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Short Communication

Preoccupied minds feel less control: Sense of agency is modulated by cognitive load

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ABSTRACT

People have little difficulty distinguishing effects they cause and those they do not. An important question is what underlies this sense of agency. A prevailing idea is that the sense of agency arises from a comparison between a predictive representation of the effect (of a given action) and the actual effect that occurs, with a clear match between the two producing a strong sense of agency. Although there is general agreement on this comparison process, one important theoretical issue that has yet to be fully determined is whether these computations are consciously performed. Here, we studied this issue by requiring participants to perform a simple judgment of agency task under conditions of different concurrent working memory load. Working memory operations are known to tax conscious cognitive resources. We found that agency judgments were moderated by working memory load, with lower agency ratings being observed in the high load condition, suggesting that the sense of agency is dependent on the availability of conscious cognitive resources. An examination of the time-course of this load effect suggests that it is the construction of the mental representation of the predicted effect which is particularly dependent on said resources.

1. Introduction

In general, people have little difficulty distinguishing between effects/outcomes they cause and those they do not. That is, people typically have a good sense of their own agency in the causation of a given effect. This ability, which is often taken for granted, is fundamental to both our private and public lives: The ability to sense or monitor our own agency is not only important to the integrity of the "sense of self", but also forms the cornerstone for many of our legal and social systems (Bandura, 2001; Jeannerod, 1999). We ascribe blame or credit largely on the basis that an individual knows that he is the author of his actions and their subsequent effects. Additionally, the ability to sense self-agency is central to a variety of social cognitive theories (Bandura, 2001), as, for example, in influential accounts of self-determination (Deci & Ryan, 1985) and controlled self-regulation (Carver & Scheier, 1998).

An enduring question, then, is how this sense of agency (SoA) arises. A prevailing idea is that SoA is the outcome of a comparison between the predicted effect (of a given action) and the actual effect that occurs, with a clear match between the two resulting in a strong sense of self-agency (Moore & Haggard, 2008; Moore, Lagnado, Deal, & Haggard, 2009; Shanks & Dickinson, 1991; Wegner & Wheatley, 1999). For example, SoA is strongest when an effect is inferred to be consistent with a "prior thought" (Pronin, Wegner, McCarthy, & Rodriguez, 2006; Wegner, Sparrow, & Winerman, 2004; Wegner & Wheatley,

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1999). Similarly, when considering simple motor actions/effects, SoA is greatest when proprioceptive feedback matches internal forward (or predictive) models (Blakemore, Wolpert, & Frith, 2002). Accordingly, experimental manipulations that influence the relationship between predicted and actual effects are known to have an impact on SoA. For example, presenting primes which are either consistent or inconsistent with subsequent actions or effects has been found to moderate agency ratings in one direction or the other (Aarts, Custers, & Wegner, 2005; Linser & Goschke, 2007; Sato & Yasuda, 2005).

While there is general agreement on the comparison process described above, one important theoretical issue that has yet to be fully determined pertains to whether or not self-agency computations are consciously performed. While the vast majority of theories and models have been silent on this issue, several accounts have hinted at the possibility that conscious thought may be involved in the production of SoA (Synofzik, Vosgerau, & Newen, 2008; Wegner & Wheatley, 1999). For example, Wegner and Wheatley (1999) posit that, while actions (and their subsequent effects) may be the result of unconscious mental events, SoA may be determined by conscious cognitive processes that infer a causal path between thought and action/effect (e.g., via the comparison process described earlier). Such accounts raise the intriguing possibility that the sense of agency may be a construction of the conscious mind. To date, though, this possibility has never been directly tested.

Several studies have demonstrated that subliminally-presented action- or effect-related information can influence explicit agency ratings (Aarts et al., 2005; Linser & Goschke, 2007; Sato, 2009; Wenke, Fleming, & Haggard, 2010). Although such findings indicate that unconsciously-processed information can be entered into self-agency computations, they do not necessarily enlighten on whether the computations are themselves consciously (or unconsciously) performed. The same type of argument can be applied to the converse findings: Demonstrations that SoA can be moderated by consciously accessible information do not necessarily imply that SoA computations are consciously controlled.

Consciously performed mental operations are thought to be reliant on a general cognitive resource pool. For example, two consciously performed mental tasks will interfere with each other, even if they are very different or involve different modalities, suggesting that they tap on a general body of resources (Arnell & Duncan, 2002). In contrast, unconscious mental operations do not interfere with conscious ones (Schneider & Schiffrin, 1977).

Accordingly, the idea that SoA may be the result of conscious mental processing suggests the tantalizing hypothesis that "agency distortions" may be produced simply by limiting the amount of conscious cognitive resources available for agency judgments. In this study, we examined this possibility with a simple experiment in which participants made explicit agency judgments under conditions of different concurrent working memory (WM) load. The application of a concurrent working memory task is a standard method for limiting the amount of general, conscious cognitive resources available to a primary task (Lavie, 2005). As such, if SoA is dependent on said resources, then judgments of agency should be moderated by the level of concurrent WM load. Specifically, we predict reduced agency ratings when concurrent working memory load is high (i.e., when there are greater demands on conscious cognitive resources). Additionally, we also manipulated the delay between actions and effects, thereby allowing us to assess the time-course of any load effects we might observe.

2. Methods

2.1. Participants and procedure

Twenty-four students from the undergraduate population of the National University of Singapore participated in this experiment. Each participant performed four blocks of a simple judgment of agency task (Fig. 1). Each block comprised 30 trials. In the experiment proper, participants made self-initiated and self-decided up- or down-arrow key presses in response to the presentation of a black dot in the center of a white screen. After the key-press, the dot either moved in a direction consistent with the key press (e.g., dot moved up after an up-arrow key press) or not (e.g., dot moved down after an up-arrow key press). We term these Consistent and Inconsistent trials respectively. Consistent and Inconsistent trials were equiprobable, with each accounting for 50% of all trials. The dot movement followed the key press after one of three possible delays (100, 400 or 700 ms). Each of the delay conditions accounted for an equal number of trials. When the dot completed its movement (which lasted 34 ms), participants rated how much they felt their action (i.e. key press) caused the effect (i.e., dot movement) using a 7-point scale (1: Not at all; 7: A lot). Trial order was randomized for each subject.

As noted above, participants performed four blocks of agency judgment trials. Two of these blocks were high working memory load blocks and two were low working memory load ones. Prior to the first trial of each block, participants were presented with a list of either 2 (Low load) or 6 (High load) randomly generated consonants, which they were required to maintain in memory for the duration of the block (Fig. 1). A memory test was conducted after the last agency task trial of each block. In the memory test, participants were asked to recall which member of the list immediately followed a probe letter (e.g., "What was the letter presented after "C" in the list?"). Block order (high and low load) was randomized for each subject.

In the subsidiary experiment, 22 different participants, from the same participant pool, performed an experiment identical in set-up to the one described above, but with one key exception: Instead of making agency ratings, they were required to estimate the length of the interval between key press and dot movement.

Both experiments were performed on a PC set-up running the E-Prime software, with the stimuli being presented on a 24″ LCD monitor.