The Effects of Light Exposure on Reaction Time for Rested and Sleep Deprived Individuals

Nicole Hanna

Department of Psychology, Thompson Rivers University

Psychology 2110: Introduction to Research Methods

Denise Weisgerber

December 1st, 2023

Abstract

Sleep often impacts our daily life and cognition skills, especially those of university students. This 2 x 2 repeated measures study aims to provide crucial sleep information to university students, and how lack of sleep can impact cognition. 55 TRU students, aged 23.1 ± 1.87 years, were exposed to bright light pulses (6000 lux) and dim light pulses (200 lux) after sleeping for 7 hours, or being awake for 7 hours. Reaction time was measured using a psychomotor vigilance test (PVT). It was observed that bright light had a greater effect on reaction time of rested and sleep deprived participants, and overall sleep deprived participants responded slower than those who were rested. Future work could investigate more levels of light luxe to determine effects of different light levels.

The Effects of Light Exposure on Reaction Time for Rested and Sleep Deprived Individuals

The amount of sleep received every night often impacts daily life. Lack of sleep can often lead to decreased focus, decreased reaction time, and physical symptoms (Mikulski et al., 2023). The CDC recommends adults (age 18-60 years) obtain seven or more hours a night, with only 77% of Canadian adults receiving this amount, in a study conducted in 2020 (CDC, 2022; Wang et al., 2022). University students are often among adults who suffer most from sleep deprivation, up to 60% of them have poor sleep habits (Schlarb et al., 2017). Poor sleep can lead to poor reaction time, especially under bright and dim light conditions. Bright light has been linked to impacted sleep and alertness during nocturnal hours and can disrupt natural circadian rhythms (Phipps-Nelson et al., 2003). This study aims to provide information to university students about their sleep habits and how lack of sleep can be detrimental to cognition, by comparing reaction time of sleep deprived and rested participants under bright and dim light conditions. This study uses a 2 x 2 repeated measures design and hypothesizes that reaction time will be lower in bright light conditions in sleep deprived individuals than in dim light. For rested participants, reaction time will be faster in bright light conditions than dim light conditions. Additionally, bright light conditions will have a bigger effect on reaction time than dim light conditions, in individuals who are sleep deprived and rested.

Method

Participants

The study was conducted with 55 participants from Thompson Rivers University, of which 27 were male and 28 were female. The average age of the participant was 23.1 ± 1.87 years old. Participants answered a brief questionnaire and were confirmed to be in good health with low caffeine consumption ($\leq$ 300mg per day). All participants gave informed consent.

Materials

Psychomotor Vigilance Task (PVT)

A psychomotor vigilance task (PVT) is a visual test measuring the speed at which a person reacts to a visual stimulus (e.g. a coloured square on a black background) that appears randomly every 3 to 10 seconds. The tasks had a duration of 5 minutes and was performed on a personal digital assistant (PALM).

Light Unit

Bright light was delivered using a Verilux HappyLight Luxe, with up to 10,000 Lux of light. The light unit can be found at https://tinyurl.com/3zrfmr73.

Lux Meter

Lux was measured using an Extech UVA/UVC Light Meter/Datalogger, Mfr. #SDL470, Item #EXTSDL470. This lux meter can be found at https://tinyurl.com/2ar44rp6.

Questionnaires

Questionnaires used for screening were the Karolinska Sleepiness Scale (KSS), which was used to self-measure the subjective sleepiness of participants at particular times during the day. Additionally, participants were asked general health questions,

Procedure

This study is a 2 x 2 repeated measures design. Participants were randomly assigned to each sleep condition to counterbalance order effects and conditions were counterbalanced using a Latin square design. Conditions A and B had rested participants that either in bright or dim light, respectively. Conditions C and D had sleep deprived participants either in bright or dim light, respectively. Participants in the sleep deprived condition were asked to return a week later, and rested participants returned 3 days later. Bright light was operationally defined at 6000 lux,

whereas dim light was operationally defined at 200 lux. Condition A and B had participants in the rested condition arrive at the lab at 6:30 a.m., after sleeping from 11:00 p.m. to 6:00 a.m. Condition C and D had the participants in the sleep deprived category attend lab at 11:00 p.m. after being awake all day and remain awake until 6:00 a.m. Participants in condition C and D were given calm activities (colouring, puzzles, talking to researcher, etc.) to prevent sleepiness, a snack at 4 a.m., and were not allowed to do any physical activity. Participants sleepiness was evaluated using the KSS. Participants in all conditions were seated 2 feet away from the light unit directly in front of them, at eye level, for 30 minutes and given a colouring book. Immediately after, participants' reaction time was tested using the psychomotor vigilance test (PVT), and their reaction time was recorded in milliseconds (ms). All participants were tested individually, and sleep deprived participants were sent home in a taxi.

Results

As seen in Table 1, there was a main effect of light and sleep conditions. Overall, reaction time in bright conditions was slower (X=700.47 ± 159.19 ms) than dim conditions (X= 657.67 ± 208.81 ms). There was also a faster reaction time for rested (X=426.05 ± 110.62 ms) than sleep deprived participants (X=932.10 ± 257.10 ms). As seen in Figure 1, there were interaction effects, as rested participants responded faster in bright conditions (X=380.15 ± 67.67 ms) than dim conditions (X=471.95 ± 153.57 ms). Sleep deprived participants responded slower in bright conditions (X=1020.80 ± 250.70 ms) than dim conditions (X=843.40 ± 264.06 ms).

	Bright	Dim	Marginal Means
Rested	380.15	471.95	426.05
Sleep Deprived	1020.80	843.40	932.10
Marginal Means	700.47	657.67	

Table 1. Calculated mean reaction time of rested and sleep deprived participants after bright and dim light exposure.

	Bright	Dim	Marginal Means
Rested	67.67	153.57	110.62
Sleep Deprived	250.70	264.06	257.38
Marginal Means	159.19	208.81	

Table 2. Calculated standard deviation of reaction times of rested and sleep deprived participants after bright and dim light exposure.

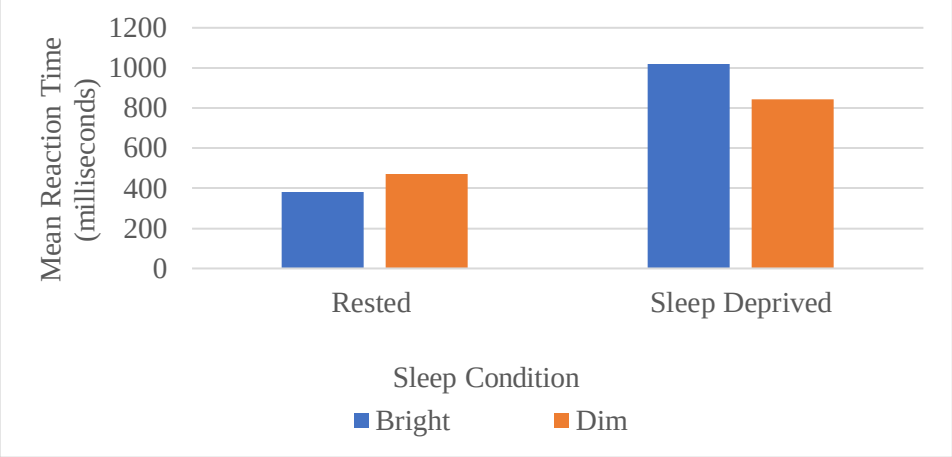

Figure 1. *2x2 Factorial Repeated Measures Design*. This figure represents the mean reaction time, in milliseconds (ms), of rested and sleep deprived participants, under bright and dim light conditions.

Discussion

This study determined the differences in reaction time of sleep deprived and rested participants under bright and dim conditions. A main effect was found for sleep conditions, in that rested participants reacted faster in both light conditions (X=426.05 ms), than sleep deprived participants (X=932.10 ms). Participants also reacted slightly faster overall in dim light

conditions, for both sleep conditions (X=657.67 ms), than in bright light conditions (X=700.47 ms), showing a main effect for illumination. There were interaction effects found for dim illumination, there was a difference between reaction times in sleep deprived and rested conditions (X= 843.40 ms and X=471.95 ms, respectively); however, a large difference in reaction time was found for bright illumination for sleep deprived and rested participants (X=1020.80 ms and X=380.15 ms, respectively). This study failed to reject each hypothesis; however, the last hypothesis that bright light will have a bigger effect on reaction time was faster for rested conditions and slower for sleep deprived conditions. This study does not agree with the previous study conducted by Phipps-Nelson et al., (2003) who stated that bright light can increase alertness during the daytime and prevent sleepiness. In this case, bright light conditions hindered reaction time of sleep deprived participants, but supported reaction time of rested participants.

The impacts of this study pertaining to reaction time could translate to alertness levels of university students, as those who are sleep deprived may have low alertness and cognitive focus during classes. This might impact grades and overall health levels of university students. Mikulski et al., (2023) found that performing exercise during instances of sleep deprivation can improve cognitive function by improving neural activation. Future research could investigate the neural activity during sleep deprivation and rested conditions and see if there is a change in brain activation and how that would effect reaction time.

Strengths of this study are the smaller sample size, which reduces confounds and more sensitive method. Limitations include the levels of light used on the lux meter, and future studies could include more levels of light to investigate if they impact reaction time, rather than having two extremes of bright and dim.

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