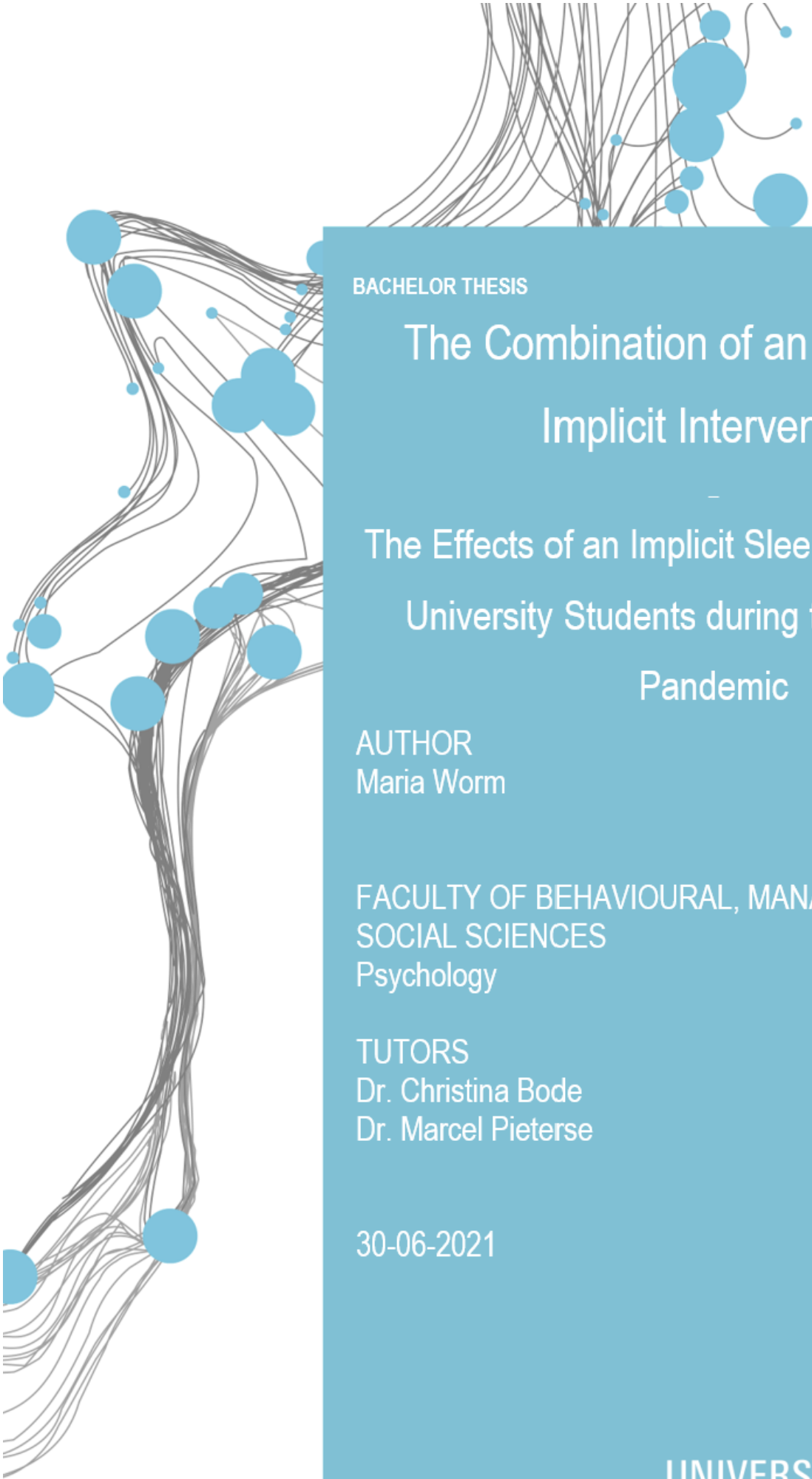

BACHELOR THESIS

The Combination of an Explicit and Implicit Intervention

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The Effects of an Implicit Sleep Intervention on University Students during the COVID-19 Pandemic

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Table of Contents

Abstract

Introduction. Sleeping problems are a detrimental trend in the general Dutch population. University students are especially affected by poor sleep as for different factors which are typically prevalent in their lives. In addition, existing COVID-19 restrictions decrease the sleep quality through their impact on the context of, for example, private, professional, or social activities. Many different interventions are already being used to tackle sleep problems. For the purpose of this study, two different types of interventions were defined, namely explicit and implicit interventions. In contrast to the explicit type, implicit sleep interventions do not exist yet. Both types were implemented in the form of a two-part study while this paper specifically focused on the implementation of a new implicit sleep intervention. Therefore, the aim of this study was to test the effectiveness of a self-made implicit sleep intervention on the sleep quality of university students. Further, the individual experience during and after the intervention as well as the impact of the COVID-19 restrictions on the intervention's effectiveness were investigated.

Methods. A total of 41 students (*M*age = 21) participated in the study. The participants were instructed to conduct the implicit intervention, the Circadian-Card-Game, in the morning and evening throughout seven days. Further, the participant's sleep quality was measured with the Sleep Quality Scale before and after the intervention. Within the program SPSS Statistics, a paired t-test was conducted for these two values to define the change in sleep quality which was interpreted as the intervention's effectiveness. In addition, a self-made process evaluation scale on the implicit intervention, including quantitative items and the option to add qualitative elaborations, has been included. The aim was to gain insight into the respondent's experience throughout the intervention and determine its impact on the intervention's effectiveness. An ANCOVA model was created including the sleep quality before the intervention as the independent variable and the sleep quality after the intervention as the dependent variable. It accounted for the process evaluation as the covariate. Lastly, the influence of the current COVID-19 measures on the participant's sleep quality was investigated to determine its impact on the intervention's effectiveness. Another ANCOVA model was utilized, exchanging the covariate from the previous model for the COVID-19 influence.

Results. It was found that sleep quality significantly increased after the implicit intervention which was interpreted as the effectiveness of the Circadian-Card-Game. The process evaluation scale revealed an overall neutral to positive experience with the intervention for most participants. It had no significant effect on the intervention's effectiveness. Further, the

influence through the COVID-19 measures was largely neutral to positive for the participant's sleep quality. This influence had no significant effect on the intervention's effectiveness. **Conclusion.** The hypothesis that an implicit intervention can improve sleep quality was confirmed. However, since this intervention was applied together with an explicit intervention, it cannot be determined which aspect actually caused the change in sleep quality but it is solely interpreted as the implicit intervention's effectiveness. The expected influences through the impact of the COVID-19 regulations and the participant's process experience did not occur. A gap in literature was found referring to implicit mechanisms involved in sleep problems as well as the implementation of implicit interventions. Further, flaws in the study design have been highlighted with the lack of a control group being the most important downside. Still, implicit sleep interventions as well as the combination of explicit and implicit techniques pose a lot of potential for future research and the treatment of sleep problems.
Keywords. University students, sleep quality, implicit intervention, COVID-19 pandemic, process experience

Introduction

Sleep Problems and their Implications

In the Netherlands, sleep problems and a decrease in sleep duration have shown to be a prevalent and detrimental trend. Over a decade ago, epidemiological studies have already proven that sleep problems are a very common occurrence among the general, modern population (Chokroverty, 2010). In 2017, Kerkhof conducted a study and found that about 32,1% of the Dutch population have a general sleep disturbance (GSD) while 43,2% suffer from insufficient sleep. Further, it has been investigated that there was a continuous decline in sleep duration throughout the last 20 years. Especially, in the late 1990s and 2000s there has been a significant change in the sleep behaviour of people (Keyes, et al., 2015). In addition, more recent research indicates that this trend persists. Twenge, et al. (2017) showed that adolescents were 16-17% more likely to report sleeping less than 7 hours in 2015, compared to 2009. These developments are concerning as for the effects that insufficient sleep and sleep quality can have on an individual.

Sleep problems have several negative effects on a person's physical as well as mental health. Many direct implications of sleep problems could already be identified, such as cognitive impairment, more negative and less positive emotions or an overall decrease in wellbeing (Alhola & Polo-Kantola, 2007; Baglioni, et al., 2010; Zhao, et al., 2019). Next to such temporary effects, sleep problems can become severe disorders in the form of, for example, insomnia or hypersomnia which creates importance to act early when sleep problems occur (Chokroverty, 2010). Further, the study of Chokroverty and Sahota (2010) found that sleeping less than five or more than nine hours regularly is associated with an increased risk of mortality.

Having identified sleep problems as a major risk within the Dutch society, it is necessary to analyse which groups among the population are mainly affected. Moreover, influential factors involved in sleep problems as well as the circumstances within the current COVID-19 pandemic need to be considered. Additionally, existing sleep interventions and their coverage on the involved factors need to be discussed. To sum up, the aim of this paper is to a) investigate sleep and its factors, and b) to create a sleep intervention for the identified risk group within the Dutch population.

University Students as a Risk Group

Reading through available literature, it becomes apparent that particular groups are more likely to experience sleep problems than others. More specifically, elderly people, students, or people within stressful occupations, such as nurses, have been the centre of attention for many papers (Myers & Badia, 1995; Montgomery & Dennis, 2003; Aycock & Boyle, 2009). Especially university students seem to be affected by sleeping problems as studies show that the prevalence of poor sleep quality ranges from 19,17% to 57,5% in this population (Feng, et al., 2005; Suen, et al., 2008; Schlarb, et al., 2017). As an example, the study of Lund, et al. (2010) found that over 60% out of 1125 university students classified as bad sleepers. In addition, the results showed that especially undergraduate university students are affected by bad sleep as for lifestyle changes which come along with becoming a student. This highlights an important aspect of investigation, as there are many reasons which lead to the overall bad sleep quality in this group.

Influential Factors

There has already been a variety of research on the different factors involved in the sleep quality of university students. First, contextual factors can have a crucial impact. As an example, one of the most prevalent aspects leading to sleep problems is academic stress (Lund, et al., 2010). This type of stress is mostly caused by outward influences and can be elicited, for example, through an approaching exam. In addition, Hamaideh (2011) suggests that some university students unconsciously multiply that stress by exerting additional pressure on themselves. As an example, this can take place by having high standards for oneself, such as wanting to achieve a specific grade in an exam. Wishing not to fail such expectations can lead to more distress in an individual. Further, there are physiological, behavioural and social factors which negatively affect university student's sleep quality. This can include being overweight, high alcohol consumption, or a lack of social activities (Carney et al., 2006; Goodhines, et al., 2019; Kenney, et al., 2014; Singleton & Wolfson, 2009; Van Reen et al., 2016; Vargas, et al., 2014). Generally, it needs to be noted that most of these factors are related to behaviours which can be consciously influenced. Only some can be considered somewhat unconscious as, for example, inflicting stress on oneself as a response to an upcoming exam can have a habitual nature. Otherwise, no underlying, unconscious psychological mechanisms could be identified that lead to sleep problems. However, the factors described might not all be applicable to the current unique situation of the COVID-19 pandemic and new ones could have occurred since it started. Thus, this aspect needs to be investigated further.

Impact of COVID-19 Regulations

Through the COVID-19 pandemic the previously explored factors are influenced by the measures taken to protect the population. The contextual, physiological, behavioural, and social factors on sleep quality in students are all affected in different ways. For example, stress through upcoming exams is influenced as the universities were forced to adapt to the new regulations. A redevelopment of the organizational aspect for exams became a necessity and many universities switched from exams in person to online exams (Sheridan, 2020; Crawford, et al., 2020). This change in itself became a source of, for example, anxiety for the students as shown by the study of Mastour, et al. (2021). Next, new studies show that the general weight gain increased since the COVID-19 pandemic started which means another factor for sleep problems is benefitted within these circumstances (Zachary, et al., 2020; Joob & Wiwanitkit, 2020). Moreover, individuals are not allowed to meet with more than a specific number of people from a specified number of households at a time since the virus spread (Government of the Netherlands, 2021). This implies that typical social gatherings for students, such as parties or study groups, are not possible in their usual way anymore. All these aspects result in one major implication that researchers found to be relevant for student's sleep quality: The lack of daily rhythm.

The general switch to online education brought a crucial change, as it is mostly not necessary anymore to, for example, get up at a specific time to go to campus (Chen, et al., 2020; Alam, 2020). The study of Morin, et al. (2020) goes into detail on this topic and specifies that rise times, social activities, eating and exercising are all important underpinnings for our sleep-wake rhythm. As this normal daily process for university students is not given anymore, their sleep quality suffers. Additionally, it is suggested that sleep-related problems resulting from the lockdown are more prevalent in students than in the working population (Marelli, et al., 2021). Romero Blanco, et al. (2020) found that even though the sleep duration of students rose by approximately 1.2 hours, the overall sleep quality significantly declined. In general, it can be stated that there is consensus across researchers that the lockdown measures during the time of the COVID-19 pandemic have a negative influence on university students' sleep quality (Khare, et al., 2021; Zhou, et al., 2020; Majumdar, et al., 2020; Cellini, et al., 2020). Nevertheless, the pandemic can still be considered a new topic in research and the current circumstances provide a basis to further investigate their impact on sleep quality and how one can oppose negative influences.

Defining Explicit and Implicit Interventions

Nowadays, there are already many interventions which should support individuals with sleep problems. Some popular examples for treatment are sleep hygiene interventions, sleep extension interventions, stimulus control therapy or mindfulness interventions (Al Khatib, et al., 2018; Shanahan, et al., 2019; Bootzin & Perlis, 2011; Hülsheger, et al., 2015). Looking at the different interventions available in literature, it becomes apparent that most are very similar in one aspect. All of them try to address the sleep problems in an explicit way. In order to elaborate on the explicitness of existing interventions further, it first needs to be clearly defined what explicit means.

The dual processing theory assumes that our behaviour is affected by two distinct systems of information processing. Strack and Deutsch (2004) state that there is a reflective (explicit) system and an impulsive (implicit) system. They can operate parallel while only the implicit system is able to be active on its own separately from the explicit system. A main distinctive feature between the two is their capacity. It is explained that the explicit system requires a higher level of cognitive capacity compared to the implicit system. Therefore, the explicit system is easier distracted in its processing while the implicit system can potentially also work under suboptimal conditions. Furthermore, the implicit system requires little to no cognitive effort which contrasts with the explicit system. Concludingly, the two different systems can both lead to behavioural change while utilizing two separate ways of processing.

For the purpose of this study and the collaborating Bachelor Thesis by Albert (2021), a definition for explicit and implicit interventions, based on the dual processing model, will be provided. This is done to assure clarity throughout the paper. In the following the two definitions are formulated.

1. An explicit intervention describes a treatment which targets the explicit processing system of an individual in order to achieve a change in (undesired) behaviour. It is characterised by a conscious, relatively slow, and high effort-consuming process.
2. An implicit intervention describes a treatment which targets the implicit processing system of an individual in order to achieve a change in (undesired) behaviour. It is characterised by an unconscious, relatively fast, and low effort-consuming process.

Looking back at the already existing sleep interventions, it can be explained why they can be categorised as explicit according to these definitions. As an example, sleep hygiene interventions teach sleep hygiene practices which the individual should implement into their day-to-day life afterwards (Brown, et al., 2002). This is without a doubt a conscious process

which is likely to take a while until the individual grasps all the information and implements the learned practices. Further, it is reasonable to assume that this process costs cognitive effort as well. Sleep extension interventions have the same basic structure as sleep hygiene interventions. They aim at behavioural change by utilizing a behavioural consultation session which is followed by the implementation of the gained knowledge (Al Khatib, et al., 2018). Thus, this intervention can also be categorized as explicit. Additionally, stimulus control therapy entails the direct control of potentially sleep-disturbing stimuli in the sleep environment (Shanahan, et al., 2019; Bootzin & Perlis, 2011). Thus, the individual needs to consciously identify such stimuli and take action to control them. This process costs cognitive effort and takes time as for the identification process and search for a fitting solution. Lastly, a mindfulness-based sleep intervention aims at redirecting an individual's attention towards the present moment and experiencing it in a non-judgmental manner. Reducing factors like stress or negative thoughts ultimately has a positive effect on the sleep quality (Kanen, et al., 2015; Bei, et al., 2013). This kind of intervention can also be defined as an explicit intervention. The individual taking part needs to consciously pay attention to the current moment, so that the thoughts do not drift away from the situation and into potentially negative or stressful thoughts. This is a high cognitive-effort consuming process and the individual needs to stick to the task consciously in order to conduct it properly. Concluding, the examples for existing sleep interventions provided in this paper can all be defined as explicit interventions. A purely implicit sleep intervention, using the implicit processing system, does not seem to exist in professional literature yet.

As this study is conducted in a collaboration with another paper by Albert (2021) it was decided that one study would cover an explicit sleep intervention while the other one implements an implicit sleep intervention. Resulting, the whole range of sleep interventions would be covered, and an overall picture would be created through both papers. Due to the heavy focus on explicit interventions in existing literature as well as the advantages that the implicit processing system potentially has over the explicit system, an implicit sleep intervention is created for the purpose of this study. The implicit intervention created and implemented is called the Circadian-Card-Game.

The Circadian-Card-Game

The goal of the Circadian-Card-Game (CCG) is to help individuals feel more active and wakeful throughout the day while the individual should also have an easier time getting into a sleepy and calm mood in the evening. This should be achieved by influencing the implicit processing system through utilizing the training techniques commonly known as

Cognitive Bias Modification (CBM) (Jones & Sharpe, 2017). CBM can be divided into different sub areas such as cognitive bias modification for attention (CBM-A) or cognitive bias modification for interpretation (CBM-I) (Jones & Sharpe, 2017). Relevant for this intervention is the area of CBM-A. Interventions making use of CBM-A do already exist but are mostly implemented in the context of, for example, anxiety or depression (Macleod & Matthews, 2012; Hertel & Matthews, 2011). No implementations of CBM-A in the context of sleep could be identified. Thus, available literature about CBM-A in the context of anxiety is reviewed to explain the positive effects that selective attention modification can have.

CBM-A in the Context of Anxiety

Selective attention biases in the context of anxiety refer to narrowing the overall attention towards threat which makes this particular aspect receive processing priority compared to others (Richards, et al., 2014). Many papers support the view that such an attentional bias can lead to the onset and maintenance of states of anxiety or anxiety disorders (Yiend, et al., 2015; Eldar, et al., 2010; Watts & Weems, 2006). Therefore, researchers investigated the effectiveness of CBM-A practices on attentional biases. Jones and Sharpe (2017) reviewed twelve different meta-analyses and found that CBM-A interventions did affect the targeted bias and led to a reduction in anxiety symptoms. Concluding, it becomes clear that CBM-A can be an effective form of treatment for anxious people with an attentional bias. This leaves room for discussion on how this knowledge can be transferred to other behaviours, such as sleep.

The Potential of CBM-A in the Context of Sleep

There are some studies which relate attentional bias with the context of sleep as well. One fitting example is the study of Spiegelhalder, et al. (2009) who investigated the relationship between sleep-related attentional biases and the sleep quality as well as sleepiness of a person. They found that there was a positive linear relationship between sleep-related attentional bias, poor sleep quality and sleepiness of a person. No further studies on this type of relationship could be found as most research focuses on attentional biases resulting from poor sleep and not the other way around. It needs to be highlighted that the study of Spiegelhalder et al. (2009) does not pose a sufficient basis to state that the poor sleep and sleepiness were a result of the sleep-related attentional bias in their study. The study does not provide evidence for a causal relation from attentional bias to poor sleep quality. It solely gives insight into the positive nature of the relationship and the fact that there is a connection between attentional bias and sleep. Therefore, there is a big gap in literature on this topic.

Nevertheless, this study will proceed based on the assumption that an attentional bias can influence sleep quality in a negative way which entails that a CBM-A intervention can potentially increase sleep quality. If the assumption holds, then this implies that there is a wide variety of potential for such types of CBM-A interventions which remains unused until today.

CBM-A implemented in the CCG

When playing the CCG, the players should pay selective attention towards either the category "Awake" or "Sleep" which should ultimately make them feel more active (focusing on "Awake") or sleepy (focusing on "Sleep"). The individual is presented with physical cards which display either words or images that clearly relate to one of the two categories. This is a contrasting point to commonly used CBM-A training techniques as these are mostly computer-based tasks. Nevertheless, for the purpose of the CCG, it is crucial to avoid exposure to a screen, as this could inhibit the effect of sleepiness that the game should achieve in the evening (Vijakkhana et al., 2015; Green, et al., 2017; Guo, et al., 2021). Further, other card-sorting tasks such as the Wisconsin Card Sorting Test (WCST) have been proven to be connected to implicit processes. More specifically, Eling et al. (2008) highlighted that implicit learning was relevant in such card-sorting, discrimination learning tasks.

Within the CCG, the task of the participant is to sort the available cards into two different decks, one for each category. The instructions are based on two main factors which should support the selective attention modification process: location and time. Both aspects are closely related in the game. The aspect of location refers to the cards and their physical distance to the person who is playing the game. By having the positive card deck closer to oneself and the negative one further away, the effect of the CCG on the practitioners should be enhanced. Further, it is dependent on the time of the day which of the decks should be close to the player. The game should be played in the morning as well as in the evening. For example, this would mean that the "Awake" category deck should be placed close to oneself when playing the game in the morning while the "Sleep" deck is placed further away. This is reversed when playing the game in the evening. The impacting locational aspect was derived from the approach-avoidance paradigm (Aupperle, et al., 2015). The two factors allow for the game to have different effects depending on the time of the day when it is played. None of the categories are either just negative or positive but their role switches. In the morning, the "Awake" category is the category that the individual should pay selective attention to, thus the at-that-time positive deck. The reverse is true for the evening. By implementing these key elements into the CCG, the CBM-A should be supported.

As the CCG is a completely new intervention, one cannot know how the individuals playing the game will experience it. It can be helpful to receive a formative evaluation of the players in order to improve upon the current version. Further, this could give insights into the influence of the process experience on the effectiveness of the intervention. If a participant does not like the game, has difficulties understanding it, or has a hard time implementing the intervention into their daily practices, the effect of the intervention might be negatively influenced.

The Present Study

Summing up all findings, it can be said that sleep problems are a common occurrence, especially among university students. There are many factors contributing to this issue and all of them seem to be influenced by the current situation created through the COVID-19 pandemic. Further, the gap of implementation of implicit sleep interventions creates a necessity to investigate the potential that such interventions can have in this context.

Therefore, the overall aim of this paper is to explore the effectiveness of a new implicit sleep intervention on the sleep quality of university students when implementing it together with an explicit sleep intervention. Further, the impact through the COVID-19 regulations as well as the subjective process evaluation are in focus referring to their influence on the implicit intervention's effectiveness.

H1: The implicit intervention has a positive impact on university student's sleeping quality.
H2: A negative influence through the COVID-19 regulations on university student's sleep quality has a positive impact on the intervention's effectiveness.
H3: A positive process experience increases the intervention's effectiveness.

Methods

Design

The ethical approval for this study was granted on March 29, 2021, by the University of Twente BMS Ethical Committee (see Appendix A). The data collection was conducted by two students, collaborating on the topic of explicit and implicit sleep interventions within the course of their Bachelor Theses. Therefore, the described study design aimed at answering different research questions. The research of Albert (2021) focuses on the effects and role of an explicit intervention in the context of sleep while this paper explores an implicit intervention. Both papers include the effects of the COVID-19 regulations on the sleep quality

of university students in relation to the interventions. Additionally, the influence of a process evaluation on the effectiveness of either the explicit or the implicit intervention is implemented. For the sake of completion, all methods and procedures will be mentioned and are available in the appendices. Nevertheless, it will solely be elaborated in detail on the means relevant for the research of this paper.

Participants

For the purpose of this study, 44 participants were recruited. Still, throughout the course of the study, two participants dropped out as for attrition. Thus, the ultimate number of participants completing the study was 42. The respondents were recruited through convenience and snowballing sampling. The researchers published and spread the study via WhatsApp within study as well as private groups. Further, the recipients were asked to forward the message to other groups and people who would fulfil the requirements and might be interested to participate. Additionally, the study was published on the platform *Sona-Systems*, an online subject pool system of the Behavioural and Management Sciences Faculty of the University of Twente. As the access is only limited to the group of people belonging to said faculty, one can consider this method as convenience sampling as well. All participants were university students and 18 years or older. 12 of the participants were male while 30 were female (71.4% female, 28.6% male). Further, this sample had an age range of 19 to 25 (*M*age = 21; *SD*age = 1.25). Most of the participants, namely 76.2%, were taking part in a Bachelors program of Psychology at the time of the study. Participants were not included if their English proficiency was below a level of B2 as for a proper understanding of the given tasks and surveys.

Materials

Gathering data within this study was mainly done by using the website *Qualtrics*. Two surveys were created on the platform for a Pre- and Post-Assessment. Both included two officially acknowledged tests as well as self-made parts. The two official measures used within both surveys were the Morningness-Eveningness-Questionnaire and the *Sleep Quality Scale.* The Morningness-Eveningness-Questionnaire has no major relevance for this paper but the resulting circadian chronotype was only utilized to communicate to the participants at which time they should play the CCG. This is why it will not be elaborated on in detail, but all information can be found in the paper of Albert (2021). Additionally, some scales were created by the researchers themselves. Relevant for this paper are namely a part for the necessary *demographic data*, the *influence of the COVID-19 regulations* on sleep quality and

a *process evaluation* scale on the implicit intervention. The demographic section will not be explained in detail. Additionally, the *CCG* was provided to the participants in a printed version through mail or as a pdf for private printing via email.

Sleep Quality Scale

The Sleep Quality Scale (SQS) is a self-report measure developed by Yi, et al. (2006). This survey can give insights into the sleep quality of an individual and has 28 items (see Appendix D). They consist of subjective statements about the current sleep, sleep behaviours and the effects of such. To give an example, the first item states "I have difficulty falling asleep". Another one says, "I wake up easily because of noise". The SQS uses a four-point Likert-type scale through which the individual indicates the frequency of the presented statement in their personal life over the last month. The scale has four categories, namely "Rarely", "Sometimes", "Often" and "Almost always". For the sake of scoring of the scale, each of the categories has an individual score assigned to them and they are added up to create a total score ("Rarely" = 0; "Sometimes" = 1; "Often" = 2; "Almost always" = 3). The items two, eight, 13, 16, 18, 20 and 27 are reversed before being tallied. The minimum score which can be achieved is zero while the maximum score is 86. Lower scores indicate a good sleep quality while high scores are associated with more acute sleep problems, still there is no official way to categorize the scores. Therefore, the two researchers of this study determined five categories which are about equally large in order to be able to classify the resulting data throughout the study. These categories are "High sleep quality" (0-17 points), "Moderately high sleep quality" (18-35 points), "Neutral" (36-53 points), "Moderately low sleep quality" (54-71 points) and "Low sleep quality" (72-86 points). A validity analysis on the scale has been conducted by the creators and they found that the content, construct, and concurrent validity were good. The 28 items of the scale, consisting of six underlying factors accounted for 62.6% of the total variance. Further, scores of normal subjects and insomniacs have been compared and the analysis revealed that construct validity could be confirmed ($t = -13.8$, $p = 0.00$). In addition, the SQS was analysed on its correlation with the official Pittsburgh Sleep Quality Index and a significant correlation could be found, confirming concurrent validity as well ($r = 0.72$, $p = 0.00$). Next to the validity, the survey has an excellent internal consistency with a Cronbach's Alpha of .92 and a high test-retest reliability with an intra-class correlation coefficient of .81 as well (Yi, et al., 2006). The reliability has been determined for the sample in this study as well. The pre-measurement with the scale has a Cronbach's alpha of .78 while the post measurement has a Cronbach's alpha of .77 which both can be considered good.

COVID-19 Impact Scale

The Pre-Assessment survey includes a self-made scale addressing the impact of the COVID-19 pandemic on the participant's sleep (see Appendix E). It consists of two questions. The first question asks for the perceived change in sleep quality while the second question addresses the sleep duration. Only two questions were chosen in order to not extend the survey even longer and gain the relevant information in a concise way. Each question has five possible answers, being "far worse/less than before", "Slightly worse/less than before", "The same as before", "Slightly better/more than before" and "Far better/more than before". Each answer has a corresponding score of one to five. The scores from the two questions are added to form a total score. The minimum score achievable is two while the maximum score is a ten. A score between two to four represents a negative impact of the changes in life structure since the COVID-19 pandemic on the sleep of the participant. This was decided because such a score could only result from both answers indicating neutral or negative impact on sleep quality and duration. If the score is from five to seven, the influence can be considered neutral as the answers would balance each other out or would both already indicate a neutral impact. Lastly, a score from eight to ten means that the impact was positive as both answers would indicate a positive or positive-neutral impact of COVID-19 on the sleep of the participant. The questions have a Cronbach's alpha of .62 for the sample in this study which can be considered okay. An if-item-deleted analysis cannot be conducted for this scale, since it solely consists of two items. Thus, none of the items can be deleted to increase the scale's reliability.

Circadian-Card-Game

The card game has two different versions: one with words and another version with images. Two different versions were created to achieve a more positive process experience and assure that the intervention does not get boring. Each of the two versions contains 16 cards in total (see Appendices F and G). Additionally, the participant received the image version of the game as either the female or male variant according to the gender that they identify as. This was done to enhance the chance of identification with the shown activities in the images. Additionally, both versions can be considered comparable, and bias was reduced as much as possible. In Appendices F and G one can see that both variants are displaying the exact same situations with the only difference in the gender of the carrier of that action. Next, there are two instruction papers for both versions of the game. Both papers show instructions for the morning as well as for the evening as the game needs to be played twice a day (see Appendix H). Further, the exact time at which it needs to be played is dependent on the individual circadian chronotype of the player. This chronotype was identified within the

course of the partner study of Albert (2021) and the participants were informed about their perfect sleep- and wake-times before the implicit intervention started.

The CCG has been pilot-tested with six volunteers which were not taking part in the study. For the word version, there was feedback about two of the words that were chosen. The words “strong” and “slow” were not entirely clear to three of the volunteers. They stated that they could not clearly identify these words as belonging to either the category “Awake” or “Sleep”. Therefore, these two words have been exchanged with words that were approved by the six volunteers as being clear and understandable. The word “strong” was exchanged for the word “powerful” while the word “slow” was exchanged for the word “cosy”. Secondly, the image version was approved except for two images as well. The images displaying a person bathing and a person listening to music were confused as being images belonging to the “Awake” category at first. This has been discussed and the images have been exchanged. The action displayed on the new cards was still the same, but the cards were chosen in a way so that the individuals carrying it out clearly represented a relaxed and cosy atmosphere. These changes have been reviewed and approved by all six volunteers.

Process Evaluation Scale

The Post-Assessment survey includes nine items about the evaluation and process of the implicit intervention (see Appendix I). More specifically, the participant is asked about the process of implementation, the subjective effects on the wake-sleep-rhythm and the cognitive effort, fun and overall attitude connected to the different versions of the CCG. As an example, item four poses the following instruction “Please indicate your opinion towards the *first version* of the Circadian-Card-Game (words) on the following scale:”. Each item has five possible answers which are structured in a similar way across the items. Namely the answers are “Not at all/Disagree/Boring/Undemanding/Negative”, “Slightly disagree/Somewhat boring/undemanding/negative”, “Neutral”, “Slightly agree/Somewhat entertaining/demanding/positive” and “Totally/Agree/Entertaining/Demanding/Positive”. Each answer has a corresponding score from one to five. For example, the answer “Not at all” is represented by the score one and “Totally” by the score five. The scale is scored by adding the nine scores and creating a total score. Items five and eight are reversed before being tallied. These questions ask about cognitive effort and as analysed in the introduction, an implicit intervention should not be cognitively demanding. Thus, if the answer is “Undemanding” the corresponding score is a five while for “Demanding” it is a one. The minimum score achievable is a nine while the maximum score is a 45. Lower scores express a negative process experience for the participant while a higher score indicates a positive one.

In order to classify what can be considered positive or negative, three categories have been created. It was decided that they needed to be about the same size to assure the categories actually represent the position of the respondent. Therefore, a score from nine to 20 represents a negative experience while a score from 21 to 33 shows a neutral one. Lastly, a score from 34 to 45 defines a positive experience with the implicit intervention. As this is a self-made scale it is important to determine its reliability. The scale has a Cronbach's alpha of .76 which means that the overall reliability of the scale in this sample can be considered good.

Additional Material

For the collaborating paper, additional other materials were used (Albert, 2021). First, there were two more self-made sections within the Pre- and Post-Assessment, namely a scale about an individual's *level of sleep knowledge* as well as a *process evaluation* on the explicit intervention (see Appendix I and J). Further, the explicit intervention itself included additional material. The participants were given a *link to a video* educating about sleep hygiene practices (see appendix K). Further, they were instructed to fill out three *self-made tests* via the online platform google forms (see Appendices L and M). This was done to administer the participant's knowledge on the video's content. Lastly, the participants had to conduct a *goal-of-the-day exercise* which instructed them to write down what they would like to achieve or improve for that given day (see Appendix N). This exercise was a means to deepen and implement the gained knowledge about sleep hygiene.

Procedure

Overall, it took 9 days for participants to complete the study. If an individual agreed to participate in the study, either via the website *Sona Systems* or through a personal request, they were instructed to fill out the pre assessment survey. The survey could be conducted on the Sona website or was provided through a link in an email. If the respondents had filled it out, the researchers investigated the results of the MEQ specifically and scored the answers. Next, the participant received their individual circadian chronotype based on the previous assessment and all the instructions for the following intervention week via email. If the respondents chose to receive the printed CCG via mail, then the game was directly sent to them. Opposing, if participants chose otherwise then they received the pdf material to print the CCG themselves. During the intervention week the participant could not be controlled in completing the different tasks, but the study relied on self-regulation. After the intervention week, the participants were instructed to fill in the last survey of the study - the post-Assessment – on the Sona website or via a link in an email.

The Intervention Week

The intervention week can be divided into explicit and implicit intervention components. Both interventions took part simultaneously throughout the seven days as can be seen in figure 1. Looking at the implicit intervention part, the participant was instructed to play the CCG every day throughout the intervention week. It was played in the morning as well as in the evening. The exact time was dependent on the individual's circadian chronotype which has been determined earlier within the pre assessment survey. From day one to four, the word version of the game was played while the participant switched to the image version on day five to seven. Next implicit intervention part, there were explicit intervention components taking part simultaneously. The participants were instructed to watch the educational video on the first day. Additionally, the three knowledge tests were conducted on day two, four and seven. Lastly, on day three and six the participants took part in the goal-of-the-day exercises.

Figure 1

Intervention week schedule

Intervention parts

Time

	Implicit Intervention	Both	Explicit intervention
Day 1		Pre-assessment	
Day 2	Game (version 1)*		Video
Day 3	Game (version 1)*		Proactive sleep behaviour test
Day 4	Game (version 1)*		Goal-of-the-day exercise 1
Day 5	Game (version 1)*		Preventive sleep measures test
Day 6	Game (version 2)*		
Day 7	Game (version 2)*		Goal-of-the-day exercise 2
Day 8	Game (version 2)*		Final test
Day 9		Post-assessment	

* Within the first hour after waking up and within the last two hours before going to bed

Note. The different tasks of the implicit and explicit intervention, arranged according to the days of the intervention week.

Data Analysis

The gathered data is analysed by means of the program IBM SPSS Statistics 27.0. First, an overall screening of the data is done to learn more about the data set. More specifically, the sample sizes of all variables are checked, as it is likely that the amount of data per variable varies due to the number of tasks which had to be conducted by the participants. If the sample sizes are sharply unequal, that can have implications for analyses conducted later. For the descriptive statistics of each variable, the mean value, standard deviation as well as minimum and maximum are the main focus to gain first insights into the available data. Further, all variables are checked for normality by creating histograms and judging the distribution of the data. Thus, outliers or any extraordinary patterns may be identified.

Four separate variables, namely the sleep quality before the intervention, the sleep quality after the intervention, the process evaluation of the participants and the impact of the COVID-19 measures on the participants' sleep quality, are involved in the hypothesis testing. For the first hypothesis, a paired t-test is conducted to compare the two means of the sleep quality before and after the intervention. For this study, the difference in the mean scores is interpreted as the effectiveness of the implicit intervention while it needs to be highlighted that it is not possible to control whether solely the implicit intervention caused the change. Additionally, the effect size is calculated by using Cohen's d for paired designs.

To investigate the second and third hypotheses two ANCOVA models are used. It was decided against repeated measures ANOVA as the sleep quality is only measured at two points in time. Still, there are some assumptions about the data which need to be met before the results of the ANCOVA can be interpreted with confidence. Namely, these are normality, homogeneity, and linearity. The first two have already been investigated when getting a first impression on the data, thus only linearity needs to be identified at this point. This is done by creating two separate scatter plots. The first one represents the relation between the sleep quality before and after the intervention dependent on the COVID-19 regulation's impact on sleep quality (three categories: negative impact, neutral and positive impact). The second one shows the same correlation but dependent on the process evaluation of the participant (three categories: negative process experience, neutral and positive process experience). If linearity can be confirmed, the two final ANCOVA models are created. The independent variable for the first model is the sleep quality prior to the intervention while the dependent variable is the sleep quality after the intervention. Further, it is accounted for the potential influence of the COVID-19 regulations on sleep quality as the covariate. The other ANCOVA model exchanges the covariate of the previous model with the influence of the process evaluation.

Results

The first overall screening through the descriptive data as well as the analyses on normality and homogeneity, are arranged according to the four different variables involved in the analysis. Following that, the paired t-test and ANCOVA models are discussed in three individual sections. This should allow for a good overview and clarity on the results.

Table 1

Participant distribution throughout the categories of all four variables

Variable	Categories	Frequency for all documented responses	Frequency for the 27 completers
Sleep Quality: Pre-measurement	High sleep quality	4.9%	7.4%
	Moderately high sleep quality	53.7%	44.4%
	Neutral	41.5%	48.1%
	Moderately low sleep quality	-	-
	Low sleep quality	-	-
Sleep Quality: Post-measurement	High sleep quality	10.7%	11.1%
	Moderately high sleep quality	67.9%	66.7%
	Neutral	21.4%	22.2%
	Moderately low sleep quality	-	-
	Low sleep quality	-	-
	Positive impact	26.8%	25.9%

COVID-19 impact	Neutral	63.4%	66.7%
	Negative impact	9.8%	7.4%
Process evaluation	Positive process experience	39.3%	40.7%
	Neutral	53.6%	51.9%
	Negative process experience	7.1%	7.4%

Note. The distribution of participants throughout the different categories of the variables Sleep Quality (pre-measurement), Sleep quality (post measurement), COVID-19 impact and Process evaluation in percentages including all documented responses in comparison to the responses from the 27 completers of the whole study.

Table 2

Descriptive statistics of all four variables

Variable	N	Minimum	Maximum	Mean	Std. deviation
Sleep Quality: Pre-measurement	41	13	53	32.41	10.01
	27	13	53	33	10.752
Sleep Quality: Post-measurement	28	8	43	28	8.52
	27	8	43	28	8.581
COVID-19 impact	41	3	10	6.41	1.53
	27	3	10	6.67	1.519
Process evaluation	28	14	37	31.21	4.80
	27	14	37	31.33	4.852

Note. The minimum, maximum, mean, and standard deviation for the variables Sleep Quality (pre-measurement), Sleep quality (post-measurement), COVID-19 impact and Process evaluation including all documented responses in comparison to the responses from the 27 completers of the whole study.

Sleep Quality: Pre- and Post-measurement

For the first measurement of sleep quality, a total of 41 responses were recorded. In contrast, only 28 participants filled in the SQS after the intervention. This can be considered a huge discrepancy. Thus, only the 27 participants who filled out both the pre- and post-measurement are being elaborated on in detail and included for the analyses of the hypotheses.

Before the intervention, most participants could be attributed to the category “Neutral” with 48.1%. Further, 44.4% of the respondents belong to the category “Moderately high sleep quality” which is nearly as big as the first category. Only a small portion, namely 7.4% of the respondents fell into the category of “High sleep quality”. It is important to note that none of the participants were part of the “Low sleep quality” or “Moderately low sleep quality” categories.

The measures after the intervention display a different distribution of the participants among the five categories of sleep quality. None of the respondents belong to the categories “Moderately low sleep quality” or “Low sleep quality” which is in line with the pre-measurement. Still, the category “Neutral” significantly decreased in size and is composed of only 22.2% for the post-measurement compared to the 48.1% for the pre-measurement. Further, the “Moderately high sleep quality” group grew to 66.7%. Lastly, 11.1% of the respondents belong to the “High sleep quality” category in the post-measurement.

The descriptive data in table 2 shows that all total scores achieved in the SQS during the pre-measurement are between a minimum of 13 and a maximum of 53. After the intervention, the overall scores are smaller with a minimum of 8 and a maximum score of 43. Thus, the overall scoring range decreased. Moreover, the mean is at 33 with a standard deviation of 10.752 for the pre-measurement. The second measurement shows a mean of 28 with a standard deviation of 8.52. This supports the assumption that the overall sleep quality of the participants increased after the intervention. Further, the change in the standard deviation expresses that the data started to stabilize around the mean after the intervention. Looking at the histogram in Appendix O, one can state that there are no extraordinary patterns, and the data of the pre-measurement can be considered normally distributed. The

same is true for the post-measurement. In Appendix P one can see that the data is normally distributed for this variable as well.

Impact of COVID-19 Regulations

The COVID-19 scale was filled in by a total of 41 respondents. Still, it will solely be elaborated on the responses of the 27 completers of the study in detail. 7.4% of the participants indicated a negative impact through the COVID-19 restrictions on their sleep quality. Most participants belong to the "Neutral" category with 66.7% of the whole sample. Further, 25.9% report that they experienced a positive impact through the COVID-19 restrictions.

The descriptive data gives further insights as it shows that the minimum score represented in this sample was a three while the maximum was a 10. This shows that none of the participants gave the most negative answer in both items available for this scale as no one received a total score of two. Further, the mean is 6.67 with a standard deviation of 1.519 which supports the point that those belonging to the "Negative impact" category rather experienced only slight negative effects. The histogram of this variable shows an almost perfectly bell-shaped distribution which means that normality of this data can be confirmed as well (see Appendix Q).

The participants had the option to elaborate on their answers in provided text boxes. The outcomes indicate that the negative impact experienced was mostly the result of a lack of schedule throughout the day. As an example, one participant stated, "I think that especially at the beginning it was harder to get a good night's sleep after spending all day in my room, but it has gotten much better since.". Further, another statement says, "I cannot really participate in activities outside of my home. Therefore, I am rarely exhausted enough to really fall asleep.". These examples further illustrate that some participants feel like there has already been an improvement in their sleep quality since the beginning of the pandemic. This is underlined by another quote "I have had major problems with falling asleep (sometimes days without falling asleep), but now having started to workout daily, to focus on eating and having enough sleep I am sleeping way better.".

Another aspect which was often picked up by people who felt like there was a positive impact on their sleep quality through the COVID-19 measures was the fact that they were able to schedule their sleep time themselves, for example, they could sleep longer in the morning. "I can sleep longer and have less stress in the morning" is an example illustrating this topic. Further another person said, "I can go to bed earlier and can often sleep like my body wants

to.”. This quote implies that some participants feel that their own circadian rhythm can be implemented easier into daily life since the COVID-19 regulations are in effect.

Process Evaluation

The process evaluation scale was conducted by 28 participants. In the following, the data of the 27 completers of the study is highlighted. The majority felt neutral towards the implicit intervention with 51.9% belonging to that category. In contrast, only 7.4% of the individuals reported a negative process experience. Lastly, 40.7% belong to the category “Positive process experience”. Therefore, one can state that the general attitude towards the CCG was neutral to positive.

Further, the descriptive data indicates that the minimum score was 14 while the maximum score was a 37. Looking at the mean of 31.33 and the standard deviation of 4.852 it becomes reasonable to assume that the individuals belonging to the “Negative process experience” category are rather an exception and that most people scatter around the values representing a neutral to positive attitude towards the intervention. The histogram on the distribution of scores for this variable displays a somewhat normal distribution but also confirms the assumptions made previously. The graph is slightly skewed to the right with only some outliers on the lower side of the scale (see Appendix R). Thus, the data will be treated as normally distributed throughout the following analyses.

It is important to highlight that the data of all participants compared to the data of the 27 completers of this study is fairly similar. This means that only looking at the completers did not create major changes in the descriptive statistics or frequency of categories. Thus, it can be proceeded without taking the non-completers into account for the following hypothesis-testing process.

The Change in Sleep Quality throughout this Study

The results of the paired t-test, including the 27 participants who conducted the pre- and post-assessment, show that there is a significant positive correlation between the sleep quality before and after the intervention with $r = .654$, $p = .000$. Further, the difference in the averages between the sleep quality before and after the intervention was significant as well with $t (26) = .3.041$, $p = .005$. There was an average decrease of 4.926 from the first sleep quality measurement to the second one. Additionally, the Cohen’s d of the t-test is .585 which can be considered close to medium (Becker, 2000). Therefore, the first hypothesis is confirmed. The implicit intervention has a positive influence on the student's sleep quality.

Influence of the COVID-19 Regulation`s Sleep Quality Impact on the Change in Sleep Quality

Before creating the ANCOVA model, it needs to be checked whether the requirement of linearity is fulfilled. The scatterplot in Appendix S shows that there is a simple linear relation between pre- and post-measurement when accounting for the influence of the COVID-19 regulations. Thus, the model can be created as all requirements, namely homogeneity, normality and linearity, are fulfilled. The model shows that there is no significant influence of the impact, through the COVID-19 regulations on sleep quality, on the change in sleep quality with $F(1, 21) = .07$, $p = .801$, and $\eta^2 = .014$. The p-value is too high above the acceptable alpha of $p \leq 0.5$. Thus, the second hypothesis is rejected: No influence of the COVID-19 impact on the intervention's effectiveness could be found.

Influence of the Process Evaluation on the change in Sleep Quality

Looking at the scatter plot, displaying the relationship between the first and second measurement of sleep quality depending on the categories of the process evaluation in Appendix T, one can state that there is a simple linear relationship. Thus, the requirements for this ANCOVA model are fulfilled as well. Therefore, the results of the ANCOVA model can be treated with confidence as well. The model shows that the process experience does not have an influence on the changes in sleep quality, as $F(1, 21) = .381$, $p = .564$, and $\eta^2 = .071$ shows. The significance value is too high above the acceptable mark of $p \leq 0.5$. Therefore, the third hypothesis cannot be confirmed: There is no influence through the participant's process experience on the intervention's effectiveness.

Discussion

Generally, this study is the first of its kind in combining an explicit and implicit sleep intervention in its design. To gain more insights into an explicit intervention in the context of sleep, it is advised to review the paper from Albert (2021). Based on this novel, two-part study, some conclusions can be drawn regarding students' sleep behaviour and future research points.

The results of this study show that the combination of an explicit and implicit sleep intervention has a positive influence on the sleep quality of university students. As this study focused specifically on the implicit component, it was hypothesized that the implicit intervention has a positive impact on the student's sleep quality. The results of the paired t-test were interpreted as representing the intervention's effectiveness and thus, the hypothesis was confirmed. With an effect size of $d = .163$ this intervention displays a very small effect.

Looking at other, already-implemented interventions, which are explicit and have a different approach than the CCG, the effect size can be considered somewhat comparable. For example, the study of Dietrich et al. (2016) investigated sleep education programs for sleep hygiene and found an overall significant positive influence on sleep quality with a similarly large effect size of $d = .57$. Further, another paper focused on a brief behavioural sleep intervention and found an overall medium effect size on sleep quality as well with $d = .55$ to 0.64 (Paavonen, et al., 2016). Still, the intervention of Walter et al. (2016) displays large effect sizes on more severe conditions such as insomnia ($d = 1$) but only medium effects on, for example, daytime symptoms with $d = 31$. As this study has not been concerned with insomnia but with arguably more innocuous sleep problems, one can state that the effect size of the implicit intervention used in this study is comparable to effect sizes of existing, explicit sleep interventions. This is in line with the view, outlined in the introduction, that addressing the implicit system, based on the dual processing model, can be an effective way to achieve change (Strack & Deutsch, 2004). One can deduct that this is a promising area for future sleep interventions, and it can utilize the potential that already-existing, explicit interventions leave unused. Additionally, looking at the combination of an explicit and implicit intervention, examples in other contexts do already exist and pose further reasons to implement such a mix into sleep-related problems. To pick up the context from the introduction, Berger, et al. (2017) investigated the combined role of explicit and implicit aspects leading to social anxiety (SA). Their study suggests that there is a significant interaction between these implicit and explicit elements, and they underline the multifaceted nature of factors leading to SA. One can argue that such interactions are also present in the context of sleep which should be a focus of future research. If one can identify in what way they interact, enhance or diminish each other, better and more effective interventions can be created which combine both: explicit and implicit elements.

Nevertheless, these results need to be treated with caution and it needs to be highlighted that they shall not be used in other studies without taking the following limitations into account. The main limitation, which heavily affects the interpretation of the first hypothesis, is the fact that there is no control group to which one could compare the results to. A major resulting problem is that it leads to an uncertainty as to which component of the overall study actually caused the improvement in sleep quality. Through a control group one would be able to differentiate the effects of the explicit and the implicit intervention. As an example, one could combine the explicit and implicit intervention only for the experimental group and let a control group conduct only one of the two components. Additionally, it could not be determined whether the participants actually conducted the implicit intervention

completely, only partly or not at all. Thus, the interpretation of the paired t-test as the intervention's effectiveness in itself already leaves room for discussion. The analysis of the data is based on the assumption that all participants conducted the CCG as instructed till the end of the study, which can be argued as being unlikely. A potential improvement could be to control for the frequency in which the CCG was played. Then it would be possible to link this frequency of playing to the improvement in sleep quality scores and would allow for more accurate interpretation. Further, the results on the SQS show that the sample in this study had a neutral to high sleep quality from the start. This opposes the findings in the introduction, as there is consensus across literature that there is a high frequency of low sleep quality within the population of university students (Vargas, et al., 2014; Lund, et al., 2010; Carney et al, 2006). Therefore, it can be assumed that the implicit intervention, if that is what the change in sleep quality resulted from, is effective for mainly neutrally good sleepers. Thus, one cannot be sure whether bad sleepers would benefit equally from this intervention. Another limitation is the sample size of the study. It was calculated that the sample size for this t-test must contain at least 34 participants in order to be representative (Faul, 2007). This criterion could not be fulfilled due to, for example, a high drop-out rate. As a future improvement, therefore, it is advised to monitor the participants more closely. If every respondent had started the intervention, for instance, on the same day, it would have been possible to send out daily reminders to all participants simultaneously. As research has shown, sending regular reminders increases the participation rate as well as decreases the drop-out rate (Svensson et al., 2012). Hence, in the case this intervention should be repeated, it is advised to ensure to monitor the participant´s process within the intervention to be able to, if needed, send reminders for (still missing) activities.

In contrast to the first one, the second and third hypotheses needed to be rejected. First, it was hypothesized that a negative influence through the COVID-19 regulations would have a positive impact on the intervention's effectiveness, since the particular factors involved in the COVID-19 regulations have been specifically implemented into the CCG. As an example, the papers of Alam (2020) or Chen et al. (2020) describe how the switch to online education results in a lack of daily structure for students, which in turn leads to a decrease in sleep quality. Addressing this issue, the CCG aimed at creating some kind of daily structure by instructing the participants to play the game only at specific times a day, fitting to their circadian chronotype. Nevertheless, the results did not support the connection between COVID-19 regulations and the intervention's effectiveness. This can be rooted in an unexpected basic condition found within this sample.

As discussed in the introduction, literature suggests that the COVID-19 restrictions lead to an overall decrease in sleep quality (Romero Blanco, et al., 2020; Khare, et al., 2021; Zhou, et al., 2020; Majumdar, et al., 2020; Cellini, et al., 2020). However, this sample indicated that the vast majority was neutrally affected while a reasonable number of participants also expressed that they experienced a positive influence through the restriction measures. This unexpected finding might have occurred since most literature used in the introduction was published in the year 2020. This means that the data gathered for such studies must have been documented at a time where COVID-19 restrictions were still a rather new occurrence within western countries. As this study was conducted within the course of May and June of 2021 it can be argued that most university students already found ways to adapt to the unique situation of the COVID-19 restrictions. This is further supported by different elaborations from the participants exemplified in the results section and literature thematizing adaptation techniques of university students (Xhelili, et al., 2021; Biwer, et al., 2021).

Lastly, the process experience of the participants did not have an influence on the intervention's effectiveness either. For the newly created intervention, the CCG, it was crucial to gain insights into the participants' process experiences and the potential impact that they might have. This knowledge should provide a basis for future improvement. The overall feedback towards the two versions of the CCG was broadly neutral while 11 out of the 28 participants indicated a positive process experience. Thus, approaching the implicit processing system playfully through a game, as done with the CCG, might be a basis to build upon in the future. Further, the word as well as the image version received comparable feedback while the image version was only perceived as slightly more positive. This suggests that both versions are broadly experienced in a neutral to positive way while images seem to be a bit more appealing than words.

However, the results need to be interpreted carefully in this case as well. The sampling conducted within this study was heavily dependent on convenience sampling through, for example, private contacts. More specifically, many friends from the researcher's study program have been recruited. This kind of affection and closeness between researchers and participants creates room for many different biases being impactful in such assessments. As an example, an in-group bias is the tendency of individuals to be more positive towards members of their own group compared to individuals belonging to an out-group (Yamagishi, et al., 1998; Terry & Callan, 1998). Such a bias might have been present while some participants conducted the process evaluation, making them indicate a more positive experience than they would have indicated towards another, unfamiliar researcher.

Strengths, Limitations, and Future Implications - Both Intervention Components

Before exploring the strengths, limitations, and future implications for this specific part of the study based on the aforementioned results, some general points for both parts of the intervention are addressed due to a large overlap in the general organisation of both papers. Hence, the authors of each bachelor thesis have decided to list some of their findings and experiences as one cohesive piece. To repeat, the main difference between both papers is the focus on either an explicit or an implicit intervention. Still, the study itself has been conducted together and as a whole.

The notable strength of the overall intervention is its novelty. To our knowledge, there are no recorded attempts of a combination of an implicit and explicit intervention in the context of sleeping behaviour. Thus, it is anticipated that this study opens the way for more interventions implementing both processing types. Moreover, combining explicit and implicit interventions could be the new middle ground for interventions solely focused on explicit or implicit processing. The participants could learn more about specific behaviours, such as in this case, sleep hygiene, while simultaneously applying the newfound knowledge in a preferably automatic and unconscious way (Strack & Deutsch, 2004). Hence, it would alleviate the participants in having to respond to everything with high, conscious mental effort, which is explicit behaviour, by introducing implicit behaviour alongside as well (Strack & Deutsch, 2004). There are already some studies on the combination of implicit and explicit intervention elements in other contexts than sleep, but it is never explicitly compared how a solely explicit or implicit intervention performs compared to a combination of the two. Still, literature provides reasons for the importance of the combination of implicit and explicit elements.

Referring back to the dual processing model, many studies highlight the interplay between both processing systems (Neys, 2006; Gamberini et al., 2014; Calder et al., 2018). Further, the study of Norman (2009) compared both processing systems in the context of psychological diagnostics and found that if a clinician uses both systems, then a consistent reduction in diagnostic error rates can be achieved. Thus, overall, one can argue that the combination of implicit and explicit intervention elements is likely to be superior compared to using only one of the two. Concludingly, by highlighting the novelty of this study, it became clear how its approach poses a major strength and could introduce a new form of intervention design.

As mentioned, by combining both implicit and explicit approaches in an innovative way, the participants simultaneously conducted both parts of the intervention. However, this also implies a major weakness of the design of the study, as it cannot be determined if the

effects and correlations between different variables are a result of the explicit intervention, the implicit intervention, or both. It is possible that only one component of the intervention was effective but, through the study design, this cannot be identified. Nevertheless, the fact that the explicit part of the intervention showed no mediation of sleep knowledge on sleep quality, it can be assumed that the implicit intervention part played a role as well. Further, it can be argued that the video used in the explicit intervention did not only pose as an educational stimulus but as a persuasive element as well. More concretely, the content creator of said video could have appealed to the participants in an underlying way as for her professional expression. This possibility was not measured in the overall intervention. Overall, it is most likely that both intervention parts had an influence on the participant's sleep quality and that there may be an interaction effect between the two intervention parts. As research has shown, implicit and explicit learning usually takes place at the same time and both systems are not as exclusive as they are treated in some studies (Sun et al., 2005). Concludingly, as it remains unclear which intervention part influenced which changes in the participant sample, a future improvement would be to introduce control groups which are receiving either the implicit or explicit intervention part. Based on these results, it can become apparent which intervention elements brought forth which developments.

Another point of critique is that many scales were self-computed and could not be tested on validity before usage due to a tight schedule. Thus, it was only possible to provide reliability scores after the study had been conducted. Still, this raises the awareness that there is a lack of generally approved scales that can identify, for example, as needed in this study, the impact of COVID-19 on people's sleep behaviour. As it can be expected that the COVID-19 pandemic is still going to impact societies socially (Franchi, 2020), psychologically (Ozili & Arun, 2020), and economically (Paredes et al., 2021) for some months or potentially years, it is a necessity to develop such scales. This does not only apply to the sleep quality but can be broadened to other categories like general mental well-being. Having reliable and valid scales in this context can provide new information on the impact of the pandemic and potentially help to find ways to help to counteract the effects of the pandemic.

All in all, the major strength of this study is its novel approach of combining implicit and explicit intervention elements. Still, by adjusting some minor modifications, the overall design of this study could be elevated, if it were to be repeated again.

The Implicit Intervention Component

As the two different parts of the study still have major differences in their structure and content, it is important to discuss the implicit sleep intervention separately. Thus, the

availability of literature as well as the underlying mechanisms and the development of the implicit intervention will be the focus of the following section. For a discussion on the explicit intervention and the associated implications it is referred to the paper of Albert (2021).

The need to design a completely new implicit sleep intervention conveys a significant lack of research in this area. Within the introduction it already became apparent that there are several explicit interventions in this context, for example sleep hygiene interventions as described by Brown, et al. (2002). Further, all other interventions found to tackle sleep problems seem to mainly address the explicit processing system but neglect implicit factors which might be relevant to this issue as well (Al Khatib, et al., 2018; (Shanahan, et al., 2019; Bootzin & Perlis, 2011). Henceforth, no existing implicit sleep interventions could be identified. Future research should focus on implicit interventions in the context of sleep as this study provides a basis to assume that such interventions can be effective in improving sleep quality. Further, the dual processing theory is a basis to argue for different advantages that the implicit processing system, and by that, an implicit sleep intervention might have over an explicit sleep intervention. For example, implicit sleep interventions could be conducted with low-effort consumption during the process which creates room for great potential (Strack & Deutsch, 2004). Still, it needs to be highlighted that the combination of explicit and implicit elements might be the most promising future for sleep interventions. As described earlier, such combinations are already being successfully used and, for example, the study of Gamberini, et al. (2014) is a paper which highlights how explicit and implicit techniques can complement each other to achieve a specific goal. Therefore, not only exploring the effectiveness of implicit interventions but also combining implicit elements with existing explicit techniques can be a promising next step to address sleep problems.

However, there is a huge obstacle which needs to be overcome before creating and testing implicit sleep interventions. As this Bachelor Thesis had a clear goal from the start - implementing an implicit sleep intervention - it was necessary to accept this obstacle and form an own solution to that problem. Namely, no research could be identified on implicit underlying mechanisms which cause sleep problems. Thus, the solution created in this study was to investigate other contexts and their underlying psychological mechanisms from which inferences were made. Literature available on anxiety and attentional biases, as well as effective CBM-A interventions in that context, functioned as a validation to argue that CBM-A might also be successful in the context of sleep (Legerstee, et al., 2009; Rozenman, et al., 2011; Roy, et al., 2015). It was not possible to test whether attentional biases are actually catalysts for sleep problems beforehand, as for the scope of the Thesis. Thus, the intervention

itself has been created based on an assumption. Still, this aspect reveals a productive insight as well. Future research needs to investigate if such attentional biases or other underlying implicit mechanisms play a role in the context of sleep or not. Gaining knowledge on this topic could lead to a new understanding of the factors involved in sleep problems and can be the basis for the creation of implicit sleep interventions.

An additional point which should be discussed is whether the CCG actually is an implicit intervention as defined in this paper. When playing the CCG, the practitioner needs to identify whether the word or image displayed on the card belongs to the "Awake" or "Sleep" category and sort them accordingly. This process implies that memory content needs to be retrieved consciously in order to be able to make the correct decision. Referring back to the WCST as a comparable card-sorting task to the CCG, literature highlights that neural activity, namely simple to more complex and manipulative working memory operations are necessary when conducting the test (Lie, et al., 2006). One can argue that this might also apply for the CCG, making it more of a cognitive effort consuming and conscious intervention than originally anticipated. In contrast, Nelson, et al. (2000) argue that such a card-sorting task might rather be based on spontaneous responses which do not involve analytic deliberation. This can be argued to be true for the CCG as well. For example, reading the word "tired" on one of the CCG cards in the evening might rather automatically make the player associate the word with going to bed than making the person have an active deliberation on whether this word would really fit the "Sleep" or the "Awake" category. Especially the fact that the game is played repeatedly with the same cards could lead to a priming effect and decrease the conscious aspect constantly throughout time. Still, such a priming effect in itself could also be problematic for the effectiveness of the CCG. Overall, it can be concluded that the CCG can be argued to be an implicit intervention as defined for this paper. Nevertheless, the exact cognitive reactions when playing the game are unknown as for the intervention's novelty.

Next to the theoretical basis, there are practical points of improvement for the CCG as well. As mentioned in the introduction, different factors were included in the game which should enhance the selective attention and effect of the CCG. Namely, the ones implemented were time and location. Still, there are other factors which could be useful, such as the posture in which the CCG is played. The study of Johns (1994) gives insights into the contextual factors which make people sleepy, also including postural elements. More specifically, he found that low-stimulus situations in daily life, such as lying down to rest in the afternoon, were associated with sleepiness. This allows for a basis to argue that the posture, if implemented correctly, can be an enhancing factor for the effectiveness of the CCG. The posture could be implemented in a meaningful way referring to the context of the morning or

evening. As an example, the player could stand up in front of the table instead of sitting down, when playing the CCG in the morning. This would create a more active engagement and would complement the effect that the game should have at that time of the day: becoming active and less sleepy. Additionally, a fitting example for the evening would be that the player lays on the bed while playing the game which could enhance the relaxing effect in the evening.

Despite some aspects of improvement, one needs to point out the positive points of the CCG as well. First, many factors that support the sleep-wake rhythm have been implemented in the game already, for example, the individual circadian chronotype as the game should be played at specific times fitting to the individual's rhythm. Further, the game was either sent to the participants as a printed version via mail or they had the opportunity to print and cut the game themselves. This was done to avoid any kind of contact with screens while playing th3e game in the evening as that could have had disturbed the effect of the CCG. The sleep-disrupting effect through screen exposure in the evening has been confirmed by many different studies (Vijakkhana et al., 2015; Green, et al., 2017; Guo, et al., 2021). Additionally, it needs to be highlighted that the overall feedback on the implicit intervention through the process evaluation scale was heavily neutral to positive, as described in the results section. This implies that, next to the aspects of improvement, the current form of the CCG already achieved a proper first step upon which can be built. Moreover, throughout the pilot testing of the game there was not much critique but solely the aspects of clarity about some words or images were addressed. Lastly, it is not to overlook that a positive effect on the sleep quality of the university students was found. Even if this might not be purely caused by the implicit, but by an interaction between the implicit and explicit intervention, it can be considered a productive result. The participants left the study with an improved sleep quality.

Conclusion

Overall, this study achieved an increase in sleep quality for the participants. This increase is partly interpreted as the implicit intervention's effectiveness which needs to be viewed critically. No effects of the COVID-19 regulations or process experience on the intervention's effectiveness were found. From this study, one can deduce that a lot of research in the implicit area of sleep needs to be done. This refers to underlying mechanisms which are involved in sleep problems as well as implicit intervention techniques which can be used to improve sleep quality. As a result of this lack in research the basis of the implicit intervention which was created in this study is not well substantiated and the results need to be treated with caution. Nevertheless, the CCG is a first approach to an implicit intervention in this context and raises

awareness that such interventions might have a promising future. Further, the combination of implicit and explicit intervention techniques should become a significant point of consideration for other researchers.

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Appendices

Appendix A

Ethical approval

APPROVED BMS EC RESEARCH PROJECT REQUEST

Dear researcher,

This is a notification from the BMS Ethics Committee concerning the web application form for the ethical review of research projects.

Requestnr. :	210371
Title :	Influencing sleep during COVID-19: An explicit and implicit intervention
Date of application :	2021-03-29
Researcher :	Worm, M.
Supervisor :	Bode, C.
Commission :	Klooster, P.M. ten
Usage of SONA :	Y

Your research has been approved by the Ethics Committee.

The BMS ethical committee / Domain Humanities & Social Sciences has assessed the ethical aspects of your research project. On the basis of the information you provided, the committee does not have any ethical concerns regarding this research project.

It is your responsibility to ensure that the research is carried out in line with the information provided in the application you submitted for ethical review. If you make changes to the proposal that affect the approach to research on humans, you must resubmit the changed project or grant agreement to the ethical committee with these changes highlighted.

Moreover, novel ethical issues may emerge while carrying out your research. It is important that you re-consider and discuss the ethical aspects and implications of your research regularly, and that you proceed as a responsible scientist.

Finally, your research is subject to regulations such as the EU General Data Protection Regulation (GDPR), the Code of Conduct for the use of personal data in Scientific Research by VSNU (the Association of Universities in the Netherlands), further codes of conduct that are applicable in your field, and the obligation to report a security incident (data breach or otherwise) at the UT.

Appendix B

Morningness Eveningness Questionnaire

Please read each question very carefully before answering. Please answer as honestly as possible.

This questionnaire aims at determining your circadian rhythm, mean

What time would you get up if you were entirely free to plan your day?	5am-6:30am	6:30am-7:45am	7:45am-9:45am	9:45am-11am	11am-12pm	12pm-5am
What time would you go to bed if you were entirely free to plan your evening?	8pm-9pm	9pm-10:15pm	10:15pm-12:30am	12:30am-1:45am	1:45am-3am	3am-8pm
If there is a specific time at which you have to get up in the morning, to what extent do you depend on being woken up by an alarm clock?	Not at all dependent	Slightly dependent	Fairly dependent	Very dependent		
How easy do you find it to get up in the morning (when you are not woken up unexpectedly)?	Not at all easy	Not very easy	Fairly easy	Very easy		

How alert do you feel during the first half hour after you wake up in the morning?	Not at all alert	Slightly alert	Fairly alert	Very alert
How hungry do you feel during the first half-hour after you wake up in the morning?	Not at all hungry	Slightly hungry	Fairly hungry	Very hungry
During the first half-hour after you wake up in the morning, how tired do you feel?	Very tired	Fairly tired	Fairly refreshed	Very refreshed
If you have no commitments the next day, what time would you go to bed compared to your usual bedtime?	Seldom or never later	Less than one hour later	1-2hours later	More than two hours later

You have decided to engage in some physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 7:00 – 8:00 am. Bearing in mind nothing but your own internal "clock", how do you think you would perform?	Would be in good form	Would be in reasonable form	Would find it difficult	Would find it very difficult	
At what time of day do you feel you become tired as a result of need for sleep?	8pm-9pm	9pm-10:15pm	10:15pm-12:45am	12:45am-2am	2am-3am
You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last for two hours. You are entirely free to plan your day. Considering only your own internal "clock", which *one* of the four testing times would you choose?	8am-10am	11am-1pm	3pm-5pm	7pm-9pm	
If you got into bed at 11:00 PM, how tired would you be?	Not at all tired	A little tired	Fairly tired	Very tired	

For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which *one* of the following are you most likely to do?	Will wake up at usual time, but will *not* fall back asleep	Will wake up at usual time and will doze thereafter	Will wake up at usual time but will fall asleep again	Will not wake up until later than usual
One night you have to remain awake between 4:00 – 6:00 AM in order to carry out a night watch. You have no commitments the next day. Which *one* of the alternatives will suit you best?	Would *not* go to bed until watch was over	Would take a nap before and sleep after	Would take a good sleep before and nap after	Would sleep only before watch
You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own internal "clock" which one of the following times would you choose?	8am-10am	11am-1pm	3pm-5pm	7pm-9pm

You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 10:00 – 11:00 PM. Bearing in mind nothing else but your own internal "clock" how well do you think you would perform?	Would be in good form	Would be in reasonable form	Would find it difficult	Would find it very difficult	
Suppose that you can choose your own work hours. Assume that you worked a *five* hour day (including breaks) and that your job was interesting and paid by results). Which *five consecutive ours* would you select?	5 hours starting between 4am and 8am	5 hours starting between 8am and 9am	5 hours starting between 9am and 2pm	5 hours starting between 2pm and 5pm	5 hours starting between 5pm and 4am
At what time of the day do you think that you reach your "feeling best" peak?	5am-8am	8am-10am	11am-5pm	5pm-10pm	10pm-5am

One hears about "morning" and "evening" types of people. Which *one* of these types do you consider yourself to be?	Definitely more a *morning* type	Rather more a *morning* than an *evening* type	Rather more an *evening* than a *morning* type	Definitely an *evening type*

Appendix C

Educational document for the circadian chronotypes

Your personal circadian chronotype

Your personal circadian chronotype is the **morning chronotype.**

This means that your **"active time"**, where you feel most energised, is the **morning, around 9am**. Thus, we advise you, if not done so already, to adust your waking and sleeping times to your active time.

Adjusting to your personal, individual chronotype can have several advantages, including

- increased mental health,
- increased physical health, and
- greater effectiveness.

Try it out yourself if you want!

In case of questions or problems, please contact ***a.n.albert@student.utwente.nl*** *or* ***m.worm@student.utwente.nl.***

Your personal circadian chronotype

Your personal circadian chronotype is the **moderate morning chronotype.**

This means that your **"active time"**, where you feel most energised, is the **late morning to noon, around 11am to 12pm**. Thus, we advise you, if not done so already, to adjust your waking and sleeping times to your active time.

Adjusting to your personal, individual chronotype can have several advantages, including

- increased mental health,
- increased physical health, and
- greater effectiveness.

Try it out yourself if you want!

In case of questions or problems, please contact ***a.n.albert@student.utwente.nl*** *or* ***m.worm@student.utwente.nl.***

Your personal circadian chronotype

Your personal circadian chronotype is **neither morning nor evening chronotype.**

This means that your **"active time"**, where you feel most energised, is the **middle of the day, around 1pm to 2pm**. Thus, we advise you, if not done so already, to adust your waking and sleeping times to your active time.

Adjusting to your personal, individual chronotype can have several advantages, including

- increased mental health,
- increased physical health, and
- greater effectiveness.

Try it out yourself if you want!

In case of questions or problems, please contact ***a.n.albert@student.utwente.nl*** *or* ***m.worm@student.utwente.nl.***

Your personal circadian chronotype

Your personal circadian chronotype is the **moderate evening chronotype.**

This means that your **"active time"**, where you feel most energised, is the **late afternoon, around 5 pm to 6pm**. Thus, we advise you, if not done so already, to adust your waking and sleeping times to your active time.

Adjusting to your personal, individual chronotype can have several advantages, including

- increased mental health,
- increased physical health, and
- greater effectiveness.

Try it out yourself if you want!

In case of questions or problems, please contact ***a.n.albert@student.utwente.nl*** *or* ***m.worm@student.utwente.nl.***

Your personal circadian chronotype

Your personal circadian chronotype is the **evening chronotype.**

This means that your **"active time"**, where you feel most energised, is the **evening, around 6pm to 7pm**. Thus, we advise you, if not done so already, to adust your waking and sleeping times to your active time.

Adjusting to your personal, individual chronotype can have several advantages, including

- increased mental health,
- increased physical health, and
- greater effectiveness.

Try it out yourself if you want!

In case of questions or problems, please contact ***a.n.albert@student.utwente.nl*** *or* ***m.worm@student.utwente.nl.***

Appendix D

Sleep Quality Scale

The following questionnaire aims at determining your sleeping quality you had over the last month.

Please answer each question as honestly as possible.

	Rarely (none or 1-3 times a month)	Sometimes (1-2 times a week)	Often (3-5 times a week)	Almost always (6-7 times a week)
I have difficulty falling asleep	○	○	○	○
I fall into a deep sleep	○	○	○	○
I wake up while sleeping	○	○	○	○
I have difficulty getting back to sleep once I wake up in the middle of the night	○	○	○	○
I wake up easily because of noise	○	○	○	○
I toss and turn	○	○	○	○
I never go back to sleep after awakening during sleep	○	○	○	○
I feel refreshed after sleep	○	○	○	○
I feel unlikely to sleep after sleep	○	○	○	○
Poor sleep gives me headaches	○	○	○	○
Poor sleep makes me irritated	○	○	○	○
I would like to sleep more after waking up	○	○	○	○

My sleep hours are enough	○	○	○	○
Poor sleep makes me lose my appetite	○	○	○	○
Poor sleep makes it hard for me to think	○	○	○	○
I feel vigorous after sleep	○	○	○	○
Poor sleep makes me lose interest in work or others	○	○	○	○
My fatigue is relieved after sleep	○	○	○	○
Poor sleep causes me to make mistakes at work	○	○	○	○
I am satisfied with my sleep	○	○	○	○
Poor sleep makes me forget things more easily	○	○	○	○
Poor sleep makes it hard to concentrate at work	○	○	○	○
Sleepiness interferes with my daily life	○	○	○	○
Poor sleep makes me lose desire in all things	○	○	○	○
I have difficulty getting out of bed	○	○	○	○
I have a clear head after sleep	○	○	○	○
Poor sleep makes my life painful	○	○	○	○

Appendix E

COVID-19 scale

How has the COVID-19 pandemic changed your *sleep quality*?

Feel free to elaborate on your answer in the text box given below.

- Far worse than before, _____
- Slightly worse than before, _____
- The same as before, _____
- Slightly better than before, _____
- Far better than before, _____

How has the COVID-19 pandemic changed your *sleep duration*?

Feel free to elaborate on your answer in the text box given below.

- Far worse than before, _____
- Slightly worse than before, _____
- The same as before, _____
- Slightly better than before, _____
- Far better than before, _____

Appendix F

Circadian-Card-Game (template, version 1)

Version 1

Energised	Active	Vital	Powerful
Fresh	Light	Excited	Productive
Tired	Warm	Soft	Cosy
Dreamy	Relaxing	Resting	Lying down

Appendix G

Circadian-Card-Game (templates, version 2)

Version 2 - Female

Version 2 - Male

Appendix H

Instructional document for the Circadian-Card-Game

Version 1

Circadian-Card-Game: *Version 1*

Instructions: *Morning*

Good morning! Please sit down at a table for this exercise. For the following game you have 16 cards, each with a word on it. Every word can be associated with one category, either "awake" or "sleep".

Mix the cards randomly in one deck. Now draw a card. If the drawn card has a word on it which belongs to the category "awake", place it right before you. Contrary, if the drawn card belongs to the category "sleep", put it in front of you but on the opposite side of the table (in width, not length). Repeat the process till there are no more cards left. Now please place the deck of the "sleep" category in a spot where the cards are not directly visible to you (e.g., a box, in between pages of a book, …). But careful: Do not forget where you put them! Lastly, please place the "awake" deck in a spot where you will notice it every now and then throughout the day (e.g., on your desk, next to the fridge, …).

If you conducted all the steps correctly, you are finished with the game for the morning! Repeat these instructions from Monday to Thursday every morning. Congrats and have a nice day!

Instructions: *Evening*

Good evening! Please sit down at a table for this exercise. For the following game you have 16 cards, all with a word on them. Each word can be associated with one category, either "awake" or "sleep".

Mix all the cards randomly in one deck. Now draw a card. If the drawn card has a word on it which belongs to the category "sleep", place it right before you. Contrary, if the drawn card belongs to the category "awake", put it in front of you on the opposite side of the table. Repeat the process till there are no more cards left. Now please place the deck of the "awake" category in a spot where the cards are not directly visible to you (e.g., a box, in between pages of a book, …). But careful: Do not forget where you put them! Lastly, please place the "sleep" deck in a spot close to your bed (e.g., on your bedside table, …).

If you conducted all the steps correctly, you are finished with the game for the day! Repeat these instructions from Monday to Thursday every evening. Congrats and good night!

Version 2

Circadian-Card-Game: *Version 2*

Instructions: *Morning*

Good morning! Please sit down at a table for this exercise. For the following game you have 16 cards, all with an image on them. Each image can be associated with one category, either "awake" or "sleep".

Mix the cards randomly in one deck. Now draw a card. If the drawn card has an image on it which belongs to the category "awake", place it right before you. Contrary, if the drawn card belongs to the category "sleep", put it in front of you but on the opposite side of the table. Repeat the process till there are no more cards left. Now please place the deck of the "sleep" category in a spot where the cards are not directly visible to you (e.g., a box, in between pages of a book, …). But careful: Do not forget where you put them! Lastly, ask yourself if there is a card in the "awake" category which represents an action which you would like to conduct throughout the day. If the answer is yes, please take that card and place it in a spot where you will notice it before or while conducting that activity. If not, simply place the "awake" deck in a spot where you will notice it every now and then throughout the day (e.g., on your desk, next to the fridge, …).

If you conducted all the steps correctly, you are finished with the game for the morning! Repeat these instructions from Friday to Sunday every morning. Congrats and have a nice day!

Instructions: *Evening*

Good evening! Please sit down at a table for this exercise. For the following game you have 16 cards, all with an image on them. Each image can be associated with one category, either "awake" or "sleep".

Mix the cards randomly in one deck. Now draw a card. If the drawn card has an image on it which belongs to the category "sleep", place it right before you. Contrary, if the drawn card belongs to the category "awake", put it in front of you but on the opposite side of the table. Repeat the process till there are no more cards left. Now please place the deck of the "awake" category in a spot where the cards are not directly visible to you (e.g., a box, in between pages of a book, …). But careful: Do not forget where you put them! Lastly, please place the "sleep" deck in a spot close to your bed (e.g., on your bedside table, …).

If you conducted all the steps correctly, you are finished with the game for the day! Repeat these instructions from Friday to Sunday every evening. Congrats and good night!

Appendix I

Process evaluation

Part 1: Explicit intervention

The following questionnaire aims at determining your satisfaction with the explicit intervention *(the video, the tests, and the goal-of-the-day exercises).*
Reflect back on the last week and please answer each question as honestly as possible.

How did the overall exercises (**video, tests, and goal-of-the-day exercise**) make you feel knowledgeable about sleep (hygiene)?

- o Not at all knowledgeable
- o Slightly knowledgeable
- o Knowledgeable
- o Very knowledgeable

Please indicate your opinion towards the **video** on the following scale.

- o Boring
- o Somewhat boring
- o Neutral
- o Somewhat entertaining
- o Entertaining

Please indicate your opinion towards the **video** on the following scale.

- o Undemanding
- o Somewhat undemanding
- o Neutral
- o Somewhat demanding
- o Demanding

Please indicate your opinion towards the **video** on the following scale.

- Negative
- Somewhat negative
- Neutral
- Somewhat positive
- Positive

Please indicate your opinion towards the **tests** on the following scale.

- Boring
- Somewhat boring
- Neutral
- Somewhat entertaining
- Entertaining

Please indicate your opinion towards the **tests** on the following scale.

- Undemanding
- Somewhat undemanding
- Neutral
- Somewhat demanding
- Demanding

Please indicate your opinion towards the **tests** on the following scale.

- Negative
- Somewhat negative
- Neutral
- Somewhat positive
- Positive

Please indicate your opinion towards the **goal-of-the-day exercises** on the following scale.

- Boring
- Somewhat boring

- Neutral
- Somewhat entertaining
- Entertaining

Please indicate your opinion towards the **goal-of-the-day exercises** on the following scale.

- Undemanding
- Somewhat undemanding
- Neutral
- Somewhat demanding
- Demanding

Please indicate your opinion towards the **goal-of-the-day exercises** on the following scale.

- Negative
- Somewhat negative
- Neutral
- Somewhat positive
- Positive

Part 2: Implicit intervention

The following questionnaire aims at determining your satisfaction with the implicit intervention *(the card game, both with words and images).*

Reflect back on the last week and please answer each question as honestly as possible.

Did the circadian card game integrate well with your daily rhythm?

- Disagree
- Somewhat disagree
- Neutral
- Somewhat agree
- Agree

Would you agree to the statement that playing the circadian card game **in the morning** helped you getting active more easily?

- Disagree
- Somewhat disagree
- Neutral
- Somewhat agree
- Agree

Would you agree to the statement that playing the circadian card game **in the evening** helped you falling asleep more easily?

- Disagree
- Somewhat disagree
- Neutral
- Somewhat agree
- Agree

Please indicate your opinion towards the *first version* of the circadian card game (**words**) on the following scale.

- Boring
- Somewhat boring
- Neutral
- Somewhat entertaining
- Entertaining

Please indicate your opinion towards the *first version* of the circadian card game (**words**) on the following scale.

- Undemanding
- Somewhat undemanding
- Neutral
- Somewhat demanding
- Demanding

Please indicate your opinion towards the *first version* of the circadian card game (**words**) on the following scale.

- Negative
- Somewhat negative
- Neutral
- Somewhat positive
- Positive

Please indicate your opinion towards the *second version* of the circadian card game (**images**) on the following scale.

- Boring
- Somewhat boring
- Neutral
- Somewhat entertaining
- Entertaining

Please indicate your opinion towards the *second version* of the circadian card game (**images**) on the following scale.

- Undemanding
- Somewhat undemanding
- Neutral
- Somewhat demanding
- Demanding

Please indicate your opinion towards the *second version* of the circadian card game (**images**) on the following scale.

- Negative
- Somewhat negative
- Neutral
- Somewhat positive
- Positive

Appendix J

Sleep knowledge questionnaire

The following questions aim at determining your sleep knowledge before the start of the intervention.

We are aware that you may not have been educated on sleep before, however, please try to answer each question.

What is **sleep hygiene**?

- Having a daily routine dedicated to promoting consistent sleep, e.g., taking the last hour of wakefulness to relax.
- Having a hygienic sleeping environment, e.g., changing the sheets every four days.
- Having a hygienic routine before going to bed, e.g., washing one's face before sleep.
- Having the awareness of sleeping disorders, e.g., insomnia.

Why is a **trained schedule** for sleeping **important**?

- To relax muscles at the same time every day.
- To eat breakfast at the same time every day.
- To get used to your alarm.
- To train the body to be wakeful and sleepy at certain times, thus, creating more possibilities for consistent sleep.

What is a **circadian rhythm**?

- A natural, internal process that regulates our sleep-wake cycle. It is the same for each individual.
- A natural, external process that tells us with light and darkness to wake up or go to sleep.
- A natural, internal process that regulates our sleep-wake cycle. It may differ for each individual.
- A natural, internal process that tells us when to wake up due to our urges, such as hunger or thirst.

Appendix K

Instructional document for the educational stimulus

Video

Day 1

- In order to educate you on sleep hygiene, the following video was chosen:
  https://www.youtube.com/watch?v=fk-_SwHhLLc
  All rights are reserved for "Therapy in a Nutshell".
- Please watch the video carefully from **01:29** until **06:59** (the rest of the video is not necessary for this intervention).

In case of questions or problems, please contact me: a.n.albert@student.utwente.nl

Appendix L

Instructional document for the tests

Tests

Day 2

- Please follow this link for your first test: https://docs.google.com/forms/d/e/1FAIpQLSdM2-p6ZdBMZ-lDUAk_nGgS8uVwahOccu9UCOK2VWhC34RbcA/viewform?usp=sf_link

Day 4

- Please follow this link for your second test: https://docs.google.com/forms/d/e/1FAIpQLSeV5gmxTXfupYbAE_oGyDWL3Zczh6yRNCSi4KTY7X7Ndc-dGQ/viewform?usp=sf_link

Day 7

- Please follow this link for your final test: https://docs.google.com/forms/d/e/1FAIpQLSeSdIEkrOJIEmsm-E-ULAGTJaAx1Ec-ys7eZuQCtPyOj7-gVA/viewform?usp=sf_link

In case of questions or problems, please contact me: a.n.albert@student.utwente.nl

Appendix M

Final test

Note. The questions 1-4 compromise the first test, “Proactive Sleep Behaviour Test”, questions 5-8 compromise the second test, “Preventive Sleep Measures Test”. The final test includes all questions.

Final test

For today, you will be taking a test about the whole video you have seen on Monday. With this, we want to compare your knowledge about sleep hygiene.

If you feel unprepared, do not hesitate to watch the video again (https://www.youtube.com/watch?v=fk-_SwHhLLc, from 01:29 until 06:59).

After taking the test, you can view your score, which is mandatory.
In case you have answered a question incorrectly, you will be presented with an explanation as to why this is not the right answer. Please also read this information.

Also, this time might be a bit longer than the previous ones (8 questions in total), but this test will be the last one.

Good luck!

* = *Required*

Please indicate your participant number below (in numbers, e.g., 54; not words). * _____

---

1. What system is responsible for making our body sleepy? *

- The somatic nervous system, by controlling your muscles to be more heavy at the end of the day.
- The somatic nervous system, by controlling your eyes to become more dry.
- The autonomic nervous system, by controlling your breathing and heartbeat to become slower.
- The autonomic nervous system, by controlling your hormonal glands to omit sleeping hormones.

---

2. How can we improve our ability to get sleep? *

- Exercise directly before going to bed.
- Training your brain by following a sleeping routine.
- Sleeping with your head towards the North cardinal point.
- Sleeping with a rose quartz under your pillow.

---

3. What should be included in a healthy wind-down routine before going to bed, amongst other things? *

- Keeping your sleeping schedule consistent.
- Lower the temperature in your room.
- Decrease stimulation as best as possible.
- All of the above.

---

4. What colour of light triggers alertness and should not be exposed to oneself before bed? *

- Red light.
- Yellow light.
- Blue light.
- Green light.

5. If you absolutely cannot avoid using screens before bedtime, what settings should you use to ensure the least interference with your sleep? *

- Turn on the night shift and dark mode of the screen.
- Lower the brightness of the screen.
- Turn on the no disturbances mode and/or having notifications on mute.
- All of the above.

---

6. When should you, at the latest, consume your last cup of coffee for the day to ensure the least interference with your sleep? *

- 6-8 hours.
- 4-6 hours.
- 2-4 hours.
- Coffee/ caffeine has no influence on sleep.

---

7. What foods and drinks can have a negative influence on your sleep? *

- Alcoholic beverages.
- Coffee and caffeinated beverages.
- Rich, fatty foods.
- All of the above.

---

8. What are the only two activities you should engage in when in bed? *

- Sleeping and sexual intercourse.
- Sleeping and studying/ attending online courses.
- Sleeping and working.
- Sleeping and calling your best friend.

Appendix N

Instructional document for the exercises

Goal-of-the-day exercises

Day 3

- For today, try to find a moment for yourself to sit down and reflect on your sleep. Grab yourself a piece of paper and a pencil and write down your thoughts. Please reflect on the following two points:

1. What are you already proud of concerning your sleeping behaviour?
   Write down this achievement.

2. Where do you have the feeling that you could improve concerning your sleep?
   Try to formulate a realistic goal for the day for you in order to work on that specific behaviour.

Day 6

- Once again, try to find a moment for yourself to sit down and reflect on your sleep. Grab yourself a piece of paper and a pencil and write down your thoughts. Please reflect on the following two points:

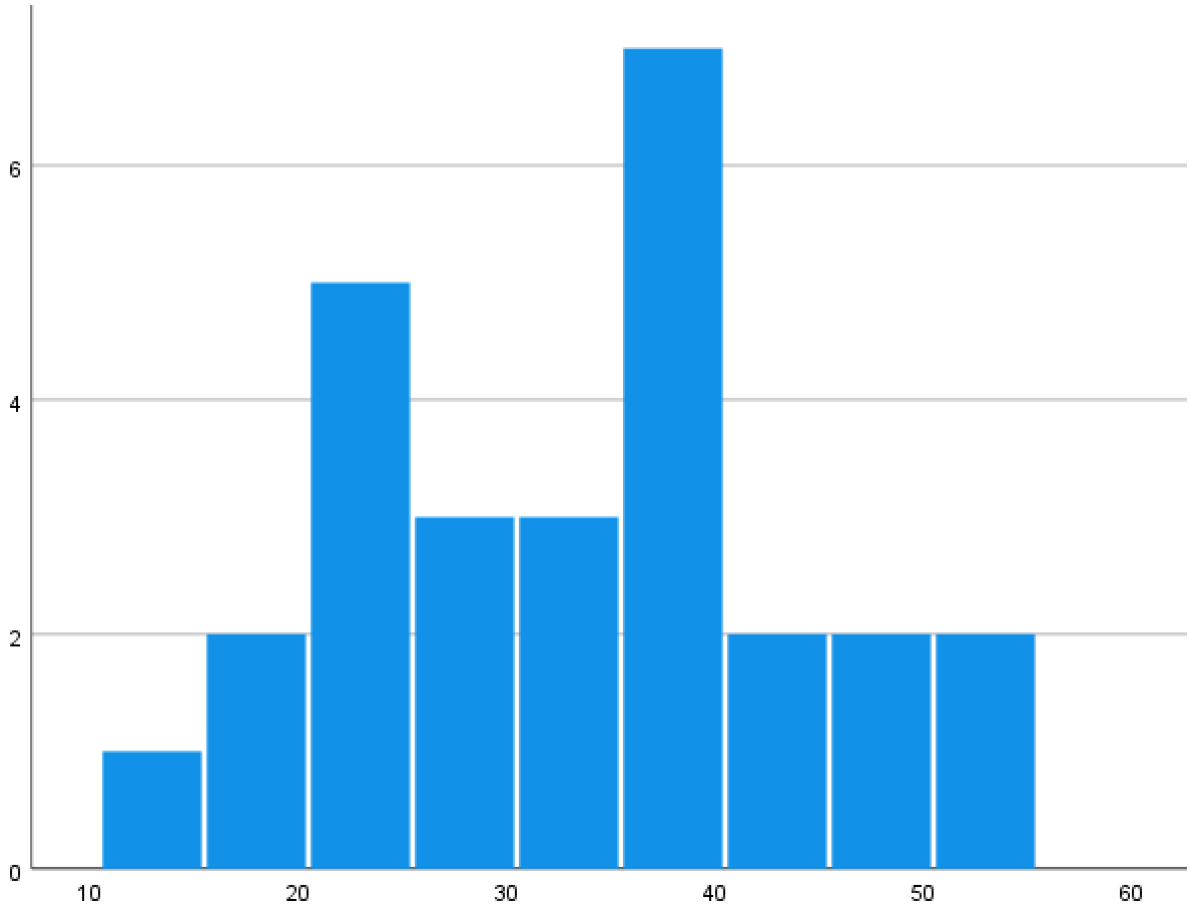
1. What are you already proud of concerning your sleeping behaviour?
   Write down this achievement.

2. Where do you have the feeling that you could improve concerning your sleep?
   Try to formulate a realistic goal for the day for you in order to work on that specific behaviour.

In case of questions or problems, please contact me: a.n.albert@student.utwente.nl

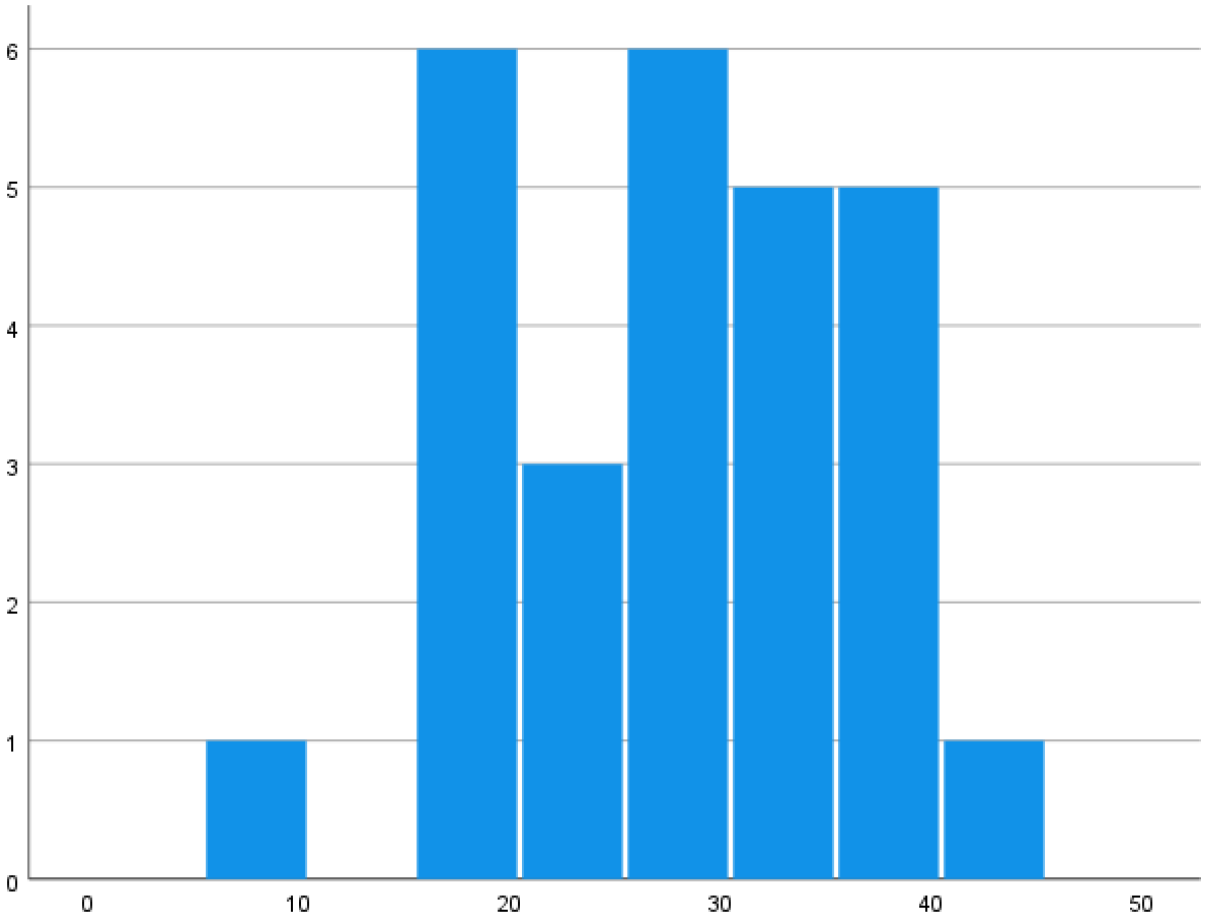
Appendix O

Distribution of data for the first measurement of sleep quality including the 27 completers



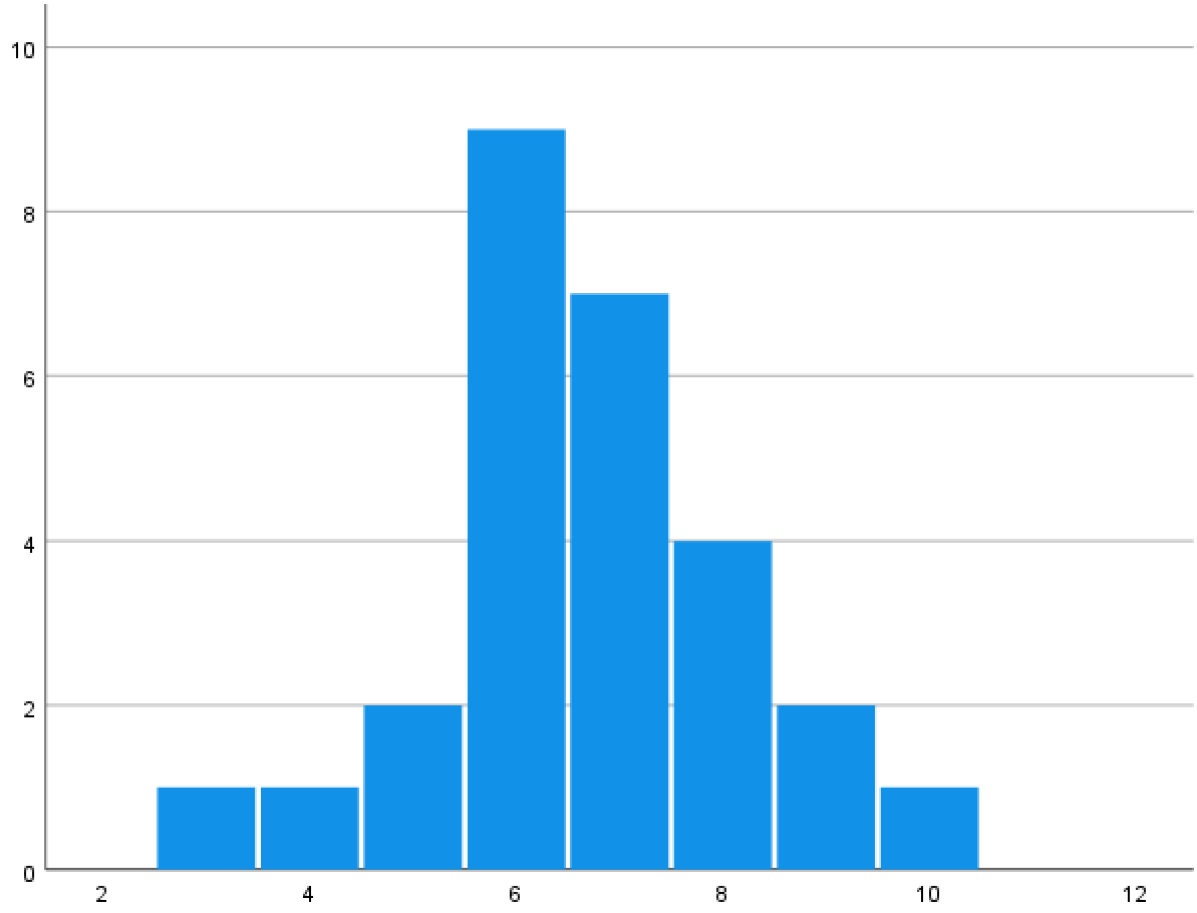
Appendix P

Distribution of data for the second measurement of sleep quality including the 27 completers



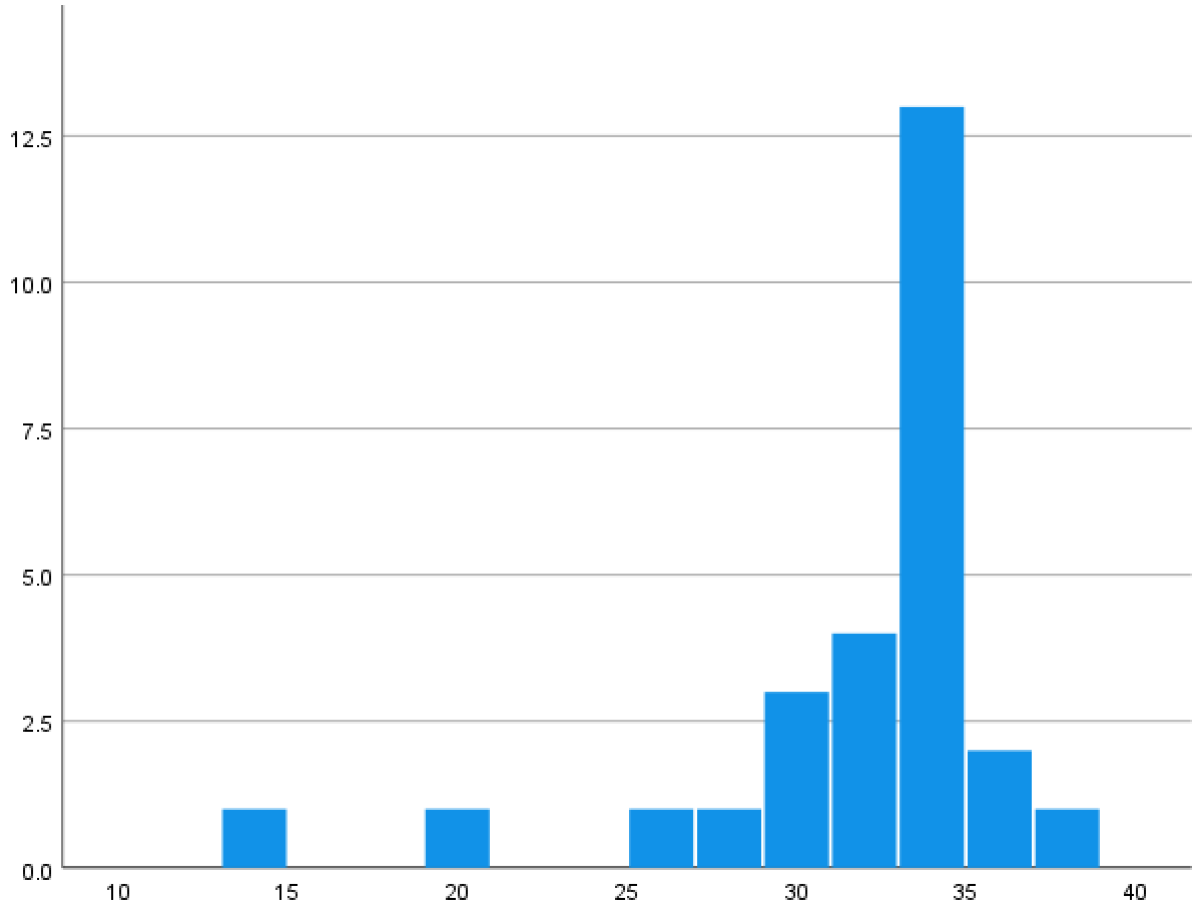
Appendix Q

Distribution of data for the COVID-19 impact including the 27 completers



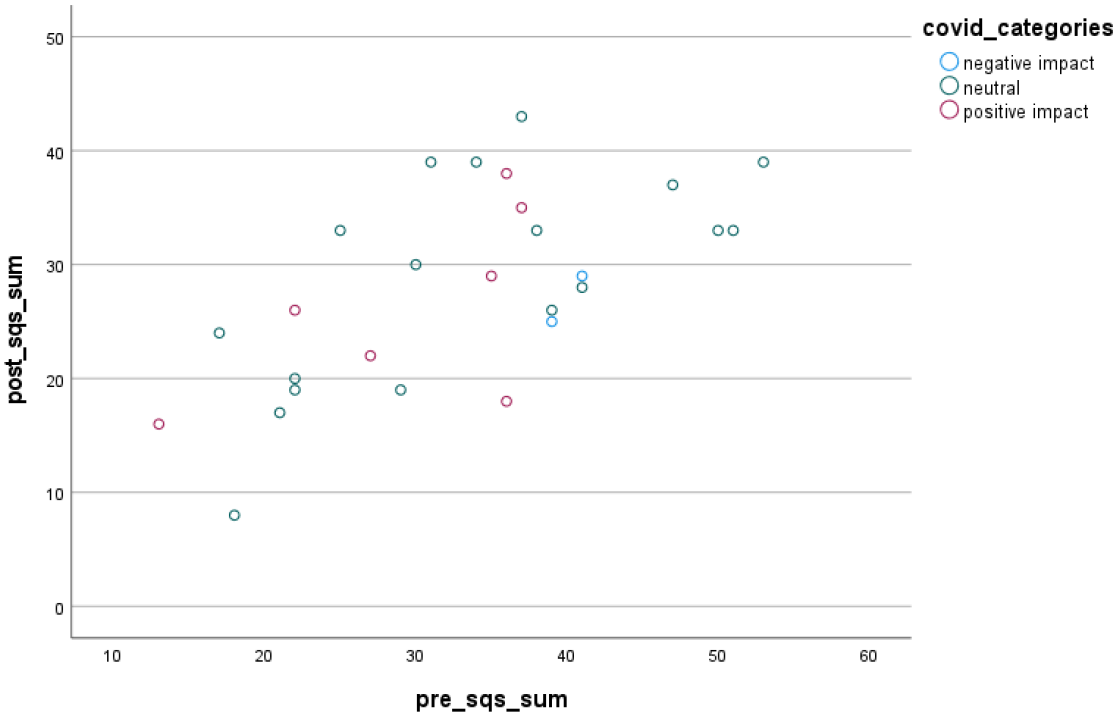
Appendix R

Distribution of data for the process evaluationincluding the 27 completers



Appendix S

Scatter plot accounting for COVID-19 regulation's impact on sleep quality as the covariate



Appendix T

Scatter plot accounting for process evaluation as the covariate