Modulating the Readiness Potential via Theta-Burst Transcranial Magnetic Stimulation

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Voluntary action is typically preceded by a slow crescendo of cortical neuronal activity, known as the readiness potential (RP). The RP begins one second or more before action onset and is composed of early and late components, often associated with the pre/SMA and M1, respectively. RP onset is commonly thought to mark the beginning of unconscious action preparation (Shibasaki & Hallett, 2006). However, the conscious decision to move is only reported ~200 milliseconds before action onset (Libet et al., 1983). Many thus concluded that action preparation begins unconsciously, leaving a diminished role for consciousness in action generation.

However, an accumulation-to-bound model suggests that RP onset may not indicate motor preparation (Schurger et al., 2012). This model further provides a testable hypothesis that pre/SMA inhibition would modulate response times in arbitrary—but not deliberate—decisions and decrease the early components of the RP (Maoz et al., 2019). Here we propose to test this hypothesis using theta-burst stimulation (TBS), which is a non-invasive transcranial magnetic stimulation protocol that creates safe, reversible inhibition of the human cortex lasting for about half an hour. In particular, we inhibit M1 and pre/SMA activity (in separate trials) in an attempt to diminish the RP and affect behavior as above.

We recorded pilot data from 7 participants. Each came in for one session of TBS to M1 and another session of TBS to pre/SMA (randomly counterbalanced; EEG recorded throughout). In each session, we ran 100 trials of the standard Libet protocol before TBS and another 100 after TBS. We investigated the causal role of TBS on waiting times, W- and M-time reports, and early and late RP. We characterized the early (late) RP as activity occurring at Cz -1.5 to -0.5 s (-0.5 to 0 s) prior to EMG.

Contrary to our prediction, we found that TBS to M1 but not pre/SMA trends towards diminishing the early components of the RP. TBS to pre/SMA did not modulate the RP. Further we found that TBS to pre/SMA, but not M1, trends towards speeding up waiting times in the Libet task. We did not find an effect of TBS on W or M times.

If our results hold up and prove reliable on more participants, they suggest a greater role for M1 on the formation of the RP. With conflicting literature and pilot data, we plan to submit a registered report to test the causal role of M1 and pre/SMA in free action.