

Electrodermal activity during napping and its relationship with performances on a reaction time task

Bachelor Thesis

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Abstract

The aim of this study was to measure and clarify electrodermal activity around and during the power nap and the benefits and disadvantages of the power nap relative to reaction time on a task. It was expected that the number of skin conductance responses (SCRs), and the amplitude thereof, were lowest of the day during the power nap. This was measured by a Q-sensor for five days from 10.00 am to 17.00 pm. Also, the participants had to perform a reaction time task every half hour. It was expected that the reaction time scores directly after a power nap were lengthened by "sleep inertia." This term meant that a person is still dull or drowsy when the person wakes up. This could be a disadvantage for taking a power nap. Further, it was expected that the alertness of the five participants was improved by the power nap. 10 Randomly chosen reaction time scores before the power nap were compared with 10 random reaction time scores after the power nap. It was expected that the reaction time scores of the participants after a power nap were shortened, compared with all reaction time scores before the power nap.

The results of the study confirmed the hypothesis that the number SCRs was lowest during the power nap for the five individuals in this study. The statistical tests were based on randomization tests suitable for small-*n* samples (Dugard, File & Todman, 2011). The results showed a marginal difference emerged with regard to the amplitude of SCRs. The amplitude during power nap was slightly lower than the amplitude at other times where the participants took no power nap. The reaction test showed that there were no differences between the response times around the power nap and the reaction directly after the power nap. There was no evidence that the participants suffered from sleep inertia. We did find that the reaction time scores after a power nap were improved, as compared to the reaction time scores before the power nap.

For future research, electrodermal lability and stability are interesting concepts. There were differences between the participants in the amplitude and number of SCRs. Some participants had many variations in the number and amplitude, which could have to do with electrodermal lability. Others scored very stable. Also, the effects of a power nap could be measured on employees during working hours. Both employers and employees may benefit from it, because a power nap can cause an improved alertness and can thereby reduce errors and accidents at the workplace.

Samenvatting

Het doel van deze studie was om elektrodermale activiteit te meten en te verduidelijken tijdens en rond de powernap en de effecten zichtbaar te maken van een powernap ten opzichte van de reactie tijd scores op een taak. Er werd verwacht dat het aantal huidgeleidingsresponsen, en de amplitude hiervan, tijdens de powernap het laagst van de dag waren. Dit werd gemeten door een Q-sensor gedurende vijf dagen van 10 uur 's ochtends tot 17.00 uur 's avonds. Ook moesten de participanten elk half uur een reactietijd taak uitvoeren. Er werd verwacht dat de reactietijd direct na een powernap langzamer was door 'slaap inertie'. Deze term houdt in dat een persoon zich nog duif of 'slaapdronken' voelt wanneer de persoon wakker wordt. Dit kan een nadeel zijn aan het nemen van een powernap. Verder werd er verwacht dat de alertheid van de vijf participanten was verbeterd. 10 random gekozen reactietijd scores voor de powernap werden vergeleken met 10 random reactietijd scores na de powernap. Er werd verwacht dat de reactietijd scores van de participanten na een powernap verkort waren, vergeleken met de reactietijd scores voor de powernap.

De resultaten van het onderzoek bevestigde de hypothese dat het aantal huidgeleidingsresponsen het laagst was tijdens de powernap. De statistische testen waren gebaseerd op randomizatie testen die pasten bij een small-*n* design (Dugard, File en Todman, 2011). Uit de resultaten kwam een marginaal verschil naar voren wat betreft de amplitude van huidgeleidingsresponsen. De amplitude tijdens de powernap bleek iets lager te liggen dan de amplitude op andere momenten wanneer de persoon geen powernap nam. De reactietijd test wees uit dat er geen verschil was tussen de reactietijden rondom de powernap en de reactietijd direct na de powernap. Er was dus geen bewijs gevonden dat de participanten last hadden van slaap inertie. We vonden wel dat de reactietijden na een powernap verbeterd waren ten opzichte van de reactietijden voor de powernap.

Voor toekomstig onderzoek zijn elektrodermale labiliteit en stabiliteit interessante concepten. Er bleken verschillen te zijn tussen de participanten in amplitude en aantal huidgeleidingsresponsen. Sommige participanten hadden veel schommelingen in dit aantal en amplitude, die te maken zou kunnen hebben met elektrodermale labiliteit. Anderen scoorden erg stabiel. Verder zou er ook gekeken kunnen worden naar de effecten van een powernap op werknemers tijdens werktijd. Zowel werkgevers als werknemers kunnen hiervan profiteren, omdat een powernap kan zorgen voor een verbeterde alertheid en daardoor een reductie aan fouten en ongevallen.

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Introduction

The world has turned into a 24-hours society. This could cause sleep deprivation and disruption (Takahashi, 2003). For this reason, napping received more and more attention and a 'powernap' had become a worldwide known term. This 'power nap' is known as a method that works as a countermeasure for sleepiness and fatigue (Pilcher, Michalowski & Carrigan, 2001). A powernap is a very short nap for less than 20 minutes, which is long enough to experience its benefits and short enough to avoid drowsiness. It has positive effects on behavioral, subjective and physiological parameters (Hayashi & Hori, 1998). Takahashi (2003) showed that young adults, between the age of 20 and 30, were sleeping less hours during the night than other people (elderly people and shift workers for example). 33% of the young adults had problems with sleepiness during the day and the influence of sleepiness on daily performances. A powernap could be a solution to this problem. The present study focused on a powernap with the aim to clarify the effects around and during a powernap. It was measured on students, because of their suggested problems with sleepiness (Takahashi, 2003). The present study assumed that the students feel great benefit of powernapping. The effects of a powernap was measured by 'electrodermal activity' (EDA), an important concept that will be explained below. Besides EDA, reaction time was measured to clarify the effects of a powernap on reaction time scores of the students.

According to Debarnot, Castellani, Valenza, Sebastiani and Guillot (2011) there are two kinds of naps: long naps and short naps. Long naps will take 60-90 minutes and include slow wave sleep and rapid eye movement sleep (REM sleep). In a short nap the person will reach sleep stage 1 and sleep stage 2 (below these sleep stages are explained in further detail). They are suggesting that a person need to sleep 10 minutes in stage 2 to feel the benefits and that it will take 19.4 minutes to reach 10 minutes of sleep stage 2. The authors also argue that the benefits underlying the brief naps are not related to sleep stage 1, but they are related to sleep stage 2. For the enhancement of cognitive performance, sleep stage 2 is required. This can suggest that sleep stage 2 will have an effect on the reaction time scores of the students. If sleep stage 2 was not reached, this can mean that the powernap have no effect on cognitive performance. To reach the 10 minutes of sleep stage 2, the students in the present study took a powernap of 20 minutes. According to the results of the study by Debarnot et al. (2011), this is enough to feel the benefits of a powernap.

The effects of a powernap may be linked to the time a person takes a nap. According to Takahashi, Fukuda and Arito (1998), a nap after lunch (around 12:30 h) is most likely related to an improvement of alertness for daytime employees. Besides this argument, one can suggest a nap around 14:00 h. The circadian rhythm can cause the alertness of a person lowest at this time of day in wake state, approximately from 14:00 until 17:00 hours (Van Dongen & Dinges, 2005). A shortened P300 represents increased alertness and results show that a nap at 14:00 h causes a shortened P300 (Takahashi et al. 1998). This thus improves the alertness of a person and the cognitive performance. Shortening of P300 only applies to 15-minute naps, compared with naps of 45 minutes or no naps. The effects of napping on alertness are visible after 7.3 minutes of sleep.

Despite of all these positive effects of taking a nap, there is a problem. Most people are not able to take a nap, because of their work or school. There are only a few companies who are offering their employees a place where they can take a nap. In the USA and Canada only 15% of the companies permit their employees to take a nap during lunch time (Takahashi, 2003). According to Baxter and Kroll-Smith (2005) the powernap improves safety and performance and reinforces the work ethic of a committed workforce. In their study, they focus on the workplace nap and how this can be achieved by employers. They discuss the ‘*Xiuxi*’ in China, a traditional three-hour midday closing of offices during summer and the two-and-a-half-hour midday closing in winter to take a nap and to improve family and society. In 1985 the Chinese State Council ended the traditional ‘*Xiuxi*’, because this time could be used more efficient. The powernap was abolished, but with the present 24-hours society, the powernap can be used for other purposes instead of family improvement. Many researchers showed positive effects of a powernap on behavior (Takahashi, 2003; Baxter & Kroll-Smith, 2005; Hayashi & Hori, 1998) and it will only take about 20 minutes.

Electrodermal activity

Electrodermal activity (EDA) was used in the present study to observe individuals around and during the powernap. An useful definition of EDA is one by Johnson and Lubin (1996): “Electrodermal activity is a common term for all electrical phenomena in skin, including all active and passive electrical properties which can be traced back to the skin and its appendages.” EDA measurements can be used in a wide variety of research, such as examining emotions, attention and arousal. Central to this measure is electrodermal response. Boucsein (2012) argues that the term ‘response’ suggests that there is a relationship between the stimulus and electrodermal responses (EDRs). Still, there are often parts of EDA which

cannot be related to a specific stimulation. These parts are called 'spontaneous' EDA. Direct current recording of EDA is the most frequently used method for obtaining electrodermal measures. This came within the 'exosomatic method'. Here, the electrodermal system is supported with electrical energy from an external source, using either a constant voltage or a constant current. Direct current recording means that EDA can be recorded directly in skin conductance units when voltage is kept constant and skin resistance units can be obtained when current is kept constant (Boucsein, 2012). The exosomatic method measures skin conductance. Skin conductance level (SCL) is the absolute level of conductance at a given moment in the absence of a measurable response (Dawson, Schell & Fillion, 2000). There are 2 other concepts related to EDA and are important in understanding the data of EDA. (1) SCR 'frequency' means the number of EDRs in a given time window, (2) SCR 'amplitude' is referring to the height of a single response (Boucsein, 2012).

Lykken and Venables (1971) suggest a linear relationship between SCL and the rate of secretion of sweat. Sweat glands are involved by the homeostatic process of thermoregulation. These mechanisms have indirect influences on EDA. Boucsein (2012) argue that the sweat glands at palmar and plantar sites are most interesting for measuring EDA, because there is sufficient evidence that these sites are linked to emotional rather than thermoregulatory sweat gland activity. He also argues that reduced sweating will lead to reduced EDA and increased sweating will lead to increased EDA. According to Schliack and Shiffter (1979) there exist different kinds of sweating, including 'emotional sweating'. This means increased sweat gland activity when psychological and emotional states appear, like high arousal or under stress. In the present study, EDA was measured on palmar site.

Sleep & Electrodermal Activity

Sleep is a fundamental biological regulation system and is related to mental health. For example, poor sleep quality is associated with child adjustment problems, including externalizing behaviors, such as depression and anxiety (El-Sheikh & Arsiwalla, 2011). This means that good sleep quality is significant for proper development and mental health. However, sleep deprivation has become a common problem. There are many employers who suffer from this problem through their work, because of the 24-hours society (Takahashi, 2003). Examples of these jobs are night shift workers, doctors and truck drivers. There are several studies on the effects of sleep deprivation. The problem of sleep deprivation and sleepiness can be solved by taking a nap sometime during the day. A powernap may become a

daily phenomenon in the future and that is why research on this topic is important. A power nap during the day can also contribute to a better night's sleep.

Humans have 4 stages of sleep (Knuistingh Neven, de Jongh & Schimsheimer, 2004). Non-REM sleep can be divided into two groups: light and deep sleep. Light sleep consists of stage 1, which is drowsy sleep, and stage 2, dormant sleep. A person, who's taking a nap of 20 minutes, will reach only these two stages. Deep sleep and slow wave sleep (SWS), consists of stage 3 and stage 4. In REM sleep breathing and heart rate will be faster and irregular, while blood pressure will show strong fluctuations. In REM sleep there is a total muscle relaxation. Non-REM sleep and REM sleep are shifting four to five times during a normal night (Javaheri & Redline, 2012). Figure 1.1. shows an example of a typical night of sleep for a healthy individual. Only 3 sleeping stages will be used in this figure. Sleep stage 1 and sleep stage 2 are united and together they form sleep stage 1.

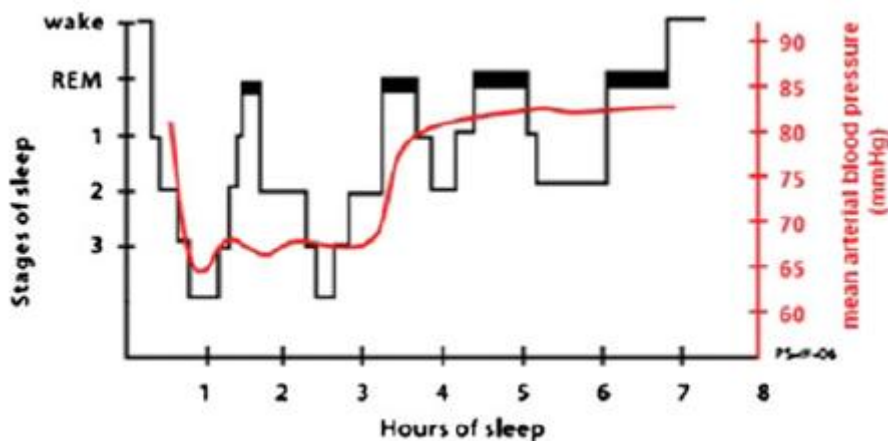


Fig. 1.1. Example of a sleep pattern and blood pressure in a healthy individual throughout a typical night of sleep.

Studies on sleep shows that (1) EDA likely appears with high frequency ‘storm’ patterns during sleep, that (2) EDA can distinguish wake and sleep and (3) EDA is able to show sleep onset (Sano & Picard, 2011). Figure 1.2. shows EDA with motion and these EDA ‘storm patterns’ of a healthy individual during sleep at night. Sleep is a process with several semi-independent, interactive changes. It does not initiate from 1 second upon the other. It is a process of decline in control over mental activity and changes in perceived state of consciousness, which comes with a decrease in arousal (Wuyts et al., 2012).

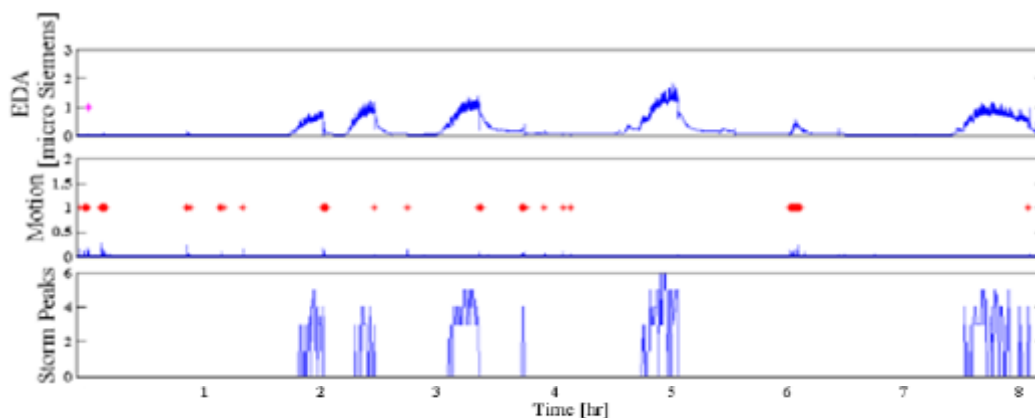


Fig. 1.2. EDA with motion and EDA storm peaks per hour.

Circadian rhythm & mental performance

Sleep regulation is controlled by two fundamental processes: a homeostatic process and a circadian process (Kas, 1999). The circadian process maintains stable endogenous rhythms and synchronizes these rhythms with periodic events in the environment, like the natural light-dark cycle (Kas, 1999). It can be seen as an internal clock that keeps track of the time of day (Van Dongen & Dinges, 2005). The circadian pattern has influence on mental performance. Van Dongen and Dinges (2005) argue that the circadian pressure for wakefulness is greatest during the day, so performances on daytime are better than nighttime performances.

The circadian rhythm not only affects mental performance, but is also related to sleep (Åkerstedt, 2007). The later a person goes to bed, the shorter the person sleeps. The circadian interference with daytime sleep is subsequently a problem for night shift workers. Many studies have tested night shift workers. These studies show that there is a reduction of capacity that sustain attention, including vigilance performance, cognitive tasks and reaction time performance, during the late night hours (Åkerstedt, 2007). At night, the accident risk is highly increased. Studies on flight simulation showed that the ability in flying a simulator at night results in a performance which is equal to that seen after consuming two glasses of 250 mL (mixed alcohol and water) up to blood alcohol levels of 0.05%. However, Bonnefond, Muzet, Winter-Dill, Bailloeuil, Bitouze and Bonneau (2001) argue that several studies showed that napping during night shift could have long-term positive effects on the circadian rhythm. A short nap during night shifts could function as a 'reset' on biological rhythms and could improve alertness of a person.

Awakening

According to Takahashi (2003), an individual first has a groggy feeling when the person wakes up, which results in impaired alertness and performance. The first description of this phenomenon comes from Broughton (1968). He calls this state ‘sleep drunkenness’ and refers to behavioral slowdown after abrupt awakening. This state is currently known by the term ‘sleep inertia’. Tassi and Muzet (2000) suggest the following definition: ‘Sleep inertia refers to the phenomenon of decreased performance and/or disorientation occurring immediately after awakening from sleep relative to pre-sleep status’. After awakening, a person should avoid tasks that immediately require a quick response or critical judgment, because of sleep inertia. Tassi and Muzet (2000) argue that sleep inertia produces a decreased reaction time, up to 360% of pre-sleep performance, depending on the type of task. The simple tasks (reaction time task) are more affected than the complex tasks (product organizing).

A nap should not be longer than 20 minutes, because sleep inertia will be severe when a person awakes from a deep Non-REM sleep (Takahashi 2003). This researcher also argues that sleep inertia disappears in about 30 minutes. Van Dongen and Dinges (2005) suggest that very short naps (circa 10 minutes) may offer a person benefits without suffering from sleep inertia.

Ambulatory research

The present study is an ideographic study. Ambulatory research is a well suited approach for ideographic studies (Wilhelm & Grossman, 2010). A key factor of ambulatory research is repeated sampling from individuals across diverse situations and over periods of time. Ideographic studies are largely neglected by laboratory research. In laboratory research, data is averaged across individuals within a single task or occasion can easily mask underlying differences in processes. Ambulatory research shows a more representative sample of diverse processes of an organism and potential environmental determinants thereof. Another point was that laboratory research is fundamentally biased, because the selected experimental stimuli are unrepresentative of cognitive processes operating in real life. The solution for ambulatory research came from Brunswik (1955). Random sampling stimuli from the environments of individuals to model the type of cognitive tasks people are face with during their daily lives. The main aim was creating laboratory stimuli in which environmental properties are preserved. Biosignals could be obtained outside the laboratory with modern recording or sampling devices (Wilhelm & Grossman, 2010). This study used electrodes of an affectiva Q-sensor to obtain biosignals.

Ambulatory research can overcome limitations of laboratory research. Because of this small number of intensively studied individuals, many scientific insights have been derived. This type of study could provide an important contribution to the study of differences among individuals and their environments and could provide help and/or support laboratory research.

Hypotheses

Napping and electrodermal activity are the central themes in the present study. Literature shows that there has been research on napping, but little or none in combination with electrodermal activity. Most of the studies on napping use EEG or self-report measurements. This study measures electrodermal activity around and during the powernap. Sano and Picard (2011) show EDA storm patterns. The first storm seems to appear around 2 hours after falling asleep of an individual during sleep at night. This means that a person, who is taking a nap, will have no sleep storm. Another important result comes from the study by Malmö (1959). This researcher argues that the SCR, reflecting overall degree of arousal, decreased with physiological relaxation such as rest and sleep. This assumes that there will be less SCRs during sleep and relaxation than at other moments of the day. The present study took this assumption and the assumption that the person would have no sleep storm during the powernap, along in the first hypothesis about SCRs during the powernap. The first hypothesis is: H1) *the number of SCRs at the day was lowest during the powernap*. Because of this hypothesis and these results, the second hypothesis arose. The number of SCRs was assumed to be lowest during the powernap, so the amplitude of these SCRs are also assumed to be lowest. H2) *the amplitude of SCRs at a day was lowest during the powernap*.

Literature shows that the phenomenon sleep inertia occurs directly after awakening (Takahashi, 2003; Tassi & Muzet, 2000). Sleep inertia produces a decreased reaction time and that made this phenomenon an interesting point for this study. Tassi & Muzet (2000) suggest namely, that there has not been much research on sleep inertia after taking a nap, especially with EDA measurement. The present study measures the performance of an individual on a task that requires a quick response. Davies and Krkovic (1965) have given the impetus for the second hypothesis. These researchers show that skin conductance decreased during sleep and they expect that this decrease will also occur during vigilance tasks (reaction time task), in which reports of drowsiness are common. However, this is only an assumption and they did not measure this assumption. To measure if this assumption is true, the present study shows the third hypothesis: H3) *Reaction time was lengthened directly after the powernap*.

The main purpose to take a powernap is because it brings so many benefits. According to Hayashi and Hori (1998), the powernap has positive effects on behavioral, subjective and physiological parameters. Takahashi et al. (1998) argue that a powernap is related to an improvement of alertness. Improvement of cognitive performance is related to sleep stage 2 (Debarnot et al., 2011). Since a person reaches sleep stage 2 in a powernap, it is assumed that cognitive performance is improved by the powernap. In the present study, cognitive performance is linked to scores of subjects on a reaction time task. Because of these results, the last hypothesis is: H4) *Reaction time scores were shortened after a powernap.*

Method

Participants

The 5 participants of the present study were students aged between the 19 and 24 years ($M = 21.6$, $SD = 2.51$). 2 participants were male and 3 participants were female. 1 female participant was studying at the University of Twente and 4 participants were studying at the Saxion Hogeschool Enschede. 4 of the participants were roommates of the researcher and 1 participant was an acquaintance. All participants had a Dutch nationality. Participation was voluntary as they received no financial contributions. Every participant performed the same procedure and reaction time task.

Instruments & Procedure

Instruments

The areas for application of EDA have been steadily widened and ambulatory monitoring has come into use more frequently during the last two decades. Ambulatory monitoring techniques are electrodermal recording techniques which are robust enough for the use in various field settings outside the laboratory. An example for ambulatory measurement is the affective Q-sensor (www.affectiva.com), used in this study. A Q-sensor is a wristband for SC-recording to be worn like a wristwatch. Two metal electrodes were placed side by side for contacting the volar surface of the wrist, since it does not contain hairs. Besides skin conductance, the Q-sensor also measures body temperature and it has an accelerometer for physical activity measurements. An accelerometer is low-cost, flexible and accurate for the analysis of posture and movement. The analog samples are sampled at 32 Hz. The battery has a nominal voltage of 3.7 V and can be recharged from a universal serial bus (USB) port. The Q-sensor contains a microSD card of 2gb, which provides enough storage capacity for 28 days of continuous measurements with a sampling rate of 32 Hz. The Q-sensor is one of the few comfortable sensors that could be worn outside the clinical environment and into the daily activities. The Q-sensor measured skin conductance during physical, cognitive and emotional stressors at palmar sites (Poh, Swenson & Picard, 2010).

Procedure

Before the participants started, they received a paper with information about the study and had to sign an informed consent. They were informed about the Q-sensor and when they had to wear the Q-sensor. The participants wore the Q-sensor from 10.00 a.m. until 17.00 p.m on the left distal forearm, for 5 days. This time period was divided by the researcher into 14 moments of a half an hour. The powernap was taken at one of these 14 moments in a day. This powernap moment was randomly chosen for each day, as described in Appendix 1. The participants wore the Q-sensor all the time, except when they did an activity whereby the Q-sensor could not be worn (during a shower, for example). When a moment of the day needed special attention, according to a participant, he or she could press the round button once. When this button was pressed, the text file with EDA data showed a complete white line. At 17.00 p.m. the Q-sensor was removed and the data was saved on a laptop.

Besides wearing the Q-sensors, the participants also had to perform a reaction time task every half an hour so their reaction time of a day became clear. The participants already performed the reaction time task a few times before they started the experiment. The reason was that there could be a learning curve by performing the reaction time task. If the participants performed the reaction time task a few times before the experiment started, than the scores were more consistent and the study achieved a more realistic view at the reaction time of a participant. The reaction time task, which was performed by the participants, was developed by the BBC (<http://www.bbc.co.uk/science/humanbody/sleep/sheep/>). The BBC created the task with the aim to show the effect of caffeine on the alertness of a person. According to this website, tiredness can affect a person's reaction time and a cup of coffee/tea could have an impact on a person's performance on the reaction time task. The reaction time task was a task where the participant had to press the tranquilizer button as fast as possible, when a sheep was leaving the flock and running for freedom. There were 5 sheep to stop. After the participants stopped the 5 sheep, their reaction time scores were shown and listed. When the person pushed the button to fast, they received a penalty of 3 seconds. These scores were excluded from the data for the study. The participant performed the reaction time task 2 times in sequence. This meant that the participant had 10 reaction time scores for every half an hour.

Design

The design was chosen based on the book by Dugard, File and Todman (2011). The present study was the closest to the ‘small- n repeated measures design with replicates’. There were a few conditions for this design. First, the study should have at least two participants, this present study had 5 subjects. Second, the study should have two conditions to compare. This present study had two conditions, ‘no powernap’ and ‘powernap’. Third, each participant should receive each of the conditions on at least two occasions and it should be possible to assign conditions in random order to each participant. Also, each participant should act as his or her own control. That was the case in the present study.

In a study, internal validity is an important concept. Dugard, File and Todman (2011) are suggesting that internal validity eliminates alternative explanations for any treatment effect observed. These researchers argued an important tool for internal validity, namely randomization. Randomization is not the same as random sampling. Random sampling means choosing a sample from a well-defined population by using random numbers. Randomization means the method of allocating different treatments, conditions or interventions. It was impossible to randomly assign participants in this small- n study, but instead it was possible to randomly assign treatments to observation occasions. This meant randomly assign powernap moments for the subjects. In this study, the subjects wore the Q-sensor from 10.00 a.m. until 17.00 p.m. This period was divided into 14 blocks of half an hour. At one of these blocks the subject took a powernap. This was randomly chosen, according to the method of Dugard, File and Todman (2011). This method is described in Appendix 1.

Data analysis

Randomization test and t-test

The present study used randomization tests, based on the book by Dugard, File and Todman (2011). These researchers showed differences between a t -test and a randomization test. With a t -test, one would calculate the t from a measurement made on the two conditions (no powernap or powernap) and then compare the t with its table of probabilities to see whether the obtained t value would have a less than 5% chance of occurring if the null hypothesis is true. In this present research, a very simple measurement was used. There was just recorded whether condition 1 or condition 2 is correct for each test period. Then the number correct was compared with all the other possible arrangements of condition 1 and condition 2. This present study used randomization tests that had an experimental setup like analysis of

variance (or t tests if there are only two conditions). This design of the test was referred as analog of ANOVA.

Random selection

With the aid of the book by Dugard, File and Todman (2011), ‘small-*n* repeated measures design with replicates’ was chosen as design. The only problem was that this design needed an equal number of observations in each condition. That was not the case in the present study. Of the 14 blocks in a day, there was 1 block with a powernap and 13 blocks without a powernap. Over 5 days, there were 5 blocks with a powernap and 65 blocks without a powernap. These blocks could not be compared in this way. The data had to be classified in the file, so that it fitted within the design. It was also not convenient to take average scores and standard deviations, because the condition without a powernap had many more observations. This led to the decision to randomly select 1 block for each day and to compare these 5 blocks with the 5 powernap blocks. The random selection was done by the manner of Appendix 1. Only this time, a day was divided in 13 blocks, because the powernap block was not taken into account. Finally there arose 5 observation moments per condition, with a total of 10 observations per subject.

Data processing with a macro

When a design was chosen that suited the study, then Dugard, File and Todman (2011) showed exactly how to implement it by using macros. A macro is a way to automate a task that you perform repeatedly and the macro of the present study is shown in Appendix 2. In the present study, the macro was used as a task that creates pseudo datasets for every possible block for a powernap. The macro calculated the differences in averages. The dataset had to be arranged for the macro. The first number in ‘limits’ column was the number of participants; the second was the number of observations per participant. The second column contained the dataset per condition, per subject. The third column was the column with the two conditions and the fourth column contained the different subjects. An example of a dataset can be found in Appendix 2.

In this present research, there were three different dataset. One dataset for reaction times, one for the number of skin conductance responses per block and one for the amplitude of the SCRs per block. In the case of the reaction time dataset, the penalties were removed. Subjects received a penalty when they pressed the button too early and this led to a lengthened reaction time. This affected the average reaction time, so they were removed by

the researcher. For the other the other hypothesis on reaction time, there were 20 random scores selected. Here, 10 scores of all reaction times before the powernap were randomly chosen and 10 of all reaction times after the powernap, per participant for all days together. This meant that there were 20 observations per participant, 10 in condition 1 (reaction times before the powernap) and 10 in condition 2 (reaction times after the powernap). In this way, any differences between the reaction times before the powernap and the reaction times after the powernap could be measured. For determining frequency and amplitude of SCR's, the data was processed in *MATLAB*. Here, the EDA and stimuli data were synchronized by coupling the registered unix timestamps. For determining SCR's the data was filtered with a Butterworth filter (cut-off frequency = 1/32 Hertz). Then, the first derivative was calculated to find speed changes above .000004 microSiemens for finding the ascent of the SCR. There had to be a minimum gap of 700 ms between peaks, otherwise the detected peaks (SCR's) were combined to one. An amplitude criterion of .01 microSiemens was used.

Self report

In the present study, there was also a self report question for the participants. The participants were asked if the participant thought he or she slept during the powernap. There were two conditions here and five observation moments (powernap moments). When the participant thought he or she slept during the powernap, this was processed in condition 'yes'. Sometimes a participant indicated that the participant was not sure whether he or she had slept, this was marked as the condition 'maybe'. There was no participant who indicated to be sure that he or she had not slept during the powernap.

For processing of the data, two observation moments were randomly chosen per participant. One of the observation moments in condition 'yes' was randomly chosen and there was also one moment taken in condition 2 'maybe'. This means that there were the same number of observation moments per condition: 1 score in condition 'yes' and 1 score in condition 'maybe'. In these moments, the skin conductance responses were taken to see if there were any differences between the two conditions.

Results

Skin conductance responses

The first hypothesis was about the number of SCR's during the powernap. The expectation was that the number of SCRs at the day was lowest during the powernap. The number of SCRs was noted in the file in blocks of a half an hour. Because the researcher expected a greater mean number SCRs on the condition without a powernap, this was taken as condition 2. This meant that condition 1 became the condition were the participant took a powernap. The test statistic of the randomization test was the mean of condition 2 minus the mean of condition 1, so $67.84 - 32.88 = 34.96$ and $p = .045$. This meant that in this randomization test (one-tailed) of the prediction that the mean number of SCRs in condition 1 was lower than the mean number SCRs in condition 2, 4.5% of a random sample of 2000 rearrangement statistics were at least as large as the experiment value. Because this was quite close to our significance level of 5% ($\alpha = .05$), the researcher took 3 more random samples of 2000 rearrangement statistics and found $p = .035$, $p = .036$ and $p = .043$. This showed that $p < .05$, so the null hypothesis was rejected. There is significant evidence that the number of SCRs at the day were lowest during the powernap.

Table 3.1. Number of observations, means and standard deviations of SCR's per condition.

	N	Mean	Standard deviation
Powernap	25	32.88	55.94
No Powernap	25	67.84	83.28

Table 3.1. shows the mean, standard deviation and the number of SCRs per condition. There was a large discrepancy in mean and standard deviation per condition. This made it interesting to look at the differences in mean number SCRs per condition between the participants. This was shown in figure 1. It was remarkable that participant 2 clearly scored lower on the mean number of SCRs than the rest of the participants and participant 4 scored higher than the other participants. Figure 3.2. shows an example of the difference between participant 2 and participant 3 and their EDA around and during the powernap of. All participants had fewer

SCRs in condition 1 than in condition 2 and this also confirmed that the mean number SCRs was lowest in condition 1 compared with condition 2. The individual differences were clearly visible in figure 3.1.

Figure 3.1. Mean number of SCR's per participant, per condition.

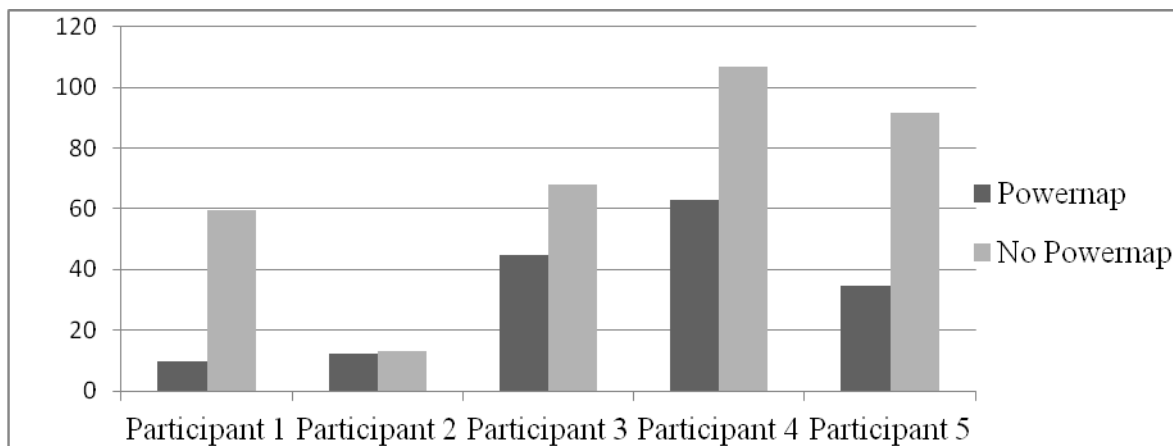
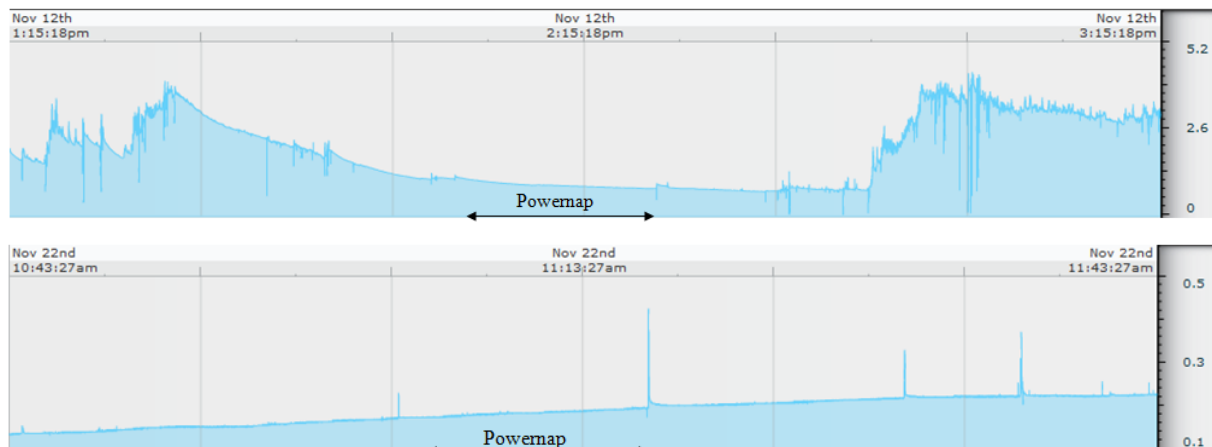


Figure 3.2. Example of a time of day with a powernap from participant 3 (top) and participant 2 (bottom). The blue graph shows EDA in microsiemens (μS) and the arrow indicates when the powernap was taken. On top, the time of day and the date can be seen.



Amplitude of SCRs

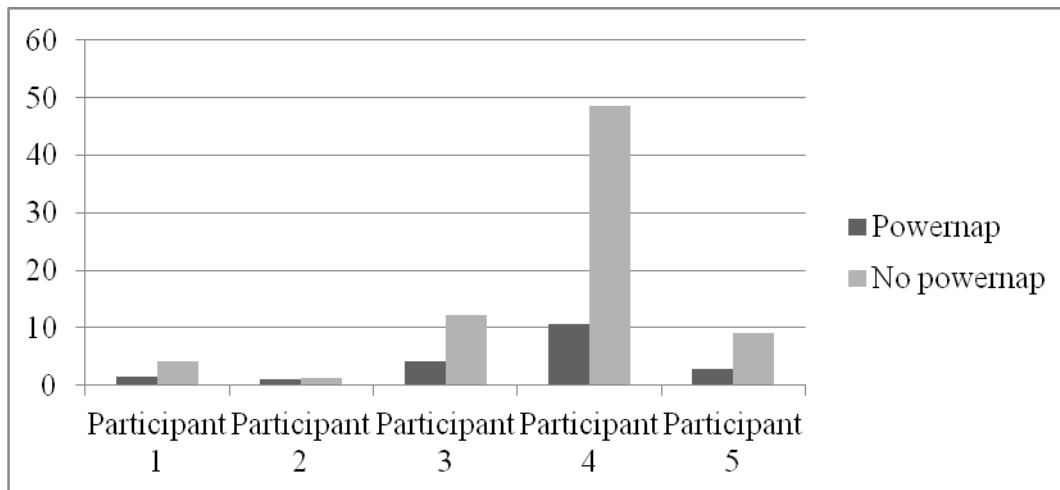
Besides SCRs, amplitude was also an important concept. The second hypothesis was that the amplitude of SCRs at a day was lowest during the powernap. Condition 1 was the condition where the participant took a powernap and condition 2 was the condition without a powernap. As table 3.2. showed, the mean score of condition 1 ($M = 4.07$) was lower than the mean score of condition 2 ($M = 15.03$) on the amplitude of SCRs. The standard deviation of condition 2 was remarkable high ($SD = 42.48$). The test statistic of the randomization test was 10.96 and $p = .083$. These results showed that in this randomization test of the prediction that the amplitude of SCRs at a day was lowest during the powernap, 8.3% of the rearrangement statistics were at least as large as the experimental value. This was not less than the significance level of 5% ($\alpha = 0.05$), but it was close to it. For that reason, the researcher took 3 more random samples of 2000 rearrangement statistics and found $p = .070$, $p = .076$ and $p = .077$. According to these findings, the experiment provided marginal evidence that the amplitude of SCRs at a day was lowest during the powernap.

Table 3.2. Number of observations, means and standard deviations of amplitude per condition.

	N	Mean	Standard deviation
Powernap	25	4.07	9.17
No Powernap	25	15.03	42.48

In figure 3.3. the mean amplitude of SCRs per condition, per participant was shown, to take a look at the individual differences. Participant 4 had a remarkably high amplitude of SCRs at condition 2 and showed a great difference between condition 1 en condition 2. This explained the high score on standard deviation in condition 2. The other participants had higher amplitude of SCRs at condition 2.

Figure 3.3. Mean amplitude of SCRs per condition, per participant.



Reaction times directly after the powernap.

The third hypothesis was the reaction time of a person. Because of sleep inertia the expectation was that the reaction time of a person directly after the powernap was lengthened. Because there was an expectation that the reaction time score directly after the powernap was lengthened, these scores were in condition 2. The scores, which were not taken directly after the powernap, were in condition 1. Table 3.3. showed the mean score of the two conditions and standard deviation. The mean score of condition 1 ($M = .2648$) and the mean score of condition 2 ($M = .2678$) were almost the same and this was also true for the standard deviation of condition 1 ($SD = .0286$) and condition 2 ($SD = .0382$).

Table 3.3. Number of observations, means and standard deviations of reaction time scores

	N	Mean	Standard deviation
No Powernap	25	.2648	.0286
Powernap	25	.2678	.0382

The test statistic of the randomization test was .003 and $p = .35$. These results showed that in this randomization test of the prediction that the reaction time scores directly after a powernap were lengthened, 35% of the rearrangement statistics were at least as large as the experimental value. This meant that $p > 0.05$, so the null hypothesis was not rejected. The experiment did not provide evidence that the reaction time scores directly after a powernap were lengthened.

Comparison between reaction times

The last hypothesis was that the reaction time of a person was shortened after a powernap, because of the powernap. 10 randomly chosen reaction time scores before the powernap were taken and also 10 randomly chosen reaction time scores after the powernap. These scores were compared. Condition 1 was the condition where the participants took a powernap and condition 2 was the condition without the powernap. Table 3.4. showed the mean score on the reaction time task in condition 1 ($M = .2686$) was slightly lower than the mean score in condition 2 ($M = .2781$). This also applied for the standard deviation in condition 1 ($SD = .0272$) and condition 2 ($SD = .0318$).

Table 3.4. Number of observations, means and standard deviations of reaction time scores

	N	Mean	Standard deviation
Powernap	5	.2686	.0272
No Powernap	5	.2781	.0318

The test statistic of the randomization test was 9.54 and $p = .031$. These results showed that in this randomization test of the prediction that the reaction time scores after a powernap were shortened, 3.1% of the rearrangement statistics were at least as large as the experimental value. This is less than the significance level of 5% ($\alpha = 0.05$), so the researcher took 3 more random samples of 2000 rearrangement statistics to be sure and found $p = .036$, $p = .040$ and $p = .035$. The experiment did provide evidence that the reaction time scores after a powernap were shortened, compared with the scores before the powernap. However, there were no major differences between the two conditions.

Self report

The self report question was about the question if the participant thought he or she slept during the powernap. The two conditions were ‘yes’ and ‘maybe’. The answers are shown in table 3.5.

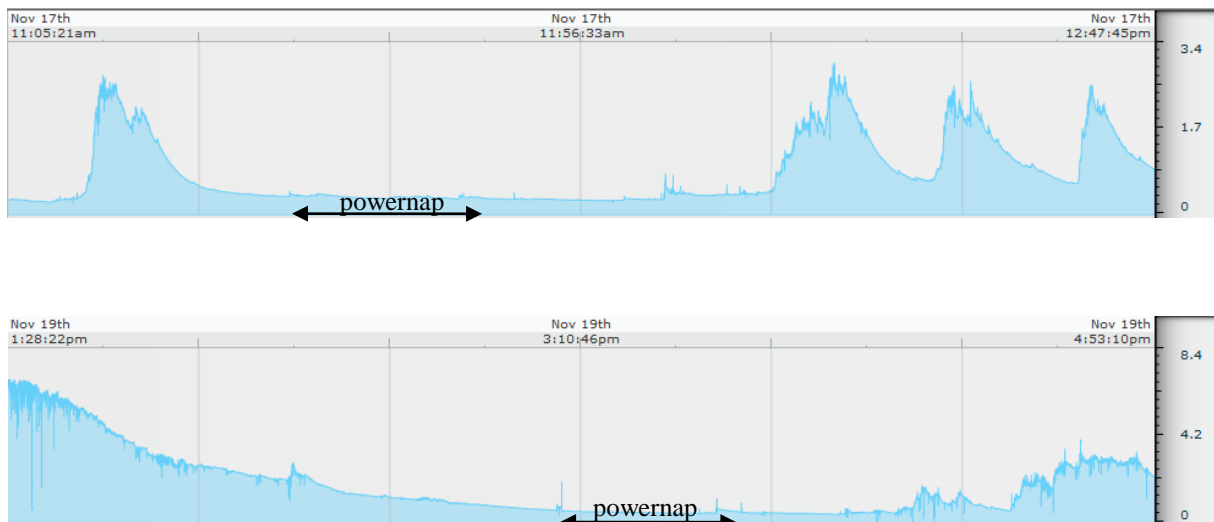
Table 3.5. Answers of participants to the self report question: ‘Did you sleep during the powernap?’

In sleep?	N	Yes	Maybe
Participant 1	5	4	1
Participant 2	5	4	1
Participant 3	5	5	0
Participant 4	5	3	2
Participant 5	5	4	1

The test statistic $F = 0.981$ and $p = .360$. Because this was higher than the significance level of $\alpha = 0.05$, there exist no differences between the two conditions. By means of these results, this study assumes that the participants were in sleep when they answered ‘maybe’.

Figure 3.4. shows two days with powernap moments of participant one. On top is a powernap moment when participant was not sure if he or she slept during the powernap and answered ‘maybe’. On bottom is a powernap moment where the participant was sure he or she slept during the powernap and answered ‘yes’. Also in this figure there are no differences found between the two conditions.

Figure 3.4. Powernap moments of participant one, when this person was not sure if he or she slept (top) and when he or she was sure about sleeping (bottom).



Discussion and Conclusion

Hypotheses

The aim of the present study was to analyze EDA around and during a powernap and its relationship to reaction time on a task. In order to analyze this aim, four hypotheses were tested. Sano and Picard (2011) showed that individuals have different sleep stages and that a person will only reach stage 2 during a powernap. Wuyts et al. (2012) argued that sleep comes with a decrease in arousal. Based on these results, it was expected in the present study that EDA will decrease during the powernap. The first hypothesis was that the number SCRs at the day was lowest during the powernap. The results showed a difference between the number of SCRs in the condition with powernap and in the condition without powernap. The number of SCRs proved to be lower when the participants took a powernap, compared with the condition where the participants had not taken a powernap. A comment on these results was that not every observation of the condition without powernap was included in the measurement, because otherwise the condition without powernap had far more measurements than the condition with powernap. This ensured that one observation of the condition without powernap was randomly chosen per day. Remarkable in these results was participant 2. This participant had a low number of SCRs during the days and had a very small difference between the condition with powernap and the condition without powernap, compared to the other participants. This can have several causes. This person can be an electrodermal stabile subject. According to Wilson (1987) electrodermal labile subjects show frequent 'non specific' fluctuations in their skin conductance and have consistently demonstrated superior signal detection performance as compared to 'stabile' subjects. This person did not show many fluctuations, as seen in figure 3.2, and this may mean that he was a stabile subject. The differences between labile and stabile subjects are an interesting point for future study.

In the second hypothesis was assumed that the amplitude of SCRs at a day was lowest during the powernap. It was expected that the participants had a decreased arousal and the lowest number of SCRs of a day during the powernap and this hypothesis ditch that view. According to the results there were no differences between the mean amplitude of SCRs when the participants took a powernap and the mean amplitude of SCRs when they did not. This did not match with the hypothesis. Still, the test statistic (0.083) was close to the significance level ($\alpha = 0.05$). This meant that there were marginal differences between in the condition with powernap and the condition without powernap, for the present participants. For example, a remarkable result was the high mean amplitude of SCRs on condition without powernap of participant 4. This participant had also the most number of SCRs according to the results of

the first hypothesis. This too may be explained by electrodermal lability, as discussed in the discussion of the first hypothesis, or the activities this subject did.

For the third hypothesis, the reaction times of participants were measured. Tassi & Muzet (2000) introduced the term of sleep inertia, which referred to a behavioral slowdown after awakening. The person may still be in a state of sleep. Because of this phenomenon, the expectation of this study was that the reaction time of a person was lengthened directly after the power nap. It was possible that the person still suffered from the sleep inertia. The results of the present study were however not in line with the hypothesis, because there was no difference found between the reaction times in the two conditions. According to the study of Tassi & Muzet (2000), there were researchers that proved no decrement on subsequent performance after a power nap of 20 minutes. However these results were based on memory tasks and this study used a reaction time task. Still, because of the results, it seemed to be that the participants did not suffer from sleep inertia, because the reaction times directly after the power nap were not lengthened compared with the reaction times before or after the power nap. An explanation could be that a person only suffers from sleep inertia when the person will reach the slow wave sleep. Many researchers showed maximum sleep inertia after awakening a slow wave sleep episode. Tassi & Muzet (2000) argued also that sleep inertia produced a decreased reaction time, up to 360% of pre-sleep performance, depending on the type of task. It is possible that this task was not accurate enough to measure reaction time. Still, van Dongen and Dinges (2005) were suggesting that very short naps (circa 10 minutes) may offer a person benefits without suffering from sleep inertia. The results of the present study were in line with this assumption, and showed another advantage for taken a power nap: a power nap will not cause sleep inertia and a person will not suffer from it.

A power nap is taken because there are several positive effects. A power nap improves alertness (Takahashi et al. 1998). A nap causes a shortened P300 and a shortened P300 represents increased alertness and this improves the cognitive performance. To measure this, the last hypothesis was tested. Because of the results with improved alertness, this study expected shortened reaction times after the power nap compared with reaction time before the power nap. The results showed a difference for the participants between the condition with a power nap and condition without a power nap. The reaction time scores of the subjects were shortened after a power nap in comparison with the scores before the power nap. This meant that power nap caused improved cognitive ability and thus a shortened reaction time. The results of the present study are in line with the earlier findings by Takahashi, Fukuda and Arito (1998).

Limitations

The present study had to do with some limitations. First of all the number of participants. The present study was a small-*n* study. It is difficult to randomize the participants. This overcome in the manner of Dugard, File and Todman (2011) described previously, but there were some complications. The participants could not always perform on the reaction time task, because of their daily activities. They had college or went sporting, for example. Participant 1 and participant 2 both had no EDA signal for about a half an hour on day 3. The reason was that participant 1 went sporting and participant 2 took a shower. They had to take the Q-sensor off for these activities. There was also a problem at day one for participant 2. Instead of taking a powernap of 20 minutes, this participant took a nap of 3 hours. The participant said he was not awakened by the alarm.

Generalization was another problem in this study. It is hard to generalize in a small-*n* study, because of the few participants. Dugard, File and Todman (2011) therefore argue: ‘It is virtually unheard of for experiments with people to meet the random sampling assumption underlying the significance tables that are used to draw inference about populations. Generalization almost invariably depends upon replication and non statistical reasoning.’ According to Lucas (2003) however, generalization of research findings refer to external validity, either from a sample to a larger population or to settings and populations other than those studied. This study used only students between 19 and 24 from Enschede. To ensure generalization, measures in any study must relate to each other consistently with theoretically derived hypotheses for the study to have external validity. Measures in any study must relate to each other consistently with theoretically derived hypotheses for the study to have external validity. For future studies, there should be selected more wide for participants. For example participants with other ages or in different settings.

The reaction time task was another point that could be improved in future research. Because the participants had to perform a reaction time task every half hour, it was convenient to choose a task that they could perform on their mobile phones. The participants carried their mobile phones always with them and so they could perform the reaction time task anywhere. The reaction time task was found on the site of BBC. The only comment here is that this task was not scientifically examined. Sometimes scores were exactly the same for some participants. It was also suggested that the participants were given a penalty of 3 seconds when they pushed too early. This means that sometimes a delayed reaction time had

because of the penalty. These scores had to be removed and therefore remained less reaction time scores. For future research it is recommended to use a scientific reaction time task.

Future research

Electrodermal lability and stability are an interesting concept for future research (Wilson, 1987), as discussed above in paragraph 4.1. Stable subjects showed a rapid habituation to tasks and had few non specific fluctuations, compared with labile subjects. However, labile subjects tended to have faster reaction time scores overall and they were better able to maintain a state of optimal preparation over longer periods. The interesting point here is that these findings were measured in experimental setting and with a Q-sensor this could be measured in the normal, daily life of a subject. Future studies could measure whether a labile subject reacts fiercer to activities than a stable subject and if the powernap has different effects on labile and stable people. These studies could also measure if labile subjects also score faster reaction times on time tasks during their daily life instead of an experimental environment.

In the study of Takahashi, Fukuda & Arito (1998), a nap after lunch is most likely related to an improvement of alertness for daytime employees. Still, there are only a few companies who offer a place where their employees can take a nap. A powernap can greatly improve the work performance of employees and it will only take about 20 minutes. For future studies, it might be an option to measure in a different setting such as a workplace. If the powernap show a positive effect, employers may introduce the powernap more often to their employees. This could provide more quality of work and less mistakes employees make.

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Appendices

Appendix 1. Randomization single-case/small-*n* study

In the present study, the subjects wore the Q-sensor from 10.00 a.m. until 17.00 p.m. This period was divided into 14 blocks of half an hour. At one of these blocks, the subject took a powernap. This will randomly be chosen in the manner described in the book of Dugard, File and Todman (2011), indicated by the following steps.

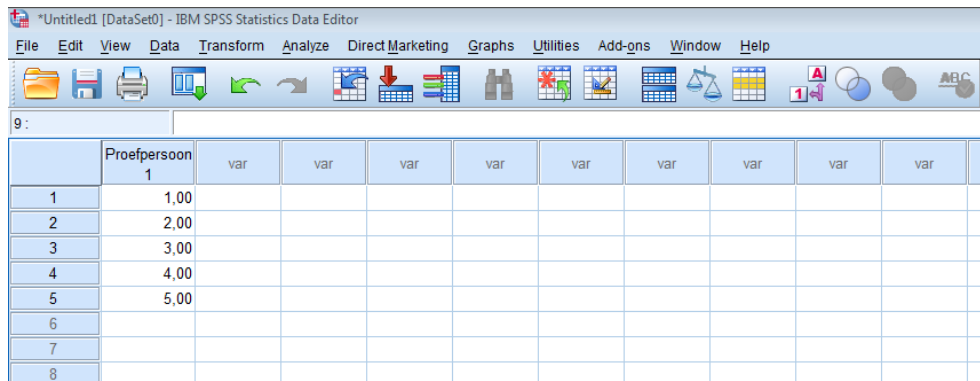
An overview of powernap opportunities

10.00-10.30u	Moment 1
10.30u-11.00u	Moment 2
11.00u-11.30u	Moment 3
11.30u-12.00u	Moment 4
12.00u-12.30u	Moment 5
12.30u-13.00u	Moment 6
13.00u-13.30u	Moment 7
13.30u-14.00u	Moment 8
14.00u-14.30u	Moment 9
14.30u-15.00u	Moment 10
15.00u-15.30u	Moment 11
15.30u-16.00u	Moment 12
16.00u-16.30u	Moment 13
16.30u-17.00u	Moment 14

Procedure ‘randomization of powernap blocks’

Step 1

The day of a subject was divided into 14 blocks of a half an hour, from 10.00 a.m. until 17.00 p.m. At one of these blocks, the subject took a powernap and this happened once a day. This meant that the subject took a powernap for 5 times in 5 days divided. This was entered in a file, in the table of subject 1, for example.



	Proefpersoon	var	var	var	var	var	var	var	var	var
1	1,00									
2	2,00									
3	3,00									
4	4,00									
5	5,00									
6										
7										
8										

Fig.1. Table with 5 powernap blocks for subject 1.

Step 2

At step 2 the researcher went to 'transform' en then to 'compute variable'. At 'function group', she clicked on 'random numbers'. After this, she had to click on 'r.v. uniform' in 'functions and special variables'. This appeared in numeric expression (figure 2). In the place of the question marks had to be completed two numbers: the first '?' contained the first opportunity block on a powernap minus a half and the second number indicated the last opportunity block plus a half. The number plus or minus a half was necessary, because then the highest and lowest block also had an equal opportunity to be selected. In this study, powernap block 1 was the smallest number, so $1 - 0.5 = 0.5$ and the last number was powernap block 14, so $14 + 0.5 = 14.5$.

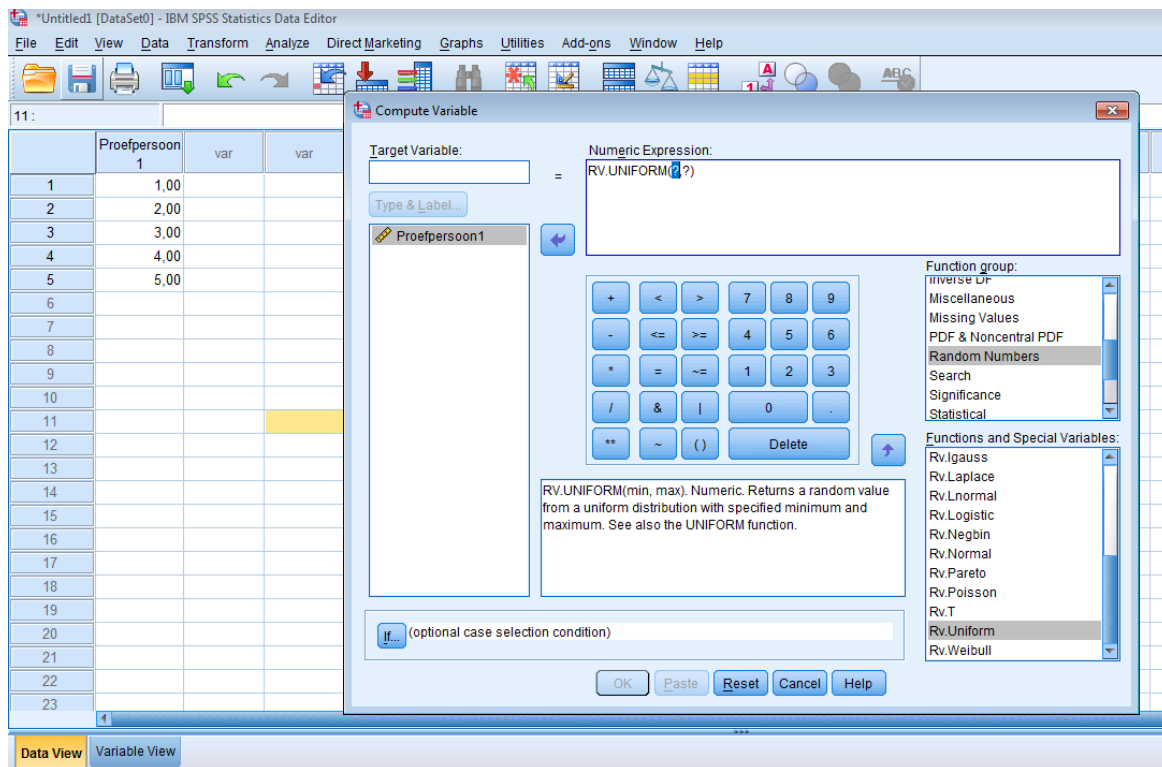


Fig.2. SPSS screen when following the instructions of step 2.

Step 3

On the question marks, the numbers 0.5 and 14.5 were filled in as described in step 2. The target variable was given a name, in this case 'NapMoment'. Then the researcher had to click on 'ok'.

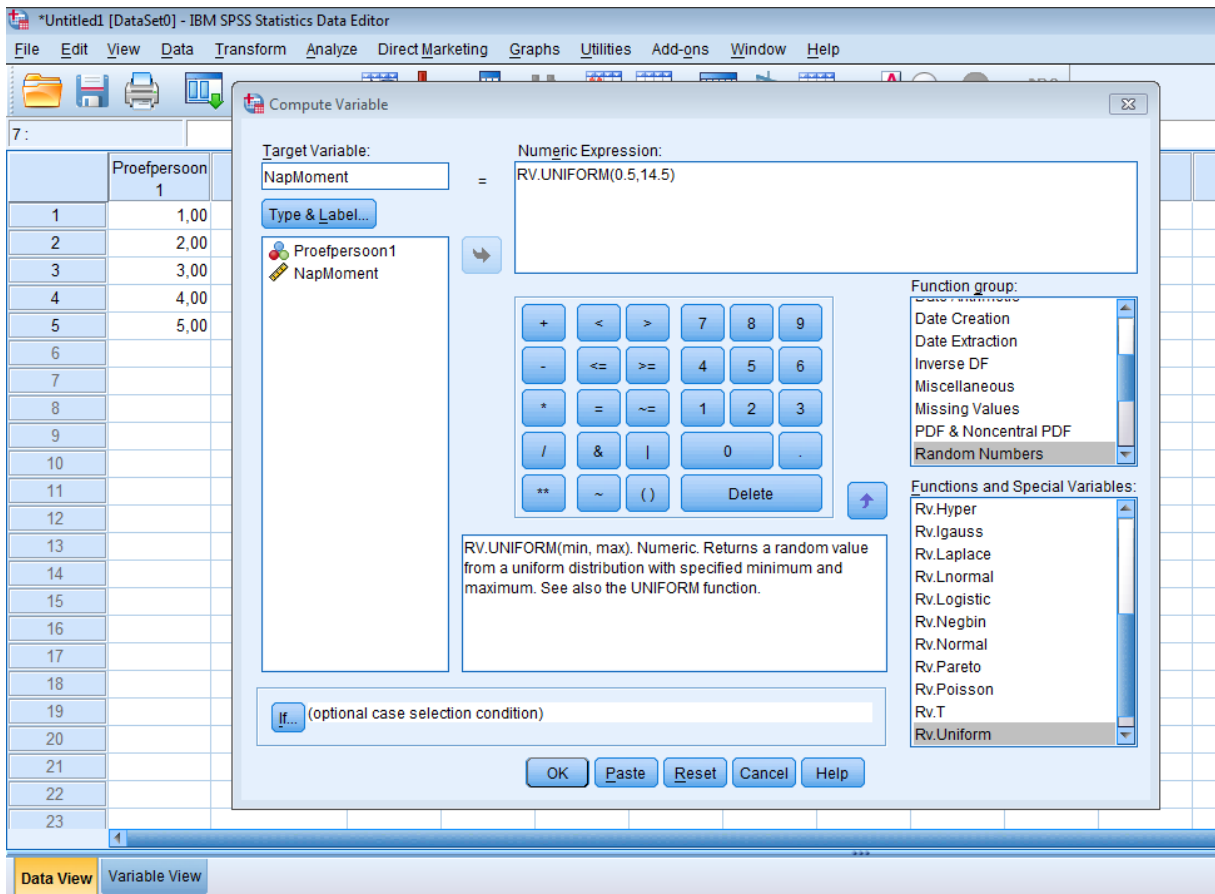


Fig.3. SPSS screen after completing the moments and giving it a label.

Step 4

In step 4, a new tab with 'NapMoment' had arisen. These were randomly chosen blocks. They had not yet been rounded to whole numbers, but this was done by the researcher. From .50 was rounded up, 0.49 was rounded down.

The screenshot shows the 'Data View' tab in IBM SPSS Statistics Data Editor. The data table now includes a 'NapMoment' column. The values for 'NapMoment' are 10,29, 5,35, 6,74, 1,23, and 1,94 for cases 1 through 5, respectively. The 'Proefpersoon 1' column remains the same as in the previous screenshot.

Case	Proefpersoon 1	NapMoment	var	var	var	va
1	1,00	10,29				
2	2,00	5,35				
3	3,00	6,74				
4	4,00	1,23				
5	5,00	1,94				
6						
7						
8						

According to this table subject 1 had to take the powernap at the following blocks:

Day 1: on nap moment 10 (this means from 14.30 p.m. until 15.00 p.m.)

Day 2: on nap moment 5 (from 12.00 p.m. until 12.30 p.m.)

Day 3: on nap moment 7 (from 13.00 p.m. until 13.30 p.m.)

Day 4: on nap moment 1 (from 10.00 a.m. until 10.30 a.m.)

Day 5: on nap moment 2 (from 10.30 a.m. until 11.00 a.m.)

If the subject could not take a nap at one of these times of the day, the researcher could choose separately another random block by following the previous steps. At that time, only one time was entered into the file.

The screenshot shows the IBM SPSS Statistics Data Editor interface. The title bar reads '*Untitled2 [DataSet1] - IBM SPSS Statistics Data Editor'. The menu bar includes File, Edit, View, Data, Transform, Analyze, and Direct Marketing. Below the menu bar is a toolbar with various icons. The main data grid shows a table with the following content:

	Proefpersoon 1	NapMoment	var	var
1	1,00	2,48		
2				
3				
4				
5				
6				

These steps had to be followed by the researcher for every subject separately.

Powernap moments after following these steps:

	Dag 1	Dag 2	Dag 3	Dag 4	Dag 5
Proefpersoon 1	16.30-17.00	11.30-12.00	11.30-12.00	15.00-15.30	12.30-13.00

	Dag 1	Dag 2	Dag 3	Dag 4	Dag 5
Proefpersoon 2	15.00-18.00	12.00-12.30	13.00-13.30	14.30-15.00	11.00-11.30

	Dag 1	Dag 2	Dag 3	Dag 4	Dag 5
Proefpersoon 3	15.00-15.30	14.00-14.30	16.30-17.00	15.30-16.00	16.30-17.00

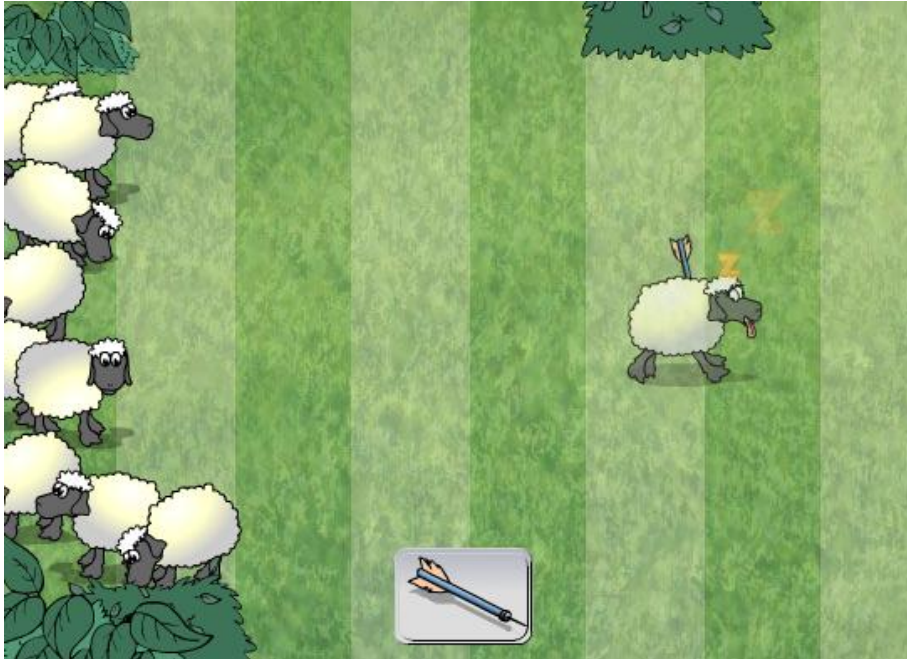
	Dag 1	Dag 2	Dag 3	Dag 4	Dag 5
Proefpersoon 4	11.30-12.00	15.00-15.30	14.30-15.00	15.00-15.30	13.00-13.30

	Dag 1	Dag 2	Dag 3	Dag 4	Dag 5
Proefpersoon 5	14.30-15.00	11.30-12.00	13.30-14.00	15.00-15.30	15.00-15.30

Reaction time

The reaction time test had to be done every half an hour, 2 times in a row. The subject recorded the results of the reaction times itself in a file. There were, per half an hour, 10 reaction times of the subject. Every half an hour the reaction of a subject (from 10.00 a.m. until 17.00 p.m.) was measured.

An example of the reaction time task:



Appendix 2. Macro and Dataset

Macro

```

set mxloops 5000.
matrix.
get limits/variables=limits/missing=omit.
get data/variables data condition participant/missing omit.
compute ncase=limits(1).
compute nswaps=limits(2).
compute nobs=ncase*nswaps.
compute total={0,0}.
loop obs=1 to nobs.
compute total(data(obs,2))=total(data(obs,2))+data(obs,1).
end loop.
compute test1=(total(2)-total(1))/(nobs/2).
print test1/title="test statistic".
compute nperm=2001.
compute results=uniform(nperm,1).
compute results(1,1)=test1-test1/1000000.
loop perm=2 to nperm.
loop case = 1 to ncase.
loop n= 1 to nswaps.
compute k=trunc(uniform(1,1)*(nswaps-n+1))+n+nswaps*(case-1).
compute obs=n+nswaps*(case-1).
compute temp=data(obs,1).
compute data(obs,1)=data(k,1).
compute data(k,1)=temp.
end loop.
end loop.
compute total={0,0}.
loop obs=1 to nobs.
compute total(data(obs,2))=total(data(obs,2))+data(obs,1).
end loop.
compute test1=(total(2)-total(1))/(nobs/2).
compute results(perm,1)=test1.
end loop.
compute absres=abs(results).
compute pos1=0.
compute pos2=0.
loop k=2 to nperm.
do if results(k,1)>=results(1,1).
compute pos1=pos1+1.
end if.
do if absres(k,1)>=absres(1,1).
compute pos2=pos2+1.
end if.
end loop.
print pos1/title="count of arrangement statistics at least as large".
compute prob1=(pos1+1)/nperm.

```

This macro was used as syntax in SPSS. The macro was used on the different datasets with the number of skin conductance, amplitude and reaction time scores. Below, you can find an example of a data set.

Dataset

An example of a dataset that used the macro above. This dataset belongs to the first hypothesis about the number of SCRs per condition, per participant.

18 :

	limits	data	condition	participant	var	var
1	5	48	2	1		
2	10	127	2	1		
3	.	99	2	1		
4	.	9	2	1		
5	.	14	2	1		
6	.	17	1	1		
7	.	2	1	1		
8	.	11	1	1		
9	.	17	1	1		
10	.	2	1	1		
11	.	16	2	2		
12	.	2	2	2		
13	.	15	2	2		
14	.	24	2	2		
15	.	9	2	2		
16	.	1	1	2		
17	.	4	1	2		
18	.	50	1	2		
19	.	1	1	2		
20	.	5	1	2		
21	.	1	2	3		
22	.	163	2	3		
23	.	112	2	3		
24	.	27	2	3		