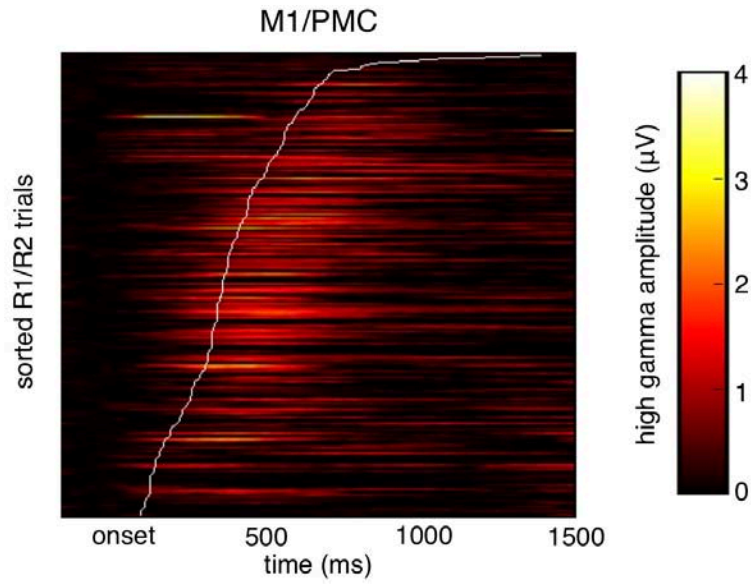


### Supplementary Figure 1

Stimulus-locked electrophysiology.

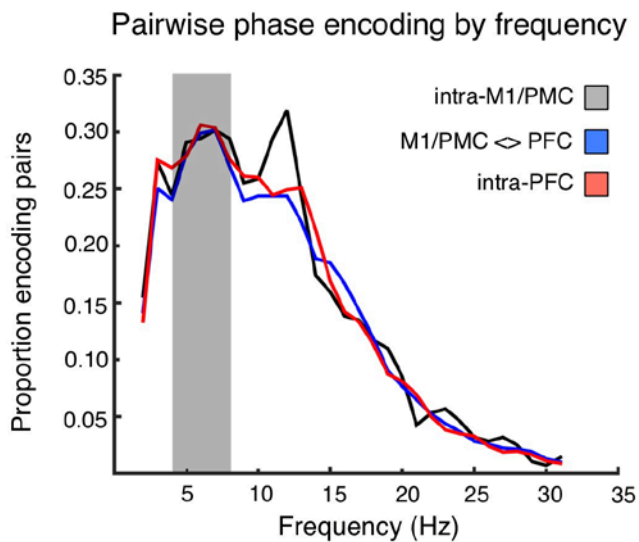
Of the 140 frontal electrodes included in the analysis, 31 (22.1%) showed a significant main effect of task on stimulus-locked high gamma (80-150 Hz) amplitude. The figure above shows the average percent variance across time and frequency bands explained by the task-responsive electrodes. Although there is also significant encoding of task on theta and beta amplitude, the neurophysiological origin of changes in those bands are less clear and thus were not addressed in our manuscript.



### Supplementary Figure 2

#### Frontal high gamma amplitude tracks trial-by-trial response times.

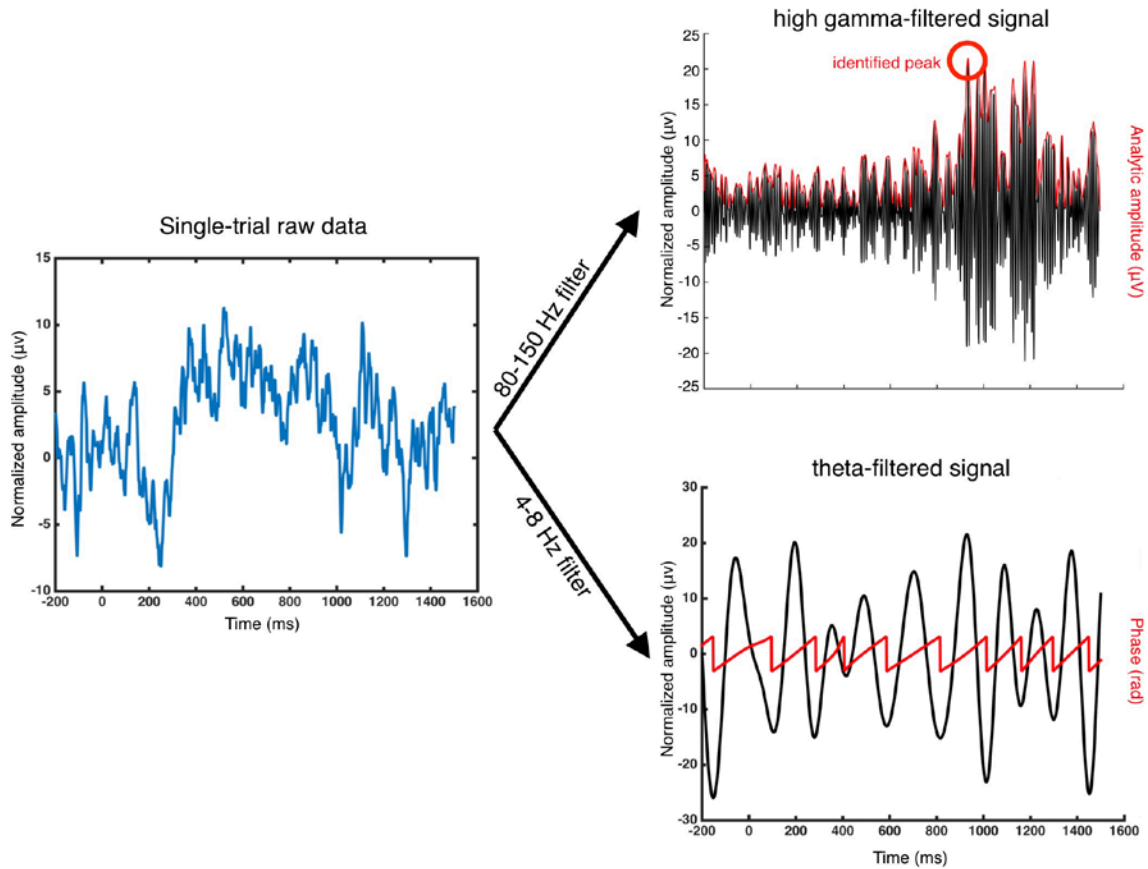
Stacked single trial M1/PMC high gamma activity sorted by response time for R1/R2 conditions demonstrates the high single trial high gamma signal-to-noise tracking motor response.



### Supplementary Figure 3

Frequency specificity of phase encoding.

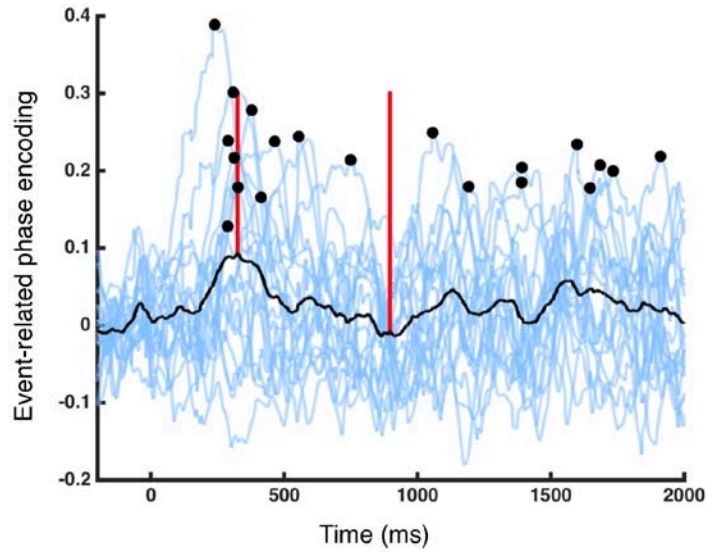
Plot showing the percent of phase-encoding electrode pairs broken out by location of the encoding pair (intraregional M1/PMC, interregional M1/PMC with PFC, and intraregional PFC) and by frequency band using 30 2-Hz overlapping passbands from 1 to 31 Hz. There is a clear density in the theta range (shaded region, 4-8 Hz). For electrodes within M1/PMC, there is also an increase in the mu-rhythm (8-12 Hz) range; this phenomenon was not further addressed in our current manuscript.



#### Supplementary Figure 4

Procedure for extracting high gamma analytic amplitude and theta phase from raw ECoG data.

The raw ECoG data is filtered in both the high gamma and theta bands, from which we extract estimates of the instantaneous high gamma analytic amplitude and theta phase. These allow us to examine the relationship between these signals and the task.



### Supplementary Figure 5

Single-trial peak finding.

This figure shows an example of 20 individual theta phase encoding trials for one subject. Each individual trial is plotted as a blue line, with the 20-trial average plotted in black. The identified individual trial phase encoding peak is plotted as a black dot at the peak location. The two red vertical lines show the average phase encoding time as identified from the 20-trial average (left) or from the average of the 20 individual trial times (right). This result highlights the peak trial-by-trial encoding time variability that is masked by a group average.