

Human brain dynamics leading to fast responses

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Sudden responses to world events are often crucial for survival, so understanding the neural origins of fast behavioral responses from a neuroscientific perspective may be key to understanding the global organization and dynamics of neural systems. Despite the large number of studies on reaction times, few have addressed the correlation between behavioral responses and brain activity preceding responses in specific brain regions. Hemodynamic studies cannot address this issue because of the poor time resolution of BOLD signal changes and for the first time, we attempt to tackle specifically this problem using ERP/EEG analysis. In target trials of a spatial attention task in which 15 subjects, recorded using a 32-channel EEG montage, responded to infrequent stimuli presentation at a cued location. Subjects responded faster when activity at a far frontal right periocular electrode was larger in a 3-cycle 4.5-Hz (theta) window centered 100 ms before button press (figure 1). Both across and within subjects reaction times were negatively correlated with theta power in this time window. Detailed analysis indicates that this effect is uniformly distributed across all data trial as the distribution of power values shift with reaction time (figure 1B). Independent component analysis identified a cluster of far frontal processes (previously termed P3f or P2a), common to most subjects, whose behavior was similar to the right periocular frontal electrode signal. In an additional 256-channel recording session, this component was best modeled using 2 bilateral equivalent dipoles that localized to the region of inferior frontal cortex (residual variance <0.01%). We conclude that increased activity in this area, possibly involving inhibition of cognitive planning in frontal inferior areas, precedes fast selective response times.

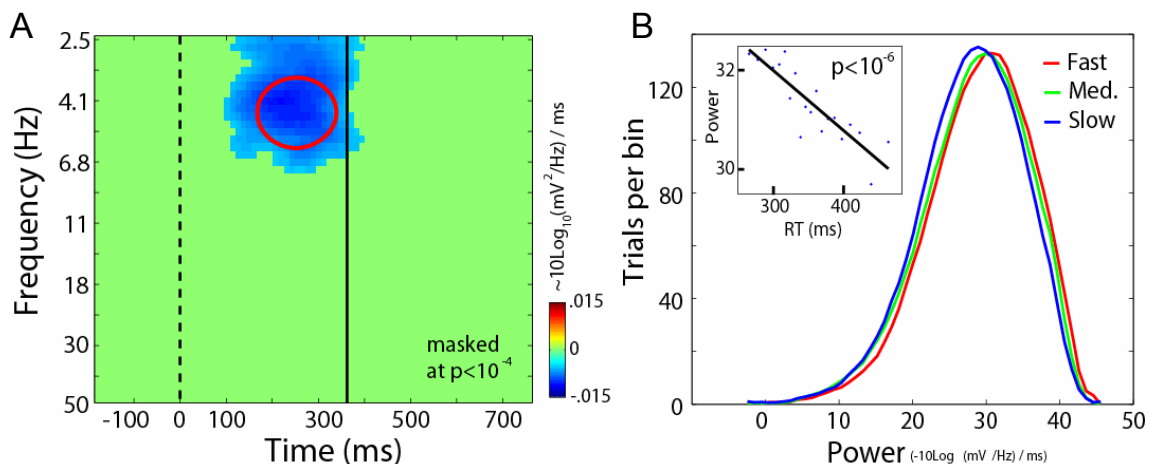


Figure 1: Correlations between response-locked non-artifact activity at the right periocular electrode and actual reaction times for all subjects. A. Correlation image showing correlations between reaction time and single-trial EEG power averaged over all trials and subjects (subject median reaction time had been subtracted from the collection of subjects' reaction time before computing correlations to remove the subject effect). In blue (negative) regions, more EEG power was associated with faster reaction times. Median reaction is 352 ms (vertical line). The negative correlation circled at low frequency prior to reaction time indicates that larger single-trial activity in this frequency band precedes fast responses. B. power histogram for the center of the circled region in A for 3 groups of data trials (of equal size) for fast, medium and slow reaction times. Distribution of power across trials is shifted uniformly with reaction time, irrespective of absolute power. It also shows that variations of power due to reaction time are small relative to the global distribution of power values. The inset panel show that the relation between spectral power and reaction time is close to linear in 20 quantile groups of increasing reaction time ($R=0.87$; $P<10^{-6}$).

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