The Combination of an Explicit and Implicit Intervention – The Effects of an Explicit Sleeping Intervention on University Students during the COVID-19 Pandemic

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Abstract

Introduction. A large number of Dutch citizens are at risk for sleeping problems and disorders. Amongst these, especially university students suffer from poor sleep, more so since the COVID-19 pandemic. To counteract these prevalences, a combined intervention directed at positively influencing both explicit and implicit sleep behaviour was created. This part of the two-fold research aims to improve students' sleep quality by educating them explicitly on sleep hygiene and, subsequently, increasing their sleep knowledge.

Methods. 42 university students (*M*age = 21) participated in the intervention. Four hypotheses concerning sleep and its factors were formulated and tested with a paired *t*-test, a mediator effect as well as two ANCOVA. Before and after the intervention, the sleep quality and sleep knowledge of the participants were measured to enable subsequent comparison between both scores. Furthermore, before the intervention, the impact of the pandemic on the students is investigated with a questionnaire. In addition, the morning-eveningness questionnaire reveals each respondent's particular circadian chronotype, on which they are informed before the start of intervention as well. Within the intervention, different activities are presented to the participants to enable change in sleep quality and knowledge: Firstly, they are educated via a video. Their sleep knowledge is then deepened with three multiple-choice tests with feedback and two reflective exercises. Thereupon, a process evaluation in the form of a questionnaire after the intervention revealed the respondents' opinions on the different activities within the intervention.

Results. Overall, sleep knowledge was found to increase after the intervention. However, when analysing whether sleep knowledge influenced the change in sleep quality, no interaction effect was found. Similarly, all other analysed factors - the effect of the pandemic as well as the subjective process evaluation of the intervention - did not influence the change in sleep quality.

Conclusion. As expected, exposing the students to a combined, educational explicit and implicit intervention led to an increase in sleep hygiene knowledge. However, in contrast, this increase could not explain the improvement in sleep quality. Moreover, further studies are needed to establish scientifically sound sleep knowledge measures. Still, this study showcases the novel and innovative approach of combining implicit and explicit measures within an intervention.

Keywords: University students, sleep quality, sleep knowledge, sleep hygiene, explicit intervention, COVID-19 pandemic

Introduction

Sleeping is a crucial as well as mundane part of our everyday life. In fact, we spend nearly a third of our time in life sleeping (Koskimäki et al., 2018). Ideally, individuals should engage in sleeping at least eight hours per day (Carskadon & Dement, 2011). However, as recent research has shown, around 43% of adults (between the age of 18 and 70) in the Netherlands struggle with non-satisfactory sleep (Kerkhof, 2017). Moreover, 32% of the identical sample suffer from general sleep disturbances, and 8% from insomnia (Kerkhof, 2017). In addition, 20% of Dutch adolescent participants (younger than 18 years) suffer from sleep disturbances as well (Verkooijen et al., 2018). Generally, it can be stated that a large part of the Dutch population is experiencing sleeping problems, at least to some extent. This gives rise to the question of why a daily activity such as sleeping poses a challenge for so many Dutch individuals.

Hence, after defining sleep and its factors more concretely, the following accumulation of literature dives deeper into specific target groups amongst the Dutch population. Furthermore, interventions for the current undesired behaviour are introduced. In summary, the aim of this paper was to a) investigate sleep and its factors, and b) to create an explicit intervention for the identified target group based on said literature.

Sleep and its Factors

Generally speaking, sleep is characterised by its quality, duration, time of onset, and regularity (Krystal & Edinger, 2008; Wright et al., 2020). Sleep quality is an especially important construct of sleep, as it positively influences the other aforementioned factors (Krystal & Edinger, 2008). Still, sleep quality in itself seems like a fragile construct, due to the large numbers of sleeping problems and disorders being present (Kerkhof, 2017). These problems further impede a healthy relationship with sleep, and thus, sleep quality, as shown in a multitude of works (Kerkhof, 2017; Hertenstein et al., 2019; Walker et al., 2020).

More concretely, sleeping problems can have short- and long-term consequences, ranging from a (temporary) decreased attention span to increased mortality, at its most extreme (Chokroverty, 2010). Sleeping problems can also manifest themselves in the form of sleeping disorders, such as insomnia, apnoea, hypersomnia, and/or nightmares (Chokroverty, 2010). Insomnia, being the most common sleeping disorder (Chokroverty, 2010), can either be self-induced, e.g., by substance abuse or certain lifestyle choices, or due to secondary factors, e.g., mental or physical disorders, or primary factors, meaning, without an underlying factor.

Furthermore, the duration of sleep can contribute to negative outcomes for affected individuals as well: On one hand, sleeping less than seven hours a day can result in increased mortality (Tobalidine et al., 2019), obesity, and a poor quality of life (Deng et al., 2017). On the other hand, sleeping longer than nine hours per day can also lead to similar health problems, up to an increase in mortality (Jike et al., 2018).

Overall, sleep is influenced majorly by its quality. Still, sleep duration also plays an important role in preventing diseases. In summary, many aspects influence sleep and form a complex network of interactions and connections. In the following paragraphs, some of these factors, namely, age, occupation, sleep knowledge, and the ongoing CVOID-19 pandemic are explored in greater detail.

University Students as Target Group

Amongst others, recent literature concerning sleep focuses on adolescents (Owens & Weiss, 2017), the elderly (Gulia & Kumar, 2018), shift-workers (Mohammadyan et al., 2019) and university students (Schlarb et al., 2017a). For university students, the degree to which they suffer from sleeping difficulties varies from study to study - see Schlarb et al. (2017b) or Lund et al. (2010), for instance. Moreover, students appear to be especially susceptible to insomnia. Again, the prevalence of students change from study to study but overall, between 9% (Taylor et al., 2013), 30% (Sivertsen et al., 2019), and 52% of university students seem to suffer from insomnia (Schlarb et al., 2017a). Aside from the differing dispersion of sleeping problems, in essence, it became apparent that a large number of university students are affected. For university students, specifically, sleeping difficulties can have the following negative consequences: Decreased cognitive performance (Kloss et al., 2016), increased stimulant use (Forquer et al., 2010) as well as increased mental health issues (Blake et al., 2016).

Additional literature outlines possibilities as to why so many university students are affected by sleeping problems. Taylor et al. (2013) highlight the transition from school to university, which is often accompanied by many changes and an increase in autonomy, also concerning one's bedtime habits. Moreover, alcohol consumption, which is usual amongst students, further negatively influences sleep duration and the timing of sleep (Singleton & Wolfson, 2009). Lastly, perceived stress was found as a significant predictor for short sleep duration, poor sleep quality, and inconsistent sleep schedules in students (Lund et al., 2010).

Concludingly, university students are significantly at risk for sleeping issues, and, therefore, represented an appropriate target group for the following intervention.

COVID-19 Pandemic and Regulations as Influence

In addition, since the onset of the COVID-19 pandemic (around March 2020 in the Netherlands), the everyday life of all affected individuals became susceptible to change once more: University students exhibited even more sleeping problems (Majumdar et al., 2020). For instance, in their study with Italian students, Cellini et al. (2020) reported a decrease in sleep quality, even though an increase in time spent in bed was found. Contrarily, another study did not find an increase in sleep duration, but rather stagnation (Hisler & Twenge, 2021). Still, they also reported a decrease in sleep quality, with their respondents experiencing sleeping problems, on average, one more day per week than before the pandemic. Furthermore, since the COVID-19 measures, a doubled difficulty with falling and staying asleep are reported (Hisler & Twenge, 2021).

Moreover, literature also supports that especially younger individuals suffer from the pandemic on a psychological level (Hisler & Twenge, 2021). More specifically, an increase in insomnia was mentioned notably in younger individuals, women, as well as individuals living in rural areas (Voitsidis et al., 2020). This increase in sleeping problems in younger populations is attributed to the increased use of screens since the pandemic (Léger et al., 2020). They note that, even if screens negatively affect sleep, for many individuals, it is not possible to decrease their screen time due to home office and stay-at-home measures (Léger et al., 2020). Again, students are no expectation in this case (Léger et al., 2020).

In conclusion, the pandemic affects sleep negatively. Further, students are particularly at risk for these consequences due to their high usage of screens.

Sleep Knowledge as Influence

Oftentimes, there is a “notion that education is an antecedent to behaviour change” (Dietrich et al., 2016, p. 121). Based on this assumption, knowledge about sleep hygiene - further referred to as “sleep knowledge” - could pose as a predictor for sleep behaviour, and, more concretely, sleep quality (Dietrich et al., 2016). In support of this, Tsai and Li (2004) found an increase in sleep quality in college students after they attended a course on sleep hygiene. Furthermore, fewer night-time awakenings were reported, positively influencing sleep duration and sleep quality (Tsai & Li, 2004).

However, other research does not fully support the hypothesis that sleep knowledge positively influences sleep quality. For instance, sleep education and the following increase in sleep knowledge did only influence sleep quality for a short amount of time (Rigney et al., 2015). In a post-assessment 18 weeks after the initial sleep education programme, most of the participants' sleep quality returned to the same level as before the intervention. Rigney et al. (2015) explain this development with the fact that only a superficial change took place. Overall, every individual has particular differences in their sleep behaviour, making it very complex to change sleep quality on a large scale (Rigney et al., 2015). In agreement with this, another study found sleep knowledge as a predictor for sleep duration, and indirectly, sleep quality, however, only in combination with a change in attitude as well (Peach et al., 2018). Thus, sleep knowledge *alone* does not pose as a significant, sufficient persecutor for sleep quality (Peach et al., 2018).

Another factor in sleep knowledge, and, possibly, sleep quality, is also age. Generally, younger people are found to be more proficient in sleep knowledge than older people (Gallash & Gradisar, 2007). Still, this larger amount of sleep knowledge does not automatically translate to an increase in sleep quality. More specifically, due to one's studies, work, and/or social environment, adolescents often do not put their sleep knowledge to practical use (Gallash & Gradisar, 2007). Thus, university students are assumed to be sophisticated in sleep knowledge but their circumstances hinder them from applying it effectively.

In summary, one study found sleep quality to be influenced by sleep knowledge (Tsai & Li, 2004). Other studies only found a small influence of sleep knowledge on sleep quality, oftentimes due to the complex nature of sleep behaviour. Due to these contradicting findings, the influence of sleep knowledge on sleep quality is explored once more in light of this study.

Defining Implicit and Explicit Interventions

After identifying some factors in sleep quality, namely, the COVID-19 pandemic and sleep knowledge, explicit interventions for sleep can be researched. However, before an explicit intervention can be selected, the distinction between implicit and explicit interventions should be made clear. Implicit and explicit interventions differ in the sense in which they tackle different forms of behaviour – implicit and explicit behaviour, to be concrete. In Strack and Deutsch's dual-processing model (2004), implicit and explicit behaviour are distinguished as impulsive versus reflective behaviour.

More concretely, reflective behaviour is defined as a conscious decision, meaning, the individual deliberately assessed the value and consequence of said behaviour (Strack & Deutsch, 2004). Furthermore, explicit behaviour includes a clear intention within the individual (Strack & Deutsch, 2004; Hofman et al., 2008). Hence, reflective behaviour is the process of deliberate evaluation and intent-formation (Strack & Deutsch, 2004). It is also able to override certain impulsive behaviour patterns by consciously inhibiting those (Hofman et al., 2008), e.g., "One (I) should go to sleep instead of watching one more episode". In the context of sleeping behaviour, a reflective behaviour could be illustrated, for example, as such: A student realises that the next exam is coming up, and consciously weighs the pros and cons of staying up to learn or to rest before a new learning session. After some consideration, they decide intentionally to stay up for a few hours at least.

In contrast, impulsive behaviour is characterised by the "spread of activation to behavioural schemata" (Strack & Deutsch, 2004, p. 227). Strack and Deutsch (2004) simplify this definition by providing the following example: Seeing a cup of water will (quickly) activate the behavioural schemata of thirst if thirst is present in the individual. Consequently, implicit behaviour can be conceptualised as a rather quick and automatic process (Strack & Deutsch, 2004). This impulsive behaviour is positively associated with arguable health behaviours, such as drug use and unprotected intercourse (Hofman et al., 2008). In terms of sleeping behaviour, implicit behaviour could be seen in a student getting ready for bed, as this is their usual bedtime. They are not aware *why* they are getting ready for bed, as this is a habitual and unconscious process, but they decide to do so anyway, which, in this case, is the behavioural schemata.

Thus, when defining explicit and implicit interventions, with respect to which forms of behaviour they focus on, the following conceptualisation emerged:

a) An explicit intervention describes a treatment that targets the reflective processing system of an individual to achieve a change in (undesired) behaviour. It is characterised by a conscious, relatively slow, and high effort consuming process.

b) An implicit intervention describes a treatment that targets the impulsive processing system of an individual to achieve a change in (undesired) behaviour. It is characterised by an unconscious, relatively fast, and low effort consuming process.

As mentioned before, this study focused on the explicit, reflective behaviour of students regarding sleep. Still, this intervention was combined with another, implicit intervention (Worm, 2021). There are no records of previous attempts of such an approach within the context of sleep and its factors. Besides this nature of novelty, one benefit is that, with this unification, both behavioural forms can be investigated. An individual exhibits both reflective and impulsive behaviour (Strack & Deutsch, 2004), also concerning health behaviour (Hofman et al., 2008). Thus, it can be of advantage of combining both aspects in one substantial intervention. Previous literature also supports this undertaking (Deutsch & Strack, 2020). Still, as this approach is innovative and not applied by previous studies, the respondents of the intervention rated each intervention aspect after completion of participation. This process evaluation enabled the researchers to conclude the combination of implicit and explicit components and future implications for such enterprises. Followingly, the subjective perception of the respondents is used as the last factor concerning sleep in this study by employing said process evaluation.

The Present Study

Considering all previously mentioned elements, it can be concluded that sleeping problems are a common issue in the Dutch population. Within that setting, an important at-risk group poses university students, as they experience sleeping problems to a large extent. Further, since the pandemic, students experience even more sleeping issues. Moreover, even though it is assumed that students already possess some form of sleep knowledge, it was investigated how their sleep knowledge can be increased still and possibly influence sleep quality.

By educating students on sleep hygiene with an explicit intervention, it was explored in greater depth whether sleeping problems, in general, as well as sleeping problems during a pandemic, can be diminished successfully. Thus, based on these assumptions, the following research questions and corresponding directional hypotheses were formulated:

RQ1. Does the explicit intervention affect the students' sleep knowledge?

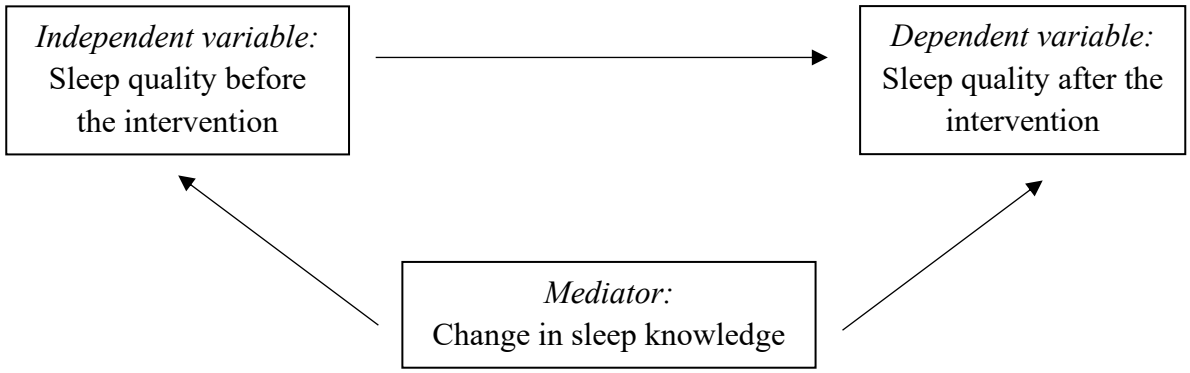
H1. The explicit intervention has a significant, positive effect on the students' sleep knowledge.

RQ2. Does the students' change in sleep knowledge have an indirect, mediating effect on the change in the students' sleep quality?

H2. The students' change in sleep knowledge has a mediating effect on the change in students' sleep quality.

Figure 1

Mediator Effect of the Change in Sleep Knowledge on the Change in Sleep Quality concerning the Second Hypothesis

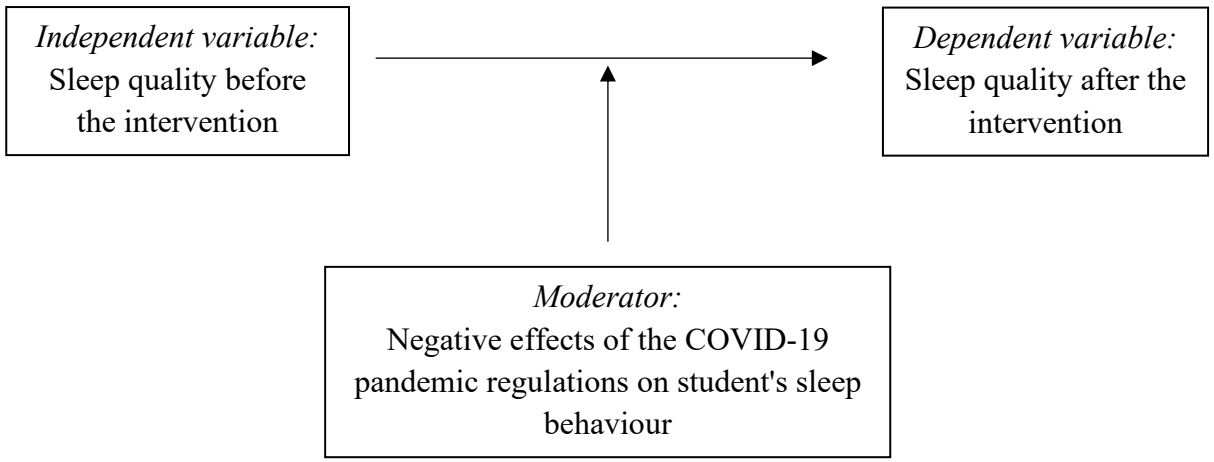


RQ3. Do the negative effects of the pandemic regulations on the students' sleep behaviour have an effect on the change in students' sleep quality?

H3. The negative effects of the pandemic regulations on the students' sleep behaviour have a significant effect on the change in students' sleep quality.

Figure 2

Moderation Effect of the Pandemic on the Change in Sleep Quality concerning the Third Hypothesis

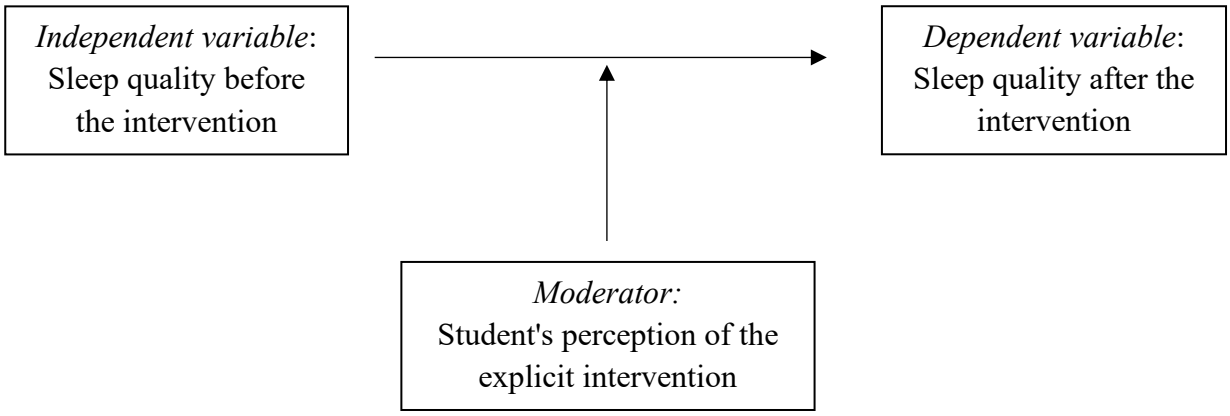


RQ4. Does the students' process evaluation of the explicit intervention part affect the change in the students' sleep quality?

H4. A student's (positive) process evaluation of the explicit intervention part has a significant (positive) effect on the change in the student's sleep quality.

Figure 3

Moderation Effect of the Students' Perception on the Change in Sleep Quality concerning the Fourth Hypothesis



Followingly, the four hypotheses are tested by means of creating an intervention including all the aforementioned factors and analysing the resulting data.

Methods

Design

For the design of the intervention, two researchers were involved. Mainly, the design process involved discussions and brainstorming as a team. This process was creatively driven rather than a clear, planned-out approach. Overall, this intervention was designed two-fold, with one researcher focusing on implicit behaviour and sleep quality (Worm, 2021), and the other focusing on explicit behaviour and sleep knowledge.

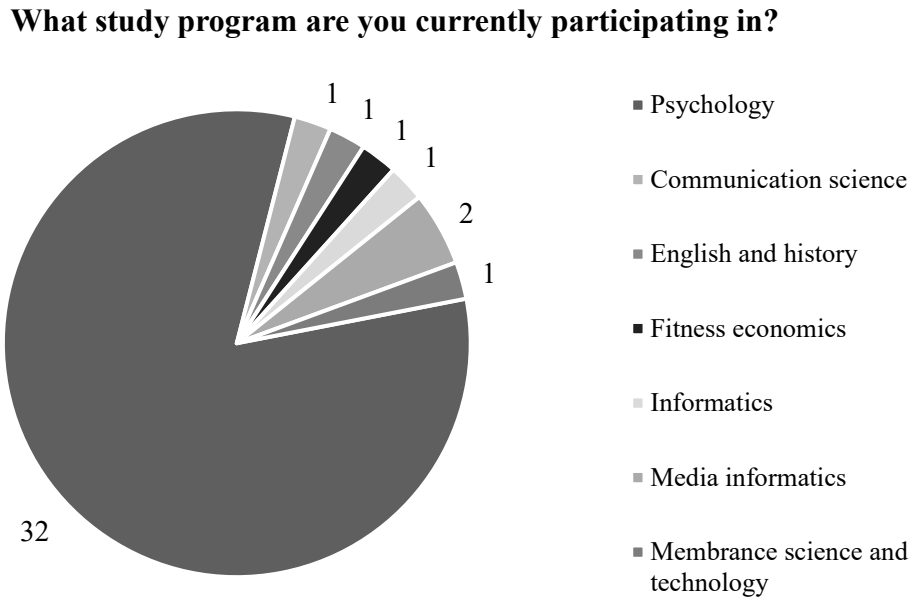
Participants

Initially, 44 participants agreed to partake in this intervention, however, two participants did not complete the intervention due to attrition.

Thus, in total, 42 respondents completed the study. 30 of the respondents identified as female and 12 as male. Their age ranged from 19 to 25 (*M*age = 21; *SD*age =1.25; 71.4% female, 28.6% male). Moreover, 41 of the students attended the bachelor's programme and one the master's, who specialised in mechanical engineering. See Figure 4 for the specific bachelor studies.

Figure 4

Study Distribution among the Bachelor Participants



For this intervention, the inclusion criterion was attendance in one of the study programmes at the University of Twente in Enschede. Furthermore, in accordance with the Common European Framework of Reference for Languages (CEFR), the participants needed to have an English proficiency of B2 or higher.

Moreover, the ethical approval was granted on March 29, 2021, by the University of Twente BMS Ethical Committee (see Appendix A). Followingly, all participants have been selected based on convenience and snowballing sampling. Firstly, the intervention was advertised via WhatsApp study groups. Moreover, the recipients of said messages were asked to forward the message to their peers if they saw fit to do so. Secondly, the study was published on Sona-Systems as well, an online subject pool system of the Behavioural and Managements Science Faculty of the University of Twente.

Materials

Pre-Assessment

For the pre-assessment, four questionnaires were applied. In general, all these questionnaires were presented via the software Qualtrics.

Morning-Eveningness Questionnaire. Firstly, to determine each participant's circadian chronotype, the Morning-Eveningness Questionnaire (MEQ) was employed (see Appendix B). This questionnaire, developed by Horne and Östberg (1976), contains 19 closed questions about circadian preference. For instance, the respondent is asked at what time of day they become tired as a result of a need for sleep. Each question is answered on a 4-, 5-, or 6-point Likert scale, depending on the question. Some scales include different times of the day, ranging from, for instance, “5 am-6:30 am” to “12 pm-5 am”. Others refer to the level of ease one experiences at certain times of the day, such as “not at all easy” to “very easy”.

Followingly, the responses of the MEQ are then scored as a sum score. Depending on the Likert scale, the score for each answer ranges from zero to four, five, or six points. Thus, the minimum sum score of the MEQ is 16, whereas the maximum score is 86. From the sum score, the participants' circadian chronotype is deducted: definitely evening type (16-30), moderate evening type (31-41), neither morning nor evening type (42-58), moderate morning type (59-69), and definitely morning type (70-86).

This prediction is established to be both reliable and valid, as previous research has shown: In a Slovene version of the MEQ, internal consistency was confirmed as good, with Cronbach's Alpha coefficient of .86 (Pišljar et al., 2019). Moreover, the intraclass correlation coefficient (ICC) showed an excellent test-retest reliability with .96 (Pišljar et al., 2019). Even though these values are based on the MEQ in another language, it can be assumed that the English version of the MEQ possesses similar values, and, thus, is both reliable and valid. This is supported by the reliability and validity scores of other translated MEQs, for instance, the Turkish version (Ozdalyan et al., 2021), the Chinese version (Li et al., 2011), the Hungarian version (Zavecz et al., 2015), as well as the German version (Griefahn et al., 2001). Further, concurrent validity is proven by investigating the correlation between the MEQ as well as subjective circadian phases questionnaire (r = -0.9, p < .001) (Griefahn et al., 2001).

In this study, the scores do not meet the requirements for a reliable questionnaire, with a Cronbach's Alpha coefficient of .39.

An if-item-deleted analysis presented that several items elevate the coefficient, however, all procedures do not result in an acceptable Cronbach's Alpha coefficient. If one were to delete item 4 (“How easy do you find it to get up in the morning when you are not woken up unexpectedly?”), the coefficient would equal .48. Similarly, the absence of item 12 (“If you go to bed at 11:00 pm, how tired would you be?”) also elevates Cronbach's Alpha to .48. As these items do not considerably change the reliability, the items are nevertheless included.

Sleep Quality Scale. The following questionnaire is the Sleep Quality Scale (SQS), measuring the respondents' sleeping quality over the last month (Yi et al., 2006; see Appendix C). It consists of 28 closed questions, which are answered on a 4-point Likert scale from “Rarely (None or 1-3 times a month)”, “Sometimes (1-2 times a week)”, “Often (3-5 times a week)” to “Almost always (6-7 times a week)”. The scale incorporates six subscales: daytime symptoms, restoration after sleep, problems initiating sleep, problems maintaining sleep, difficulty waking, as well as sleep satisfaction. For example, one question aimed at measuring the respondents' sleep satisfaction asks whether the sleeping hours are enough.

For scoring, the Likert scale points are converted into the following scores: Rarely = 0, Sometimes = 1, Often = 2, and Almost always = 3. Thus, the maximum score attainable for the SQS is 84, whereas the minimum score is zero. Of importance are the tallied categories, namely, restoration after sleep and satisfaction with sleep (scales 2 and 5; items 2, 8, 13, 16, 18, 20, and 27). Based on the overall sum score, the quality of sleep can then be assessed. The developers of the SQS indicated that the higher the score of the respondent, the more pressing sleeping problems are present. Therefore, instead, the two researchers developed the following categories themselves to classify the respondents more accurately: High sleep quality (0-16), moderately high sleep quality (17-33), neutral sleep quality (34-50), moderately low sleep quality (51-67), and low sleep quality (68-84).

The psychometrics of the SQS show a reliable and valid scale. The Cronbach's Alpha coefficient for this scale is .92, which equals excellent internal consistency (Yi et al., 2006). Furthermore, the scale is valid in construct, content, and concurrent validities. Through a control group, construct validity could be confirmed ($t = -13.8$, $p < .001$) (Yi et al., 2006). All six underlying factors measured with the scale accounted for the majority of the variance (62.6%), confirming content validity. Further, when comparing the SQS with the Pittsburgh Sleep Quality Index, a significant correlation was reported. Thus, concurrent validity is present as well ($r = 0.72$, $p < .001$).

Similarly, in the pre-assessment, the Cronbach's Alpha coefficient is acceptable with .78. Further, the post-assessment shows an acceptable Cronbach's Alpha coefficient equal to 0.77, meaning, this assessment is reliable as well.

COVID-19 Sleep Questionnaire. Thirdly, two self-computed questions focused on the change in sleeping behaviour since the pandemic are employed, one focused on sleep quality, and one on sleep duration (see Appendix D). These questions are mixed open-closed: A 5-point Likert scale ranging from “Far worse/less than before” to “Far better/more than before” is presented to the respondent. Furthermore, the participants are encouraged to elaborate on their answers in a text box given below the question.

The Likert scale corresponds to the scoring with “Far worse/less than before” = 1, “Slightly worse/less before” = 2, “The same as before” = 3, “Slightly better/more than before” = 4, and “Far better/more than before” = 5. Thus, the minimum score obtainable is two, and the maximum score is ten. A score between two and four indicates a negative influence of the pandemic, a score between five and seven no influence, and a score between eight and ten a positive influence of the COVID-19 pandemic and its regulations.

The reliability of the questionnaire is questionable, with a Cronbach's Alpha coefficient of .66. Still, an if-item-deleted analysis cannot be computed due to the questionnaire only containing two items in total.

Sleep Knowledge Questionnaire. At last, the sleep knowledge of each participant before the intervention is inquired (see Appendix E). Again, this questionnaire is self-computed to be tailored to this specific intervention. Overall, three questions are presented, with each question having four multiple-choice answers for the respondent to decide between. The participant is asked, for instance, what a circadian rhythm is, with the right answer being “A natural, internal process that regulates our sleep-wake cycle. It may differ for each individual”.

All right answers are scored with one point each, whereas each wrong answer equals zero. Thus, if all questions are answered correctly, the participant can score three points, which indicates high sleep knowledge. A score of zero or one indicates low sleep knowledge, and a score of two indicates intermediate sleep knowledge.

The Cronbach's Alpha coefficient for the pre-assessment is .04, which indicated unacceptable reliability. An if-item-deleted analysis reports an increase of the coefficient to .34 if item 3 (“What is a circadian rhythm?”) is deleted, meaning, the reliability cannot be acceptable in all cases.

In the post-assessment, Cronbach's alpha is .50, which, again, shows unacceptable reliability. Still, if item 1 (“What is sleep hygiene?”) were to be deleted, the reliability would be acceptable with .75. Nevertheless, for the following data analysis, this item is not deleted as it would change the scoring of the participants' sleep knowledge considerably.

Intervention week

For the intervention week, participants are presented with multiple activities. Figure 5 sums up all activities within the time frame of nine days.

Figure 5

Intervention Week Timetable containing all Activities

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

Video. On the second day of the intervention, the participants are asked to watch a four-minute video on YouTube. The video summarises sleep hygiene as well as points to practice and avoid to achieve satisfactory sleep hygiene. See Appendix F for the instructional document regarding the video.

Tests. On days 3, 5, and 8, respectively, the participants are urged to take a short test inquiring about their knowledge of sleep hygiene. The first test, named “Proactive Sleep Behaviour Test” due to its focus on what one can do to increase one's sleep quality, includes four questions concerning the first half of the video.

Test 2, “Preventive Sleep Measures Test” includes four questions about the latter half. At last, test 3, the “Final test” then combines both tests, meaning, all eight questions are included once again (see Appendix G for the final test). The tests are made available on GoogleForms. See Appendix H for the instructional document regarding the tests.

Goal-of-the-day exercises. For days 4 and 7, the participants are encouraged to write down two points: what they are proud of regarding their sleeping behaviour, and what they still want to improve. See Appendix I for the instructional document regarding these exercises.

Post-Assessment

The post-assessment contains two questionnaires as well as a process evaluation. It is, again, displayed by Qualtrics. Firstly, the SQS and Sleep Knowledge Questionnaire are employed once again.

At last, a process evaluation is presented to the respondents (see Appendix J). In total, ten closed questions are available, asking the participant, for instance, to indicate their opinion towards the tests. Firstly, one general question concerning all intervention elements (video, tests, and exercises) is given, in which the participant can indicate the level of knowledge gained. In essence, they are asked how the overall exercises (video, tests, and goal-of-the-day exercises) made them feel knowledgeable about sleep (hygiene). There, the following choices were given: “Not at all knowledgeable”, “Slightly knowledgeable”, “Knowledgeable”, and “Very knowledgeable”. Moreover, each particular element of the intervention is rated on three 5-point Likert scales: From “Boring” to “Entertaining”, from “Undemanding” to “Demanding”, and from “Negative” to “Positive”.

For the scoring, a minimum of ten points and a maximum of 50 points is possible, derived from the sum score of the evaluation. For the first general question, the following points were given, depending on the answer: “Not at all knowledgeable” = 1, “Slightly knowledgeable” = 2, “Knowledgeable” = 4, and “Very knowledgeable” = 5. Followingly, the questions for each intervention element are scored as “Boring”/“Negative” = 1, “Somewhat boring”/“Somewhat negative” = 2, “Neutral” = 3, “Somewhat entertaining”/“Somewhat positive” = 4, as well as “Entertaining”/“Positive” = 5. The Likert scale concerning the level of demand is reverse-coded, thus, it is scored as “Undemanding”/“Demanding” = 1, “Somewhat undemanding”/“Somewhat demanding” = 3, and “Neutral” = 5. Overall, the higher the score of the process evaluation, the more satisfied is the respondent with the intervention. On this basis, a score between ten to 23 indicates an overall negative attitude.

Scores between 24 and 36 show a neutral attitude, whereas an overall positive attitude is expressed with scores between 37 and 50.

The process evaluation's psychometric properties are shown to be unreliable: The Cronbach's Alpha coefficient, with .0.68, demonstrates barely questionable internal consistency. An if-item-deleted analysis shows that the exclusion of item 6 (“How demanding did you perceive the tests?”) could lead to acceptable reliability with a Cronbach's alpha of .74. Thus, for further analysis, this item is excluded.

Additional materials

The additional materials include all materials used by Worm (2021) in her part of the intervention. The pre-assessment includes the same, aforementioned materials for both researchers. For the intervention week, a circadian card game is distributed to the participants. This game has two versions, one with words, and one with images. Therefore, two instructional papers, one for the word-version, and one for the image-version of the game (see Appendix K), and the game template itself, which is adjusted to the female and male gender (see Appendix L) are shared as well. At last, for the post-assessment, the same questionnaires are included. Further, nine additional questions are included in the process evaluation (see Appendix J). These questions focus specifically on the implicit intervention parts provided by Worm (2021), meaning the circadian card game.

Procedure

Pre-Assessment

Before distributing the pre-assessment, each participant was assigned a participant number. Then, the pre-assessment was distributed in two ways: Either the respondents were sent the Qualtrics link via mail by the researchers if they have contacted the researchers themselves, or they were given the link via Sona-Systems if they have signed up on that platform. The pre-assessment is then filled in by the participant online, which could be on their phone, laptop, tablet, or any other digital device. Still, in the introduction of the pre-assessment, the respondents were advised to participate with a laptop, as the display logic on Qualtrics works most effectively that way. In general, the participants were asked for general demographics such as age or gender identity. Followingly, they were then given the four aforementioned questionnaires.

On average, the participants took 53 minutes and 23 seconds to fill in the pre-assessment (*SD*time = 282.4; in minutes), ranging from 6 minutes and 8 seconds minimum to a maximum of 25 hours and 22 minutes. After the pre-assessment, both researchers distributed and analysed the responses to determine each participant's circadian chronotype.

Intervention week

For the intervention week to start, each participant was sent the materials utilising email. Additionally, a timetable was added to provide participants with an overview (see Appendix M). All instructional documents for the video, tests, and exercises mentioned in the materials were enclosed in the annexe (see Appendix F, H, and I). Furthermore, each participant received a short informational document explaining their particular circadian chronotype (see Appendix N). Thus, the participants were provided with all materials necessary to attend and complete the intervention week.

Post-assessment

Similarly, as with the pre-assessment, the respondents received the link for the post-assessment either via mail or via Sona-Systems. Then, they were asked to fill in the questions on the platform Qualtrics. Once again, it was advised to fill in the post-assessment on a large digital device such as a laptop. On average, this time, participants took 57 minutes and 50 seconds to answer all questions, ranging from a minimum of 3 minutes and 6 seconds to 18 hours (*SD*time = 208.0; in minutes).

At last, if they signed up via Sona-Systems, the participants are rewarded with their credit points after successful completion. Overall, the participants spent a total of nine days with the overall intervention, including each one day for the pre- and post-assessment, as well as seven days for the intervention week in itself.

Additional procedure

As mentioned in the procedure for the intervention week, all materials were emailed to the participants before the actual start of the intervention. This also includes certain materials mentioned in Worm's study (2021). All participants received the instructional documents for the circadian card game versions as well (see Appendix K). If the respondents indicated that they wanted to print and cut out the game themselves, they received the game via email. Moreover, if they received the female or male version of the template depended on their gender preference in the pre-assessment.

However, the participants also could indicate that they would prefer to have the game sent to them via post, which then included a pre-printed and cut version. This was done to consider those respondents who had no printer available to them or had other reasons to fail to fulfil this requirement before starting the intervention. Thus, those respondents were asked specifically to wait with the start of the intervention until they have received the game in the mail.

For the post-assessment, both interventions compromised the same procedure.

Data Analysis

For the analysis of the data, the statistical software IBM SPSS Statistics 27.0 is used. Before testing the four hypotheses, the data is screened. This ensures whether the sample size, overall data and outliers are appropriately distributed. For instance, it could be the case that not all participants have participated in the post-assessment, which means some data has to be excluded for some parts of the data analysis. Concerning the overall data, histograms will highlight whether the data is evenly distributed or not. Furthermore, if applicable, certain items of the data were reversed, such as for the SQS. For the general descriptive statistics, the mean values, standard deviations, ranges, and additional data, if necessary, was computed.

Afterwards, the first hypothesis was tested. To repeat, the first hypothesis states that the explicit intervention has a significant, positive effect on the change in the students' sleep knowledge. In order to investigate this change, a one-tailed, paired *t*-test was employed. By using a paired test, specifically, it is possible to compare a particular sleep knowledge score before the intervention with the corresponding one after the intervention. Based on these results of the *t*-test, the effectiveness of the explicit intervention, or lack thereof, could be concluded. Further requirements for confirming the hypothesis included a significance value of $p \leq .05$ of the *t*-test and effect size (Cohen's *d*) higher than .05. Moreover, based on Cohen's *d*, the statistical number needed for a sufficient sample size will be computed with the additional software G*Power 3 (Faul et al., 2007).

For the second hypothesis, it is assumed that the change in students' sleep knowledge has a significant, positive effect on their change in sleep quality. Therefore, a mediator effect was tested. The sleep quality before the intervention is the independent variable, whereas the sleep quality after the intervention is the dependent variable. The change in sleep knowledge poses a mediator variable. To accept the hypothesis, the following requirements need to be present:

Firstly, the relationship between the independent and dependent variable needs to contain a significant *p*-value ($p \leq .05$) as well as a significant standardised beta coefficient ($p_\beta \leq .05$). Thus, a simple linear regression between both variables is run initially. If the relationship proved to be significant, the simple linear regression is run again with the mediator variable being present. The hypothesis is accepted if the standardised beta coefficient for the independent variable is not significant anymore but for the mediator variable. In this case, the change in sleep knowledge is present as a mediator variable.

The third hypothesis will be analysed via an ANCOVA. This time, the hypothesis estimates that the effects of the pandemic on the students' sleep behaviour have a significant, positive impact on the change in students' sleep quality. Therefore, the sleep quality before the intervention is used as an independent variable; the sleep quality after the intervention is used as a dependent variable. The co-variate is the impact of COVID-19. Requirements for accepting this hypothesis are a) all assumptions of a linear model being met and b) a *p*-value of $p \leq .05$.

Lastly, the fourth hypothesis assumes that the students' perception of the explicit intervention positively influences the change in the students' sleep quality. Correspondingly, a second ANCOVA will be used. This time, the students' perception of the explicit intervention, gathered through the process evaluation, will be used as a covariate. Once again, the sleep quality before the intervention poses as the independent variable and the sleep quality after the intervention as the dependent variable. If all four assumptions for a linear model hold as well as a significant *p*-value of $p \leq .05$ being present, the fourth hypothesis can be accepted. For the last two hypotheses, it is not chosen to conduct a repeated-measures ANOVA, as the points of measurements (before and after the intervention) only provide two data points.

Results

Descriptive statistics

Table 1

Descriptive Statistics concerning the Main Variables

Variables	*n*	Mean	Minimum	Maximum	*SD*
Circadian chronotype					
All participants	42	46.98	31	67	8.52
Completers	27	46.44	31	63	8.41
Sleep quality					
Pre-Assessment (AP)	41	32.41	13	53	10
Pre-Assessment (C)	27	33	13	53	10.75
Post-Assessment (C)	27	28.07	8	43	8.74
Impact of COVID-19 regulations					
All participants	41	6.41	3	10	1.53
Completers	27	6.67	3	10	1.52
Sleep knowledge					
Pre-Assessment (AP)	41	2.37	1	3	.70
Pre-Assessment (C)	27	2.41	1	3	.64
Post-Assessment (C)	27	2.85	2	3	.36
Process evaluation					
All participants	28	38.57	18	47	5.22
Completers	27	38.52	18	47	5.31

Note. AP and C are used as abbreviations for all participants and only completers, respectively.

Circadian Chronotype

No participants fell into the categories of “definitely morning type” or “definitely evening type”. The majority of respondents, 26 to be exact, possess a “neither morning nor evening type”, followed by 11 “moderately evening types” as well as five “moderately morning types” (*M*chronotype = 46.98, *SD*chronotype = 8.52; 61.9% neither morning nor evening type, 26.2% moderately evening type, 11.9% moderately morning type).

Sleep Quality

Before the start of the intervention, no participants showed “low sleep quality”. At that time, the majority of participants were categorised under “moderately high sleep quality”, more specifically, 21 participants. Seventeen participants showed “neutral sleep quality”, whereas two respondents revealed “moderately low sleep quality”. At last, one participant showcased “high sleep quality” (*M*presleepquality = 32.41, *SD*presleepquality = 10; 51.2% moderately high sleep quality, 41.5% neutral sleep quality, 4.9% moderately low sleep quality, 2.4% high sleep quality).

In contrast, after the intervention, all participants did not present as either “low sleep quality” or “moderately low sleep quality”-types (see Table 1). Thus, the students' sleep quality after the intervention ranged from neutral to high sleep quality. Seven participants exhibited “neutral sleep quality”, 19 participants “moderately high sleep quality”, and two participants “high sleep quality” (*M*postsleepquality = 28.07, *SD*postsleepquality = 8.74, 67.9% moderately high sleep quality, 25% neutral sleep quality, 7.1% high sleep quality).

Impact of COVID-19 regulations

The majority of participants, meaning, 16 participants, reported no influence of the pandemic on their sleep quality. Furthermore, 12 participants stated that the pandemic influenced their sleep quality slightly negatively. Nine participants reported a slight increase in sleep quality, whereas two respondents each felt that the pandemic affected their sleep quality far worse or far better than before (*M*covidimpactsq = 3.15, *SD*covidimpactsq = .91; 39.0% no influence, 29.3% slightly negative influence, 22.0% slightly positive influence, 4.9% negative influence, 4.9% positive influence).

Regarding sleep duration, 21 respondents showed a slight increase since the pandemic (see Table 1). Moreover, 11 participants disclosed no influence, six a slightly negative influence, and three a significantly positive influence.

No respondents reported a considerably negative influence (*M*covidimpactsd = 3.56, *SD*covidimpactsd = .85; 51.2% slightly positive influence, 26.8% no influence, 14.3% slightly negative influence, 7.1% positive influence). Moreover, as the respondents were encouraged to elaborate on their answers in a text box given below the questionnaire, more in-depth answers were accumulated as well. In summary, students mainly focused on their daily structures concerning their sleep quality. For some, a sudden lack of structure (e.g., not going to a campus anymore) led to a decrease in sleep quality. In contrast, others found a new structure for themselves, which affected their sleep quality positively.

Concerning sleep duration, again, structure played a large role. For an increase in sleep duration, the main reasons mentioned were autonomy and routines, which contribute to more time. Still, one participant reports that "as I study in the same room as I sleep, I think it has become harder to sleep".

Sleep Knowledge

Similarly with the other variables, sleep knowledge in students increased after the course of the intervention (see Table 1). In line with this development, no participant scored zero on the test, before as well as after the intervention, which would indicate poor sleep knowledge. However, before the intervention, five respondents scored one point on the test, meaning, they are categorised under "low sleep knowledge" still. Furthermore, 16 students showed "intermediate sleep knowledge" with two points. Lastly, the majority showcased "high sleep knowledge" even before the sleep education took place, with 20 participants scoring three points (*M*presleepknowledge = 2.37; *SD*presleepknowledge = 0.7; 48.8% high sleep knowledge, 39% intermediate sleep knowledge, 12.2% low sleep knowledge).

After sleep education occurred, the respondents only scored either two or three points. Five respondents scored with "intermediate sleep knowledge". Therefore, the majority of participants, 23 to be exact, showed "high sleep knowledge" (*M*postsleepknowledge = 2.85, *SD*postsleepknowledge = 0.36; 82.1% high sleep knowledge, 17.9% intermediate sleep knowledge).

Overall, a development of *M*changesleepknowledge = 0.48 transpired. Only one respondent scored one point lower in the post-assessment than their score in the pre-assessment, whereas 15 respondents showed no change in their sleep knowledge. Nine participants scored one point higher, and two participants scored two points higher in the post-assessment compared to the pre-assessment (55.6% no change, 33.3% positive change of one score, 7.4% positive change of two scores, 3.7% negative change of one score).

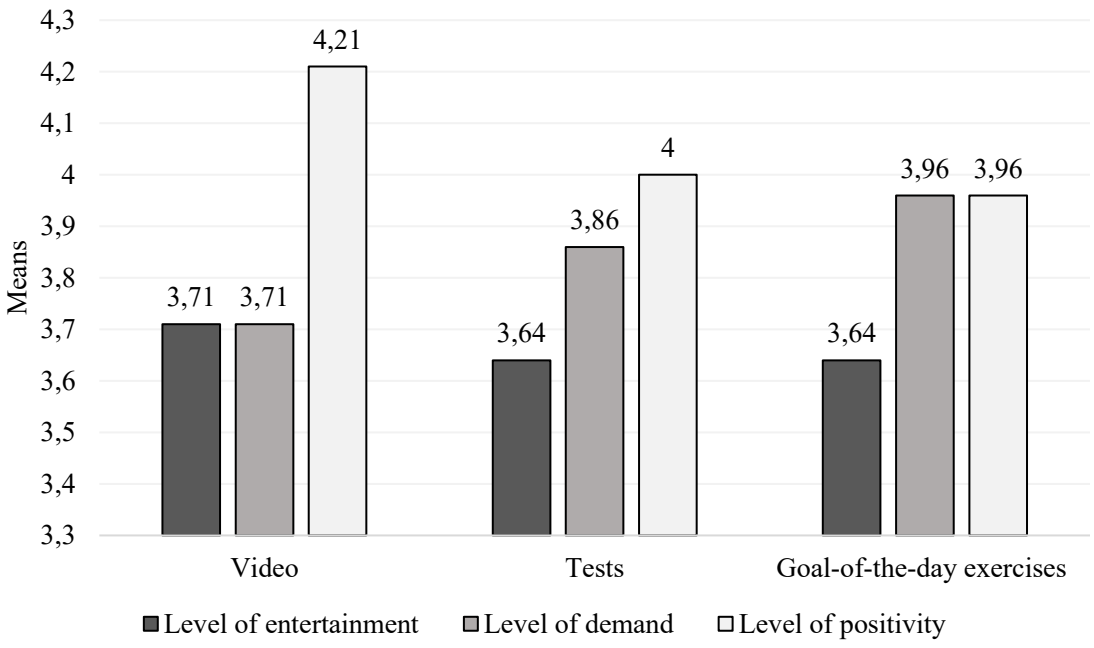
Process evaluation

For the process evaluation, the data of 284 participants is used. Overall, the larger part of participants, 22 to be concrete, rated the explicit intervention with a positive attitude. Five participants expressed a neutral attitude towards the intervention, and one participant judged the intervention negatively (*M*processevaluation = 38.57, *SD*processevaluation = 5.22; 78.6% positive attitude, 17.9% neutral attitude, 3.6% negative attitude).

See Figure 6 for the means for all activities within the intervention. When comparing these means, the video is rated with the most positive attitude, with an accumulative mean of *M*video = 3.88. Followingly, the exercises are rated as second-highest concerning demand, entertainment, and positivity, with an accumulative mean of *M*exercises = 3.85. Lastly, the tests are rated as lowest (*M*tests = 3.83).

Figure 6

Mean Values for each Explicit Intervention Activity



Overall knowledge. The first, general question asked to which extent the overall exercises (video, tests, and goal-of-the-day exercises) made the participants feel knowledgeable. No one answered with “not at all knowledgeable”. The majority of participants (20 participants) found the overall intervention “knowledgeable”, followed by each four participants rating it with “somewhat knowledgeable” or “very knowledgeable” (*M*overall = 3.86, *SD*overall = .85; 71.4% knowledgeable, 14.3% somewhat knowledgeable, 14.3% very knowledgeable).

Data Screening

The screening of the data reveals the following sample sizes available for the particular analyses: 27 for the *t*-test, 27 for the linear regression, 27 for the first ANCOVA, as well as 27 for the second ANCOVA. Furthermore, all variables have been investigated to be fit for a linear regression model. Both the impact of the pandemic and the process evaluation, as variables, are normal distribution shaped histograms. Still, it is worth mentioning that the histograms concerning the sleep knowledge before as well as after the intervention are slightly skewed to the right. However, in the context of a score between zero and three for the test, thus, it being a short-ranged score, the histograms can still be considered normally distributed.

Hypothesis 1: Paired t-test for sleep knowledge

The mean of the pre-intervention sleep knowledge score equalled 2.41, whereas the mean of the post-intervention sleep knowledge score is 2.85. Thus, the average increase in the test score was .44. Moreover, the *t*-test revealed a statistically significant, positive difference ($t = 3.31$; $n = 27$; $p = .003$). The effect size (Cohen's *d*) equalled .7, meaning, the effect of the intervention is considered moderate to large. Overall, the first hypothesis can be accepted.

In addition, the statistical analysis with G*Power revealed that, with an effect size of .7, a participant number of 24 is deemed as appropriate.

Hypothesis 2: Linear regressions for testing the mediating effect of change in sleep knowledge on sleep quality relationship

The linear regression between sleep quality before and after the intervention revealed a significant relationship with a *p*-value of $p < .001$ and a significant standardised beta coefficient ($\beta = .65$, $p < .001$). Adding the change in sleep knowledge to the linear regression showed that it is not a mediator for the change in sleep quality. More concretely, the relationship between sleep quality before and after the intervention remained significant ($p < .001$) and with a significant beta coefficient ($\beta = .65$, $p < .001$).

In contrast, the relationship with the change in sleep knowledge was not significant for both sleep quality before ($p = .26$) and after the intervention ($p = .13$). Furthermore, the beta coefficient was not significant as well ($\beta = .02$, $p = .92$). On this basis, the second hypothesis cannot be accepted as the data reveals an absence of the change in sleep knowledge as a mediating variable for the relationship of sleep quality before and after the intervention.

Hypothesis 3: ANCOVA 1 for testing the moderating effect of the COVID-19 regulations on sleep quality relationship

The scatterplot between sleep quality, both before and after the intervention, as well as the impact of the COVID-19 pandemic and its regulations, illustrated a linear and homoscedastic relationship between all present variables. Therefore, the following analysis can be evaluated with statistical confidence: The pandemic has no effects on the effectiveness of the explicit intervention ($F(4,1) = 10.90$, $p = .22$, $\eta^2 = .98$). Based on the p-value being higher than .05, the third hypothesis is rejected.

Hypothesis 4: ANCOVA 2 for testing the moderating effect of the process evaluation on sleep quality relationship

The scatterplot between sleep quality (before and after the intervention) and the students' perception of the explicit intervention, accumulated through the process evaluation scores, shows a linear, homoscedastic relationship. Meaning, the ANCOVA model confirmed all four assumptions. Still, the process evaluation scores did not influence the effectiveness of the explicit intervention.

Once more, the model did not exceed statistical significance, with $F(4,1) = 4.59$, $p = .28$, and $\eta^2 = .82$. This establishes that the fourth hypothesis cannot be accepted as well.

Summary

It was found that the explicit intervention increased the students' sleep knowledge. However, the increase in sleep knowledge did not entail an increase in sleep quality as well. Furthermore, the pandemic and its measures did not interact with the increase of sleep quality throughout the intervention. Similarly, the subjective perception of the intervention did not influence the students' sleep quality.

Discussion

To this date, this particular study is the first study combining an explicit and implicit sleep intervention; see Worm (2021) for the description of the implicit intervention part. Based on this novel, two-part study, some conclusions can be drawn concerning students' sleep behaviour and future research points.

Overall, as anticipated, an increase in the students' sleep knowledge was found as a result of this intervention.

Notably, as Gallash and Gradisar stated (2007), younger people show more sleep knowledge than older individuals. As this study includes a largely younger sample with a mean of 21 years, it undermines this assumption since, even before the intervention took place, only 12% of the participants showcased low sleep knowledge. The majority of respondents, with 88%, either expressed intermediate or high sleep knowledge. Still, after the intervention, the number of respondents with low sleep knowledge diminished completely, as no one scored lower than one (item) in the test. Hence, one can say that the intervention was successful in increasing sleep knowledge in university students. This is also reflected in the effect size of the intervention (Cohen's d = .70), which equals a moderate to large effect. This learning effect could be explained by the combination of visual stimuli and the following exercises focused on deepening the obtained knowledge. Further, the expert in the video could have acted as a role model for the respondents. This gives rise to future research to investigate in which way role models could play a role in obtaining knowledge, specifically sleep hygiene knowledge.

However, it is crucial to note that these results must be interpreted with caution and that the measures should be replicated tentatively in other studies. The reliability and validity coefficients of the sleep knowledge test showed unacceptable or poor scores. This is largely due to the test only compromising three items, as well as the test being self-designed. Therefore, for future research, it is necessary to develop and test sleep knowledge questionnaires. Without reliable and valid measures, this determinant for sleep behaviour cannot be investigated properly, leading to a missing piece in understanding sleep and sleep knowledge as influences and holistic framework.

Further, all other hypotheses were rejected. First and foremost, there was no influence of the change of sleep knowledge throughout the intervention on the change in students' sleep quality. This disputes the findings of Tsai and Li (2004), in which students' increase in sleep knowledge after an intervention led to an increase in sleep quality as well. Nevertheless, multiple other studies are in line with the findings of a lack of sleep knowledge as a predictor (Peach et al., 2018; Dietrich et al., 2016; Rigney et al., 2015). As Peach et al. (2018) and Dietrich et al. (2016) previously suggested, sleep education and knowledge are not necessarily sufficient for behavioural change. More concretely, human behaviour is very complex and does not only has knowledge as a precursor. This is also illustrated in the findings of Peach et al. (2018), where attitudinal change also influenced sleep behaviour. Hence, in the future, it would be of scientific interest to conduct a factor analysis concerning sleep behaviour to investigate the different factors which could influence said behaviour.

Furthermore, the time onset of education also seems to play a role in behavioural change. To repeat, Rigney et al. (2015) found a change in sleep quality due to the participants' increase in sleep knowledge, however, in a post-assessment 18 weeks after the study, this development had vanished again. Thus, from this point forward, it is advisable to conduct not only one post-assessment, as it was done in this study (one week after the intervention). A second collection of data after a longer period could shine a light on the longitudinal influence of sleep knowledge on sleep quality, in the case it is present. Generally speaking, this study confirms the majority of other studies in finding that sleep knowledge does, indeed, not influence sleep quality.

Additionally, the effects of the pandemic did not influence the development of sleep quality. These results widely contradict the findings discussed in the introduction section of this paper (Cellini et al., 2020; Léger et al., 2020; Majumdar et al., 2020; Hisler & Twenge, 2021). To summarise, these studies found students to be vulnerable to the measures of the pandemic. Therefore, the study at hand proposes a new perception of the pandemic's effects, namely, that the pandemic does not influence the students' sleep behaviour. As to why this intervention shows conflicting results, one can only hypothesise that the external factors of the study setting differ to such a great extent from the other settings that the findings were influenced by this. More specifically, at the point of data collection, which was between April and June 2021, the pandemic countermeasures have been lifted more and more in the Netherlands. Thus, as the everyday life of all citizens slowly returns to “normal” again, it could be the case that the effects of the pandemic were so little or not present anymore that this moderator variable was not present at the point of data collection. Still, once again, a certain caution when interpreting these findings is advised. As the reliability analysis showed, the employed COVID-19 questionnaire possesses questionable properties. For these reasons, it is of importance for future research to investigate how different measures of the pandemic, e.g., curfews, influence the general public and their health.

At last, the subjective perception of the intervention did not affect the increase in sleep quality as well. Still, even though a lack of interaction is present, it could be of interest for future research to consider using similar elements to the ones used in this explicit part of the intervention due to the overall positive evaluation of the intervention. All three components of the explicit intervention - the video, the tests, and the exercises - were rated positively, with very small differences. Even though the video was rated as the most positive, entertaining, and doable activity, the distance to the tests (the activity ranked lowest) is only marginal.

Therefore, one major strength of the explicit intervention part is the overall positive reception of the intervention aspects. For this reason, it is advised to present a visually appealing education stimulus in the beginning, followed by an activity where the learned material can be applied (e.g., small tests). Lastly, exercises where conscious, profound reflection can take place, such as the goal-of-the-day exercises, further supports knowledge implementation (Strack & Deutsch, 2004). In addition, this intervention proved to positively influence sleep knowledge and sleep quality. Thus, overall, the effects of said intervention can be considered successful in the sense that a major target group for sleeping problems experienced an increase in sleep quality.

Strengths, Limitations, and Future Implications - Both Intervention Parts

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.

As mentioned, a 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 participants' 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 that 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 limitation is the high drop-out rate of participants. Hence, the results are biased towards the part of participants who chose to finish the intervention. Still, this limitation only poses as a minor treat, as the deviations of the completers are only marginal (see Table 1).

Nevertheless, as a future improvement, 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 participants' process within the intervention to be able to, if needed, send reminders for (still missing) activities.

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 peoples' 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.

Strengths, Limitations, and Future Implications - Explicit Intervention Part

In addition to the aforementioned strengths, limitations and future implications, some specific aspects of the explicit intervention can be concluded. Besides the major strength of the innovative and new nature of this study, the effect size of the intervention reflects its effectiveness in successfully transfer sleep hygiene knowledge. Further, based on the effect size, the statistical analysis revealed that a participant number of 23 is needed (Faul et al., 2007). The overall participant number (42 respondents) as well as the completers of the intervention (27 respondents) lie within that suggestion. Thus, the intervention profitably achieved its purpose whilst also recruiting enough participants to declare the overall findings with statistical confidence.

One previously mentioned point for improvement is the lack of monitoring of the participants. Specifically applied to this intervention, only one aspect of the activities, namely, the tests, could be monitored. However, the goal-of-the-day exercises and the video could not be overseen. This poses a major limitation since even though the test participation could be observed, all three activities are interconnected in their purposes. On one hand, without watching the video, education on sleep hygiene cannot take place. On the other hand, failing to reflect on one's sleep behaviour within the goal-of-the-day exercises, a deeper understanding and transition of knowledge cannot develop. Thus, as mentioned, for the future, it is advisable to implement checkpoints for the participants, where a certain activity can be ticked off, for instance. This ensures that all integral parts of the intervention are exercised completely.

Conclusion

Overall, it can be deduced that only an increase in sleep knowledge and sleep quality was ensured with this part of the intervention. All other aforementioned factors did not influence the development of sleep quality, as previously assumed. Moreover, one primary limitation includes the self-composition of questionnaires and tests. Due to this predicament, statistically significant reliability and validity are not present for some scales, which leads to a lack of informative value.

In addition, a means for checking regular participation in all activities of the intervention can ensure greater attendance (Svensson et al., 2012), which could lead to greater statistical power. For future research, there is a need for the development and testing of sleep knowledge questionnaires and scales exploring the effects of the pandemic. Furthermore, a combination of explicit and implicit interventions is advised.

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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

Morning-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 a 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 the usual time, but will *not* fall back asleep	Will wake up at the usual time and will doze thereafter	Will wake up at the 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 4 am and 8 am	5 hours starting between 8 am and 9 am	5 hours starting between 9 am and 2 pm	5 hours starting between 2 pm and 5 pm	5 hours starting between 5 pm and 4 am
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

Sleep quality scale

The following questionnaire aims at determining the 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 D

Sleep behaviour during the pandemic questionnaire

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 E

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 F

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 G

Final test

Note. 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 heavier at the end of the day.
- The somatic nervous system, by controlling your eyes to become drier.
- 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 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 does not influence 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 H

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 I

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 J

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

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

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

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

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

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

- o Disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o 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 K

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 L

Print templates for the circadian card game

Version 1

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

Version 2 - Female

Version 2 - Male

Appendix M

Overview of all activities for the intervention week

Schedule	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Within the first hour after waking up	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 2)	Play the circadian card game (version 2)	Play the circadian card game (version 2)
Throughout the day	Watch the video	Fill in the first test	Conduct the first goal-of-the-day exercise	Fill in the second test		Conduct the second goal-of-the-day exercise	Fill in the final test
Within the last 2 hours before going to bed	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 1)	Play the circadian card game (version 2)	Play the circadian card game (version 2)	Play the circadian card game (version 2)

Appendix N

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 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 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.