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LETTER

Beyond the point of no return: Last-minute changes in human motor performance

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Schultze-Kraft et al. (1) tested whether human volunteers can win a "duel" against a brain–computer interface (BCI) predicting movements based on real-time classification of early movement-related brain electric signals. The authors aimed to determine the exact time at which interruption or cancellation of movements is not possible anymore, and found this "point of no return" to be around 200 ms before the onset of muscle contractions measured by electromyography (EMG). However, even after onset of EMG activity, movements could be altered or cancelled. Having identified this point of no return, Schultze-Kraft et al. (1) argue against the idea that the onset of early movement-related brain signals, e.g., the Bereitschaftspotential (BP) (English: readiness potential) (2, 3) triggers a causal chain that cannot be interrupted. Such an idea, promoted by the interpretation of an experiment performed by Libet et al. (4), was used to deny the existence of a "free will." We would like to congratulate Schultze-Kraft et al. for their significant contribution toward clearing up this false doctrine. We would like to raise, however, an important point regarding the experimental setup and its link to previous work on the BP. Although the original work characterizing the BP (2) did not introduce any external cues or stimuli, several authors have introduced external cues, e.g., a "green light" or "go signal" (1), into their paradigms while still stating that movements were self-initiated. Such a statement, however, is not correct as the presence of such stimuli interferes with the self-initiatedness of movements. Furthermore, the prescription of a specific time window for initiation of movements combined with a green light or go signal shifts the paradigm from a clean BP experiment toward a contingent negative variation (CNV) paradigm, in which voluntary movements are externally triggered. This notion is important as the underlying neural substrates of the BP and CNV differ (5). We, thus, suggest to perform the same experiment without a green light and, if possible, without prescription of a specific time window to increase the impact and scope of the findings regarding the aspects of self-initiatedness and free choice.

Although, according to Libet et al.'s suggestion (4), humans are not consciously aware of their own planning during the early BP (~1.25–0.5 s before the muscular contraction), such awareness was found during the late BP (~0.5–0 s before muscular contraction). Interestingly, the late BP coincides with the point of no return as identified by Schultze-Kraft et al. (1) while allowing for "last-minute" changes beyond the point of no return even to the extent of not performing the action at all (Libet's veto). Thus, the identified time point may rather signify a state change from unconscious planning to conscious execution (and "on-line" learning). Motor learning does not only occur during actual practice but also in absence of overt movements ("off-line"). When consciously performed, such "mental rehearsal," e.g., in sports, also termed motor imagery (MI), is essential for performance management and improves motor learning. Besides facilitation of MI, BCI-based detection of altered or aborted movements may extend the point of no return, e.g., by neutralizing the execution of machine-based actions, e.g., when a soldier pulls a trigger.

1 Schultze-Kraft M, et al. (2016) The point of no return in vetoing self-initiated movements. *Proc Natl Acad Sci USA* 113(4):1080–1085.
2 Kornhuber HH, Deecke L (1965) Hirnpotentialänderungen bei Willkürbewegungen und passiven Bewegungen des Menschen: Bereitschaftspotential und reafferente Potentiale. *Pflugers Arch* 284(1):1–17.
3 Kornhuber HH, Deecke L (2012) *The Will and Its Brain—An Appraisal of Reasoned Free Will* (University Press of America, Lanham, MD).
4 Libet B, Gleason CA, Wright EW, Pearl DK (1983) Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act. *Brain* 106(Pt 3):623–642.
5 Cui RQ, et al. (2000) High resolution spatiotemporal analysis of the contingent negative variation in simple or complex motor tasks and a non-motor task. *Clin Neurophysiol* 111(10):1847–1859.

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