



LETTER TO THE EDITOR

Sleep and delay discounting: is insufficient sleep a cause or a manifestation of short-sighted choice?

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Delay discounting, or impulsive choice, refers to the tendency to prefer immediate rewards over delayed but greater benefits. Resisting the temptation to receive immediate rewards is thought to be an active process of self-control that requires cognitive and energetical resources [1]. The idea that sleep loss reduces the availability of such self-control resources and could consequently lead to more delay discounting has been expressed in several theoretical accounts [2]. In a recent study, Curtis *et al.* [3] report an analysis of data from the Human Connectome Project (HCP) database, including a large sample of individuals ($N = 1190$) who had performed a delay discounting task and had provided habitual sleep reports (Pittsburg Sleep Quality Index; PSQI). Results showed that habitual short sleep was associated with increased delay discounting, such that individuals who slept less than 6 hours discounted delayed rewards more steeply than those who had average sleep duration (7–9 hours). The effect sizes associated with sleep duration were considerable (Cohen's d ranging from 0.34 to 0.48), outweighing the effects of other factors (i.e. income, education, fluid intelligence) known to be related to delay discounting. Furthermore, the effects of habitual sleep duration were independent of self-reported daytime dysfunction. Given the effect sizes and the large sample size, these findings can be considered strong, well-powered, and convincing evidence for an association between sleep duration and impulsive choice.

The findings are also surprising, in the light of earlier experimental studies on sleep and delay discounting. Although an initial study reported increased delay discounting after a night of sleep deprivation [4], later studies involving total sleep

deprivation, partial sleep deprivation, and daytime naps, have not found changes in delay discounting after short-term sleep manipulations [5–9]. How could this discrepancy be explained? The authors point to a few differences between their study and previous reports with respect to task variables (delay duration/reward amount), statistical power, and the differential nature of sleep effects (habitual vs. acute/short-term) that could have contributed. Another important point is that this study is correlational in nature, and previous studies have experimentally manipulated sleep. The authors are careful to acknowledge this and refrain from strong directional conclusions; however, the results are still mostly framed as “the effects of short sleep on cognitive impulsivity.”

We would like to offer an alternative perspective: that short habitual sleep may instead be a result of a tendency to choose instant gains (e.g. watching TV late at night), over long-term benefits (e.g. being productive the next day). Several studies have suggested a relation between insufficient sleep and such choice behavior. For instance, Kroese and colleagues [10] found that in a large representative population sample ($N = 2637$), more than 50% of participants indicated they regularly go to bed later than they planned (2 or more nights per week)—a phenomenon the authors called “bedtime procrastination.” Such failure to keep to intended bedtime was associated with shorter subjective sleep duration, dissatisfaction with sleep, and daytime fatigue. Moreover, bedtime procrastination was negatively correlated with trait self-control, a construct closely related to resisting temptations and making short-sighted choices. The decision to extend bedtimes beyond one's intentions is often made

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despite knowing the negative consequences. Other studies have reported similar associations between low self-control and other behaviors that amount to poor sleep hygiene (e.g. failing to avoid stressful activities before sleep, or to make the bedroom a restful environment) [11]. These findings suggest that the tendency to ignore future benefits may actually be a factor contributing to the development of poor sleep habits. From this perspective, delay discounting could be viewed as a trait that relies on stable preferences and habits. As such it may be less sensitive to temporary changes in sleep state (e.g. experimental sleep deprivation). It is relevant to note that excessive delay discounting has also been associated with a wide range of other disadvantageous health behaviors (e.g. smoking, drug abuse, failure to keep to a diet, unsafe sexual behaviors), and may therefore reflect an overall trait of low self-control [12]. It should be noted that the evidence obtained to date remains correlational in nature. Therefore, similar to the data described by Curtis *et al.* [3], it cannot directly inform about the causal direction of the relationship.

Whether insufficient sleep leads to impulsive decision making or is instead, a consequence of such short-sighted choice, matters with respect to the type of intervention that could be efficacious. If poor sleep is a root cause for impulsive choice, interventions targeted at improving sleep should lead to better, less impulsive decision making. However, we are not aware of any studies assessing changes choice impulsivity following sleep extension or after treatment of sleep disorders. Such intervention studies could clarify the direction of the reported association. On the other hand, if a strong preference for immediate reward is a driving factor leading to poor decisions about sleep, other interventions may be more effective. In the latter case, it could be particularly useful to incorporate approaches that are aimed at altering these sleep-related decisions, and reducing the influence of immediate temptations (e.g. TV, internet, social activities). In an age of mobile electronics, social media, and online entertainment this seems an area of growing importance. In the fields of health psychology and behavioral change, techniques that could help to change habits and guide behavioral choices towards healthy options, are under active investigation. Some of these techniques (e.g. “implementation intention”: a technique of pre-planning relevant behaviors in concrete situation) have been found to improve sleep hygiene and increase sleep quality [13]. Similarly, techniques aimed at reducing delay discounting (e.g. “episodic future thinking”: a technique of vividly imagining positive future events), have shown success in improving other healthy behaviors (e.g. smoking or healthy eating) [14].

Finally, it must be noted that the proposed mechanisms need not be mutually exclusive. In fact, theories on the relationship between sleep and self-control do propose that inadequate self-control may lead to the development of poor sleeping habits, while at the same time, a lack of sleep may interfere with the ability to exercise self-control [2, 10]. Such a bidirectional relationship has been found for other conditions that are associated with poor sleep (e.g. depression or stress), and is argued to be a factor sustaining sleep problems, and/or their exacerbation over time [15, 16].

In conclusion, it remains a highly relevant question how the association between habitual sleep and delay discounting comes

about. The study by Curtis *et al.* [3] provides convincing evidence that such association exists. Analysis of large scale databases, such as the Human Connectome Project, allows for well-controlled and highly powered investigation of this matter. Whether changes in sleep (quantity or quality) can lead to cognitive improvement in the domain of delay discounting remains to be determined. Longitudinal and intervention studies are needed to shed light on this question. We further argue that the reverse relationship, that is, the role that impulsive choice may have in causing poor sleep, is a plausible pathway through which unhealthy sleep habits may be formed and sustained. Similarly, evidence for this mechanism, beyond correlational data, has yet to surface. Taking inspiration from health psychology and behavioral change to target alteration of decision processes that are underlying sleep-related behaviors, may prove fruitful in investigating this relationship and developing interventions.

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