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Short Report

Body Locomotion as Regulatory Process

Stepping Backward Enhances Cognitive Control

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Theories of embodiment have recognized the significance of the motor system in influencing cognitive and affective processes (e.g., Barsalou, Niedenthal, Barbey, & Ruppert, 2003). Specific movements may become so strongly associated with a cognitive or affective state that their mere initiation elicits the corresponding state. Among these movements, approach and avoidance arm movements are the most widely studied. Arm flexion is habitually used for pulling something toward oneself, and arm extension is habitually used for pushing something away. As a result, these movements have become associated with positive and negative outcomes, respectively, and performing them tends to invoke corresponding reactions. Such approach and avoidance arm movements influence, for instance, individuals' liking for objects (Cacioppo, Priester, & Berntson, 1993), reaction latencies to positive and negative stimuli (Chen & Bargh, 1999), and even motivation to eat or drink (Förster, 2003).

Recently, we showed that approach and avoidance arm movements also regulate the recruitment of cognitive control (Koch, Holland, & van Knippenberg, 2008). Avoidance movements are usually performed in the context of aversive or problematic conditions that require enhanced control in order to focus on relevant information and to ward off negative consequences (e.g., Schwarz, 2002; cf. Kahneman, 1973). Thus, such movements are associated with the mobilization of cognitive resources. In line with this account, performing avoidance arm movements increased cognitive control relative to performing approach arm movements (Koch et al., 2008).

In the most fundamental and literal sense, approach refers to decreasing, and avoidance to increasing, the physical distance between the self and the outside world. In our view, *body locomotion* most purely taps into this fundamental nature of approach and avoidance. In everyday life, individuals typically approach desired stimuli by stepping forward and avoid aversive stimuli by stepping backward. Hence, it may be argued that body locomotion constitutes the purest and most ecologically valid form of approach and avoidance behavior. The idea that body locomotion may trigger approach and avoidance orientations has, so far, not been tested.

The research described here aimed to test the role of body locomotion in the recruitment of control processes. Because of the conditioned link between stepping backward and aversive situations, we expected that stepping backward would increase the recruitment of cognitive control relative to stepping forward. To test this prediction, we gauged cognitive functioning by means of a Stroop (1935) task immediately after a participant stepped in one direction. The Stroop task requires naming the color in which stimulus words are printed while ignoring their semantic meaning, which is actually processed more automatically than the color. Cognitive control is required to override the tendency to respond to the semantic meaning and instead respond to the color.

METHOD

In a study ostensibly on motion and language, 38 native Dutch-speaking university undergraduates (8 males, 30 females; mean age = 21.5 years) at Radboud University Nijmegen completed eight blocks of a Stroop task. In this task, the color in which stimulus words were written had to be named as quickly as possible. Stimulus words were color and noncolor words written in different ink colors. In consistent trials, the ink color matches the semantic meaning of the stimulus word (e.g., "blue" written in blue ink); in inconsistent trials, the ink color and stimulus word are mismatched (e.g., "red" written in blue ink). Filler trials used noncolor words. Responding in the Stroop task is generally facilitated on consistent trials and impeded on inconsistent trials, relative to responses to noncolor filler words. On the critical, inconsistent trials, performance depends on the ability to suppress the natural tendency to read the word.

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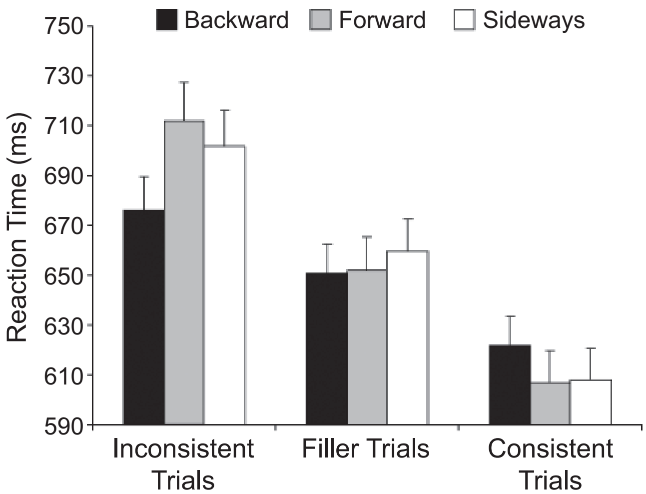

Fig. 1. Mean reaction times (in milliseconds) on inconsistent, filler, and consistent trials as a function of stepping direction (backward, forward, or sideways). Error bars indicate standard errors of the means.

Each block of the Stroop task consisted of 12 trials (4 consistent, 4 inconsistent, and 4 filler trials) that were presented in a random-like order. Before each block of trials, participants received instructions via the computer program to take four steps in one of four directions: forward (approach), backward (avoidance), left (control), or right (control). Stepping direction was manipulated within subjects, with each direction occurring twice. The order of the stepping directions was randomly determined, with the restriction that all four directions were used before a direction was repeated. The Stroop task was run on a laptop computer mounted on a mobile, height-adjustable cart, enabling completion of the Stroop task in a standing position. When executing the specified steps, participants moved the cart along with them.

Response latencies were measured via voice key, and response accuracy was recorded by the experimenter. Participants were unaware of the actual purpose of the experiment.

RESULTS

A 3 (type of trial: consistent, inconsistent, filler) × 3 (stepping direction: forward, backward, sideways) repeated measures analysis of variance was performed on response latencies (reaction times after left and right steps did not differ significantly, $F < 1$). Beforehand, reaction times from error trials (1.9%) and those deviating more than 2.5 standard deviations from a participant's mean reaction time (3.5%) were removed. In addition to the standard Stroop facilitation and inhibition effects, $F(2, 74) = 78.14$, $p_{rep} > .99$, $\eta_p^2 = .68$, there was a significant Trial Type × Stepping Direction interaction, $F(4, 148) = 7.65$, $p_{rep} = .99$, $\eta_p^2 = .17$. On inconsistent trials, reaction times were significantly faster after stepping backward ($M = 676$ ms, $SD = 83$ ms) than after stepping forward ($M = 712$ ms, $SD = 95$ ms), $t(37) = 4.67$, $p_{rep} = .99$, $d = 0.79$, or sideways ($M = 702$ ms, $SD = 83$ ms), $t(37) = 3.60$, $p_{rep} = .99$, $d = 0.58$ (see Fig. 1). Reaction times after stepping forward did not differ significantly from reaction times after stepping sideways, $p > .27$. On consistent and filler trials, stepping direction did not have a significant effect, $ps > .08$.

CONCLUSION

Forward and backward body locomotion constitutes a pure form of approach and avoidance behavior with high ecological validity. Corroborating previous evidence that avoidance cues facilitate the recruitment of cognitive control, the current study showed that stepping backward significantly enhanced cognitive performance compared to stepping forward or sideways. Considering the effect size, backward locomotion appears to be a very powerful trigger to mobilize cognitive resources. Thus, whenever you encounter a difficult situation, stepping backward may boost your capability to deal with it effectively.

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