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Sleep deprivation produces feelings of vicarious agency

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ABSTRACT

A variety of self-related psychological constructs are supported by the fundamental ability to accurately sense either self-agency or lack of agency in some action or outcome. Agency judgments are typically studied in individuals who are well-rested and mentally-fresh; however, in our increasingly fast-paced world, such judgments often need to be made while in less optimal states. Here, we studied the effect of being in one such non-optimal state – when sleep-deprived – on judgments of agency. We found that 24 h of total sleep deprivation elevated agency ratings on trials designed to produce a strong sense of *non-agency*. These data provide the first evidence that physiological state variables can affect agency processing in the normal population.

1. Introduction

We are able to distinguish between actions and outcomes that we author and those we do not. The first of these, the ability to monitor our own agency in some action or outcome, is central to our self-evaluations and supports our self-regulatory behaviours (Carver & Scheier, 1998). The second, the ability to monitor our lack of agency (or "*non-agency*") in an action or outcome, is equally essential because it aids in maintaining the integrity of our self-concepts, ensuring we are able to appropriately distinguish ourselves from others and from the workings of the world around us. Beyond personal relevance, these abilities underpin our social and legal systems, wherein the ability to recognize personal responsibility or lack of responsibility plays an important role in the attribution of blame or the giving of credit (Bandura, 2001; Haggard & Tsakiris, 2009).

A prevailing idea is that a sense of self-agency is produced when the predicted outcome of a specific action matches the actual outcome that occurs (Frith, Blakemore, & Wolpert, 2000; Moore & Haggard, 2008; Wegner & Wheatley, 1999). For example, we feel a strong sense of agency if we push an object and it moves away from us in a direction and speed consistent with the applied force. On the other hand, a mismatch between the predicted and actual outcome is generally an indicator of one's non-agency. We might, for example, feel a lack of agency if we pushed an object and it came towards us. Supporting the notion that sensing either self-agency or non-agency is determined by a comparison process like the one described above, a number of studies have demonstrated what have come to be known as "agency distortions" by manipulating the relationship between predicted and actual outcomes. For example, agency ratings can be diminished via manipulations that produce (real or perceived) discrepancies between these (Sato, 2009; Sato & Yasuda, 2005; Wenke, Fleming, & Haggard, 2010). Conversely, when a situation is crafted such that actual outcomes strongly match prior thoughts, agency ratings are elevated even when the individual has no real control over said outcomes; that is, a kind of "vicarious agency" is experienced (Wegner, Sparrow, & Winerman, 2004; Wegner & Wheatley, 1999).

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Now, agency processing is typically studied with participants who are in a state of rested wakefulness; that is, when generally well-rested and mentally "fresh". However, in our increasingly fast-paced and time-demanding world, agency judgments will often need to be made when one is in a less optimal psycho-physiological state, and it is unclear whether simply being in a non-optimal state can affect the accuracy of agency judgments. In fact, it is still unknown whether state variables in general have any effect on agency processing. In the study reported here, we were particularly interested in the effects of a common non-optimal state – when one is sleep deprived – on agency processing. Sleep deprivation is known to negatively affect a number of cognitive operations including attention, memory and decision making (Harrison & Horne, 2000; Lim & Dinges, 2010). Of greatest relevance here, there is also evidence that processing of mismatches between expectations and actualities in general is compromised by sleep deprivation (Morris, So, Lee, Lash, & Becker, 1992; Raz, Deouell, & Bentin, 2001). As mentioned earlier, a sense of non-agency is experienced when there is a mismatch between the predicted and actual outcome. Hence, we made the minimal prediction that sensing non-agency, in particular, would be susceptible to the effects of sleep deprivation.

In this study, participants encountered trials designed to produce either a strong sense of agency or a strong sense of non-agency. We assessed explicit agency judgments on these trials when participants were in a state of rested wakefulness and when sleep deprived.

2. Materials and methods

2.1. Participants

Thirty-six participants (15 females and 21 males, range: 18–26 years old) contributed to this study. All participants had regular sleep habits, were not on any long term medications, had no symptoms or history of sleep disorders, had no history of psychiatric or neurological disorders and drank less than 3 caffeinated drinks per day.

Sleeping patterns for each participant were monitored, via wrist-worn actigraphs, throughout the entire duration of the study, and all participants had a regular schedule of 6.5–9 h of sleep (sleeping no later than 1230 h and waking no later than 0900 h). Furthermore, all participants indicated that they had not taken any medication, alcohol or caffeine within 24 h of the test sessions.

2.2. Rested Wakefulness (RW) and Total Sleep Deprivation (TSD)

Participants made three visits to the laboratory, attending an initial briefing session, followed by the RW and TSD sessions. RW–TSD session order was counter-balanced across participants. Each session was separated by at least one week to ensure that, for those who underwent the TSD session first, the effects of sleep deprivation would have time to dissipate before the subsequent testing session.

For the TSD session, participants arrived at 2100 h on the evening prior to the day of the experiment. Participants were kept awake and monitored in the laboratory, with hourly assessments of subjective sleepiness and psychomotor vigilance being performed until 0600 h, after which the experimental session proper began. Participants took part in the RW session at 0800 h after a normal night of sleep. These represent the point at which the deleterious effects of a single night's sleep loss on behaviour is at its greatest (Doran, Van Dongen, & Dinges, 2001; Graw, Krauchi, Knoblauch, Wirz-Justice, & Cajohen, 2004) and the typical start of a school/work day respectively. Hence, the TSD effects described here reflect the interaction of circadian and homeostatic contributions (e.g., Liu, Verhulst, Massar, & Chee, 2015; Venkatraman, Huettel, Chuah, Payne, & Chee, 2011).

This procedure was approved by an Institutional Review Board, and all participants provided informed written consent prior to participation.

2.3. Agency judgment task

Participants performed a single block of a judgment of agency task (Fig. 1). In this task, they made self-initiated and self-decided up- or down-arrow key presses in response to the appearance of a white dot in the centre of a black screen. Following the key press, the dot moved in a direction that was either spatially congruent with the key press (e.g. dot moved down after a down-arrow key press) or not (e.g. dot moved down after an up-arrow key press). We term the former *agency trials* because spatial congruence between actions and outcomes in this type of paradigm typically produces a strong sense of agency, and the latter *non-agency trials* as spatial incongruence typically produces a strong sense of non-agency (Hon, Poh, & Soon, 2013; Shanks & Dickinson, 1991). The dot's movement lagged the key press with a delay of 100, 400 or 700 ms, with all delay periods being equally represented in agency and non-agency trials. Preliminary analysis revealed that delay did not interact with the critical state manipulation ($F < 1$, n.s.); therefore, for the main analysis, the data were collapsed over delay periods.

Agency and non-agency trials each accounted for 50% of the total number of trials. For each trial, after the dot had completed its movement, participants were asked to indicate how much they felt the dot's movement was caused by their