) depict orientation vs. grip type, laterality vs. grip type, and orientation vs. laterality, respectively.

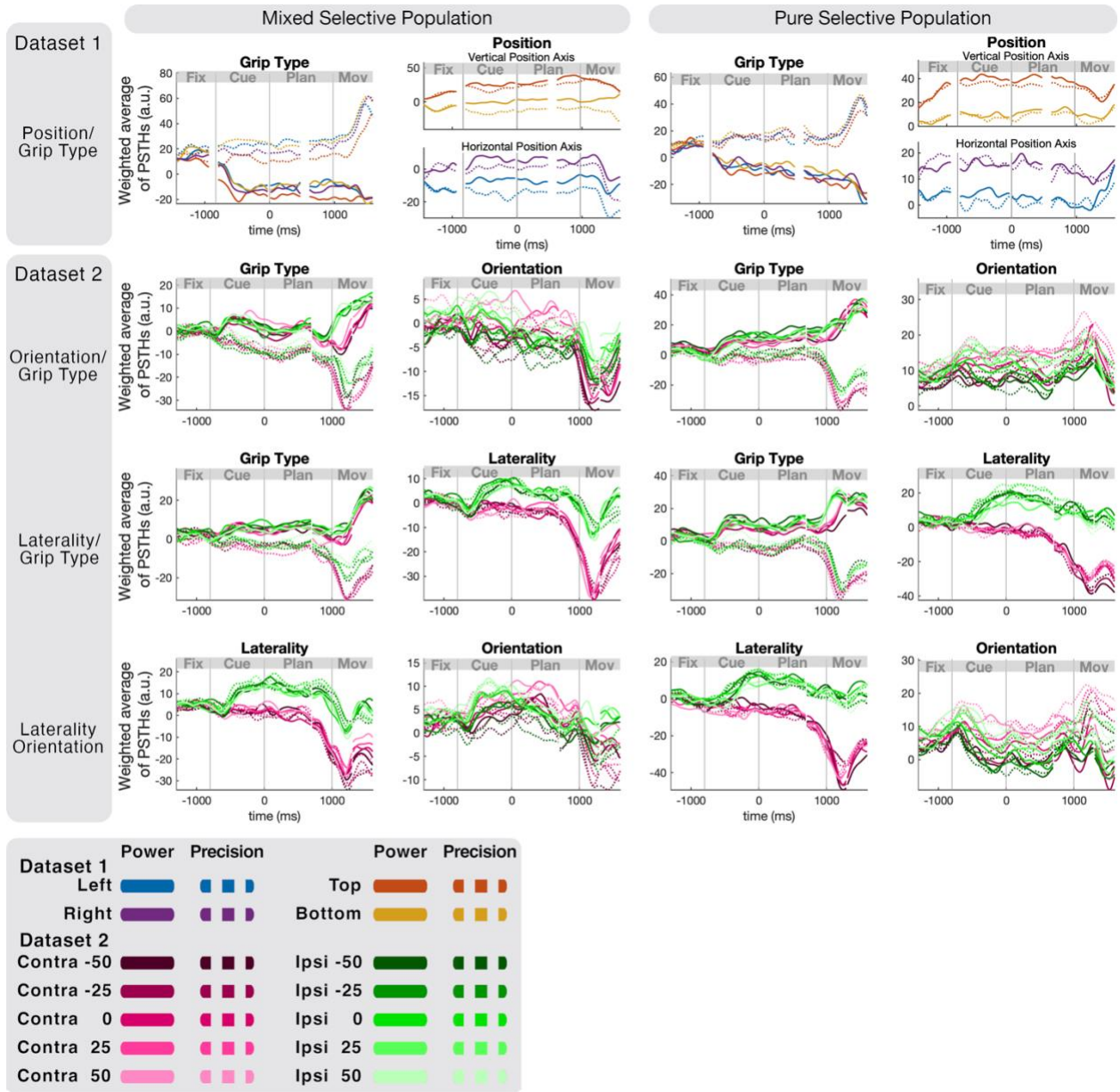


Figure S4. Task parameters are extractable from both mixed and pure selective populations in the F5 area. Weighted averages of peri-stimulus time histograms (PSTHs), using regression coefficients as weights, reveal parameter-specific population responses. Each row shows the population responses for two groups of pure and mixed selective neurons categorized based on the Mixed Selectivity Index (MSI) corresponding to a parameter pair. The top row (Dataset 1) shows position vs. grip type, while the remaining rows (Dataset 2) depict orientation vs. grip type, laterality vs. grip type, and orientation vs. laterality, respectively.

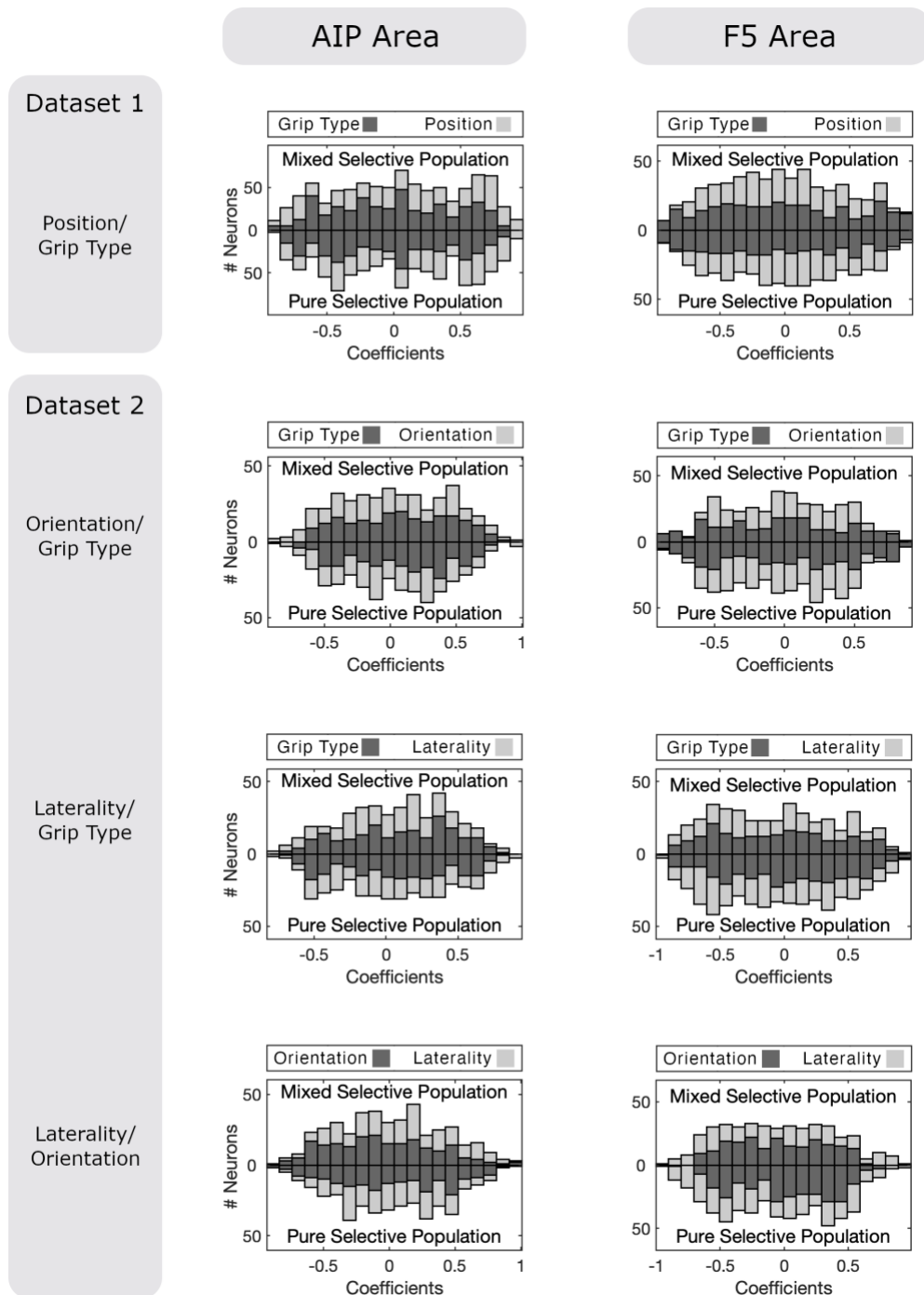


Figure S5. In each panel, the distributions of regression coefficients for a parameter pair are shown separately for mixed (top) and pure (bottom) selective subpopulations.

AIP Area

F5 Area

Dataset 2

Orientation/ Grip Type

MSI > 0:
Grip Type
MSI < 0:
Orientation

Laterality/ Grip Type

MSI > 0:
Grip Type
MSI < 0:
Laterality

Laterality/ Orientation

MSI > 0:
Orientation
MSI < 0:
Laterality

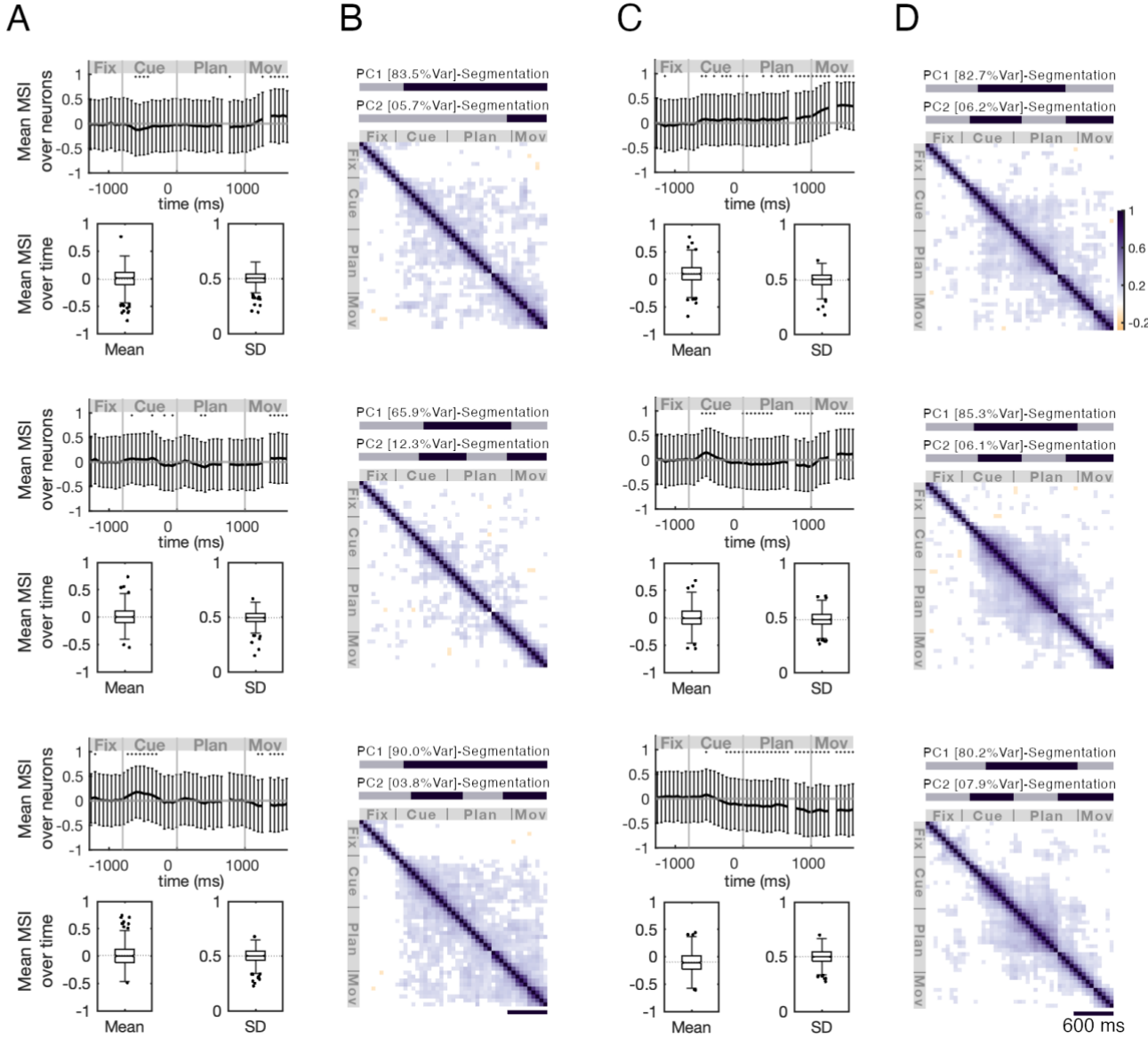


Figure S6. Dynamics of neural selectivity. Each row of panels represents a parameter pair from dataset 2. For each area, the top row shows orientation vs. grip type, and the remaining rows depict laterality vs. grip type and orientation vs. laterality, respectively. **A** and **C**: Single neurons' selectivity fluctuates substantially across the task. In each panel, the top plots show the time-dependent Mixed Selectivity Index (MSI), computed in 60-ms bins and averaged across neurons in AIP (**A**) and F5 (**C**). Error bars indicate the standard deviation across neurons within each time bin. Asterisks above the error bars mark time points at which the mean MSI differs significantly from zero (t-test, $p < 0.01$). The bottom plots summarize each neuron's temporal selectivity profile by displaying its mean (left) and the standard deviation (right) of its time-dependent MSI across all 60-ms bins. These measures reflect both the central tendency and variability of each neuron's selectivity over the course of the trial. **B** and **D**: Population-level selectivity is organized within a low-dimensional structure. Each panel shows a similarity matrix displaying the significant correlations of neuronal MSI values across all pairs of time bins. The bar plots indicate the time segmentation of the first two MSI principal components (PCs), obtained by detecting change points in their root-mean-square (RMS) values. Gray and black intervals indicate segments of stable PC activity.

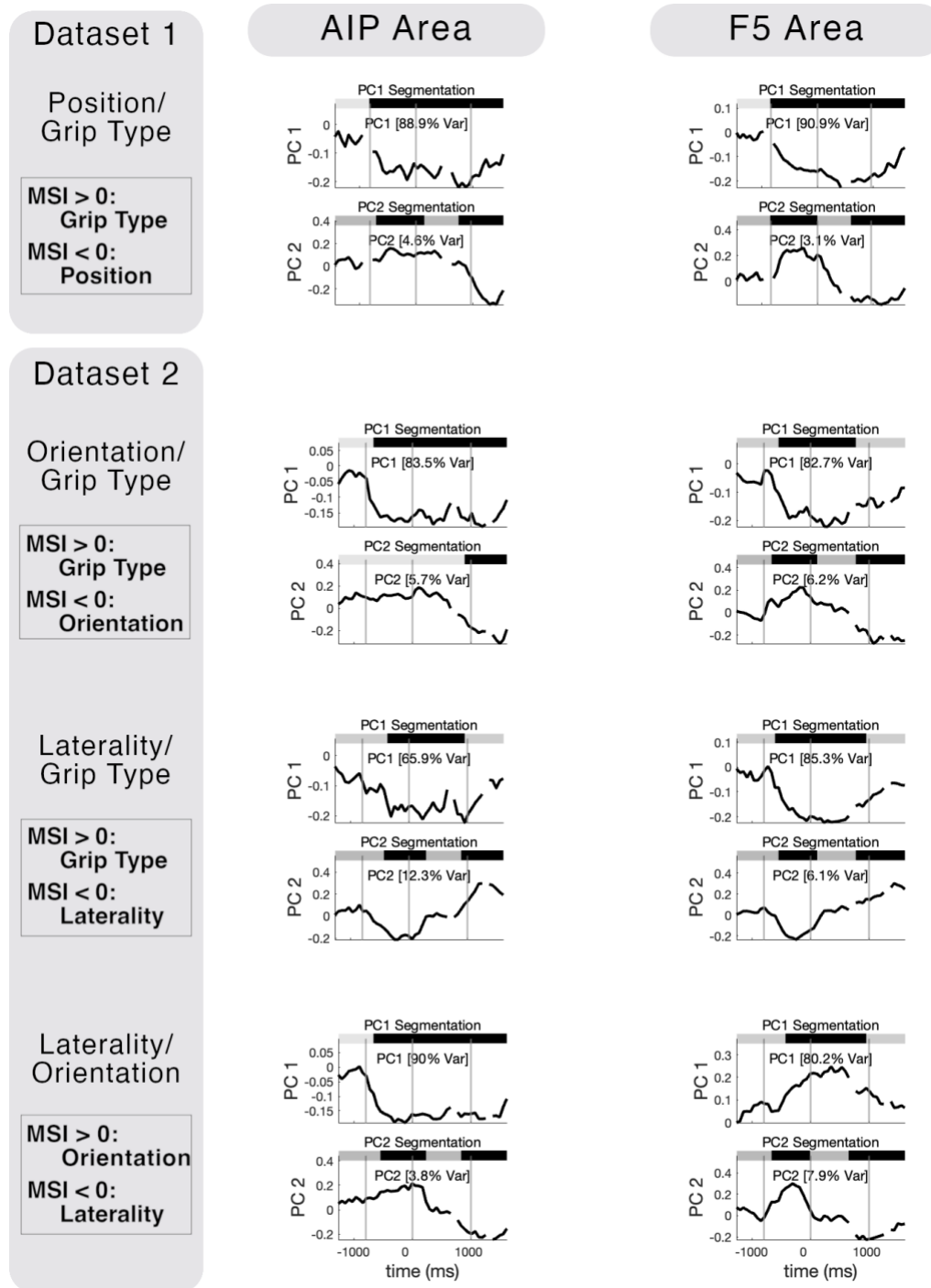


Figure S7. PCA analysis of the time-dependent MSI values. For each parameter pair, the panels show the loading vectors for the first two principal components (PC1 and PC2) computed from the MSI data. Each loading represents a set of weights across time points that defines a temporal pattern explaining a substantial portion of the variance across neurons. Together, PC1 and PC2 illustrate the primary temporal profiles driving population-level MSI variability. Vertical lines indicate different task epochs, and the variance explained by each component is noted in the plots. Similar to Fig. 5 and S6, the bar plots indicate the segmentation of the first two MSI PCs over time, obtained by detecting change points in their root-mean-square (RMS) values. Gray and black intervals indicate segments of stable PC activity.

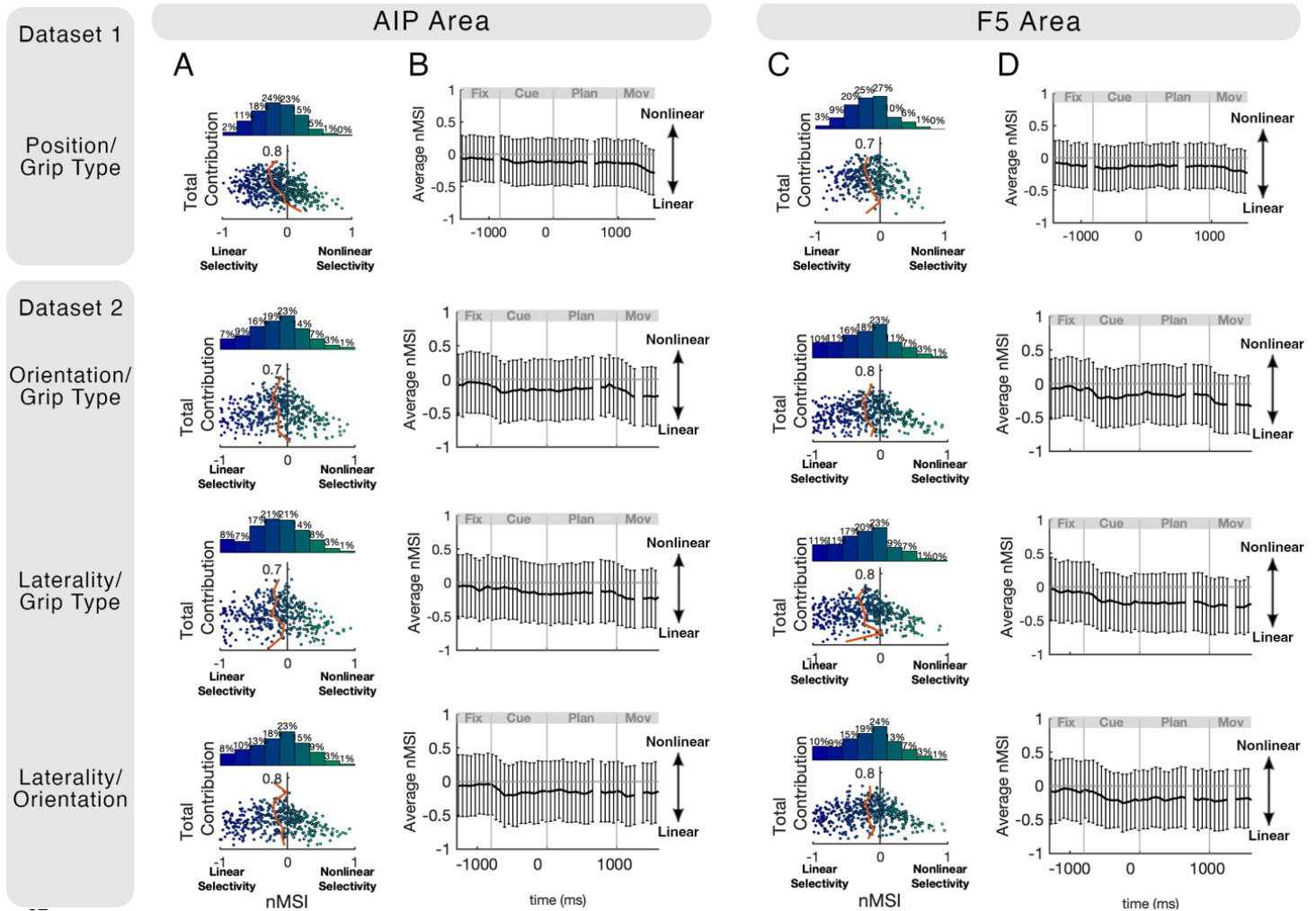


Figure S8. Interaction between task parameters. Each row of panels is dedicated to the nonlinear Mixed Selectivity Index (nMSI) of a task parameter pair. The top row (Dataset 1) shows position vs. grip type, while the remaining rows (Dataset 2) depict orientation vs. grip type, laterality vs. grip type, and orientation vs. laterality, respectively. **A** and **C**, Each figure displays nMSI distributions of a task parameter pair. The top histograms show the distribution of nMSI values, while the bottom scatter plots illustrate the total contribution strength of each neuron against the nMSI index. Red lines indicate moving bin averages of nMSI along the (vertical) total contribution strength axis. **B** and **D**, Average nMSI across neurons in 60-ms time bins for AIP (**B**) and F5 (**D**) areas. Error bars indicate standard deviation, and vertical lines separate task epochs.