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Supplemental Information

Deliberation and Commitment in the Premotor and Primary Motor Cortex during Dynamic Decision Making

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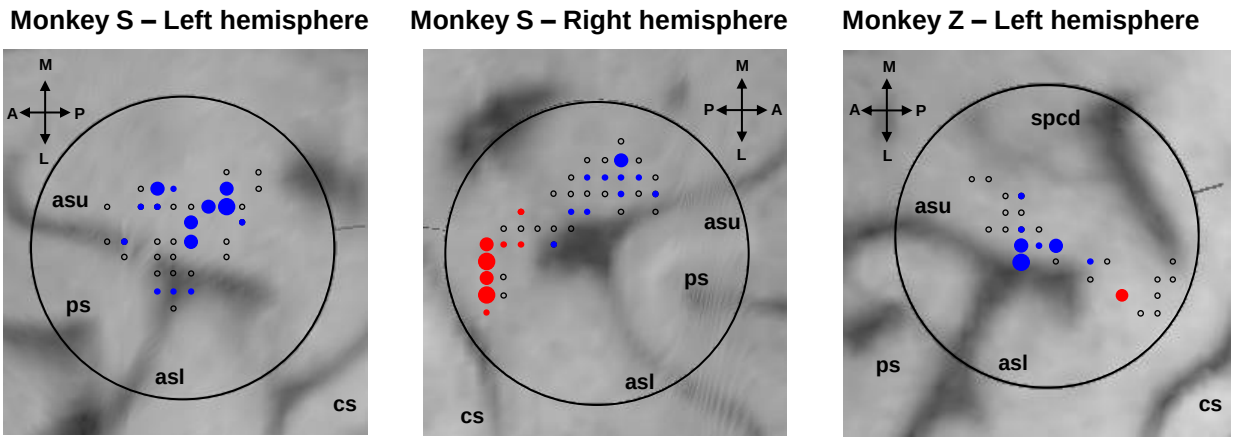
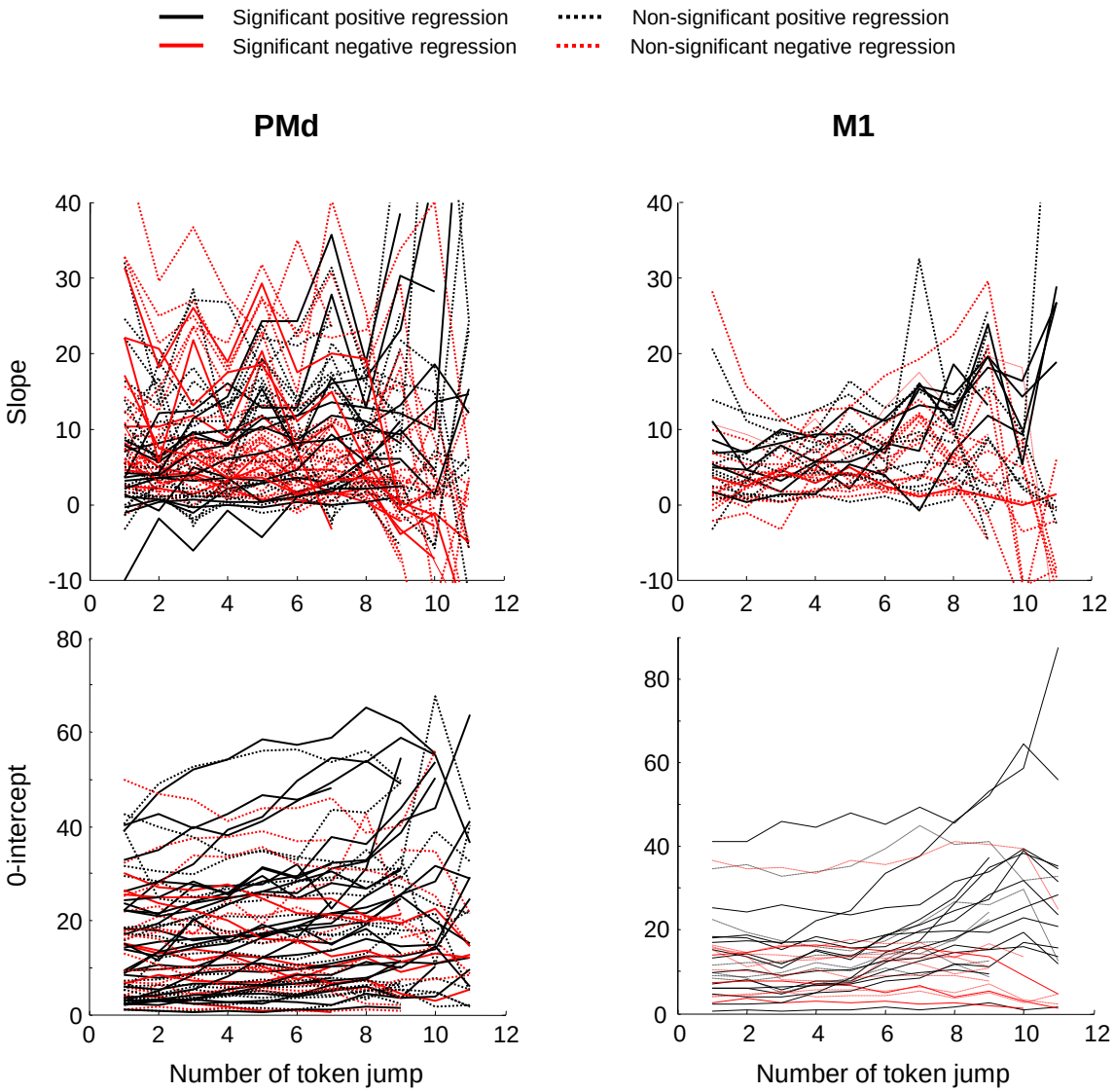
Supplemental figure S1 – Location of recording sites in PMd and M1 (related to Figures 2 and 6)



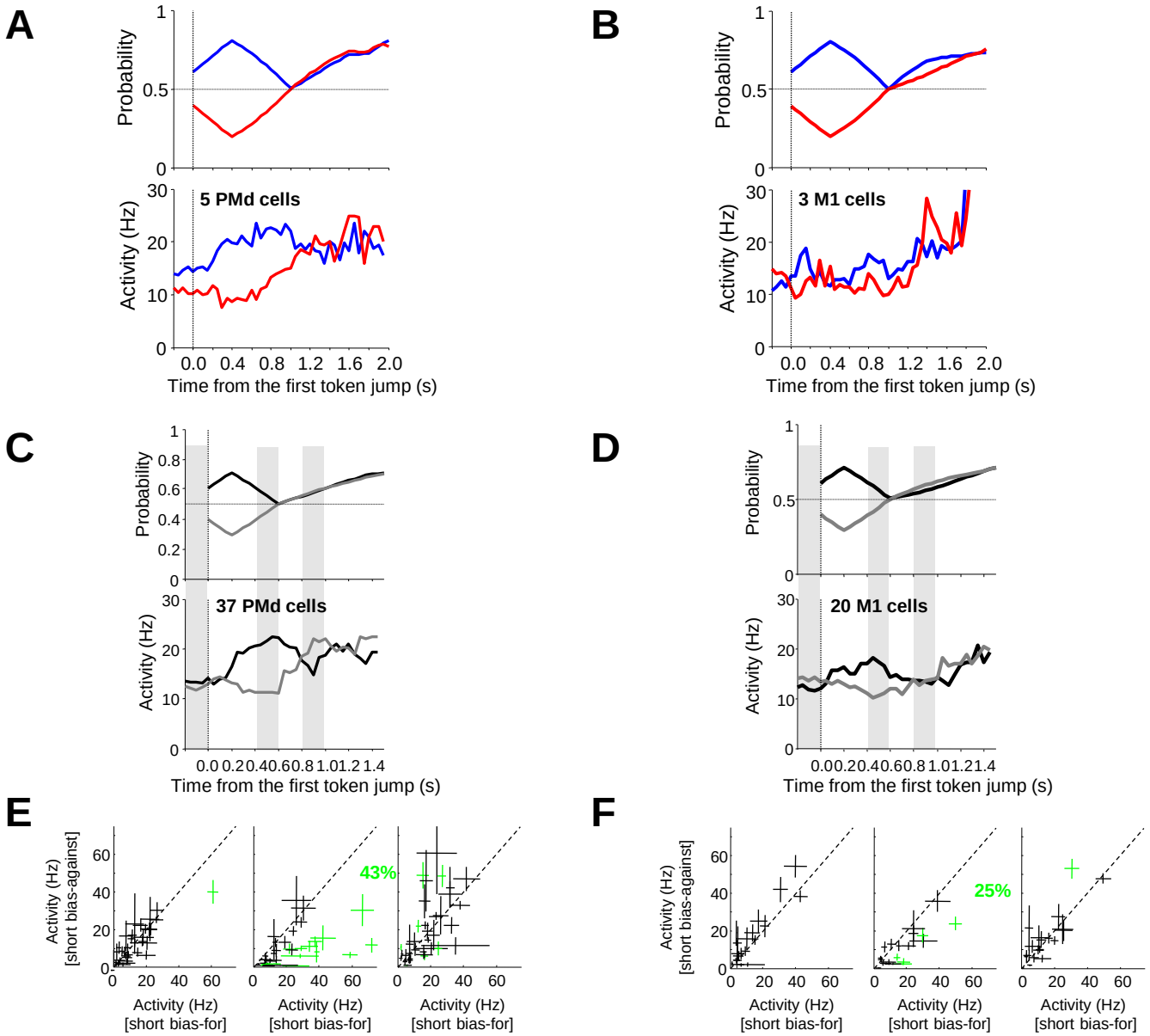
Reconstructed images of the brain surface from anatomical MRI scans. Large black circles illustrate the location of the recording chambers. Locations of decision-related cells tuned in the tokens task are shown with colored circles (blue, PMd; red, M1). Locations where other cell types were recorded are illustrated with small black circles. A: anterior; P: posterior; M: medial; L: lateral.

Supplemental figure S2 – Effect of decision duration on correlation parameters (slope and baseline) between neural activity and sensory evidence (related to Figure 3)



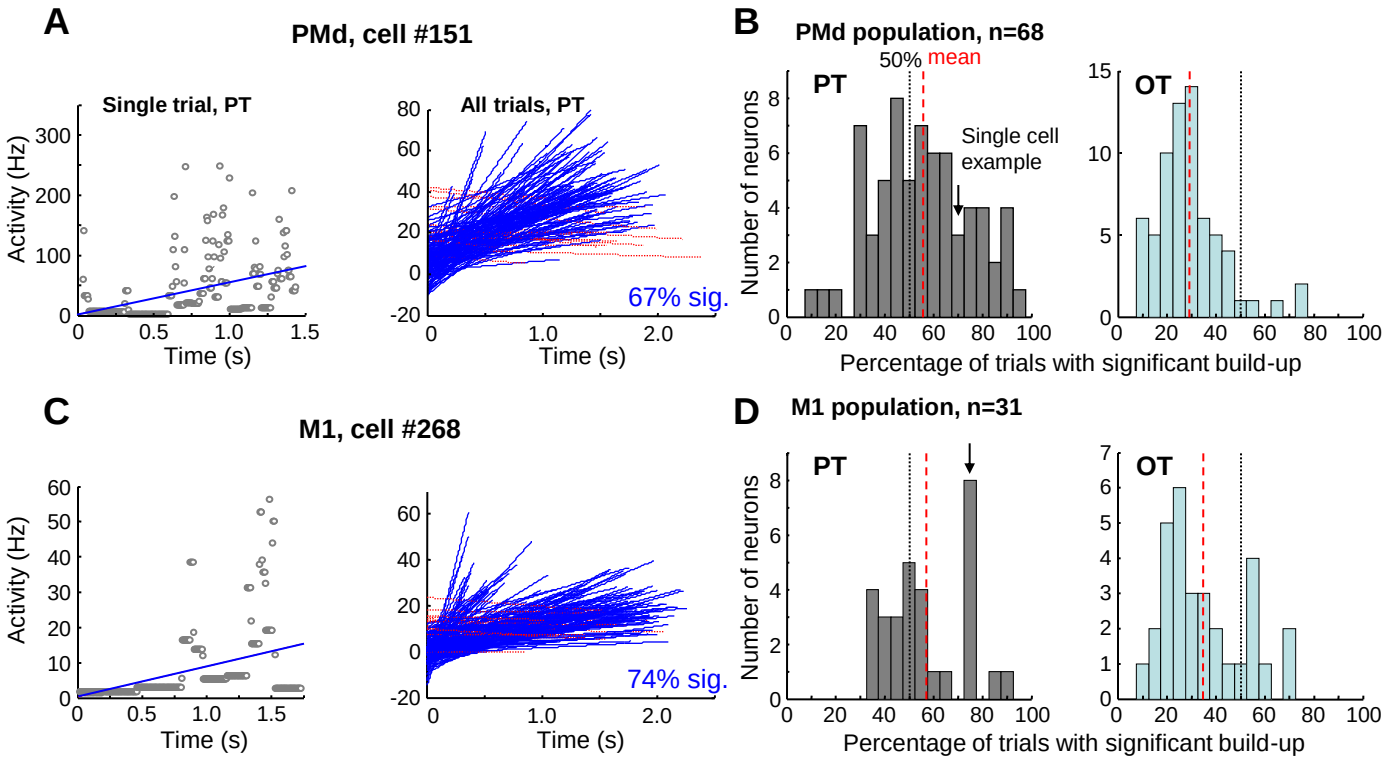
In Figure 3, we illustrate the relationship between the neural activity of decision-related neurons averaged in a 200 ms epoch and the SumLogLR values computed 200 ms before that time as a function of elapsing time (i.e., after each token jump before decision time). Figure S4 shows for each of these cells in PMd and M1 the coefficients (slope, top panels; baseline; bottom panels) of the linear regressions calculated through the data illustrated in Figure 3. Calculations are based on the equal evidence point between the two targets (i.e., SumLogLR = 0, see the vertical dotted line in Figure 3). Colors and line style illustrate the result of a linear regression calculated through the data, reflecting the evolution of the parameters as a function of the number of token jumps before the decision. The plots demonstrate that many cells in both PMd and M1 show a change in both the slope and the baseline of their activity as a function of elapsing time. We note also that overall, the main effect of time on the neural activity is a baseline shift, and slope changes are much more modest.

Supplemental figure S3 – Neural activity does not integrate the sensory state (related to Figures 4 and 5)



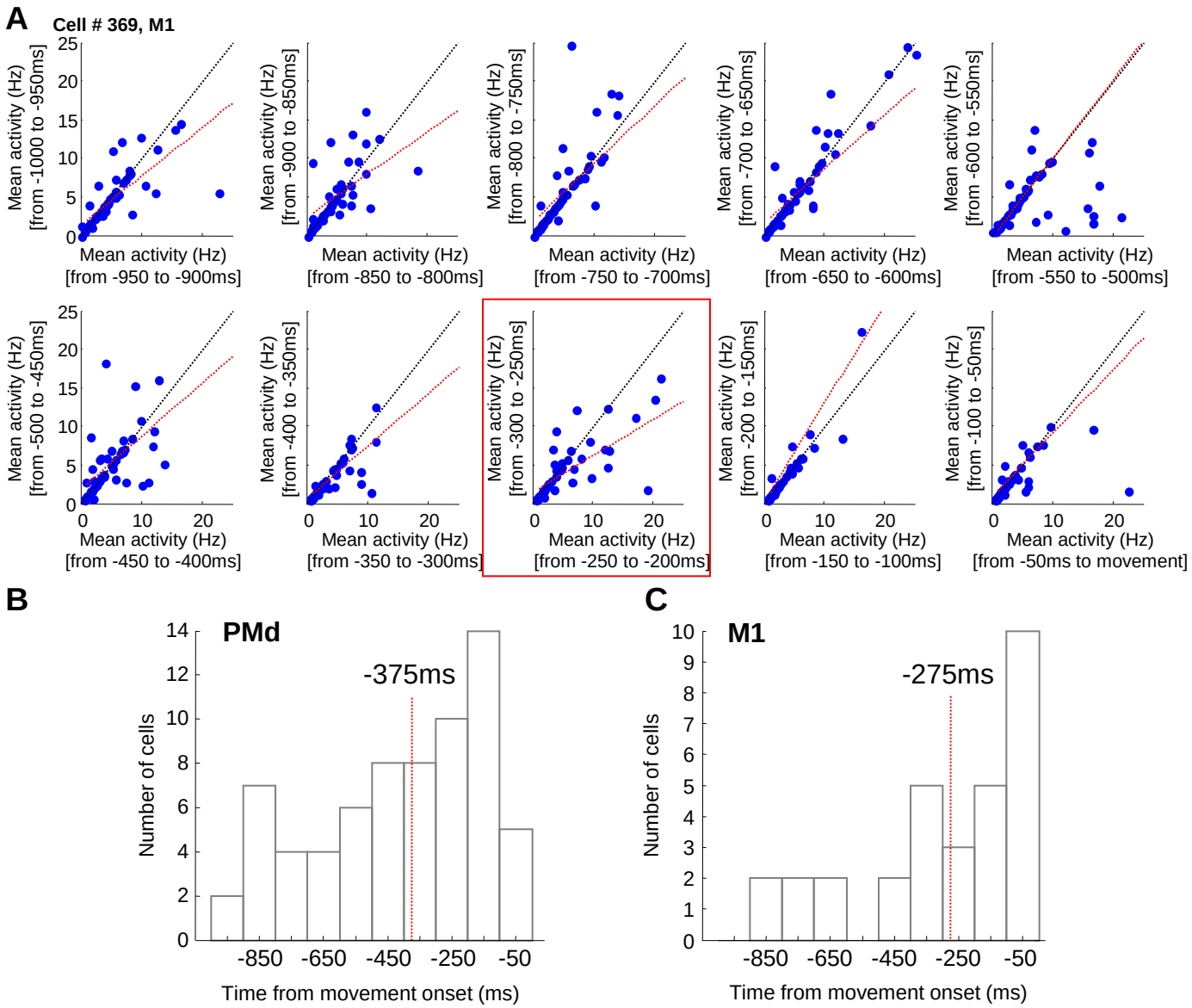
A. Top: Mean success probability with respect to PT during long bias-for (blue) and long bias-against trials (red). Bottom: Average activity of 5 decision-related PMd neurons during the two trial types. Only 5 neurons were recorded during at least 4 trials of each type with DT ≥ 1000 ms and are included in this plot. **B.** Same as A for 3 M1 cells. **C.** Top: Mean success probability with respect to PT during short bias-for (black) and short bias-against trials (gray). Bottom: Average activity of 37 decision-related PMd neurons during the two trial types (to be included, neurons had to be recorded for at least 4 trials of each type with DT ≥ 600 ms). Gray shaded areas illustrate the periods of analysis shown in E. **D.** Same as C for 20 M1 cells. **E.** Comparison of mean neural activity (±SE) of the 37 PMd neurons recorded during short bias-for versus short bias-against trials, from -200 ms to the first token jump (left panel), from 400 to 600 ms after the first token jump (middle panel), from 800 to 1000 ms after the first token jump (right panel). Green crosses illustrate neurons with a significant modulation of activity. Percentages denote the proportion of significantly modulated cells. **F.** Same as E for the 20 M1 cells.

Supplemental figure S4 – Neural activity as a function of time at the individual trial level (related to Figure 6)



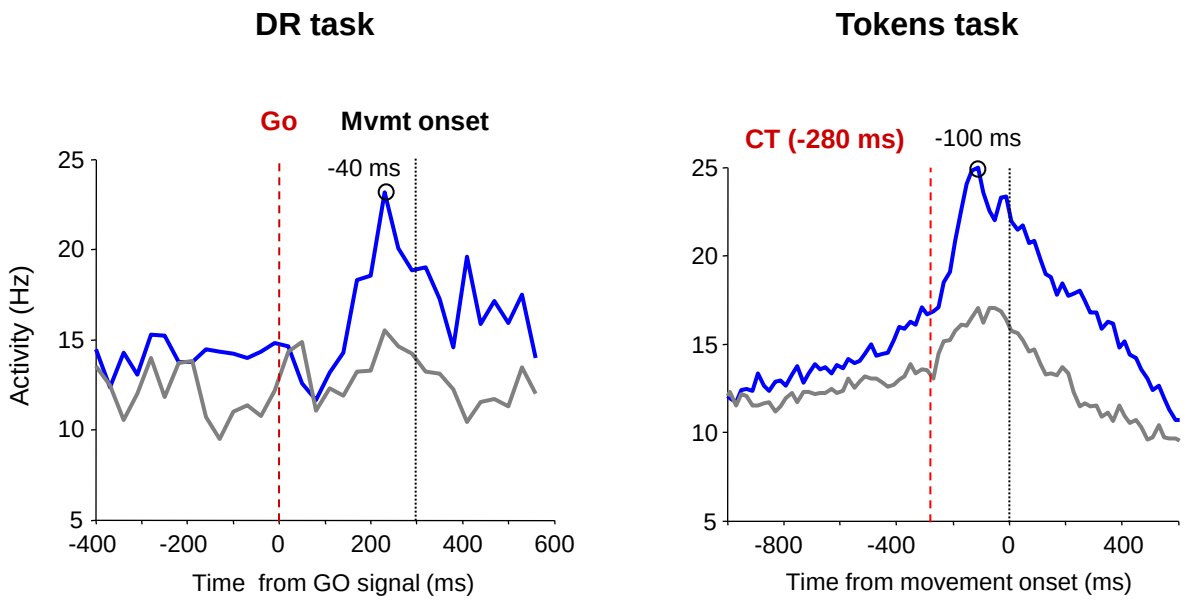
This analysis tests whether the build up to a peak (Figure 6) exists at the single-trial level or is an artefact of averaging over trials of different lengths. **A.** Left panel: For one PMd cell, we show the instantaneous firing rate in one example trial in 5 ms bins (gray circles, partial inter-spike interval method) from 200 ms after the first token jump to our estimated decision time. The blue line indicates a linear regression through the resulting data. Right panel: The same regression analysis for each individual trial during which the monkey chose the cell's preferred target (PT). Blue line: increasing linear regression; red line: decreasing regression; solid line: significant regression; dotted line: non-significant regression. Percentage denotes the proportion of significantly increasing regressions. In this example, neural activity significantly increases until the decision time in 67% of trials. **B.** Distribution of the percentage of individual trials showing a significant increase of activity during the decision process for each PMd neuron. Trials are grouped as a function of whether the monkey chose the cell's preferred (left) or opposite (right) target. Across the population, 38/68 PMd cells had a significant regression in at least 50% of individual PT trials. **C.** Same as A for one example M1 cell. **D.** Same as B for a population of 31 M1 neurons. In M1, 18/31 cells had a significant regression in at least 50% of PT trials. Given the highly noisy nature of cortical activity, this is strong support that the phenomena we report in Figure 6 exist at the level of each individual trial.

Supplemental figure S5 – Timing of the suppression of the activity related to the unselected option (related to Figure 6)



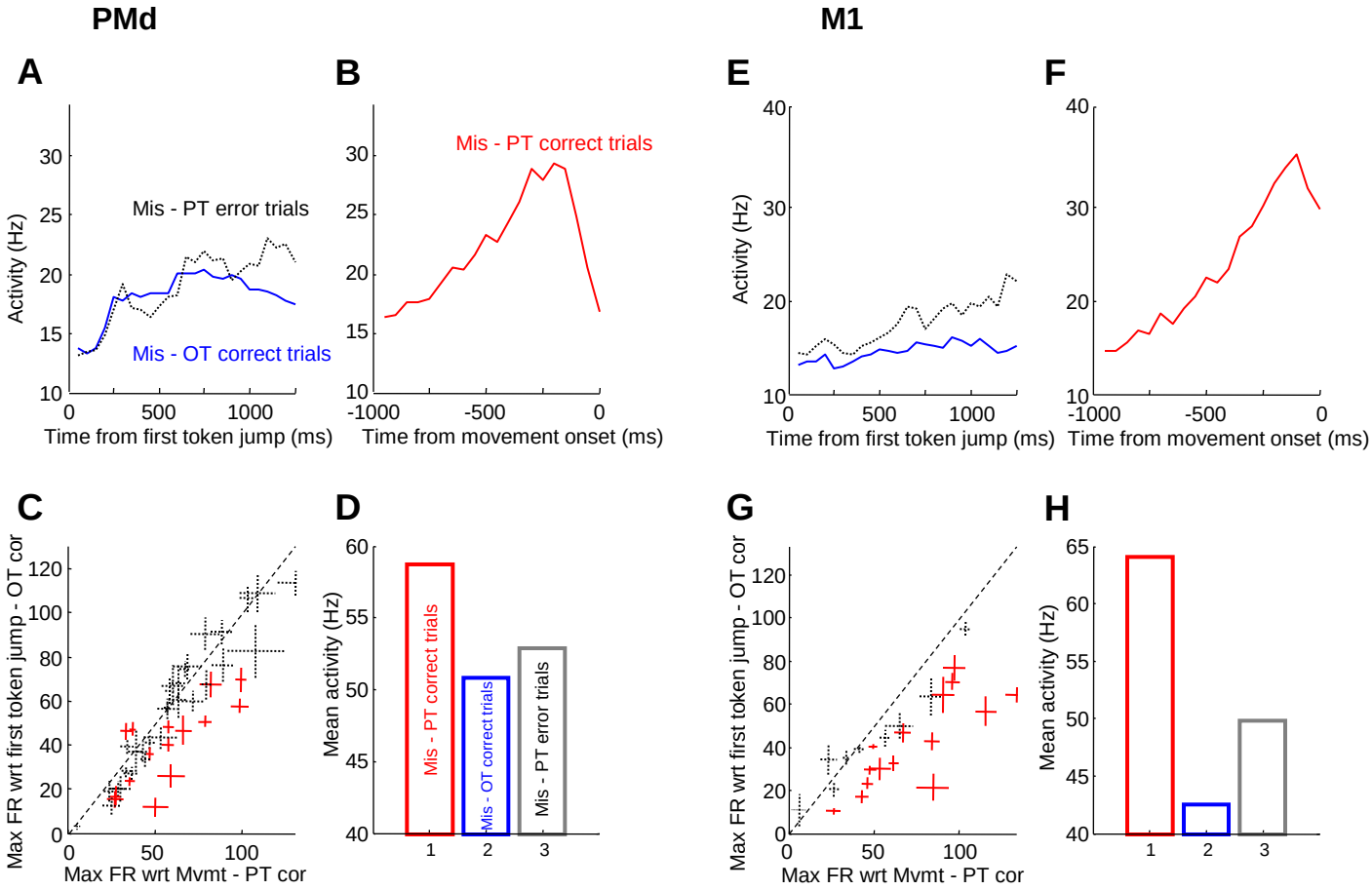
Visually, it appears on Figure 6C that M1 neural activity related to the unselected option is suppressed at the time of commitment (i.e. when PMd activity related to the selected option reaches a peak). In contrast, no such clear suppression is apparent in PMd. Here, we present an analysis aiming to determine, at the level of individual cells, the timing of the suppression of activity when the monkey chooses the cell's non-preferred target. To this end, for each cell we performed a trial by trial analysis comparing activity related to the unselected option between consecutive 50ms bins at different latencies with respect to movement onset, from 1000ms preceding movement onset and every 100ms thereafter until movement onset (10 comparisons). Panel A illustrates each of the 10 resulting scatter plots for an example M1 cell, comparing mean activity in the two consecutive bins on each individual trial. We computed a regression through the data for each of these scatter plots and calculated its slope. The time at which the slope differs most from the unity line was considered the approximate time at which the suppression occurred. In the example cell in A, this happened 250ms before movement (red box). The distributions of these timings are shown for all PMd (B) and M1 cells (C). Note that the distribution for PMd cells is broad, suggesting an absence of a specific robust suppression. In contrast, the distribution for M1 has a peak at 350ms and another at 50ms before movement onset, and a mean of 275ms.

Supplemental figure S6 – M1 pre-movement activity in the DR task and in the tokens task (related to Figure 8)



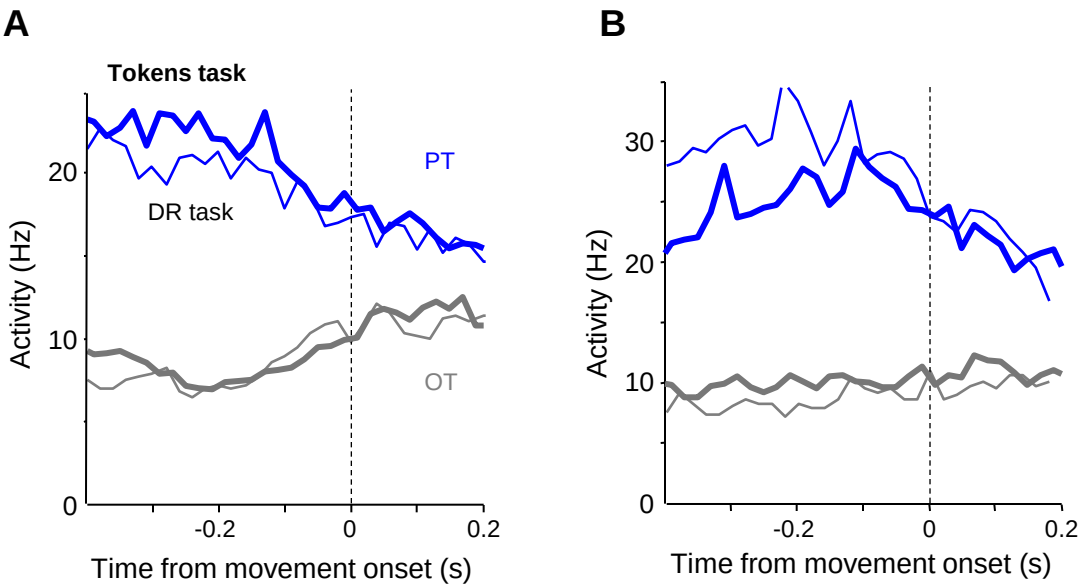
Left panel: Average activity of 19 M1 neurons recorded in the delayed reach task. These cells satisfied two following criteria: (1) they were not tuned before the decision in the tokens task and (2) their pre-movement activity (in the last 300 ms preceding movement onset) was significantly correlated with upcoming movement speed. Activity is aligned on the GO signal when monkey either chose the cell's preferred target (blue) or opposite target (gray). These targets are selected based on each cell's highest/lowest pre-movement response in the tokens task. **Right panel:** Activity of the same population of cells in the tokens task. Activity is now aligned on movement onset. The vertical dotted red line illustrates our estimate of commitment time (see figure 7).

Supplemental figure S7 – Analysis of misleading trials (related to Figures 2, 6, 7)



A. Average activity, aligned on the first token jump, of 33 PMd cells during misleading trials when monkeys correctly chose the cells' non-preferred target (blue line) or erroneously chose the cells' preferred target (black dotted line). Cells must be recorded for at least 5 misleading trials in each condition to be included. **B**. Average activity of the same 33 PMd cells aligned on movement onset when monkeys correctly chose the cells' preferred target. **C**. Comparison of the mean maximum firing rate (±SE) of 33 PMd neurons recorded during misleading trials, during a 1250ms period following the first token jump in trials during which monkeys correctly chose the OT *versus* during the 1000 ms preceding movement onset in trials during which monkeys correctly chose the cells' PT. Red crosses illustrate neurons with a significant difference in activity. **D**. Average maximum neural activity computed across PMd cells during a 1000ms period preceding movement onset in correct PT-chosen trials (red bar), during a 1250ms following the first token jump in correct OT-chosen trials (blue bar) and during the same period in error PT-chosen trials (gray bar). **E-F**. Same as A-D for a population of 25 M1 neurons.

Supplemental figure S8 – PMd and M1 decision-related activity in the DR task and in the tokens task (related to discussion)



A. Average activity of the 30 PMd neurons illustrated in Figure 8 during the delayed reach task (thin lines) and during the tokens task (thick lines), when the monkey chose either each cell's PT (blue lines) or OT (gray lines). Activity is aligned on movement onset. **B.** Same as A for the population of 18 M1 neurons illustrated in figure 8.