Title: The readiness potential and antecedent pupil dilations reflect two distinct aspects of conscious volition

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When we act voluntarily, we experience a distinct subjective feeling of willing our actions that is noticeably absent from involuntary actions such as reflexes. Notably, the feeling of will (a.k.a. conscious volition) is reliably preceded by the Readiness Potential (RP; Libet et al., 1983), a buildup of brain activity beginning more than one second before movement. How the RP relates to conscious volition remains unclear because two different methodologies for assessing conscious volition have found conflicting patterns of results. “Probe method” studies interrupt participants while they make voluntary movements and ask whether they were preparing to move when the probe occurred (e.g. Matsuhashi & Hallett, 2008; Parés-Pujolràs et al., 2019). Notably, reported awareness of preparation was associated with RP-like buildups (Parés-Pujolràs et al., 2019), suggesting the RP *is* related to conscious volition. However, the RP does not correlate with the timing of motor intention retrospectively reported using a clock (Haggard & Eimer, 1999; Schlegel et al., 2013), suggesting the RP *is not* associated with conscious volition.

We hypothesized that conflicting results emerge because clock and probe methods target two different types of awareness: clock studies target the phenomenal experience of action initiation, or conscious volition, whereas probe studies target the metacognitive accessibility of preparatory processes. To investigate this hypothesis, we developed a novel probe method that controls for confounds present in prior studies. We found that reported awareness of preparation was not associated with RP-like buildups (BF = 0.091), indicating the RP does not relate to conscious volition. Computational modeling found that metacognitive access to the motor-preparatory process can explain these results, whereas a traditional RP model cannot.

What physiological process then, if not the RP, could reflect conscious volition? Pupil dilations reflect processing related to awareness (e.g., Wierda et al., 2012; Kang et al., 2015) and were shown to precede volitional actions (Richer & Beatty, 1985). We hypothesized that pre-movement pupil dilations relate to conscious volition and investigated this hypothesis in a modified clock paradigm. Earlier pupil dilations correlated with earlier reported onsets of the urge to move ($p = 0.0359$), suggesting that antecedent dilations relate to conscious volition. Controls demonstrated that such dilations did not reflect general expectation, motor execution, or action awareness. Our results thus indicate that the phenomenal experience of conscious volition may be reflected better by antecedent pupil dilations than the RP, but that the preparatory process the RP reflects may nevertheless be introspectively accessible. Furthermore, conceptually clarifying that clock and probe methods target different types of awareness has major implications for our understanding of volition and interpretation of prior work.