



Sleep restriction and circadian effects on social decisions



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ABSTRACT

Our study examines how chronic sleep restriction and suboptimal times-of-day affect decisions in a classic set of social tasks. We experimentally manipulate and objectively measured sleep in 184 young-adult subjects, who were also randomly assigned an early morning or late evening experiment session during which decision tasks were administered. Sleep restriction and suboptimal time-of-day are both estimated to either directly or indirectly (via an impact on sleepiness) reduce altruism, trust, and trustworthiness. We conclude that commonly experienced adverse sleep states, most notably chronic sleep restriction, significantly reduce prosocial behaviors, and can therefore limit benefits from short-term social interactions.

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1. Introduction

Prosocial behaviors help encourage positive interactions and promote economic institutions that require trust/trustworthiness. There are numerous factors that may influence the propensity to exhibit prosocial behaviors. The variable considered in this paper is one that receives little attention in this area of decision-making research: sleepiness. We examine the impact of commonly experienced sleep and circadian states on outcomes in three well-known simple social interaction tasks: the ultimatum, dictator, and trust games. Prosocial behaviors in these games, such as trust, are at least a simple indication of social capital of the decision maker (Putnam, 1993). Some researchers have even found that increases in survey-based measures of country-level trust promote desirable macroeconomic outcomes, such as increased economic growth (Knack and Keefer, 2007) or reduced government corruption (LaPorta et al., 1997). As such, factors that influence the micro-level choice to behave prosocially—a type of individual investment in social capital (Glaeser et al., 2002)—have multiplier effects in society and the economy, and so the importance of this decision domain should not be underestimated.

The limited research that exists on sleep loss and simple social decisions has utilized highly controlled total sleep loss protocols (Anderson and Dickinson, 2010; Ferrara et al., 2015). Such protocols help establish the dose-response of behavior

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to extreme levels of sleep loss, but the external validity of such findings remains unclear. Observation or field data on sleep levels and choice are highly externally valid, but the limited or lack of experimental control in such data (or the potential bias in self-reports of one's sleep level) reduce one's ability to identify causal effects. In short, we believe that generating primary experimental data using an ecologically valid sleep setting is a valuable approach for studying this particular research question. Here, we utilized an at-home sleep manipulation protocol with objective sleep data acquisition, random treatment assignments, and within-subjects behavioral measures, which increase our ability to claim causal effects. Sleepiness is one of the more concerning health trends at present, and so sleepy decision-making is hardly a rare occurrence. Nevertheless, the weight of the research on sleep and decision making has focused on individual decision tasks (e.g., [Harrison and Horne, 2000](#); [Killgore et al., 2006](#)), which leaves a gap in our understanding of how adverse sleep states affect choices in a critical decision domain.

A main contribution of our work is to experimentally manipulate sleep in ecologically valid ways that are highly applicable to the real world—the levels of sleep restriction we examine are pervasive in modern society and part of everyday life for nearly 30% of U.S. adults ([Schoenborn and Adams, 2010](#)). And, while the U.S. Centers for Disease Control and Prevention has labeled sleep deprivation a public health epidemic, little is known about how commonly experienced adverse sleep states impact social interactions. We hypothesize that increased sleepiness will reduce prosocial behaviors given the (limited) related research and given our understanding of deliberative thinking and social decisions ([Anderson and Dickinson, 2010](#); [Ferrara et al., 2015](#); [Rilling and Sanfey, 2011](#); [Krajbich et al., 2009](#); [McCabe et al., 2001](#); [Chee and Chuah, 2008](#)). This hypothesis suggests that sleepiness leads to inefficiencies or unrealized benefits in social exchanges.

Results from our 3-week at-home sleep protocol study indicate that both sleep restriction and suboptimal time of day either directly or indirectly (through sleepiness) reduce simple behavioral measures of prosocial decisions. Estimated reductions in dictator giving are the most robust, though our multivariate estimation results show significant decreases for trust and trustworthiness in most specifications as well. Given that these simple games can be considered building blocks for more complex social interactions, such findings have important implications. A significant portion of adults in many countries have habitual sleep levels similar to those we study, and sleep restricted decision-making at suboptimal times of day is common in modern society as well. Our data draw attention to a typically overlooked behavioral “cost” of these modern sleep trends. At least in the area of social interactions, sleepiness may contribute to a type of dead-weight loss of potential benefits that has not been previously highlighted.

1.1. Background

Our behavioral hypothesis stems from the argument that prosocial behavior requires deliberative thinking and active suppression of myopic self-interest ([Rilling and Sanfey, 2011](#); [McCabe et al., 2001](#); [Fehr and Camerer, 2007](#); [Achtziger et al., 2016](#)). Interestingly, recent evidence suggests that reduced deliberation may promote altruism and cooperation in certain contexts ([Rand et al., 2012](#); [Rand et al., 2014](#); [Rand et al., 2016](#)), although other studies found no such relationship ([Verkoeijen and Bouwmeester, 2014](#); [Tinghög et al., 2013](#); [Krajbich et al., 2015](#)). It is important to note, however, that these studies typically employ standard cognitive load or time pressure manipulations that are not directly comparable to our manipulation.¹ Another distinct manipulation in the literature that is intended to reduce deliberation is referred to as “ego depletion”, which seems to impact motivational aspects of task performance more than cognition ([Inzlicht and Schmeichel, 2012](#)).² Notably, [Ainsworth et al. \(2014\)](#) reported reduced trust following ego depletion, and a study by [Vohs et al. \(2010\)](#) crossed ego-depletion with sleep deprivation and found that only ego-depletion influenced the expression of the negative social behavior of aggression. Thus, the existing research leads to the natural question of whether we believe our sleep manipulations will affect pro-social behavior by harming cognition or task motivation.

It has been argued that sleep loss may impact motivation as well as cognition, but the mixed evidence includes examples where no significant motivation decline is reported (e.g., [Drummond et al., 2004](#)), while others report significant motivational decline following sleep deprivation (e.g., [Almklov et al., 2015](#)). However, even when short, novel, or incentivized tasks are used to mitigate motivational decline caused by sleep loss (see [Alhola and Polo-Kantola, 2007](#), and sources therein), performance decrements are still observed. This argues that cognitive effects likely dominate any motivation effects of our treatment manipulation—our tasks are incentivized, short, and relatively novel for the subjects. Another recent study concludes that self-regulation (the target of ego depletion manipulations) and fatigue are not overlapping constructs ([Vohs et al., 2010](#)), which supports our view of dominant cognition effects over motivational effects in our design. Thus, compared to commonly used alternative protocols aimed at reducing deliberative processes, ours is unique and focused on cognitive effects of mild adverse sleep states. We also argue that our ecologically valid at-home sleep protocol implies that our results have more clear implications for real world decision makers.

For our research question, another relevant stream of literature has identified the importance of deliberative thinking for prosocial decisions ([Rilling and Sanfey, 2011](#); [Krajbich et al., 2009](#); [McCabe et al., 2001](#); [Fehr and Camerer, 2007](#)). This is important because the prefrontal cortex (PFC) is particularly vulnerable to sleep deprivation. Some studies report negative sleep impacts on PFC function ([Horne, 1993](#); [Muzur et al., 2002](#); [Chee and Chua, 2008](#)), and [Horne \(1993\)](#) reports a

¹ Distinct from the other studies mentioned, [Krajbich et al. \(2015\)](#) examined patients with prefrontal lesions.

² With an ego depletion manipulation, a subject is made to exert self-control of some sort at time t , and then administration of another task requiring self-control is administered at time $t+1$. Ego depletion is meant to reduce one's capacity to self-regulate in the time $t+1$ task.

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