Urgency tunes center-surround inhibition in the motor system during action selection

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Action selection involves a tight balance between the competing demands of decision speed and accuracy. Recent work suggests that this balance is regulated by a context-dependent urgency signal, operating as a gain modulator of task-related activity: when decision between reaching movements are made under time pressure, activity in motor areas involved in arm movements is amplified. An open question relates to the generalization of this gain modulation in the motor system. Here, we investigated the impact of urgency on the excitability of different task-related and task-unrelated motor representations in humans by applying transcranial magnetic stimulation (TMS) over the primary motor cortex.

Subjects performed a modified version of the tokens task (Cisek et al., 2009, J Neurosci). In each trial, 15 tokens jumped one-by-one every 200 ms from a central circle to one of two lateral target circles; participants had to guess which of those two targets would ultimately receive the majority of the tokens, and to report their decision on a keyboard with either the left or right index finger. Importantly, the reward provided for correct choices was proportional to the number of tokens remaining in the central circle at the time of the response. Hence, because this number decreased as time elapsed during the trial, the urge to act grew accordingly. More critically, we manipulated the overall level of urgency by providing a different penalty for incorrect responses in two separate block types. The use of a low penalty encouraged the subjects to make hasty choices, thus ensuring a high urgency in a category of blocks, called $Urgency_{High}$. Other blocks were associated with a low urgency (called $Urgency_{Low}$) as they involved a higher penalty, promoting accurate choices at the cost of speed. We exploited TMS to elicit motor evoked potentials (MEPs) at different times during the token jumps, in muscles that were either involved in the task (*i.e.* an index finger "task-related" muscle) or in surrounding muscles that were not involved (*i.e.* thumb and pinky "task-unrelated" muscles). MEP amplitudes obtained from these muscles provided us with a muscle-specific assay of corticospinal excitability at the time of stimulation in $Urgency_{High}$ and $Urgency_{Low}$ blocks.

MEP amplitudes in task-related muscles became larger over time when elicited in a selected muscle. In contrast, MEPs obtained from task-unrelated muscles showed a progressive decrease in their amplitude. Interestingly both of these effects were stronger in the $Urgency_{High}$ than in the $Urgency_{Low}$ blocks. That is, higher urgency concomitantly increased facilitation of selected task-related muscles and suppression of surrounding task-unrelated muscles, a mechanism reminiscent of center-surround inhibition.