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Fake feedback on pain tolerance impacts proactive versus reactive control strategies

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ABSTRACT

It is well-known that beliefs about one's own ability to execute a task influence task performance. Here, we tested the hypothesis that beliefs about a specific self-control capacity, namely pain tolerance, modulate basic cognitive control processes. Participants received fake comparative social feedback that their ability to tolerate painful stimulations was either very poor or outstanding after which they performed an unrelated go/no-go task. Participants receiving low-tolerance feedback, relative to high-tolerance feedback, were less successful at inhibiting their responses and more influenced by previous trial conditions, as indicated by an increased slowdown following errors and more failed inhibitions following go-trials. These observations demonstrate a shift from a more proactive to a more reactive control mode. This study shows that providing feedback about one's own capacity to control impulsive reactions to painful stimulations directly influences low-level cognitive control dynamics.

1. Introduction

Folk psychology assumes that believing in yourself is often half the battle. This is particularly the case when we are required to control our behavior and refrain from automatic and impulsive actions, such as when you are on a diet or trying to quit smoking. In line with this intuition, a long tradition of psychological research has shown that the ability to carry out a task depends on individuals' expectations about how good they are in performing that specific task (e.g. Bandura, 1997). Only recently, studies started to indicate that self-control also depends on more general beliefs about self-control (Hamburg & Pronk, 2015; Inzlicht, Bartholow, & Hirsh, 2015; Job, Dweck, & Walton, 2010; Job, Walton, Bernecker, & Dweck, 2013). For instance, Job et al. (2010) demonstrated that implicit theories on willpower determine self-control resources. Manipulating more abstract beliefs about self-control, such as the belief in free will, has been shown to hamper self-control as evidenced by increased aggressive and cheating behavior (Baumeister, Masicampo, & Dewall, 2009; Vohs & Schooler, 2008).

Most research on the influence of control-related beliefs focuses on complex behavior such as overcoming addiction or gambling (Baumeister, Heatherton, & Tice, 1994). However, behavioral control can also be conceptualized in more basic components, often referred to as cognitive control (Miller & Cohen, 2001; Robinson, Schmeichel, & Inzlicht, 2010). At this level of information processing, researchers often focus on specific processes such as the inhibition of prepotent responses

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(Verbruggen & Logan, 2008), the ability to switch between different tasks (Monsell, 2003), or the monitoring of errors and conflict (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Recent studies showed how these processes can also be subject to controllability beliefs. For instance, challenging the idea that people have free will affects both neural and behavioral reactions to performance errors (Rigoni, Pourtois, & Brass, 2015; Rigoni, Wilquin, Brass, & Burle, 2013) and intentional motor inhibition (Rigoni, Kühn, Gaudino, Sartori, & Brass, 2012). However, free will entails a series of heterogeneous aspects (e.g., scientific or fatalistic determinism, the possibility to do otherwise, the idea of a soul; Nadelhoffer, Shepard, Nahmias, Sripada, & Ross, 2014) that can be linked only indirectly to beliefs about control abilities over our own behavior. Therefore, the present study set out to investigate if manipulating beliefs about one's ability to tolerate pain, as an instance of self-control, impacts basic cognitive control processes.

The avoidance of pain is considered to be a basic drive of human behavior, and it often takes place as an automatic and reflexive reaction, such as when we quickly remove our hand from a hot stove. In many situations one may need to inhibit these instinctive reactions in order to attain a greater reward or achieve a long-term goal. For instance, removing a bad tooth may be very painful, but most people would decide to tolerate the pain in order to have a better smile or avoid infections. Pain management can therefore be considered a typical instance of self-control (Campbell & Misanin, 1969; Dolce, 1987; Elliot, 2006; Lynn, Van Dessel, & Brass, 2013). Here, we challenged people's belief about their capacity for pain management by engaging participants in a task where they had to tolerate heat stimulation (Dolce, 1987; Elliot, 2006), and then providing them with fake feedback about whether or not they showed a high tolerance to this painful stimulation.

To measure the influence of pain tolerance beliefs on cognitive control, we zoomed in on inhibition performance in a go/no-go paradigm, where participants are required to respond to "go" stimuli and withhold responding to "no-go" stimuli. We focused on mean inhibition accuracy as a measure of global changes in performance, as well as sequential dependencies in performance by studying the impact of previous trial conditions (i.e., local changes in performance). Our focus on these different measures was motivated by the influential dual-mechanisms of control framework (Braver, 2012; Braver, Gray, & Burgess, 2007), which proposed that variability in cognitive control can be explained by differences in proactive versus reactive control strategies. Proactive control actively maintains goal-relevant information throughout the experiment in order to optimally steer behavior in a sustained and goal-driven manner. Reactive control, on the other hand, functions as a "late correction" mechanism (Braver, 2012) that is engaged only when the environment calls for it, or when high interference is detected. In light of this framework, mean inhibition accuracy (independent of preceding task conditions) can be considered an index of proactive control, while the sequential analyses serve as markers of reactive control. Specifically, the sequential analyses focused on the observations that people often slow down following errors (Botvinick et al., 2001; Rabbitt & Rodgers, 1977) and inhibit more following no-go trials (Bissett & Logan, 2011; Feldman, Clark, & Freitas, 2015), which have both been hypothesized to index a reactive motor inhibition reflex (Danielmeier & Ullsperger, 2011; Verbruggen, Best, Bowditch, Stevens, & McLaren, 2014). Interestingly, in his control theory, Braver (2012) suggested that in the prospect of positive feedback, people often engage in a more proactive mode, while negative feedback conditions promote a more reactive control mode. Consistently, reward or punishment schemes have been found to shift cognitive control in this hypothesized direction (Braver, Paxton, Locke, & Barch, 2009; Locke & Braver, 2008). While these studies focused on the effects of task-relevant reinforcement schedules, we hypothesized that high-tolerance versus low-tolerance (task-unrelated) feedback will similarly promote a more proactive versus reactive control mode. Since negative and positive feedback on performance may influence participants' emotional state, which in turn would influence cognitive control (Dreisbach & Fischer, 2012), we also controlled for this factor by including in the statistical analysis participants' affective state, as measured by the Positive and Negative Affective Scales (PANAS; Watson, Clark, & Tellegen, 1988).

2. Method

2.1. Participants

Sixty-one undergraduate students from Ghent University took part in the experiment in exchange for course credits. Four participants were excluded prior the statistical analyses due to age (n = 1, more than 3 SDs above sample mean), suspicion about the cover story (n = 2), or because no heat sensation was reported during thermal stimulation (n = 1). The remaining sample included 57 participants (27 females, mean age 21.6 ± 3.1, age range 18–31) with no history of psychiatric or neurologic conditions. All participants reported normal or corrected-to-normal vision and gave informed written consent.

2.2. General procedure

Upon arrival, participants were told that the experiment aimed at investigating the relation between their ability to tolerate pain and behavioral indices of cognitive control. After signing the informed consent, their *pain threshold* and their *pain tolerance* were measured (see below). Participants were explicitly told that these measures concerned their pain sensitivity and their capacity to tolerate pain, respectively. They were then randomly assigned by the experimenter to the Low-tolerance group (N = 19, 14 females, mean age 20 ± 2.6), the High-tolerance group (N = 19, 7 females, mean age 21.9 ± 3.2), or the No feedback group (N = 19, 16 females, mean age 22.8 ± 2.8). Following the fake feedback, participants seated in front of a computer screen and were given instructions about the go/no-go task (see below). Participants performed