Beyond the threshold: Stimulus lexicality affects motor response execution in lexical decision.

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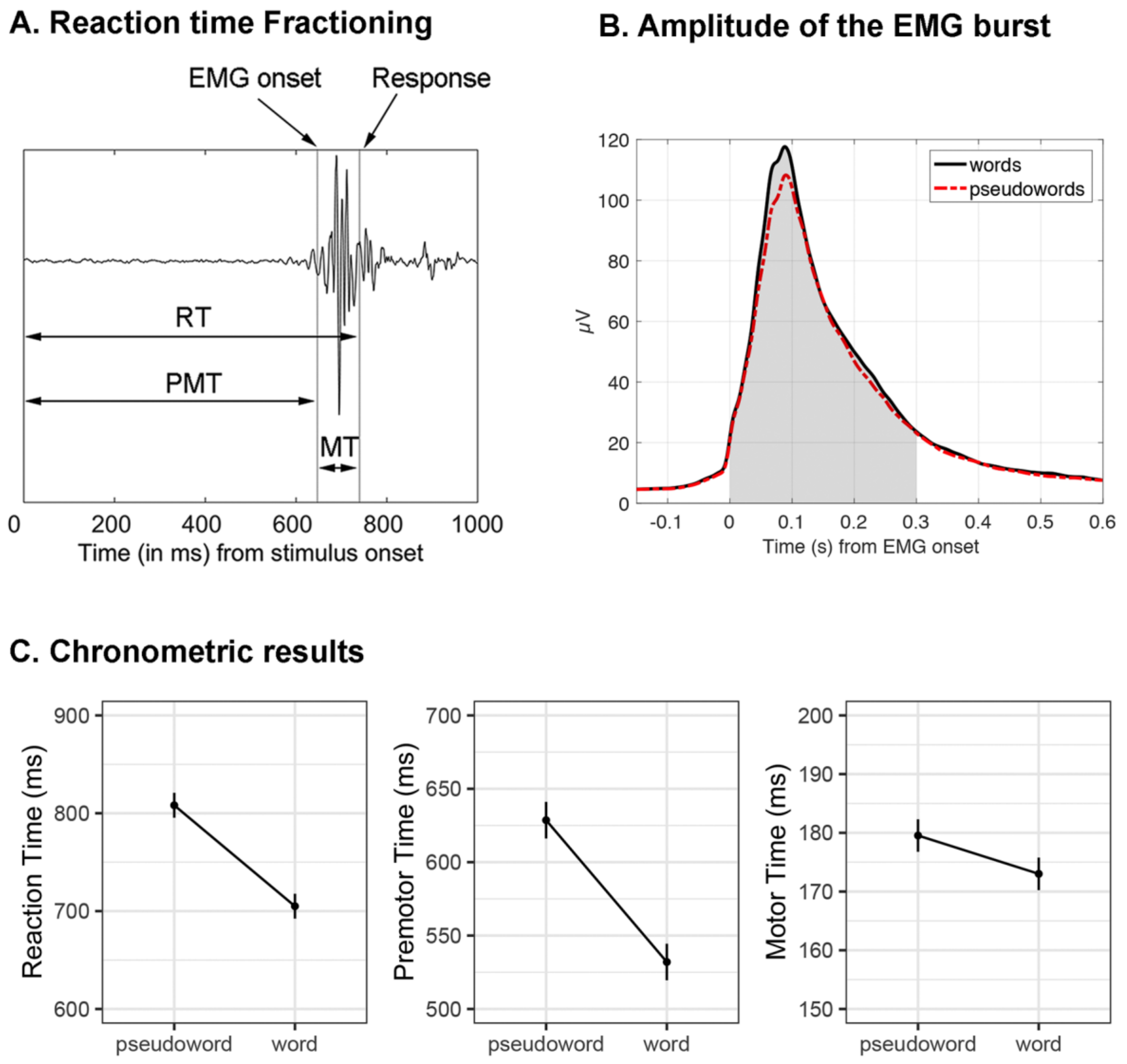
Models of word recognition (e.g., Coltheart et al., *Psychol Rev*, 2001) and production (e.g., Dell, *Psychol Rev*,1986) often rely on the notion of cascaded processing, with a continuous flow of information across different representational and processing stages yielding a parallel activation of multiple representations at different levels (e.g., semantics, phonology). The stage of motor response implementation, however, is typically excluded from this continuous flow of information, and is viewed as a discrete stage that serially follows the termination of upstream cognitive computations. Notably, psycholinguistic models share this cognition-action thresholding (Calderon et al., *Psychol Rev*, 2018) with decision-making models. For example, sequential sampling models of (binary) decision making, such as the drift-diffusion model (e.g., Ratcliff et al., *Trends Cogn Sci*, 2016), describe the decisional stage as a process of noisy evidence accumulation unfolding continuously over time until reaching a functional threshold, which would trigger the delivery of the motor-response.

In this work, we tested the assumption of a serial functional separation between lexical and motor processes in the context of a lexical decision task featuring simple, discrete motor-responses such as button presses. Participants (N = 42) were instructed to categorize strings of letters as either real words or pseudowords, by pressing the corresponding joypad triggers using their thumbs. In addition to reaction times and accuracy, we also recorded the electromyographic (EMG) signal from the muscles controlling the motor-response of the two hands (i.e., the flexor pollicis brevis). Using single-trial EMG traces, we partitioned the reaction times (i.e., the time elapsing from stimulus onset until button-press) into a premotor component (from stimulus onset until the onset of the EMG burst) and a motor one (time elapsing from the onset of the EMG burst until the button-press; Figure 1A).

The results (Figure 1C) showed the traditional effect of stimulus lexicality, with slower reaction times for pseudowords compared to real words. The bulk of the effect was captured at the level of premotor times but, importantly, it was fully reliable also at the level of motor times, with a longer time elapsing between the onset of the EMG burst to the final button press for pseudowords. Additionally, the average EMG bursts showed a significantly enhanced amplitude for word compared to pseudoword responses (Figure 1B).

The modulation of peripheral measures of motor response execution as a function of stimulus type challenges the widely held notion of a functional segregation between lexical-semantic processing and motor ones. These results may suggest that, at least for the lexical decision task, decisional processes may not be terminated before motor-response initiation. Differently, decisional processes might be envisaged as a continuous stream of processes that progressively map stimulus evaluation onto motor response channels. Notably, this continuity between cognition and action would seem to surface even in the case of discrete motor-responses such as the simple button-presses requested in the current experiment, which typically pose the most challenging test for continuous accounts of the transition from cognitive processing onto motor-response implementation. Possibly, motor-time modulations further reflect response monitoring processes intervening after response initiation, for example, to correct potential errors (e.g., Servant et al., *J Neurosci*, 2015). More in general, these findings call for additional investigations on the transition from cognitive-linguistic processing onto action, beyond the assumption of a strict serial architecture.

Figure 1. Measures and results from the lexical decision experiment



Note. A: Single-trial EMG signal is shown as a function of time (x axis, 0 = stimulus onset) together with the corresponding fractioning of the reaction time. RT = reaction time (time elapsing from stimulus onset until the button-press response); PMT = premotor time (time elapsing from stimulus onset until the onset of the EMG burst); MT = motor time (time elapsing from EMG onset until the final button press response). B: Grand-average EMG burst time-locked to its onset (0 on the x axis). The gray area represents the time-window on which differences in amplitude between words and pseudowords were tested, and resulted significant. C: Results for the lexical decision experiment with respect to the three measures extracted via reaction time fractioning (see panel A). Black points represent sample averages and error bars indicate corresponding 95% confidence intervals. The difference between words and pseudowords was significant for all the 3-indexes.