Neural Dynamics of Motor-Induced Attention during the Encoding and Retention of Temporal Intervals

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Accurate timing is essential for perception, decision-making, and action. Theories ranging from pacemaker-accumulator models to population dynamics converge on a key role for attention in modulating time perception. For instance, the Attentional Gate Theory (Zakay & Block, 1994) proposes that perceived duration increases with attentional allocation. Yet, how attention operates across encoding and retention phases, especially under momentary motor demands, remains less understood. To investigate this, we used a time reproduction paradigm while recording EEG, manipulating attentional load through continuous force exertion. Participants reproduced three interval durations (2, 3, or 4 seconds) under both force and no-force conditions. Linear mixed-effects modeling revealed that reproduced durations scaled with interval length ($p < .001$), indicating accurate encoding. However, reproductions were overall shorter under force ($p < .001$), especially at longer intervals (interaction $p = .002$), suggesting under-reproduction due to heightened attentional load. Variability increased with interval length ($p < .001$), in line with Weber's Law, but was not modulated by force. EEG analyses showed that alpha (8–12 Hz) desynchronization increased with interval length, peaking just before interval offset ($p < .0001$), consistent with temporal anticipation (Rohenkohl & Nobre, 2011). Crucially, alpha desynchronization during both encoding and retention predicted the reproduced durations, particularly for longer intervals ($p < .001$). Moreover, encoding under force elicited greater alpha desynchronization in EEG channels ipsilateral to the effector hand ($p < .01$). These findings suggest that alpha oscillations mark temporal attention and support the encoding and maintenance of time across both visual and motor regions. Our results extend timing theories by showing that sustained alpha desynchronization under motor load reflects the dynamic allocation of attentional resources during temporal processing.

Keywords: Timing, Memory, Alpha desynchronization, Force exertion, EEG