



UNIVERSITEIT TWENTE.

Are we as tired as we think we are?
A study over the relation of the explicit and
implicit within-day variability of fatigue

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1 Abstract

Background:

It is well known that our daily sleep-wake cycle follows a 24-hour circadian rhythm, including within day fluctuations known as circadian variations. With the progression of wakefulness, the level of fatigue or tiredness increases, and sleep latency shortens. But till now this has only been assessed explicitly. It is not known if these circadian fluctuations also apply to the implicit level. Research about fatigue indicate a possible difference between people's explicit and implicit assessment of their level of fatigue. The dual process model gives a possible explanation. People inhibit two ways of information processing, one explicit one and one implicit. The self-reported explicit interpretation of their level of fatigue could be influenced through certain biases, like the self-concept bias, which describes an internal tendency to associate oneself more with fatigue than vitality. Because there are no short assessment scales for the explicit momentary level of fatigue in a healthy population a new scale, namely the EMMF had to be developed.

Objective:

The aim of this study was to get a better insight in the relationship between the explicit and implicit level of fatigue and their specific circadian nature. A second goal was to validate the new developed assessment scale for momentary fatigue, the EMMF.

Methods:

The chosen study design was a longitudinal observational study. In total four measurements were conducted online, via the website 'socosurvey.de'. 41 participants (26 men, 17 women, mean age was 38.5 years old) took part in the study. First the explicit level of fatigue was assessed with the Checklist Individual Strength (CIS). Second the momentary explicit interpretation was measured with the Explicit Momentary Measurement of Fatigue (EMMF). And last the implicit level was indicated by a D-score resulting from a self-concept BIAT with the two groups 'I – fatigue' and 'I-vitality'. On day 1, the baseline test was conducted including the CIS, EMMF, BIAT and some questions concerning demographic variables. On day 2, the measurements had to be conducted at different times of the day (morning, afternoon, evening) including the EMMF, BIAT and some specific questions about possible confounding variables. Data were analyzed using SPSS. The circadian variations were assessed by six paired sample t-tests. Whereas the relationship between the two measurements and the validity of the EMMF were investigated using Pearson correlations and factor analysis.

Results:

The paired sample t-tests showed a significant change in explicit level of fatigue throughout the day, whereas the implicit level seems to be relatively stable with no significant fluctuations. After a slight non-significant decrease in fatigue, the participants in this study seem to feel more tired with progressive wakefulness. Correlations between the two types of measurements revealed no significant associations for any given time. However, a slight trend in scores can be observed suggesting a very

slightly stronger relationship in the morning/ afternoon than in the evening. This trend changes direction in people with a high self-concept bias, as the post hoc analyses for subgroups revealed. Again, no significant correlations have been found, but here the strongest non-significant correlation is to be found between the two evening measurements. Furthermore, the results strongly support the validity and reliability of the EMMF.

Conclusion:

In conclusion these results support the assumption of the dual process model and therefore that the explicit and implicit assessment of fatigue are two distinct processes. The implicit level of fatigue, indicated by the self-concept bias, is a more stable trait than the explicit level. It thus falls not prey to circadian variations as the explicit level. The explicit level of fatigue did not have any significant influence on the reaction times of participants. If people thus explicitly think they are tired, they do not necessarily perform slower, indicating a higher than expected level of energy left. This suggests that the explicit assessment of fatigue has not just the function to give us a true indication of the momentary energy level at our disposal. Its purpose could rather lie in protecting us unconsciously from physical/muscular, mental/cognitive or motivational/emotional restraint, by inducing the normal sleep-wake cycle. Furthermore, the implicit level of fatigue for people with a high self-concept bias tends to have a stronger relationship with their explicit level in the evening hours. Future research should focus on further investigating the difference between people with a high self-concept bias and a low one to explain how and why their explicit and implicit assessment of fatigue differs. A look into the relationship between the implicit and explicit level of fatigue outside the normal circadian rhythm, for example under prolonged sleep deprivation will provide more insight into the interplay of these two systems for vitality and fatigue.

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2 Introduction

2.1 Fatigue

Feeling fatigued is something everybody experiences in his life. Normally people even experience it daily, as part of one's normal life. In this form it even serves a health protecting function. Glaus, Crow, and Hammonds (1996) describe fatigue as: "a non-specific state, indicative of a decreased level of vitality, which has the protective function of forcing the body to avoid further stress". Fatigue does therefore help to avoid overstraining, by helping us to avoid further stress and forcing the body to rest, thus allowing recovery to take place (Glaus, et al., 1996; Grandjean, 1977). But fatigue can also take on a different form, a more pathological and health risky form. Carierri-Kohlman, Lindsey, & West (2003) describe it in this context as an "[...] unusual, abnormal or excessive whole-body tiredness, disproportionate to or unrelated to activity or exertion". Possible negative consequences of fatigue can include impairments in motivation, performance, health, well-being, and safety, but can also result in considerable economic consequences for the individual or the whole community/ government (Jason, Evans, Brown, & Porter, 2010; Sonnentag, & Zijlstra, 2006; Van Yperen, & Janssen, 2002; Zohar, Tzschinski, & Epstein, 2003). Suffering from a pathological form of fatigue can consequently result in a decline in work capacity or overall productivity (Kant et al., 2003). In extreme cases, this can even lead to a reduced economic power, resulting in financial burdens and consequences (Curt, 2000; Reynolds et al., 2008; Versnon, Bouchery, & Reeves, 2004). Both the direct and indirect consequences of fatigue show the pending and growing importance of the topic and as such the rising need for scientific research.

Interesting, however, is that even if fatigue is such a generally well-known construct, there exists no common definition of the concept. One of the most prominent ones, and the one that will be used for this study, is the one from Jones et al. (2007). They define fatigue as "[...] a perception of a lack of energy, or a feeling of tiredness that affect mental and physical activity, which may be aggravated by, but is not primarily attributed to, exertion or diagnosable disease". Interesting here is the inclusion of the term 'perception', that indicated that fatigue does not necessarily have to describe an explicit biological or physiological state. It can also refer to the subjective perception of that biological state. Furthermore, it seems that fatigue does not only operate on one dimension but can have influences on physical as well as mental activities and processes. On a normally daily basis the term fatigue can be used interchangeably with tiredness (Shahid, Shen, & Shapiro, 2010). As such it follows a certain repeating circadian rhythm, also known as a 24-hour cycle. So, it is a phenomenon that repeats itself every 24 hours. But the individual level of fatigue is not a single or definite state (Grandjean, 1970). It is susceptible to some circadian variation, meaning that the subjective level of fatigue changes over the day (Claros-Salinas et al., 2010; Morris, Cantwell, Vowels, & Dodd, 2002). With the progression of wakefulness, the level of fatigue or tiredness increases, and sleep latency

shortens (Carskadon, & Dement, 1981; Fröberg, Karlsson, Levi, & Lidberg, 1975). With the highest need arising in the evening, and a minimum need around morning and noon (Powell, Spencer, Holland, Bradbent, & Petrie, 2007; Czeisler, 1978; Wever, 1979; Zulley, 1979). Therefore, feeling fatigued is part of a natural cycle, everybody experiences repeatedly. And as such there is nothing wrong with it. On the contrary. In this case, it can be categorized as one of nature's protective functions, like thirst, hunger, or other similar sensations (Grandjean, 1970).

Here Grandjean (1970) makes the important distinguishing between two aspects of fatigue. The muscular/ physical fatigue, and the mental/ cognitive fatigue. Physical fatigue can be described as a phenomenon that arises in overstressed muscles. With increasing physical burden, the performance of the muscle falls off, until the stimulus no longer produces a response, resulting in a reduction of power and slower movements. Muscular fatigue thus can impair coordination and increase susceptibility to errors and accidents. On the other hand, it also serves as indication of the physical limits of the body and therefore protects for physical overstraining (Grandjean, 1970). It can be offset by adequate sleep (Barnes, & Van Dyne, 2009). Mental fatigue, on the other hand, can be characterized by an overall feeling of weariness. Individuals feel inhibited, and their activities impaired. They do not feel the desire to participate in mental or physical effort, feel heavy or drowsy. If the individual can rest, this feeling of weariness is nothing unpleasant or harmful. It just helps to discourage us from mental overstraining and forces us to rest (Grandjean, 1970).

Sometimes a third sub-concept of fatigue can be found in the scientific literature, namely 'emotional/ motivational fatigue'. Maslach (1982) defines it as feeling overwhelmed, drained, and used up by the emotional demands imposed by others. As such it describes a feeling of emotional exhaustion wherein the individual is unable to emotionally invest in tasks or interpersonal relationships (Iiies, Huth, Ryan, & Dimotakis, 2015). Emotional/ motivational fatigue can be the result of interpersonal conflict, job expansion, empowerment, and downsizing, (Cropanzano, Rupp, & Byrne, 2003; Lee & Ashforth, 1996; LePine et al., 2004; Maslach, Schaufeli, & Leiter, 2001).

With so many concepts and constructs involved in the definition of the term fatigue, it becomes hard to clearly define the continuum of fatigue (Glaus et al., 1996). Given the complex nature and interactions of involved biological and cognitive processes, the psychosocial phenomena, and behavioral manifestations it is not surprising that a clear definition proves problematic. Questions about the deviation of fatigue from normal tiredness arise. So which level of fatigue is acceptable or normal, given specific circumstances. And it seems there is no easy answer to this. Some distinguish normal fatigue from pathological fatigue and psychological fatigue, while others simply view normal fatigue as an acute state and pathological fatigue as a chronic state (Aaronson et al., 1999).

Overall fatigue is considered as nonpathological if the feeling of fatigue does not follow the normal circadian variations but becomes a more constant feeling and thus even possibly impairing factor. Symptoms last fewer than 3 months and have an identifiable cause, like an acute illness for example. This nonpathological form of fatigue is mostly self-limited and often resolved by treating the

underlying condition or illness (Jason et al., 2010). Pathological fatigue on the other hand is often accompanied by chronic illnesses such as rheumatoid, arthritis, diabetes, multiple sclerosis, AIDS and cancer in connection with radiation or chemotherapy. It is experienced with a greater intensity and prolonged duration (5+ months) (Christodoulou, 2005; Jason, & Choi, 2008; Piper, 1993).

Treating pathological fatigue can be a complicated matter, cause of the multitude of possible reasons, related concepts, and possible interaction effects with underlying severe medical issues. The variety of possible treatments can be huge. Up to this point different forms can include medications, antibiotics, vitamins, or physical exercises, but no golden rule has been established so far (Thorsteinsson & Brown, 2009).

Given the facts, it can be assumed that clinical populations experience more fatigue than healthy individuals (Piper, 1993). But fatigue is a universal symptom not only associated with major or acute diseases, but also with normal, healthy functioning. Lifestyle or situational factors, like lack of sleep or stress can be important influencing factors in this context. As such it is commonly experienced by the general population, and even one of the most common complaints in the primary health care (Aaronson et al., 1999; Jason et al., 2010; Lewis, & Wesseley, 1992; Van't Leven, Zielhuis, van der Meer, Verbeek, & Bleijenberg, 2009). The reason for this rising is still controversial. Cardol, Bensing, Verhaak and Bakker (2005), assume it could be a newly arising trend in the population to complain about fatigue symptoms. Their results indicate that people report more fatigue symptoms but do not really seem to be more fatigued or suffer from more fatigue-related symptoms than in the past or than other people. So overall, they indicate that the rising complaints about fatigue, doesn't necessarily mean an explicit rise in symptoms related to fatigue, but could also be an indication of a sort bias or trend, that people just think they are more fatigued (Cardol et al., 2005). Understanding the reasons for this newly arising trend is of specific importance in this case. To try on finding its possible origin it is important to fully understand the complexity of the topic by looking the biological and mental origin of fatigue.

2.2 Circadian processes

The two-process model of the sleep-wake circle regulation describes two distinct processes, a homeostatic and a circadian process. Together these two processes determine the timing of the onset and offset of sleep (Van Dongen & Dinges, 2000). The homeostatic process is characterized by the drive to sleep or rest that increases during wakefulness and declines during sleep. If this ‘homeostat’ rises above a certain degree, sleep is triggered, if it falls below a certain degree, wakefulness is initialized (Van Dongen. & Dinges, 2000). Circadian processes, on the other hand, can be described as internal cycles of approximately 24 hours, that are independent of external factors. Recent advances in the field of genetics have shown that circadian systems are tightly connected with processes that control sleep as well as metabolism and are relevant to other physiological and behavioral phenomena, like rest-activity, sleep-wake, body temperature and hormone levels (Dijk, & Czeisler, 1995; Huang et al., 2002; Huang, Ramsey, Marcheva, & Bass, 2011).

It is often assumed that a circadian ‘clock’ is responsible for this universal 24-hour rhythm. Differing theory’s over the origin of this clock include its origin in the reticular formation of the midbrain, a population of oscillators coordinated by the central nervous system, or a biological clock located in the suprachiasmatic nuclei of the hypothalamus (Fröberg, Karlsson, Levi, & Lidberg, 1975; Saper, Scamell, & Lu, 2005). This biological clock does not only tell us when to fall asleep or wake up, it also modulates our-hour to hour waking behavior, which is reflected in fatigue, alertness, and physical performance, creating a circadian rhythmicity in almost all neurobehavioral variables (Fröberg et al., 1975; Van Dongen, & Dinges, 2000). These internal cycles have the function to ensure that the energy metabolism is coordinated in an appropriate temporal pattern and can also be influenced by the energy status of the organism. A Disruption of either function, the circadian rhythm or the metabolism can lead to a disturbance in the other, resulting in a possible predisposition to metabolic disorders like obesity or diabetes type 2 (Huang et al., 2011).

Circadian variations, on the other hand, are the other side of the coin and stand for the within-day variability of certain phenomena, as for example the display of performance, subjective arousal, or adrenaline excretion (Fröberg et al., 1975; Kleitman, 1963). The concept of fatigue follows thus, a circadian rhythm, and additionally inherits some circadian variations, also called ‘within day variability’ (Claros-Salinas et al., 2010; Morris et al., 2002). But scientific research indicates some irregularities concerning the measurement of these within day variations of fatigue, indicating that there might be more to the concept than assumed (Cai, McDevitt, & Mednick, 2010; Feys et al., 2012; Rieth, Lericollais, Gauthier, Bessot, Sesboüe, & Davenne, 2009). The level of self-reported fatigue seems to change significantly over the day, indicating that it is connected to the time of day, and thus susceptible to within-day-variability. But other forms of measurements of physical and mental fatigue show occasionally differing results from the self-reported level. For example, does the level of physical activity not seem to be dependent on the time of day, or the self-reported level of fatigue (Feys et al., 2012). It seems that higher levels of fatigue do not necessarily have to lead to a

deteriorated level of physical performance. The explicit measured level of fatigue thus seems not go in accordance with one of the major subfactors of fatigue, the physical fatigue. There is also indication for differing test results for the second major subfactor, the mental or cognitive fatigue (Rieth, Cai, McDevitt, & Mednick, 2010). Most of the results come from studies with clinical populations, but there is growing evidence that this phenomenon also applies to the general, healthy population (Lericollais et al., 2009). This could indicate that the explicitly measured level of fatigue is an insufficient indicator of the level of fatigue people inherit. It seems that something does not go in accordance with the self-reported level of fatigue, resulting in differing test results. Possibly indicating that people explicitly think of themselves as more fatigued than they really are. This could be connected to the way how people process information and the ways of measurement that have been used to far to assess the concept fatigue.

2.3 Measurement of fatigue

Given its complex and interconnected nature and a missing common definition, fatigue is a construct that has been difficult to scientifically measure and study (Aaronson et al., 1999). Often measures of fatigue are specifically tailored to the situation or target group in which it is studied, limiting the possibility of generalizing the findings. Another problem with measuring fatigue is the fact that fatigue is a symptom, and as such is prone to subjective interpretations and biases, which present additional measurement difficulties. Furthermore, it has almost exclusively been measured explicitly, with the help of self-reporting measures (Carskadon, & Dement, 1981; Claros-Salinas et al., 2010; Fröberg et al., 1975; Lericocallais et al., 2009; Sonnentag, & Zijlstra, 2006; Van Yperen, & Jansen, 2002). But explicit measurements are just one side of the coin.

According to the dual-process theory, people have two distinct ways of information processing. One implicit and one explicit one (Evans, & Curtis Holmes, 2005; Evans, & Frankish, 2009; Kahnemann, 2007). The heuristic or implicit process can be described as fast, mostly automatic, associative, often emotionally charged and heavily contextualized, so dependent on contextual factors. These processes are often governed by habit and are therefore difficult to control or modify. Whereas the analytic or explicit process can be characterized as sequential, slow, effortful, and likely to be consciously monitored and deliberately controlled. Therefore, these processes are capable of more complex and conscious thought and evaluations like abstraction and generalization (Evans, & Curtis-Holmes, 2005; Kahneman, 2007). The biggest difference between the two processes is its mental origin. Explicit processes are mostly consciously and sequential processes that require the use of the central working memory and are therefore limited by its capacity. The implicit processes operate a little different. By using the parallel implicit system these processes can unconsciously influence an individual's response to a given phenomenon without deliberate or conscious control (Devos, & Banaji, 2003; Evans & Curtis-Holems, 2005).

In the context of this study, Ryan et al. (2010) found out that certain unconscious contextual, or environmental cues can influence our subjective feeling of depletion or fatigue and vitality. Only the perceived level of regulatory depletion can for example be enough to impact subsequent motor task performances (Clarkson, Hirte, Jia, & Alexander, 2010). Individuals who perceive themselves as less (vs. more) depleted, are more successful at subsequent task performances than individuals that perceived themselves as more depleted, independent of their actual depletion level (Clarkson et al., 2010). When an individual thus explicitly interprets oneself as depleted, the implicit level of depletion can stay largely unaffected by this conscious interpretation (Kahnemann, 2007). Baumeister (2002) assumes that depletion affects the explicit self-concept of individuals. The individual embeds his explicit interpretation of depletion in his self-concept, making him feel more fatigued and thus also reporting himself as more fatigued. This could thus be a possible reason for the found measurement irregularities concerning the concept of fatigue. The explicit assessment of fatigue could thus be influenced by a certain bias in self-evaluation (Felson, 1981). The self-evaluation can be biased out of several reasons. First people tend to evaluate themselves favorably to maintain their self-esteem. Second, the overall attitude the individual has about themselves can affect their personal evaluation on particular characteristics. This can lead them to see what they expect to see, or: “In other words, people are likely to see either what they want to see or what they expect to see [...]” (Felson, 1981; MacLeod, & Mathews, 2012).

To check whether this self-concept bias has an influence on the individual explicit interpretation of fatigue and their related circadian variations, this research will include an implicit measurement method for the assessment of the self-concept bias. One possibility to measure biases implicitly is the use of an Implicit Association Test (IAT), developed by Greenwald, McGhee, and Schwartz (1998). The idea behind it is to measure this associations strength between concepts implicitly, thus on a more unconscious level by comparing reaction times of two different combined classification tasks (Greenwald et al., 1998; Glashouwer, Smoulder, de Jong, Roefs & Wiers, 2013; Grumm, Erbe, von Collani, & Nestler, 2008).

Given the specific context of this study, a specific form of IAT seems to best fit the circumstances. The so called ‘self-concept BIAT’, a short version of the original IAT lets participants classify fatigue or vitality related items with “I” or “other”, and investigates the implicit reaction times, participants need for these different conditions (Greenwald, & Farnham, 2000). The underlying assumption is that it is easier for participants to classify stimuli that are related or associated with memory and that it is more difficult for participants to classify unrelated or not associated stimuli. More difficult classification decisions should result in longer reaction times, whereas more easy classifications should result in lower response times (Glashouwer et al., 2013). To fit the context of this study the concepts of fatigue and vitality are added to the categories of “I” and “other”, and reaction times between the different categories “I - fatigue” and “Other – fatigue” are compared to

assess whether a participant inherits a self-concept bias regarding fatigue. The difference in reaction times serves also as an indication of the subjective implicit level of fatigue.

Furthermore, has fatigue almost exclusively been measured by explicit measurements that were related to the average trait level of fatigue, not the situational level (Carskadon, & Dement, 1981; Fröberg et al., 1975; Van Yperen, & Jansen, 2002). To be able to get a closer look at the situational explicit subjective interpretation of fatigue levels by individuals, a new 3-item assessment scale (EMMF) has been developed to assess the situational explicit interpretation of fatigue. This will help to compare the circadian variations of the explicit fatigue level of participants with the variations of the implicit self-concept bias, as indicator of the implicit level of fatigue.

2.4 Hypotheses

Summarizing all the given facts, it seems that fatigue is a problematic topic of pending and rising importance. An increasing number of people claim to suffer from fatigue-related symptoms. But the origin of this increasing number is still unclear. Scientific research indicates several irregularities regarding the measurement of fatigue, especially regarding the circadian variations of fatigue and its related sub-constructs. Suggesting that the so far used measurement methods do not fully reflect all relevant aspects of fatigue. There seems to be more to the concept than has been assumed so far, raising the question: Are we as tired as we think we are? A possible reason for these irregularities could be the almost exclusive use of explicit measurements to assess fatigue in the scientific world, therefore completely neglecting the possible influence of implicit processes. Explicit measurement methods can be influenced by several confounding variables or measurement biases, like motivational issues, social desirability, or most importantly in the context of this study, the self-concept bias (Fazio, & Olson, 2003). These biases could possibly distort the results and hide the true circadian nature of fatigue. Making the explicit subjective interpretation of fatigue more susceptible to situational influences, whereas the implicit measurement should stay largely unaffected by situational influences, making it a possibly more stable interpretation of the individual fatigue level. People could thus just interpret themselves as more fatigued with continued wakefulness, while their self-concept bias, as indicator of their implicit level of fatigue, stays rather untouched by the time of day. A self-concept BIAT shall therefore be included as an indicator of the implicit level of fatigue people inherit at a given point in time. To this point, there is no research available that investigates the relationship between the circadian variation of explicitly reported fatigue and the self-concept bias, or implicit measured level of fatigue. So, there is a need for further scientific research examining the topic to improve and broaden the understanding of the concept, its true circadian nature, and the possible ways of assessment. This study tries to contribute to the topic by investigating the following hypotheses:

1. The within-day-variability of the implicit measured level of fatigue is more stable than the within-day-variability of the explicit measured level of fatigue.
 - 1.1. *The level of explicit reported fatigue does not significantly change between the morning and afternoon measurement*
 - 1.2. *The level of explicit reported fatigue does significantly rise between the afternoon and the evening measurement*
 - 1.3. *The level of explicit reported fatigue does significantly rise between the morning and evening measurement*
 - 1.4. *The level of implicit reported fatigue does not change significantly between measurements*

2. The relation between the implicit and explicit level of fatigue is stronger in the morning/ afternoon than in the evening.
 - 2.1. *The implicit and explicit morning/ afternoon measurement correlate higher than the explicit and implicit evening measurements.*

3. The momentary, explicit one item assessment scales of fatigue correlate positively with the related subscales of the general explicit, multi item fatigue assessment questionnaire.
 - 1.1. *The explicit one item assessment scale of physical fatigue correlates positively with the reduced level of physical activity subscale of the CIS*
 - 1.2. *The explicit one item assessment scale of mental/cognitive fatigue correlates positively with the concentration problem subscale of the CIS*
 - 1.3. *The explicit one item assessment scale of emotional/ motivational fatigue correlates positively with the reduced motivation subscale of the CIS*
 - 1.4. *The mean score of the three EMMF items correlates positively with the severity of fatigue experience subscale of the CIS*

4. The three items of the EMMF are measuring one overarching factor
 - 4.1 *A factor analysis of the three EMMF items will reveal one overarching factor*

3 Method

3.1 Design

The study was an online longitudinal observational study. Participants had to fill in four-time specified parts of the study in chronological order, distributed over two days. For a comparison of explicit and implicit measures, it included several explicit questionnaires and a short experiment in the form of an BIAT.

3.2 Participants

In the study a total of 41 Participants took part. From these 41 People only 31 completed all four parts of the study. The participants were recruited via convenience sampling, because of the high motivational demand of the study. Participants would have to actively remember to fill in the four parts over two days, without any material reward for participating. To reduce the possible dropout rate Participants have been chosen and addressed personally to ensure that they want to take part and try to remember all parts of the study.

Exclusion criteria for the study were: not being able to speak, understand and write German, being under the age of 18, no internet access, no access to a laptop or desktop, suffering from chronic diseases like COPD, Rheumatism, Cancer or CFS, and scoring higher than 40 on the severity subscale of the CIS. No participants were excluded based on age, 3 Participants were excluded because of pre-existing chronic diseases and 6 Participants with exceeding scores on the seriousness subscale of the CIS were excluded. These exclusion criteria left 32 valid participants, and 25 complete cases. Overall 26 man and 17 women participated in the study. The 41 Participants were spread over 4 differing age categories. With 24 people, almost 55 percent of the Participants population was between 18 to 35 years old, four participants were between 36 to 50, thirteen participants between 51 to 70, and 2 Participants were over 70 years old. The mean age was 38.53 years old. Almost 91 percent of the participants have achieved the educational degree of '(Fach-) Abitur (highest achievable school graduation level in Germany). Just three percent absolved school with the 'Mittlere Reife/ Realschulabschluss (medium school graduation level)' and only one percent achieved the 'Haupt/- Volksschulabschluss (lowest school graduation level)'. Whereas for the work graduations, around 30 percent had no completed work graduation, 25 percent had a specific job training, around 14 percent achieved a bachelor's degree in their life, 23 percent absolved a 'Diplom/Magister/Master or Staatsexamen', close to 5 percent achieved and 'Promotion (PHD)' and 2 percent had a non-specified work graduation.

3.3 Procedure

The survey was created via the website soscisurvey.de and spread via e-mail to the participants. It was ethically approved by the Ethical commission from the University of Twente (file nr. 18165). The survey itself was distributed over four points of time on two days. While conducting the study participants first had to read the description and instructions on how to proceed with the study (see Appendix A: Introduction). Participants were informed that they had to complete four parts of the study distributed over 2 days. The first part can be filled in at any day, at any time. The other three parts of the study had to be filled in on one day, optimally a day where they are free and have enough time to conduct the study. Each time was bound to a specific time of the day and was supposed to take around 5 minutes. The first measurement was supposed to be conducted between 6am and 12pm, the second between 12pm and 4 pm and the last one between 8 pm and 12 am. After reading the instructions the Participants had to agree with the conditions of participation in form of an informed consent, which stated that all data will be processed anonymously and will not be made accessible to third parties (see Appendix B: informed consent). Participation was voluntarily, and participants could stop with the study at any given moment. After they agreed with the terms of the study and confirmed their voluntary participation, some general information was being asked to assess relevant demographic data, like age, sex, education level, chronic diseases, and work status (see Appendix C: demographics). Participants with any of the stated chronic diseases like COPD, Rheumatism, Cancer or CFS were excluded. After completing these general questions, participants had to fill in the Checklist Individual Strength (CIS), to explicitly measure the overall level of subjective fatigue and related sub-constructs and the self-developed three item assessment scale to get an indication of their baseline momentary fatigue level (Vercoulen et. al., 2011). To assess their momentary explicit level of fatigue Participants were asked to fill in the short 'Explicit Momentary Measurement of Fatigue' (EMMF). Additionally, they had to complete the BIAT as a trail run and an indicator of their baseline level of implicit tiredness. All in all, this part of the study took participants around 5 minutes. Within the other three, time specific parts, participants first had to name the actual time of day they were filling in the study. Followed by a quick indication of their momentary subjective fatigue level, with the help of the EMMF and an assessment of their implicit fatigue level, using the BIAT. At the end of the last part of the study, namely the evening part (8pm -12 am), Participants were asked to indicate how active their day has been, and name if necessary, special circumstances or events that could have been on influence on their results on that day. The use of both an explicit and implicit measure made it possible to compare the implicit and explicit level of measured fatigue and to investigate differences within and between these measures regarding the time of day effect. Furthermore, it made the comparison possible of the already validated CIS and the self-developed three item EMMF, in order to look at the correlation of the two tests and investigate the reliability and validity of the EMMF. After the participants completed all parts of the study, they were thanked for their participation and the e-

mail address of the researcher was provided for further questions about the content and results of the study. All in all it took the participants around 20 minutes to complete all parts of the survey.

A visual representation of the study design and its procedure can be found in figure 1.

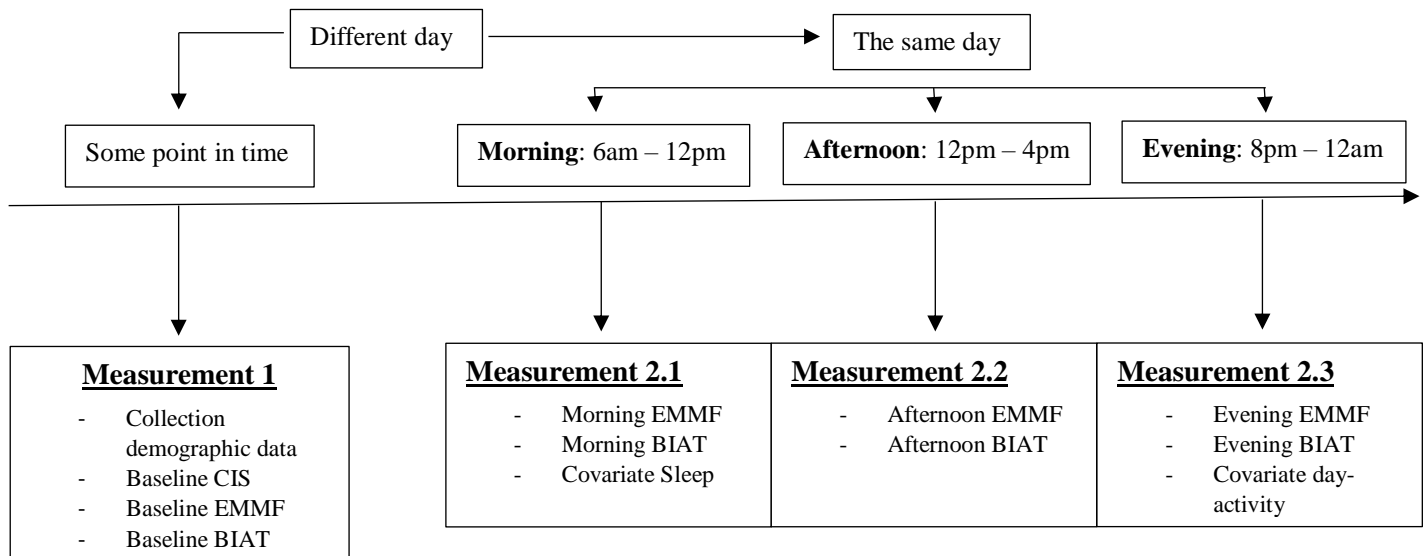


Figure 1. Timeline of study design, with all relevant measurements.

3.4 Materials/ Explicit measurements

3.4.1 Checklist Individual Strength (CIS)

To explicitly measure the overall tiredness of participants, the German version of the Checklist Individual Strength (CIS) was used (Vercoulen et al., 1994). This multidimensional, self-report questionnaire was originally developed, for patients with CFS and other tiredness-related diseases, but scientific evidence indicates that it is also applicable in a healthy population (Hewlett, Dures, & Almedia, 2011). It consists of 20 statements, that can be separated in 4 sub-scales. The four sub-scales measure different aspects of fatigue, the severity of fatigue (8 items), concentration problems (5 items), reduced motivation (4 items) and a reduced level of physical activity (3 items). Participants indicate on a 7-point Likert scale in how far they agree with the given statement, with “ja, stimmt (yes, true)” as the left end of the continuum and “Nein, stimmt nicht (no, not true)” as the right end. All answers of respondents refer to their own subjective experience of fatigue within the last two weeks. A detailed view of all questions can be found in Appendix D: CIS.

For the purpose of the study the sum scores of all the different subscales were calculated. From all the 4 scales, the ‘severity of fatigue’ subscale was used as an exclusion criterion for participants in the analysis. With a minimum score of 1, a maximum score of 7 and a total of 8 statements, the possible total score within this sub-scale can vary between 8 and 56. A higher score indicating a higher level of fatigue. People with a score above 40 were excluded from the analysis,

because this indicates a severe level of fatigue, comparable to people with CFS and cannot be counted as normal or healthy anymore (Worm-Smeitink et al., 2017). The other three subscales were used as indicators of the physical/ muscular, mental/cognitive and emotional/motivational level of fatigue and compared to the three explicit momentary measurements of fatigue. The sub-scale concentration problems indicated the mental/cognitive fatigue, reduced physical activity the physical/muscular fatigue and reduced motivation the emotional/motivational fatigue.

Nine of the statements (2, 5, 6, 7, 8, 11, 12, 15, 20) are formulated in a positive way, regarding fatigue, thus for example: "Ich fühle mich müde (I feel tired)". For these statements a 1 means a low score and a 7 a high score, regarding the subjective level of fatigue and relevant sub-constructs. The other eleven statements (1, 3, 4, 9, 10, 13, 14, 16, 17, 18, 19) are formulated in a negative way regarding fatigue and therefore had to be re-coded for the analyses. An exemplary statement is: "Ich bin voll Aktivität (I am full of energy)". There exist no valid norm scores for the German version of the CIS so far, therefore the norms of the English version are used in this study (Hewlett et al., 2011). Hewlett et al., (2011) report a good reliability for the CIS with a Cronbach's alpha of .90 and a Gutman split-half reliability coefficient of .92. Cronbach's alpha for subscales ranged from .83 – .92 (Vercoulen et al., 1994). The Cronbach's alpha in this study were .90 for the general questionnaire and scores ranging from .72 – .84 for the subscales. It also seems to inherit a good content, construct and criterium validity (Hewlett et al., 2011).

3.4.2 Explicit momentary measurement of Fatigue (EMMF)

For this study a three-item assessment scale was developed, to shortly assess the situational subjective level of fatigue in individuals. The three items are intended to reflect the three relevant sub-constructs of fatigue physical/muscular, mental/cognitive and emotional/ motivational fatigue. The items are formulated as statements regarding the subjective, momentary level of fatigue related to the different sub-constructs. Participants must indicate on a 11-point bipolar adjective scale for each of the sub-constructs which level best reflects the psycho-physical state they experienced in the last 10 minutes. With 1 as the least possible level of fatigue and 11 as the highest possible level.

Physical/muscular fatigue is tried to be assessed by the statement "Ich fühle mich körperlich in der Lage aktiv zu sein (I feel physically in state to be active)" as the minimum end of the continuum and "Ich fühle mich kaum in der Lage körperlich aktiv zu sein (I feel barely able to be physically active)" as the maximal end of the continuum. "Ich kann mich sehr gut konzentrieren (I can concentrate very well)" is used as the minimum end of the mental/cognitive fatigue item, and "Ich habe starke Schwierigkeiten mich zu konzentrieren (I have strong difficulties to concentrate)" as the maximum end. The third, refers to emotional/motivational fatigue and uses "Ich habe starke Lust etwas zu unternehmen (I have the strong desire to do something)" as the minimum end and "Ich habe absolut keine Lust etwas zu unternehmen (I have absolutely no desire to do something)" as the maximum end.

The mean score of these three items can be used as a general indicator of the momentary level of fatigue, ranging from 1 to 11. The exact statements can be found in the Appendix E: EMMF.

The items are inspired by items from the 'Checklist Individual Strength' (CIS) described above, the 'Karolina Sleepiness Scale' (KSS) and the 'Verkorte Vermoeidheidsvragenlijst' (VVV) (Blijenberg, van Horst, van der Meer, & Knoop, 2012; Vercoulen et al., 1994). The mean of all the three sub-scales form a fourth sub-scale, 'momentary subjective fatigue experience'. It can be used as a global indicator of the explicit subjective level of fatigue. Because it has never been tested before there are no information available regarding its reliability or validity. The Cronbach's Alpha in this study was .74.

3.4.3 Implicit measures (BIAT)

For the baseline and momentary level of fatigue a 'Brief Implicit Association Test' (BIAT) was used. The BIAT was created and distributed via the website soscisurvey.de. The BIAT is a short form of the original Implicit Association Test (IAT), a chronometric procedure that quantifies strength of conceptual associations by contrasting latencies across conditions (Nosek, & Siriam, 2007). In the IAT Participants categorize stimuli representing four categories in two different conditions. While conducting the test, stimuli, or words, would appear on screen that belong to one of the four categories and as such to one of the two assigned conditions (Nosek, Bar-Anan, Siriam, Axt, & Greenwald, 2014). Whenever they see a stimulus appearing on screen, Participants would have to push the related button as fast as possible. The difference in average response latency between conditions is taken as an indicator of differential association strengths among the concepts (Nosek et al., 2014). The IAT underlies the assumption that it is easier for participants to classify stimuli which are associated with themselves in their own memory, leading to faster reaction times than, when participants must classify stimuli, which are unrelated or not associated with themselves (Grumm et al., 2008). The BIAT is also a two conditions reaction time task, that was developed to shorten the time required to measure associations, while retaining some of the valuable design properties of the IAT (Nosek, et al., 2014). Siriam and Greenwald (2009) have shown that a good focal-attitude BIAT and a self-concept BIAT were psychometrically comparable to a standard IAT measure of the same underlying construct. But in comparison to the original IAT, the BIAT just takes around 1/3 of the number of trials, resulting in a possible completion between one and two minutes and a reduced need for practice trials (Nosek et al., 2014).

In the given context of the study the BIAT it used to measure the self-concept bias regarding the subjective fatigue level of individuals. So, in how far people identify themselves with being tired. To measure this bias two blocks of 20 trials each are conducted, with the stimulus response mappings of the four categories tiredness, vitality, self and other, and several stimuli relating to each of the categories. The categories 'Ich (I)' is represented with 'Ich (I)', 'mich (me)', 'mein (mine)', 'mir (me)'

and 'selbst (self)'. The category 'Andere (others)' is represented by 'ihr' (they), 'euer' (yours), 'dein' (yours), 'euch' (you), 'andere' (others), 'du' (you). 'Müdigkeit (Fatigue)' is related to the stimuli 'erschöpft (fatigued)', 'unkonzentriert (unconcentrated)', 'lustlos (dull)', 'schlapp (tired out)', 'träge (sluggish)', 'niedergeschlagen (depressed)', 'kraftlos (feeble)' and 'energielos (weak)'. The category "Vitalität (vitality)" is represented by 'energiegeladen (energized)', 'lebenslustig (in love with life)', 'gesund (healthy)', 'fit (fit)', 'motiviert (motivated)', 'freudig (joyful)', 'sportlich (sporty)' and 'aktiv (active)'. All stimuli are taken from the study of Klaus, (2016). A detailed description of the used items and instructions can be seen in Appendix G: BIAT 1 and Appendix H: BIAT 2.

While participants in the original IAT would have to focus on all four categories, when using a BIAT they just must focus on two of the four categories, at the same time. This simplifies instructions and decreases the need for practice, shortening the total administration times (Nosek et al., 2014). In the first trial the categories 'Ich' and 'Müdigkeit' are shown together on screen as the focal categories and assigned to one response key (eg. the "k" key). The categories 'Andere' and 'Vitalität' are not shown on screen and represent the non-focal categories. They are assigned to another response key (eg. the "d" key). People would then have to categorize the appearing stimuli on screen as fast as possible, by pushing the assigned button. So, when a word related to the focal category appears they must push the 'k' key, and for all other stimuli the 'd' key. In the next block of trials, the focal and non-focal categories are reassigned. Leaving 'Andere' and 'Müdigkeit' as the focal categories on screen and 'Ich' / 'Vitalität' as the non-focal categories, that are not shown on screen. Now participants had to push the k key for stimuli relating 'Andere' and 'Müdigkeit' and the d key for all else.

To analyze the BIAT, reaction times D-scores were calculated. The D-algorithm is according to Greenwald, Nosek and Banaji (2003) a substantial improvement for the scoring procedure of the IAT and BIAT. The *D* represents in this context the difference in average response latencies between the different conditions, divided by the standard deviation of response latencies across the conditions (distinct from the pooled within-conditions standard deviation) (Greenwald, et al., 2003). *D* has a theoretical minimum of -2 and a theoretical maximum of +2 (Nosek et al., 2014). To calculate a realistic representation of *D*, some trials must be excluded. These trials are cases with reaction times faster than 300ms or slower than 10.000ms for 10% of all their reactions. The more positive a D-score of a participant, the more did he associate words from the category 'Ich (I)' with the words from the category 'Müdigkeit (fatigue)'. Consequently, the more positive the D-score, the more implicit tired are participants.

3.5 Covariates

To be able to account for some possible confounding variables a few additional questions have been implemented within the study. The first confounding questions had also the function of an exclusion criteria. Here Participants were asked if they suffer from any chronic diseases like COPD, Rheumatism, Cancer or CFS. Furthermore a few questions about demographic data were being asked. These questions include an indication of the Participants age, in the form of 6 age categories (under 18, 18 – 35, 36 – 50, 51 – 70, 70+). Followed by a question about gender, with the possible answers “männlich (man)”, “weiblich (women)”, “anders (other)”. Also included were questions about the highest form of education the participant has achieved so far. Possible answers ranged from: „kein Schulabschluss“, „Haupt-/Volksschulabschluss“, „Mittlere Reife/Realschulabschluss“, „(Fach-)Abitur“, „unbekannter Abschluss“, „ohne beruflichen Bildungsabschluss“, „Berufsausbildung“, „Bachelor“, „Diplom/Magister/Master/Staatsexamen“, „Promotion“, „unbekannter Abschluss“. Because of the time distributed nature of the study, it is important to control for the variable of time. Therefore, Participants had to first indicate the time of day, thus “Morgens (morning)/ Nachmittags (afternoon)/ Abends (evening)”, followed by an indication of the exact time of day the Participant fills in this part of the study. To control for the Participants quality of sleep a question about the quality of last night’s sleep was implemented in the morning part of the survey, right before the BIAT. Here possible answers ranged from “sehr gut (very good)” to “sehr schlecht (very bad)”. At the end of the study a question was implemented to assess in how far it has been an exhausting day for the Participants. Here Participants could choose between “ruhiger Tag (quiet day)”, “normaler Tag (normal day)” and “sehr aktiver Tag (very active day)”. Additionally, they had the possibility to indicate any special circumstances or events that could have been an influence on their performance on this day.

3.6 Analysis

First off, some preparatory steps had to be taken, before the data could be analyzed. Participants that fulfilled certain exclusion criteria, thus were suffering from a fatigue related chronic illness, were under the age of 18, or scored above 40 on the seriousness subscale, had to be excluded from the analyzes. Furthermore, eleven items from the CIS (1, 3, 4, 9, 10, 13, 14, 16, 17, 18, 19) had to be recoded. To calculate the D-scores for the BIAT-reaction times, certain cases had to be excluded. These cases were people with a reaction time faster than 300ms or slower than 10.000ms for 10% of all their reactions. Followed by the calculation of the final D-scores of the BIAT and Cronbach’s Alpha for the CIS and EMMF to determine their reliability.

To be able to give a sophisticated insight in the relationship of the implicit and explicit circadian variation of fatigue the three hypotheses must be tested. To test the first hypothesis, six paired sample t-tests were conducted to compare the different explicit and implicit measurements on their different times of day. Respectively the morning measurement with the afternoon and evening

measurement, the afternoon measurement with the evening ones. To compare the different measurements in time, three new variables had to be created. One for each explicit momentary measurement and their respective time of the day. So, the mean score for all participants on the three EMMF items on the morning, afternoon and evening measurement. These three variables were then tested against each other, as well as the morning, afternoon and evening D-scores of the participants. For better understanding of the nature of the scores the descriptive means, standard deviations and minimum/ maximum were calculated.

For the second and third hypothesis a Pearson correlation test was used to investigate the relationship of the relevant variables. To test the second hypotheses the BIAT D-scores of the different time of day measurements, were correlated with the mean scores of the EMMF at the same time of day. So, correlations were calculated between the explicit and implicit measurements at morning, afternoon, and evening.

Before the post hoc analysis of the second hypotheses, all participants with a high negative D-value lower than -0.75 were excluded from the analysis. Afterwards the paired sample t-tests from the first hypotheses were repeated. Followed by a repeated calculation of the Pearson correlation between relevant variables.

For the third hypotheses the scores of the different EMMF items of the baseline measurement were correlated with the scores of the relevant sub-scales of the CIS. Thus, the 'physical/muscular', 'mental/cognitive' and the 'emotional/motivational' and 'momentary subjective fatigue experience' (mean score of the EMMF) sub-scales of the EMMF were compared with the 'reduced level of physical activity', 'concentration problems', 'reduced motivation' and 'severity of fatigue' sub-scales of the CIS, to verify the validity of the EMMF. To do this, five new variables had to be computed. Sum scores were calculated for the total score of the CIS and the four subscales of the CIS.

For the fourth hypotheses a principal component analysis was conducted to test whether the three relevant items measure one overarching construct. Before the test was conducted a Kaiser-Meyer-Olkin (KMO) and Bartlett test was made to test whether the items were related sufficiently for a factor analysis.

4 Results

To test the first hypotheses a paired sample t- test was conducted to investigate the daily changes in self-reported fatigue. The test showed no significant difference between the mean score of the Morning EMMF ($M = 3.47$, $SD = 1.65$, $N = 26$) and the mean scores of the Afternoon EMMF ($M = 3.14$, $SD = 1.46$, $N = 26$); $t(25) = 0.83$, $p = 0.41$ (figure 2.). This does go accordingly with hypothesis 1.1 and indicates that people do not explicitly assess themselves as less or more tired in the afternoon than in the morning. The next paired sample t-test revealed a significant difference in scores between the Afternoon EMMF ($M = 3.17$, $SD = 1.46$, $N = 25$) and the evening EMMF ($M = 5.03$, $SD = 2.09$, $N = 25$); $t(24) = -3.8$, $p = .001$ (figure 2.). This does go accordingly with hypothesis 1.2 and indicates that people do explicitly assess themselves as more tired in the evening than in the afternoon. At last a significant difference in mean scores between the Morning EMMF ($M = 3.52$, $SD = 1.66$, $N = 25$) and the Evening EMMF ($M = 5.03$, $SD = 2.09$, $N = 25$) was revealed; $t(24) = -2.46$, $p = 0.02$ (figure 2.). This goes in accordance with the hypotheses 1.3 and indicates that people assess themselves as significantly more tired in the evening than in the morning.

The next paired sample t-test investigated the circadian variation of the implicitly measured level of fatigue. A comparison between the D-scores of the morning BIAT ($M = 0.13$, $SD = .62$, $N = 26$) and the afternoon BIAT ($M = .06$, $SD = .58$, $N = 26$) showed no significant difference in scores; $t(25) = .48$, $p = .64$ (figure 3.). There was also no significant difference found between the afternoon BIAT ($M = .08$, $SD = .58$, $N = 25$) and the Evening BIAT ($M = 0.1$, $SD = .42$, $N = 25$); $t(24) = -.16$, $p = .88$ (figure 3.). As well as between the morning BIAT ($M = .16$, $SD = .62$, $N = 25$) and the evening BIAT ($M = .10$, $SD = .42$, $N = 25$); $t(24) = .345$, $p = .73$. All three results stand in favor of hypothesis 1.4. It seems that the D-scores do not significantly change over the day. People seem to react equally fast to the two conditions on the three times the measurement was taken. Taken together three of the four relevant sub-hypotheses of the first hypothesis seem to be confirmed. It seems that the implicit measurement of fatigue is more stable than the explicit one. Even if there was no significant difference between the mean morning and afternoon EMMF scores, the scores did significantly change between the afternoon/ morning and evening measurement, whereas the relevant D-scores did not seem to significantly change over the day at all.

Paired sample t-test EMMF Mean

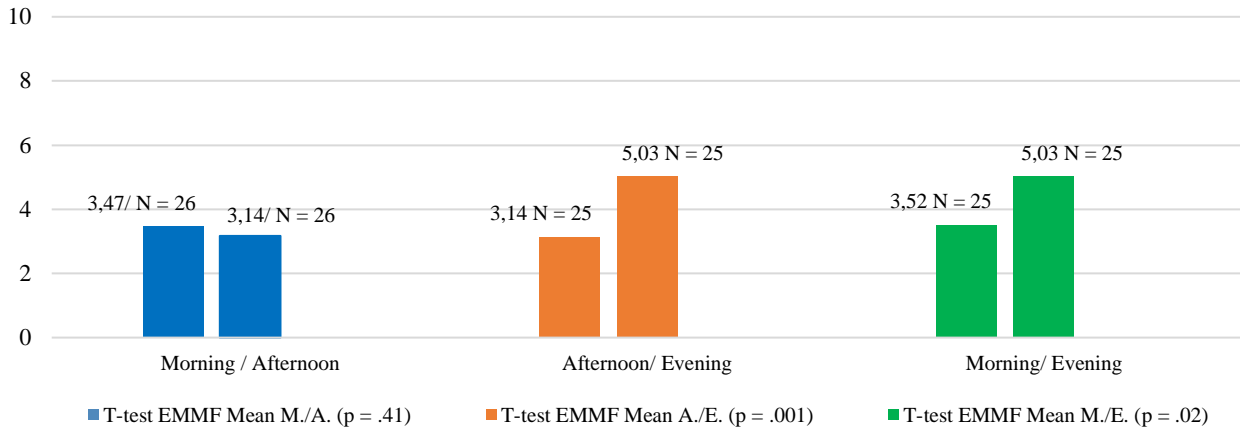


Figure 2. Mean scores of the three paired sample t-tests between the morning, afternoon and evening EMMF.

Paired sample t-test BIAT D-scores

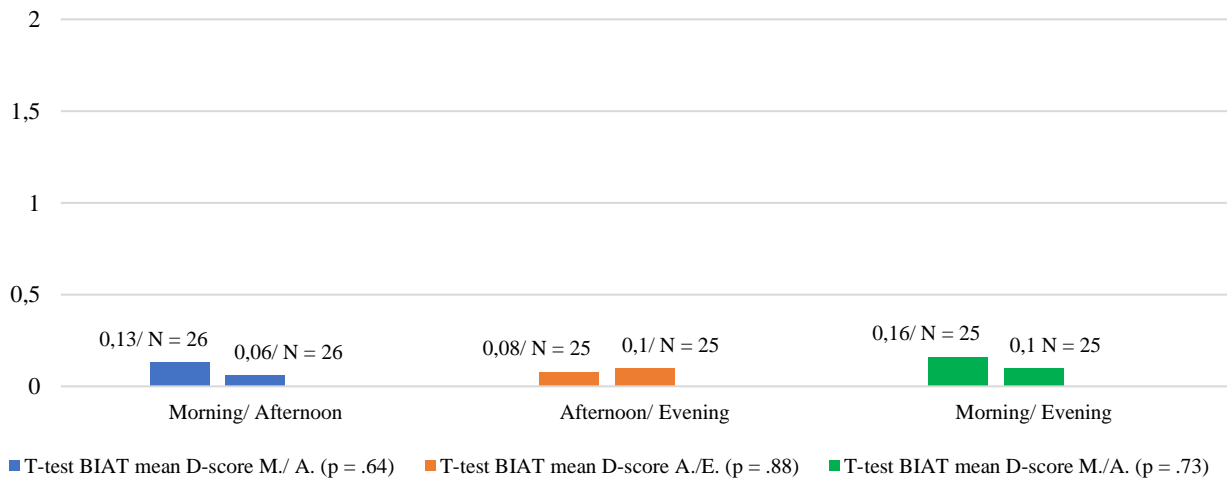


Figure 3. Mean D-scores of the three paired sample t-tests between the morning, afternoon and evening BIAT.

For the reason that through the exclusion criteria of the paired sample t-test some participants are not included in the analysis the reported mean scores and standard deviations of the relevant variables can differ from the descriptive including all Participants. Therefore, a descriptive analysis was conducted to get the original means and standard deviations. Of specific interest here is that the average D-scores for all measurements are slightly positive. Meaning that people tend to identify themselves more with fatigue than with vitality. But the standard variations in this case are quite large, indicating a wide confidence interval and therefore reducing the reliability of the mean scores. This accounted slight positive tendency must thus be taken with caution. The details can be seen in table 1.

Table 1. *Descriptive means, standard-deviations, minimum/ maximum scores and number of Participants*

	Mean	Standard Deviation	Minimum	Maximum	Number of participants included
Morning EMMF	3.47	1.65	1.3	8.7	26
Afternoon EMMF	3.19	1.45	1.3	7	27
Evening EMMF	5.02	2.09	1.7	9.7	25
Morning D-score	.13	.62	-.86	1.3	26
Afternoon D-score	.04	.58	-.99	.92	27
Evening D-score	.10	.42	-.84	1	25

For the second hypothesis Pearson Correlations were calculated between the implicit and explicit morning, afternoon and evening measurements. Thus, the Mean scores of the morning, afternoon and evening EMMF and the related D-scores of the morning, afternoon and evening BIAT. The test revealed no significant correlations between the two types of measurements. It showed a non-significant, slight positive correlation between the mean score of the morning EMMF and the D-scores of the morning BIAT ($r = 0.11$, $N = 26$; $p = .6$). Also, the slight negative correlation between the mean scores of the afternoon EMMF and the D-scores of the afternoon BIAT is non-significant ($r = -.15$, $N = 27$; $p = .46$). And almost none correlation can be seen between the mean scores of the evening EMMF and the D-scores of the evening BIAT ($r = .04$, $N = 25$; $p = .86$). The test results can therefore not be used to support the second hypothesis. But when looking at the data in more detail an interesting trend in scores can be found.

The second hypothesis states that the correlation between the morning and afternoon mean EMMF scores and their respective D-scores are higher than the correlation between the evening mean EMMF scores and the related D-scores. A slight indication in the direction of this predicted tendency can be seen within the scores. When looking at the results with restriction, it thus seems that the relationship between the implicit and explicit measurement of fatigue is slightly stronger in the morning or the afternoon than in the evening. But again, none of the correlations and their differences are significant. So, the second hypothesis cannot be accepted. The exact details can be seen in table 2.

Table 2. Correlations of the different EMMF measurements with the related D-scores

	Mean Morning EMMF	Mean Afternoon EMMF	Mean Evening EMMF	Morning D-score	Afternoon D-score	Number of Participants included
Mean Morning EMMF						
Mean Afternoon EMMF	.14					26
Mean Evening EMMF	-.32	.10				25
Morning D-score	.11	-.20	.09			26
Afternoon D-score	.29	-.15	.10	.30		27
Evening D-score	.00	-.23	.04	-.04	.36	25

*Note: *p < .05, **p < .01, ***p < .001

To get a deeper understanding of the interesting nature of these results regarding the second hypotheses a post hoc analysis was conducted. This analysis had the aim of achieving a better understanding of the scores for participants with a high self-concept bias, thus people with a positive D-score who associate themselves more with fatigue. Therefore, participants with a high negative D-score had to be excluded from the analysis. In total 8 participants with a D-score lower than -.75 were excluded. After that the paired sample t-tests for the first hypotheses were repeated, revealing the same results as before. No significant difference has been found between the morning EMMF (M = 3.63, SD = 1.78, N = 18) and the afternoon EMMF (M = 2.85, SD = 1.20, N = 18); $t(17) = 1.77, p = .10$ (figure 4.). Whereas compared to the results of the first paired sample t-test the difference in scores gets bigger, leading to a slightly reduced p-value. As before does the afternoon EMMF (M = 2.89, SD = 1.23, N = 17) significantly differ from the evening EMMF (M = 5.24, SD = 2.17, N = 17); $t(16) = -4.05, p = .001$ (figure 4.). Surprisingly does the morning EMMF (M = 3.72, SD = 1.80, N = 17) not differ significantly from the evening EMMF (M = 5.24, SD = 2.17, N = 17); $t(16) = -2.00, p = .06$ (figure 4.) The D-scores of the morning BIAT (M = .25, SD = .61, N = 18) and the afternoon BIAT (M = .26, SD = .52, N = 18) are again, not significantly different from each other; $t(17) = -.06, p = .95$ (figure 5.). Furthermore no significant difference was found between the afternoon BIAT (M = .31, SD = .50, N = 17) and the Evening BIAT (M = .20, SD = .37, N = 17); $t(16) = .76, p = .46$ (figure 5.). As well as between the morning BIAT (M = .30, SD = .60, N = 17) and the evening BIAT (M = .20, SD = .37, N = 17); $t(16) = .55, p = .59$ (figure 5.). All these results repeat the findings of the first paired sample t-tests.

For the relevant part of the second hypotheses the Pearson correlation between the mean EMMF scores and the related D-scores were calculated again. Again, the test revealed no significant correlations, so all inferences from the results must be taken with caution. It showed almost no correlation between the morning EMMF and the morning BIAT ($r = .05, N = 18; p = .85$) and the afternoon EMMF and the afternoon BIAT ($r = .02, N = 19; p = .93$). Both correlations seem to have lost in overall strength, whereas the second correlation also changed direction compared to the first analysis. The also non-significant positive correlation between the evening EMMF and the evening

BIAT ($r = .21$, $N = 17$; $p = .42$) seems to have become surprisingly stronger than before. Meaning that within this data set, the higher positive D-scores of the evening measurement correlate more strongly with its related higher EMMF scores. The related figures for the post hoc analysis are to be found in Appendix H: post hoc graphs.

To test the third hypothesis and thus assess the validity of the EMMF the differing three items of the EMMF and their mean score, at the baseline measurement, were compared with the related sub-scales of the CIS. To do this the relevant Pearson Correlations were calculated. This revealed a significant positive correlation between the cognitive/mental fatigue item of the EMMF and the concentration problems sub-scale of the CIS ($r = .76$, $N = 31$; $p < .01$). Also, the correlation between the physical/muscular fatigue item of the EMMF and the reduced physical activity sub-scale of the CIS proved to be positive and significant ($r = .75$, $N = 31$; $p < .01$). Furthermore, a positive significant correlation between the motivational/emotional fatigue item of the EMMF and the reduced motivation sub-scale of the CIS could be found ($r = .65$, $N = 31$; $p < .01$). So, it seems that hypothesis 3.1, 3.2 and 3.2 can all be confirmed. To assess the mean score of the three EMMF items as a good indicator of the overall level of fatigue, it was correlated with the total sum score of the CIS and the severity of fatigue sub-scale. Pearson's correlation showed a positive correlation between the mean EMMF score and the total CIS score ($r = .72$, $N = 31$; $p < .01$) as well as the severity of fatigue sub-scale ($r = .48$, $N = 31$; $p < .01$). The exact details can be found in table 2.

Table 2. Correlations of the different EMMF measurements with the related CIS subscales

	CIS total	CIS severity	CIS concentration problems	CIS reduced motivation	CIS reduced physical activity	EMMF Mean	EMMF Cognitive/ mental fatigue	EMMF Physical/ muscular fatigue
CIS total								
CIS seriousness	.89**							
CIS concentration problems	.65**	.39*						
CIS reduced motivation	.76**	.62**	.24					
CIS reduced physical activity	.79**	.62**	.41*	.57**				
Mean EMMF	.72**	.48**	.63**	.57**	.65**			
EMMF	.56**	.30	.76**	.30	.48**	.75**		
Cognitive/ mental fatigue								
EMMF	.59**	.38*	.43*	.42*	.75**	.89**	.57**	
Physical/ muscular fatigue								
EMMF	.60**	.49**	.38*	.65*	.36*	.80**	.32	.58**
Motivational/ emotional fatigue								

*Note: *p < .05, **p < .01, ***p < .001 N = 31

Taken together these findings seem to confirm the validity of the EMMF. The higher the scores of the differing items of the EMMF, the higher the scores on the relevant CIS sub-scales. The third hypothesis can thus be accepted.

To test the last and fourth hypothesis the three items of the baseline EMMF were factor analyzed using principal component analysis. The analysis showed one factor explaining 66.2% of the variance within the set of items. This factor was labeled momentary fatigue. All three items load relatively high on this factor with factor loadings ranging from .77 for the cognitive/ mental fatigue and motivational/ emotional fatigue item of the EMMF, to .9 for the physical/ muscular fatigue item.

A Kaiser-Meyer-Olkin (KMO) and Bartlett test revealed an at least adequate relatedness of the items for factor analysis.

The results stand in favor of the fourth hypotheses. It supports the assumption that the three items of the EMMF adequately do measure the same construct, namely momentary fatigue, and can be seen as additional support for the validity of the new developed EMMF assessment scale.

5 Discussion

The discussion tries to summarize the most important implications of this longitudinal observational study, within a small sample of the German population ($N = 32$), about the relationship between the circadian variation of explicitly reported fatigue and the self-concept bias, or implicit measured level of fatigue. These implications will then be integrated to give answer to the research question: Are we as tired as we think we are?

The discussion will be split in three parts. First the meaning of the results will be discussed in relation to the research question. In the second part the resulting practical implications will be reviewed. The third and last part then deals with the limitations of this research and possibilities for future research.

The first hypotheses states that the within-day-variability of the implicit measured level of fatigue is more stable than the within-day-variability of the explicit measured level of fatigue. From the results it seems that participants in this study tend to report comparable levels of fatigue in the morning and afternoon. Whereas their reported levels of fatigue in the evening are significantly higher than in the afternoon or morning. This goes in accordance with the scientific literature that expects an increasing level of fatigue over the day, with a minimum arising around morning and noon, and the highest level in the evening. The slight, but non-significant drop in scores between morning and afternoon also fits within the theoretical framework, that expects a peak of wakefulness around noon (Czeisler, 1978; Powell, Spencer, Holland, Bradbent, & Petrie, 2007; Wever, 1979; Zulley, 1979). Concerning the implicit assessment of the level of fatigue, people's D-scores on the BIAT do not tend to change significantly over the day. Meaning that their reaction times, as indicator of their implicit level of fatigue, stay rather the same for the morning, the afternoon and the evening measurement. This does also go in accordance with the literature, that expects a difference between the explicit and implicit assessment of fatigue (Feys et al., 2012; Lericollais, Gauthier, Bessot, Sesboüe, & Davenne, 2009; Rieth et al., 2010). The results support their assumption that if an individual explicitly interprets oneself as depleted, the implicit level of depletion can stay largely unaffected by this conscious interpretation (Kahnemann, 2007). So, it seems the two levels are at least to some degree independent of one another. When looking at the D-scores, as an indicator of the self-concept bias, it becomes clear that participants in this study tend to slightly identify themselves stronger with fatigue than vitality. They react faster to words shown in the category 'I-fatigue' than to the words shown in the category 'I-vitality'. This bias seems to be a relatively stable trait that does not significantly change over the day. Combined, all three sub-hypotheses seem to stand in favor of the assumption of the first hypothesis. The within-day variability of the implicit measurement of fatigue does seem to be more stable than the within-day-variability of the explicit measurement. The implicit level of fatigue thus seems largely unaffected by the circadian variations the explicit level does fall prey to.

The second hypotheses anticipated a stronger correlation between the implicit and explicit level of fatigue in the morning and afternoon, than in the evening. On the first look none of the found correlations between the explicit and implicit measurements are significant and can, as such, not be used in favor of the hypothesis. It can therefore not clearly be stated that the relationship between implicit and explicit level of fatigue are stronger in the morning/ afternoon than in the evening. But there must be made some additions to this conclusion. Because two totally different types of measurements were compared with each other, one explicit, based on full scores on the EMMF, and the other implicit, based on a difference in reaction times, no high or significant correlations were expected to be found. Also, when looking at the statistical nature of correlations, it can't be expected to find a strong positive or negative correlation between a changing and an unchanging score. A correlation describes a linear positive or negative relationship. If the scores on one variable increase, the scores on the other must also increase or decrease. The results in this study clearly show that the D-scores did not significantly change over the day, whereas the related EMMF scores did change.

When inspecting the relationship between the correlations, a light indication in favor of the second hypotheses can be found. The slight positive correlation between explicit and implicit measurement of fatigue in the morning and the slight negative correlation in the afternoon were both stronger than the correlation in the evening. Indicating that the relationship between the two different levels of fatigue is slightly stronger in the morning/ afternoon than in the evening. So, when taking with utmost caution, the results might give a first indication in the direction of the second hypothesis.

The post hoc analysis revealed the same patterns concerning the first hypothesis. When excluding people with a high negative D-score, thus a low self-concept bias as indicator of a low level of implicit fatigue, the difference between the morning and afternoon mean EMMF score slightly increases, but it stays insignificant. The difference between the explicit afternoon and evening measurement stays significant. Concerning the D-scores, the overall level of self-concept bias, expressed in a higher positive D-score did rise for all three measurements. Surprisingly the morning and afternoon D-scores rose stronger than the evening scores. But no significant difference was found between the D-scores. The correlations however did change in a rather unexpected way. Whereas the correlations between the relevant morning and afternoon measurements did slightly decrease, the correlation of the evening measurements did increase to a point where it exceeds both other correlations. A possible explanation here could be that because people with a higher self-concept bias do implicitly identify themselves as more tired than people with a low self-concept bias. Therefore, their implicit level of fatigue does have a stronger relationship with their explicit assessment of fatigue in the evening, when they also explicitly identify themselves as more fatigued. Whereas the strength in relationship decreases with the morning and afternoon measurement, because here they do explicitly assess themselves as less tired. But again, none of the correlations were found significant. So, all interpretations of the results must be taken with extra caution.

To summarize the main findings, it seems that on the one side participants interpretation of their explicit level of fatigue changes significantly over the day. People tend to assess themselves as less fatigued in the morning with a slight, but non-significant, drop in the afternoon and a strong increase in fatigue towards the evening. Their self-concept bias, or implicit fatigue level, however does not significantly change, leading to a bigger discrepancy between the implicit and explicit level of fatigue. Especially in the evening hours. This research used the EMMF as indicator of the subjective momentary fatigue experience and can therefore not make detailed claims about the specific influence of the different sub-types of fatigue.

The results of this study thus show that, in accordance with the dual process model, it seems that the individual assessment of fatigue is prone to two distinct processes. One explicit, conscious one and one implicit, unconscious one (Evans, & Curtis Holmes, 2005; Evans, & Frankish, 2009; Kahnemann, 2007). The implicit and explicit assessment and level of fatigue are therefore not the same and do not follow the same circadian variations. The explicit assessment of fatigue seems to be a conscious and significantly changing process. The indicated explicit level of fatigue seems to increase with progressive wakefulness. Rather than just to serve as an accurate indicator of the personal level of fatigue, the main purpose of the explicit assessment process could be the in the introduction described, natural protective function (Glaus, et al., 1996; Grandjean, 1970). Therefore, people could explicitly and consciously interpret themselves as more tired over the day to initiate the natural circadian sleep-wake rhythm, that protects them from physical, mental or motivational overload which would follow from prolonged sleep deprivation (Grandjean, 1970). The implicit assessment of fatigue or self-concept bias, measured by the reaction times of people, seems to be a rather stable, unconscious process that does not significantly change over the day. Participants test performance was, as such, not influenced by an increasing explicit interpretation of their individual fatigue level, which goes in accordance with the findings of Kahnemann (2007). Even if people explicitly identify themselves as very tired, their reaction time speed does not change. Indicating that they have possibly more mental, physical or motivational energy at their disposal as they would explicitly think.

Taken together the results concerning the first two hypotheses are sufficient to give a preliminary answer to the research question. Considering the chosen definition of fatigue from Jones et al., (2007) as “[...] a perception of a lack of energy [...]” it seems that there two parts to the answer. If we attend to the ‘perception’ part of the definition, the explicit assessment process could be a conscious reminder of peoples need to sleep, to avoid possible overload and other negative consequences from sleep deprivation. In this case people would be as tired as they think they are. But if we consider the ‘lack of energy’ and understand fatigue or tiredness as an indicator of the amount of energy at our disposal, then the implicit level could possibly be a more stable and accurate baseline indicator of that amount. Here the results would indicate that people tend to think that they are more tired than they really are.

The third hypothesis was not explicitly directed at the research question. It was meant to assess the validity of the self-developed three item EMMF. The hypothesis expected the situational, explicit three item assessment scales of fatigue (EMMF) to correlate positively with the related subscales of the multi item questionnaire 'Checklist Individual Strength' (CIS). The results show a strong positive correlation between all three items and their related sub-scales. An increase in scores of the EMMF item does seem to go in accordance with an increase in scores on the relevant CIS sub-scale. The findings indicate a good internal validity for the three items. They seem to measure the same sub-aspects of fatigue and have therefore some form of discriminative value for a healthy population sample. Furthermore, the significant positive correlation between the mean-score EMMF and the severity of fatigue sub-scale of the CIS, as well as the total CIS score, supports the validity of the mean EMMF score as a sufficient indicator of the overall momentary explicit level of fatigue. Combined these results strongly support the validity of the EMMF and therefore the third hypothesis. Additionally, its Cronbach's alpha, with .74 was sufficiently high to indicate a good reliability.

The last and fourth hypothesis expected one overarching factor for all three items of the EMMF. The conducted principal component analysis strongly supports this expectation. It therefore seems that all three items do measure one overarching construct. The individual items do correlate strongly with their related CIS sub-scales, but they all seem to be connected by one common factor. All three items thus seem to measure aspects of the same construct, namely fatigue. On the first view this seems to contradict the results of the third hypothesis. But given that the assessment scale consists just out of 3 items this is no surprise. Three items are the minimum number of items necessary for a factor analysis. So, for a higher discriminative value more items would have to be included for the relevant sub-scales. Overall the factor analysis thus further boosts the validity claims of the EMMF measurement. The EMMF seems to be a good overall indicator of the momentary level of fatigue. But the discriminative value of the three individual items is limited. Therefore, all interpretations about the influence of the different sub-aspects of fatigue, must be taken with caution. Combined with the results of the third hypotheses the EMMF seems to be a valid and sufficiently reliable measurement method to explicitly assess the individual momentary level of fatigue.

Because of the methodological nature of the research, its value lies in a better understanding of the concept of fatigue and related sub-aspects, as well as practical implications for further future research. Practical implications for future research, dealing with the topic of fatigue or other variables in relation to fatigue, could be to assess the explicit level of fatigue with a questionnaire that measures their general fatigue level over time, as well as a momentary one, like the EMMF. The EMMF showed relatively good psychometric properties for a healthy population sample. It is indicated that the three different items have some discriminative value and can thus limited be used for interpretations of the different sub-aspects of fatigue. But it seems more fit to be used as a general indicator of the overall momentary level of fatigue. For an even more complete picture a onetime assessment of the implicit level can be added. Possibly measured by the self-concept bias, in the form of a BIAT or a full IAT for

even better psychometric properties. Here the overall D-score can be used as an exclusion criterion to differentiate between groups and/ or compare people with equally positive or negative D-values.

Limitations of this study were numerous. The biggest limitation of the study was its time bound nature in combination with the online conduct, resulting in a high dropout rate and a small sample size. The fact that it was spread via e-mail and participants could fill it in from home, left a huge range for confounding variables to influence the results. Participants could not explicitly be reminded to timely fill in the relevant measurements, because it was not known or prescribed when they had to fill them in. It was known at which points in time at a specific date people would have to conduct the measures, but it was not determined at which date they would have to do it. Without the possibility to actively and timely remember participants, it is hard to work against an increasing dropout rate. From 48 people, only 32 filled in all relevant measures in time.

Furthermore, it could not be controlled whether the participants really took the test at the right time of the day. They had to indicate the exact time themselves, leading to a possibility to cheat and therefore alter the results of the study. Additionally, with an online study, there is no possibility of controlling when, where and in which state participants filled in the study. Even when certain questions about the quality of sleep, the daily activity level, or other confounding variables were included it is impossible to account for all confounding variables that could influence the participants over the day. The study design demanded a high level of motivation from the respondents. Without the possibility of receiving any rewards this could be a factor involved in the high dropout rate. People had to intrinsically be motivated to take part in the study. Leading to another possibly limiting factor. The sampling method. For this study a convenience sampling method was used to guarantee the motivation of participants. Only people that stated a personal interest in the research, and or were known by the researcher, were asked to participate in the study. Leading to a not totally random sample of the German population, which could possibly influence the results. Especially the age group of 35-50 years was not well represented with only 4 people before exclusion, and just 2 people included in the analysis. Furthermore, most results of the study were based on correlational analysis, which gives information about the relationship between certain variables or constructs, but it does not give any indication of causal relationships. For the explanatory nature of this research this is not a direct limiting factor, but it does offer some free space for future research.

Future research could try to rule out the limiting factors of this study and try to repeat the study design in a controlled, experimental environment. Participants would therefore have to be randomly sampled from the population, with a good and relatively equal distribution of age and gender. Also, more Participants should be included ($N > 100$) to give a more detailed and representative picture of the German population. Then participants would be invited to conduct all parts of the study in a controlled environment, where it can be directly assessed when and how the participant completes the measurement, leading to the exclusion of a lot of possibly confounding variables, like noise or other environmental cues. In a perfect condition people should have slept the

same length before conducting the tests and having a comparable physical and mental activity level over the day. In this way it can be better guaranteed that the results reflect reality and not just the influence of for example the length or quality of sleep. These confounding variables could possibly influence both implicit and explicit test results, by either influencing their individual interpretation of their level of fatigue or disturb their concentration or motor functions while conducting the implicit association test. Furthermore, using a controlled environment could minimize the dropout rate. Resulting in more complete cases and thus more valid and reliable results. Additionally, it could be interesting to repeat the study within different nationalities and cultures to investigate whether the observed phenomena are transferrable to other populations.

For time saving reasons and the minimization of motivational burdens for participants, it was not practical to use a full scale IAT, with a test time of 7 minutes. Even if scientific literature indicates comparable psychometric properties for the two types of measurement, the IAT has the clear advantage of having an integrated trial round and giving a more detailed and specific insight in the individual differences of reaction times between and within participants (Nosek, et al., 2014; Siriam & Greenwald, 2009). The used BIAT in this study did not include a trial run for each measurement. It is therefore possible that certain 'skill effects' had an influence on the results. People could have achieved faster reaction times through a better understanding of the functioning of the BIAT with continuing number of measurements. Future research could try to overcome this limitation, by implementing a full IAT, including a trial run at each measurement time.

To extend the insight gained by this explorative research, controlled experiments could be conducted to gain further insight in the circadian nature of implicit levels of fatigue. Here a field of interest could be the comparison of a implicitly highly fatigued sample of individuals and a rather low one. So, people with a high self-concept bias vs. people with a low self-concept bias. Also, the influence on sleep quality, sleep length or/ and sleep deprivation could be examined more closely with an experimental design and a control group. Furthermore, as stated above the specific influence of the different aspects of fatigue, mental/ cognitive, physical/ muscular and emotional/ motivational, on the implicit and explicit level of fatigue and their relationship, could be investigated in greater detail.

Even if this study showed relatively good internal validity and reliability for the EMMF within an overall healthy sample, future research would have to assess its psychometric properties with different populations. It is not said that the EMMF will keep its properties with a highly or pathological fatigued sample. Furthermore, the factor analysis indicates that all three items measure one overarching concept, namely fatigue. Whereas this was useful in the given study design, it is not clear whether the three items individually have enough discriminative value to make interpretations about the differing aspects of fatigue. Thus, the mental/cognitive, physical/ muscular and emotional/ motivational aspect of fatigue. Future research should further examine the specific properties of the EMMF with different population, to further support or disclaim its validity and reliability with different samples. Additionally, a fourth item could be included, which would serve as an indication of

the overall momentary level of fatigue. This second global indicator of the explicit momentary level of fatigue could, exchange or support the mean score as global indicator, possibly further strengthen the psychometric properties of the EMMF.

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7 Appendix

7.1 Appendix A: Introduction



Einleitung

Im Rahmen meiner Bachelorarbeit im Bereich Gesundheitspsychologie an der Universität Twente (NL) untersuche ich mit dieser Studie den Zusammenhang zwischen expliziter und impliziter Tagesvariabilität von Müdigkeit. Studien haben angedeutet, dass bisherige explizite Messmethoden von Müdigkeit nicht alle wichtigen Faktoren von Müdigkeit umfassen. Implizite Prozesse wurden bislang weitestgehend vernachlässigt. Daher untersuche ich inwieweit sich Müdigkeit implizit und explizit über den Verlauf des Tages verändert und in welcher Relation diese beiden Prozesse zueinander stehen.

Hierfür ist es erforderlich zuerst gewisse Basis Informationen zu versammeln in der Form von Fragen zu demografischen Daten und zum Thema Müdigkeit. Dieser erste Teil der Studie kann an jedem beliebigen Tag zu jeder Zeit ausgefüllt werden. An einem anderen Tag (vorzugsweise ein Wochenendtag mit ausreichend Zeit zur Verfügung) sollte zu drei verschiedenen Tageszeiten: morgens (6:00-12:00Uhr), nachmittags (12:00-16:00Uhr) und abends (20:00-24:00Uhr) ein kurzer Test (ca. 3 Minuten) ausgeführt werden.

Hierbei ist es nicht wichtig an welchem Tag die drei Tests ausgeführt werden. Allerdings ist es entscheidend, dass alle drei Tests am selben Tag ausgeführt werden.

Leider ist es nicht möglich bestimmte Teile der Studie auf dem Handy oder Tablet auszuführen. Daher ist der Zugang zum Internet und zu einem Laptop oder Desktop mit Tastatur erforderlich.

Da bei diesem Test Reaktionszeiten gemessen werden, wäre es von Vorteil den Konsum von Alkohol oder anderen Bewusstseinsverändernden Substanzen bis zum Abschluss der Studie zu vermeiden, da diese sonst die Resultate der Studie beeinflussen könnten.

Die Daten dieser Studie werden vertraulich behandelt. Ergebnisse dieser Studie werden daher nur anonym für Dritte sichtbar gemacht. Die Teilnahme ist freiwillig und Sie können die Teilnahme jederzeit ohne Angaben von Gründen beenden.

Der erste Teil der Studie dauert ungefähr 5-7 Minuten, die anderen drei Teile nehmen jeweils 3-5 Minuten in Anspruch. Insgesamt dauert die Teilnahme ca. 15-20 min.

Mit freundlichen Grüßen
Nando Rund

Nando Rund, Universiteit Twente, NL – 2018

7.2 Appendix B: informed consent



1. Einverständniserklärung

Titel der Studie: Sind wir wirklich so müde wie wir denken?

Verantwortlicher Untersucher: Nando Rund

Ich bestätige hiermit, dass ich im Begrüßungstext genügend informiert wurde über die Art, die Methode und das Ziel dieser Studie.


Ich weiß, dass die Daten vertraulich behandelt werden und die Ergebnisse dieser Studie nur anonym für Dritte sichtbar gemacht werden.

Ich nehme freiwillig an dieser Studie teil. Dabei halte ich mir das Recht vor die Teilnahme jederzeit und ohne Angabe von Gründen zu beenden.

[Bitte auswählen] ▾

Nando Rund, Universiteit Twente, NL – 2018


7.3 Appendix C: demographics



1. Zu Beginn der Studie möchte ich Sie bitten anzugeben, ob Sie derzeit an einer oder mehreren der unten genannten Erkrankungen leiden oder deswegen in den letzten 12 Monaten in Behandlung waren.

CFS (Chronisches Erschöpfungssyndrom)	ja	<input type="radio"/>	<input type="radio"/>	nein
Krebserkrankung	ja	<input type="radio"/>	<input type="radio"/>	nein
Rheumatische Erkrankung	ja	<input type="radio"/>	<input type="radio"/>	nein
COPD (Chronisch obstruktive Lungenerkrankung)	ja	<input type="radio"/>	<input type="radio"/>	nein
Eine andere Erkrankung, die mit starker Müdigkeit einhergeht	ja	<input type="radio"/>	<input type="radio"/>	nein

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Ich möchte Sie nun bitten noch ein paar Angaben zu sich selbst zu machen.

Wählen Sie Ihr derzeitiges Alter (in Jahren) aus:

[Bitte auswählen] ▾


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Wählen Sie hier Ihr Geschlecht aus:

[Bitte auswählen] ▾


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Wählen Sie Ihren derzeit höchsten beruflichen Abschluss aus:

[Bitte auswählen] ▾

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Wählen Sie Ihren derzeit höchsten schulischen Bildungsabschluss aus:

[Bitte auswählen] ▾

Nando Rund, Universiteit Twente, NL - 2018

7.4 Appendix D: CIS




Checklist Individual Strength (CIS)


Bitte geben Sie zu den folgenden Aussprachen an inwieweit Sie Ihrer persönlichen Erfahrung der **letzten 2 Wochen** entsprechen.


Klicken Sie bei jeder Aussage auf den entsprechenden Kreis rechts, welcher angibt, inwiefern diese Aussage für Sie zutrifft.

- | | | | |
|---|------------|---|--------------------|
| 1. Ich fühle mich müde | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 2. Ich bin voll Aktivität | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 3. Nachdenken strengt mich an | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 4. Körperlich fühle ich mich erschöpft | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 5. Ich habe Lust etwas Schönes zu unternehmen | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 6. Ich fühle mich fit | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 7. Ich wäre in der Lage körperlich sehr aktiv zu sein | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 8. Wenn ich mit Irgendetwas beschäftigt bin, kann ich meine Aufmerksamkeit gut darauf richten | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 9. Ich fühle mich schlapp | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 10. Ich bin körperlich nur wenig in der Lage aktiv zu sein | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 11. Ich kann mich gut konzentrieren | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 12. Ich fühle mich ausgeruht | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 13. Es kostet mich viel Anstrengung meine Aufmerksamkeit auf etwas zu richten | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 14. Körperlich fühle ich mich in einer schlechten Verfassung | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 15. Ich habe viele Pläne | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 16. Ich bin schnell müde | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 17. Mein mögliches Niveau körperlicher Aktivität ist gering | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 18. Mir fehlt die Lust etwas zu unternehmen | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 19. Meine Gedanken schweifen leicht ab | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |
| 20. Körperlich fühle ich mich in einer ausgezeichneten Verfassung | Ja, stimmt | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> | Nein, stimmt nicht |

7.5 Appendix E: EMMF

	<p>Explicit momentary measurement of Fatigue (EMMF)</p> <p>Bitte geben Sie bei der folgenden Aussprache an inwieweit Sie ihrer jetzigen persönlichen Empfindung entspricht.</p> <p>Bitte klicken Sie auf den entsprechenden Kreis rechts, welcher angibt, inwiefern diese Aussage für Sie zutrifft.</p> <p>1. Ich kann mich sehr gut konzentrieren <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Ich habe starke Probleme mich zu konzentrieren</p> <p>Nando Rund, Universiteit Twente, NL - 2018</p>
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	<p>1. Explicit momentary measurement of Fatigue (EMMF)</p> <p>Bitte geben Sie bei der folgenden Aussprache an inwieweit Sie Ihrer jetzigen persönlichen Empfindung entspricht.</p> <p>Bitte klicken Sie auf den entsprechenden Kreis rechts, welcher angibt, inwiefern diese Aussage für Sie zutrifft.</p> <p>3. Ich habe starke Lust etwas zu unternehmen <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Ich habe absolut keine Lust etwas zu unternehmen</p> <p>Nando Rund, Universiteit Twente, NL - 2018</p>
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	<p>1. Explicit momentary measurement of Fatigue (EMMF)</p> <p>Bitte geben Sie bei der folgenden Aussprache an inwieweit Sie Ihrer jetzigen persönlichen Empfindung entspricht.</p> <p>Bitte klicken Sie auf den entsprechenden Kreis rechts, welcher angibt, inwiefern diese Aussage für Sie zutrifft.</p> <p>2. Ich fühle mich in der Lage körperlich aktiv zu sein <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Ich fühle mich nicht in der Lage körperlich aktiv zu sein</p> <p>Nando Rund, Universiteit Twente, NL - 2018</p>
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7.6 Appendix F: BIAT 1



Ich
ich mich mein mir selbst
oder
Müdigkeit
schlapp träge niedergeschlagen energielos
kraftlos erschöpft lustlos unkonzentriert

Legen Sie Ihre Mittel- oder Zeigefinger auf die Tasten **E** und **I**. Wörter oder Bilder ("Items") werden nacheinander in der Mitte des Bildschirms erscheinen.

- Wenn das Item zu den oben genannten Kategorien **Ich** oder **Müdigkeit** gehört, drücken Sie bitte die Taste **I**.
- Für alles andere, drücken Sie die Taste **E**.

Nach einer korrekten Zuordnung erscheint automatisch das nächste Item. Wenn Sie einen Fehler machen, erscheint ein rotes **X**. Korrigieren Sie den Fehler, indem Sie die andere Taste drücken.

Während dieser Zuordnungsaufgabe wird die Zeit gemessen. **REAGIEREN SIE SO SCHNELL SIE KÖNNEN** und machen Sie dabei so wenig Fehler wie möglich.

Bitte die **Leertaste** drücken, um anzufangen.

Nando Rund, Universiteit Twente, NL – 2018



Ich
oder
Müdigkeit

lebenslustig

Wenn das rote **X** erscheint, drücken Sie die andere Taste, damit das rote **X** wieder verschwindet.
Falls die Tasten nicht funktionieren, klicken Sie bitte in den Rahmen, und versuchen Sie es erneut.

Nando Rund, Universiteit Twente, NL – 2018

7.7 Appendix G: BIAT 2

Category C:	<input type="text" value="Müdigkeit"/>	
(Category D):	<input type="text" value="Vitalität"/>	
Stimuli	Text/Description	Image (optional)
Category C	1. <input type="text" value="schlapp"/>	<input type="text"/>
	2. <input type="text" value="träge"/>	<input type="text"/>
	3. <input type="text" value="niedergeschlagen"/>	<input type="text"/>
	4. <input type="text" value="energielos"/>	<input type="text"/>
	5. <input type="text" value="kraftlos"/>	<input type="text"/>
	6. <input type="text" value="erschöpft"/>	<input type="text"/>
	7. <input type="text" value="lustlos"/>	<input type="text"/>
	8. <input type="text" value="unkonzentriert"/>	<input type="text"/>
(Category D)	1. <input type="text" value="energiegeladen"/>	<input type="text"/>
	2. <input type="text" value="fit"/>	<input type="text"/>
	3. <input type="text" value="sportlich"/>	<input type="text"/>
	4. <input type="text" value="gesund"/>	<input type="text"/>
	5. <input type="text" value="motiviert"/>	<input type="text"/>
	6. <input type="text" value="lebenslustig"/>	<input type="text"/>
	7. <input type="text" value="freudig"/>	<input type="text"/>
	8. <input type="text" value="aktiv"/>	<input type="text"/>

Category A:	<input type="text" value="Ich"/>	
Category B:	<input type="text" value="Andere"/>	
Separation "or":	<input type="text" value="oder"/>	
Stimuli	Text/Description	Image (optional)
Category A	1. <input type="text" value="ich"/>	<input type="text"/>
	2. <input type="text" value="mich"/>	<input type="text"/>
	3. <input type="text" value="mein"/>	<input type="text"/>
	4. <input type="text" value="mir"/>	<input type="text"/>
	5. <input type="text" value="selbst"/>	<input type="text"/>
	6. <input type="text"/>	<input type="text"/>
	7. <input type="text"/>	<input type="text"/>
	8. <input type="text"/>	<input type="text"/>
Category B	1. <input type="text" value="ihr"/>	<input type="text"/>
	2. <input type="text" value="euer"/>	<input type="text"/>
	3. <input type="text" value="dein"/>	<input type="text"/>
	4. <input type="text" value="euch"/>	<input type="text"/>
	5. <input type="text" value="andere"/>	<input type="text"/>
	6. <input type="text" value="du"/>	<input type="text"/>
	7. <input type="text"/>	<input type="text"/>
	8. <input type="text"/>	<input type="text"/>

7.8 Appendix H: Post Hoc Graphs

Paired sample t-tests EMMF Mean

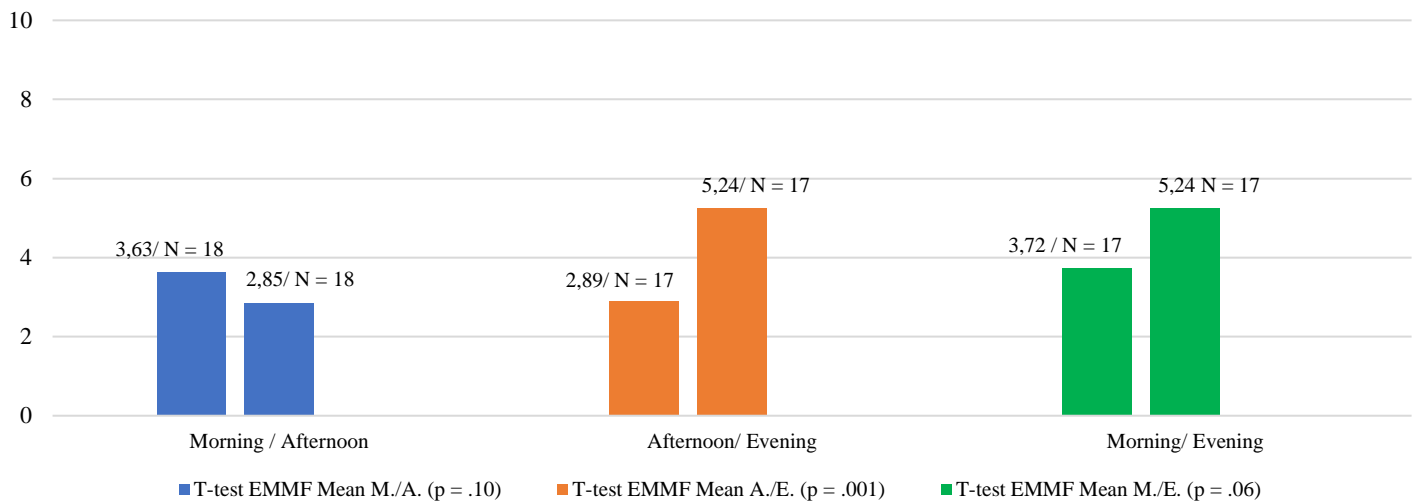


Figure 4. Mean scores of the three paired sample t-tests between the morning, afternoon and evening EMMF within the post hoc data-sample.

Paired sample t-test BIAT D-scores

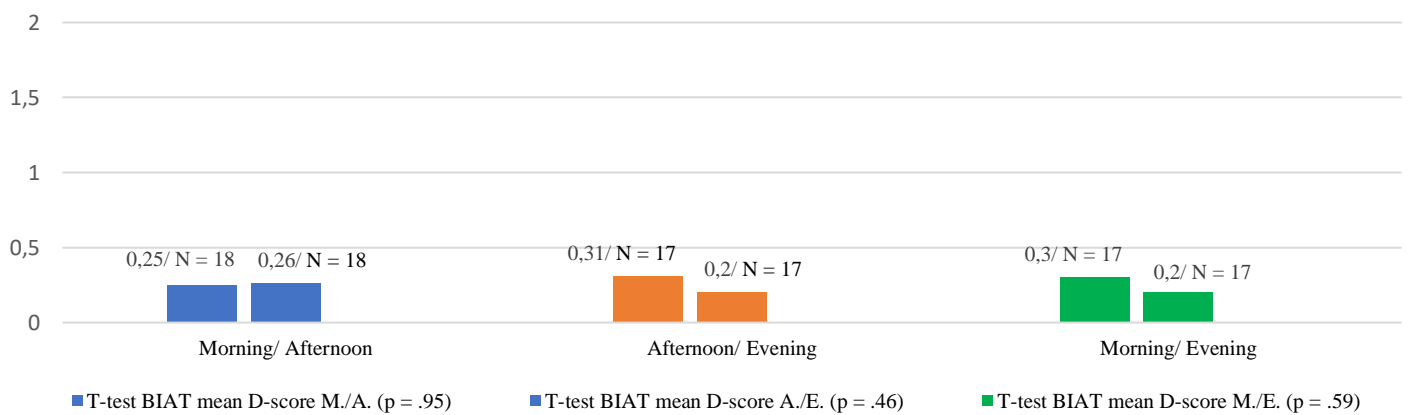


Figure 5. Mean D-scores of the three paired sample t-test of the morning, afternoon and evening BIAT within the post hoc data-sample.