



Sleep Buddy

Report M2.2

Created by: Lester Moorman

M2.2 Industrial Design studentEindhoven University of TechnologyP:+31 6 16 201 907E: I.f.moorman@student.tue.nl

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Coaches: Jun Hu Begüm Erten-Uyumaz



Executive Summary

This document reports the process and results of the "Sleep Buddy" project, done at the Eindhoven University of Technology, department of Industrial Design. This project is a version of the so called "Subjective Sleep Monitoring" project, done for the Sleep squad.

This project was done in collaboration with Kempenhaeghe Center for Sleep Medicine and was also part of a larger PhD study conducted by doctoral candidate of the Tu/e, Begüm Erten-Uyumaz.

This collaboration aimed to develop a mobile application of a sleep diary, a tool mostly used by insomnia patients to track their daily subjective sleep patterns. Main problem with the current pen-and-paper version sleep diary of Kempenhaeghe is that patients do not fill out the diary on time consistently.

The sleep diary developed, called Sleep Buddy, was developed iteratively through multiple idea generations and user tests on different aspects of the diary. The diary conceptually consists of roughly the following aspects: reminders/notifications, a simple and understandable interaction, both daily & long-term data visualizations of sleep patterns and persuasive techniques implemented throughout the app to positively influence the attitudes and behaviors of the users of Sleep Buddy.

An online questionnaire was administered and analyzed using SPSS statistics to assess if the aim of the sleep diary was achieved. It could not be proven that the use of the developed sleep diary did indeed lead to a higher consistency in filling out the sleep diary daily, compared to the Kempenhaeghe sleep diary.

The user experience of the sleep diary was also assessed using the user experience questionnaire and feedback on different aspects was solicited through an online questionnaire. The findings resulted in a benchmark dataset and points for improvement for future iterations of the sleep diary.

Stakeholder benefit for Kempenhaeghe is a prototype of a digital sleep diary application, which was user tested iteratively forming a basis for further development towards a fully functional application which could be used in treatment.

For PhD Begüm Erten-Uyumaz insights were obtained regarding diary inputs and an exploration of data visualization. A collaboration has been initiated to write a paper together which, if published, will be added to her thesis as initial exploration on diary input.



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Introduction

Dear reader,

Over the past few months a project called "Sleep Buddy" was done in the Sleep Squad at the Eindhoven University of Technology, department of Industrial Design. This project is an execution of the original project called "Subjective Sleep Monitoring."

The goal of this project is to design an improved version the sleep diary, a tool which is used to log subjective sleep data. This data is used to diagnose and treat people with sleep disorders, insomnia in this specific case. The aim of the improved sleep diary is to achieve higher consistency rates of people filling out the diary on time each morning and eliminate the need to convert paperwork to a digital form. Higher consistency rates will result in more accurate insights into treatment progress for both doctor and patient and will thus improve treatment for insomnia patients.

The duration of this project was two semesters. The M2.1 semester has been used to set the focus, boundaries and goals for the project in a Final Masters Proposal as well as running a first iteration. This semester was the M2.2 semester which has been used to execute the project and develop a sleep diary application, called Sleep Buddy, iteratively.

This document reports on the process, as well as looking at the final results.

If any questions occur, please feel free to contact me.

Enjoy!

Lester Moorman L.f.moorman@student.tue.nl +31616201907

S146949 - M2.2 Faculty of Industrial Design Eindhoven university of Technology

Backgrounds

This chapter contains information to get aquainted with the context and background of the project.

Befor diving into specifics, this chapter gives an idea of what insomnia is and what the demographics of insomniacs are. The preferred treatment for long-term insomnia, cognitive behavioral therapy for Insomnia, is discussed as well as an important tool used during this process and the main topic of this project: the Sleep Diary.

WHAT IS INSOMNIA?

Insomnia is a medical condition in which a person can have trouble falling asleep, trouble staying asleep, waking up too early, or having poor quality of sleep. Common causes for insomnia are stress, alcohol, caffeine, distractions or disruptive sleep environments, changes in work schedules, pain or other symptoms from health conditions (Masters, 2014).

Insomnia may present itself as an independent problem (primary insomnia) or as part of a coexisting medical or psychiatric condition (secondary insomnia) (Sharma & Andrade, 2012).

Long-term insomnia is associated with depression and anxiety, cognitive difficulties (memory, attention, concentration), and workplace underperformance. Increasing evidence also suggests that patients with insomnia may have an increased risk for cardiovascular disease and diabetes (Masters, 2014).

INSOMNIA DEMOGRAPHICS

In the Netherlands , 15% of men and 32% of women report to their general practitioner to have problems with sleeping (Stichting Gezondheid, 2014). Especially among women and elderly sleeping problems are more frequent and twice as much among women than men. Recent research shows that one out of five of youth suffer from sleeping problems. (GGZ Groep, n.d.)

The same trend can be seen in the United States, where insomnia is also more prevalent in women and elderly people. Women are more likely than men to experience insomnia symptoms and are twice as likely to be diagnosed with insomnia disorder. Insomnia is particularly prevalent in the elderly, with insomnia symptoms present in as many as 65% of individuals 65 years of age or older, with a high level of persistence of symptoms over time (Masters, 2014).

Population studies also suggest that individuals who are unemployed, divorced, widowed, separated, or of lower socioeconomic status have a higher prevalence of insomnia (Masters, 2014).

WHAT IS COGNITIVE BEHAVIORAL THERAPY FOR INSOMNIA (CBT-I)?

CBT-I is a multi-component therapy that includes both cognitive components (sleep education and addressing maladaptive beliefs and expectations about sleep) and behavioral components (Sleep-restriction therapy and relaxation techniques). Many studies show the efficacy of CBT-I for in both the long-term, for which it is more effective than sleep medications, and the short-term (Masters, 2014). In recent years, CBT-I has emerged as preferred treatment for insomnia (Sharma & Andrade, 2012).

In their protocol book for CBT-I the GGZ, the association for mental healthcare in the Netherlands, bases their treatment on the three-factor model by Spielman and Glovinsky (See figure 1). The model posits that, when developing long-term insomnia, three factors are at play: predisposing factors, precipitating factors and perpetuating factors (Verbeek & van de Laar, 2015)

If bad sleep becomes chronic, depends mostly on how someone copes with acute sleeplessness, especially the person's thoughts and behavior are important (precipitating and perpetuating factors). Worrying about bad sleep can lead to too much physical and emotional activity causing more bad sleep and thus creating a vicious circle.

The most important goal of CBT-I is breaking this vicious circle. The most important pillars of this treatment are: information about sleep, self-registration of sleep- and wake behavior, breaking bad sleeping habits (sleep hygiene), tackle negative thoughts about sleep and reducing physical tension (Verbeek & van de Laar, 2015). A closer look at some specific components about CBT-I:



tension (Verbeek & van de Laar, 2015). A closer **Figure 1 - Factors in developing long-term insomnia** look at some specific components about CBT-I: **(Verbeek & van de Laar, 2015)**

RELAXATION TECHNIQUES

Relaxation therapy is based on observations that insomnia patients often display high levels of physiologic, cognitive and/or emotional arousals, both at night and during the daytime. A number of formal relaxation therapies have been applied to insomnia since such therapies reduce the sleep-related performance anxiety and bedtime arousal common to this condition (Sharma & Andrade, 2012). Examples of these relaxation techniques are progressive muscle relaxation and abdominal breathing techniques.

STIMULUS_CONTROL THERAPY (SCT)

Stimulus-control therapy is particularly important in helping patients associate the bed and bedroom with sleepiness. Because the bedroom is often used for purposes other than sleep (such as watching television or exercise), individuals may lose the association of the bedroom with sleep when going to bed. To reinforce this connection, patients should be advised to keep set bedtimes and rising times, remove sleep-incompatible stimuli (such as electronic devices) and use the bedroom only for sleep (Masters, 2014).

The set of instructions in stimulus control therapy are designed to help the patient with insomnia to establish a consistent sleep-wake rhythm, strengthen the bed and bedroom as cues for sleep, and waken them as cues for activities that might interfere with sleep (Sharma & Andrade, 2012).

SLEEP RESTRICTION THERAPY (SRT)

The most demanding and for patients exhausting component of CBT-I is sleep restriction therapy (SRT). SRT is a behavioral intervention that attempts to increase the drive to seep by limiting, and then slowly increasing, the time for sleep. The time in bed of patients is reduced to their average total sleep time from 1 to 2 weeks prior (determined by keeping a sleep diary, not less than five hours a night). The sleep efficiency (the reported time asleep relative to the amount of time spent in bed) is used to increase the amount of sleep time allowed: 15 to 30 minutes is added when sleep efficiency exceeds 85%. This process continues until the patient feels optimal during the day and/or sleep efficiency begins to drop due to reaching the patient's sleep need (Masters, 2014).

SLEEP HYGIENE EDUCATION

Sleep hygiene involves educating the patient about health practices such as diet, exercise and substance use, and about environmental factors such as light, noise, temperature and bedding, that is, important personal and environmental factors that can be positive or negative for sleep (Sharma & Andrade, 2012).

THE SLEEP DIARY

One of the recurring assignments in CBT-I is filling out sleep diaries. A sleep diary is a week-overview in which the patient can indicate when he or she was sleeping, was awake in bed or was out of bed (See appendix A – Sleep Diary Kempenhaeghe). The sleep diary is indispensable in the treatment of insomnia because it gives a good overview of the patient's sleep complaints and it provides a starting point for applying advices and assignments adequately. The sleep diary can then be used to determine the effect of the treatment (Verbeek & van der Laan, 2015).

The patient Is expected to bring a filled out sleep diary to each session of the treatment, resulting in a minimum of eight week-overviews. Depending on the time in between sessions at the clinic this could be more.

It is important that the sleep diary is filled out in the morning and the patient does not do this during the night or looks at the clock to do so. The data is about estimations (Verbeek & van der Laan, 2015). Looking at the clock during the night is advised against to prevent stress from lying awake late.

Additionally, it is important that the sleep diary is filled out in the morning and not in the afternoon because it will be harder to remember relevant data later in the day and it might be biased by positive or negative events during the day.

The exact time in which it should be filled out may differ per diary. There are a lot of different diaries with different items and instructions, there is not yet a consensus diary that is universally used. However, an effort has been made to present an expert consensus, standardized, patient-informed sleep diary (Carney et al,2012). The consensus sleep diary instructs users to complete the sleep diary within one hour of getting out of bed in the morning, if possible. As indicated, the sleep diary by Kempenhaeghe instructs users to complete it in the morning.

Stakeholders

There are two clients involved in this project: Kempenhaeghe Center for Sleep Medicine and Tu/e doctoral candidate Begüm Erten-Uyumaz. The project coaching is done by both Dr. Jun Hu, head of the sleep squad at the Tu/e and Begüm Erten-Uyumaz.





All projects in cooperation with Kempenhaeghe are conducted in the context of a PhD research. This means that the project should serve both Kempenhaeghe and the doctoral candidate involved. The goal of this approach is to prevent the project results to be lost after completion because of a lack of "ownership" of the project. In the current set-up, at the very least, the doctoral candidate will proceed with the results in the context of his or her PhD research. A closer look at the clients:

KEMPENHAEGHE CENTER FOR SLEEP MEDICINE

A specialist from a general or academic hospital, or at times a general practitioner, can refer a patient to the Kempenhaeghe Center of Sleep Medicine. Reasons for referral include when uncertainties remain about the cause of the sleeping problems or sleep disorder or it has proven impossible to gain control over the sleeping problems (Kempenhaeghe, 2011).

Characteristic of the Kempenhaeghe Center of Sleep Medicine is that there are different specialisms available, like neurology, psychiatry, psychology and pediatrics. Together the specialists conclude the optimal diagnosis and treatment of the sleep problem or disorder (Kempenhaeghe, 2011).

In this project Kempenhaeghe is represented by Dr. Sebastiaan Overeem, somnologist (expert in sleep medicine) at Kempenhaeghe and Laury Quaedackers, GZ-psychologist at Kempenhaeghe.



PHD BEGÜM ERTEN-UYUMAZ

Begüm Erten-Uyumaz is a doctoral candidate at the Eindhoven University of Technology (Tu/e) with a background in psychology and User Experience (UX) design. Begum has taken a double role in this project of both client and coach.

Begüm's PhD focusses on insomnia and CBT-I, especially sleep-scheduling, which consists of two components of CBT-I: Sleep Restriction Therapy and Stimulus Control. The project Begum runs with students at the Tu/e is called "sleep scheduling to improve sleep quality". Possible challenges for students include educative games to overcome sleep state misperceptions, data visualization to get insight into the therapy effect and smart tangible products to track the progress of sleep scheduling (See appendix B – Challenges from the Coach).



Problem Statement

The goal of the project is to develop a digital version of the Kempenhaeghe sleep diary that patients will fill out on time, consistently and accurately.

From conversations with Dr. S. Overeem, Industrial Design students from Tu/e identified the following problems of the current pen-and-paper sleep diary and the underlying factors of these problems (Thoolen & de Vogel, 2016):

- 1. Patients don't fill out their sleep diaries, because:
 - It's not done quickly. This is because it's hard to remember all relevant timespans of the previous night
 - Patients forget
- 2. Patients fill out their diaries too late or inaccurately, because:
 - Patients fill out their diary without thinking about it after they initially forgot in the morning

Another pain point of the current diary is that it's non-digital, thus only reviewable for medical staff whenever the patients visits them. Also, converting a paper diary to a digital one is a time consuming process.

As mentioned earlier, the proejct results should benefit both Kempenhaeghe and Begüm, to prevent the project results to be lost after completion because of a lack of "ownership" of the project.

In order to do so, a couple of approaches were explored that might could be used to solve the problems presented by Dr. Overeem and look for opportunities to support the PhD thesis of Begüm.

Literature Research

How to influence behaviors between humans has long been topic of research in (consumer) psychology, marketing and other fields.

With the emergence of smartphones, the internet of things and all kinds of interactive products, new topics of research have emerged that study how technology can be used to influence behaviors for the good or create healthy habits and routines.

PERSUASIVE TECHNOLOGY

An important pioneer is B.J. Fogg, who defines "Persuasive Technology"(PT), as interactive information technology designed for changing users' attitudes or behavior (Fogg, 2003).

Fogg identifies in his functional triad of computer persuasion (see Figure 2), three ways in which it can influence users attitudes or behaviors: as a tool, as a medium or as a social actor (Fogg, 1999).



Figure 2 - Fogg's functional triad of computer persuasion

As a tool, a computer application or system can provide humans with new abilities allowing people to do things more easily. As a medium, a computer will provide simulations and virtual environments as well as sensor input to prompt insights into causeeffect relationships. Finally, as a social actor the persuasive technology aims to change attitudes and behaviors by providing social support or leveraging other social rules and dynamics.

Technology can persuade on two levels: macro and micro. If persuasion and motivation are the sole reasons a products exists (like a simulation to avoid teenage pregnancies) it is called macrosuasion to describe this overall persuasive intent of the product. (Fogg, 2009)



FOGG'S BEHAVIOR MODEL

Other works by B.J. Fogg include the "Fogg Behavior Model" (FBM, see figure 3). The model asserts that for a target behavior to happen, a person must have sufficient motivation, sufficient ability and an effective trigger present at the same time (Fogg, 2009) or in other words: Behavior = Motivation & Ability & Trigger (B=MAT). Each component has it's subcomponents: the three core motivators in Motivation, the six elements of simplicity in Ability and three types of Triggers

As can be seen in figure 3, motivation and ability can trade off. In other words: if the behavior is very easy to do (and thus the ability is high), not a lot of motivation is required for the trigger to be effective and spark the intended behavior, en vice versa.

THE HOOK MODEL

Nir Eyal also uses elements of B.J. Fogg's research to present a model on how to build habit-forming products, called the hook model (Eyal, 2014, see figure 2). The hook model uses triggers, an action, variable rewards and investment to engage people and make them return as well. Through consecutive hook cycles, successful products reach their ultimate goal of unprompted user engagement

In short, the model entails that an external trigger will prompt the user to an action, which is done in anticipation of a reward. This rewards has to be variable to keep grasping the users attention over longer periods of time. Then the user is asked to make an investment in time, effort, e.g. which makes the product more valuable the next time the user uses it (adding friends on Facebook improves timeline content for the next visit, e.g.). Over time, the user starts associationing internal triggers, like feeling bored, with the product. An example of that is when people grab their phone to check facebook when feeling bored.





For a more elaborate description of these approaches, see Appendix C - Theories behavior change. At a later stage in the project, Persuasive Systems Design by Harri Oinas-Kukkonen was also discovered. It was too late to take into account or implement in the project, but it is described in the appendix for reference.

CONCLUSION LITERATURE RESEARCH

The models explored describe different ways of looking at behavior and behavior change. The FBM describes the drivers of human behavior, what factors control whether a behavior is performed or not: Ability (simplicity of the behavior), Motivation and a Trigger: B=MAT. In this model, "persuasion" refers to attempts to influence people's behaviors, not attitudes (Fogg, 2009).

The hook model by Nir Eyal (2014) describes a way to create habits, behaviors done with little or no conscious thought and create unprompted, repeated customer engagement. This is done through triggers, an action done in anticipation of a reward (which must be simple and motivating), a variable reward (variable to maintain appeal of the reward) and an investment (a bit of work the user does to improve the experience of the product over time).

Persuasive Technology by Fogg (2003) explores how interactive information technology can be designed to change users' attitudes or behavior. As a tool (to increase capability), as a medium (to provide experiences) and as a social actor (to create relationships). Fogg also discusses topics like credibility of the system and how it improves persuasion power, how connected products can leverage social influence (computer-mediated communication) and the ethics of PT.

PT is more practical than the other two models because it describes specific techniques on how to influence behavior or attitudes. For example: the principle of Cause and effect entails that simulations can persuade people to change their attitudes or behaviors by enabling them to observe immediately the link between cause and effects (Fogg, 2003). For an overview of these techniques, see Appendix D – Brainstorm cards PT.

Although the models are different, some aspects are the same, overlap, or are very similar. For example, both Fogg's Behavior Model and the Hook Model posit a trigger to be needed to initiate the behavior. In the Persuasive Technology book, Fogg also describes a persuasive technique called "suggestion technology": an interactive computing product that suggests a behavior at the most opportune moment (Fogg, 2003).

Another example is that the "Action" phase of the Hook Model by Nir Eyal (2014) is based almost entirely on Fogg's Behavior Model.

The variable rewards and investment phase of the hook model also show overlap with PT. Rewards of the self, as described by Eyal (2014) states that the brain is adapted to seek rewards that make us feel accepted, attractive, important and included. This overlaps with Fogg's (2003) principles of social facilitation (people know they are being observed via technology or can discern that others are doing the behavior with them), social comparison (competition with others) and normative influence (peer pressure).

An example of an investment as defined by Eyal (2014), where the user stores value in the product, is generated data. This could overlap with Fogg's (2003) principle of self-monitoring where computer technology is applied to take track the users performance or status, which feeds the natural human drive for self-understanding

To conclude: the models show many similarities, but have different focus points. In general: The FBM describes the drivers of human behavior, the hook model describes a general model on how to create a habit and PT describes more specific techniques of how interactive technology can be used to influence behaviors and attitudes.

They are all (partly) applicable in the development of the new sleep diary. An adapted model for the sleep diary will be presented in the next chapter.

Behavior change & the sleep diary

The goal of the digital sleep diary is that patients will fill it out on time, each day, and accurately. In addition, the goal was to find an approach that serves all stakeholders involved. Following the literature research an approach for creating a routine out of that particular behavior has been defined.

The basis for the approach has been adapted from the hook model by Nir Eyal (2014). It is made up out of a trigger(the reminder), the action phase (filling out the sleep diary),

a variable reward (the calculation of sleep efficiency scores) and an investment (stored value in the form of generated long-term data).

This cycle is contained in a cloud of persuasive techniques (See figure 5), meaning to depict that anywhere in the digital sleep diary, through the entire cycle, persuasive techniques can be implemented to positively influence behaviors and attitudes regarding the sleep diary. This is called microsuasion, as defined earlier. As mentioned earlier, the reminder in itself is also a persuasive technique (suggestion technology) and so is the calculation of Sleep Efficiency (SE) scores and long-term data overviews (Self-monitoring technology).

REMINDER

The reminder is the first phase of the cycle. It has been defined by all three models as necessary to trigger a behavior. Eyal (2014) states that triggers should always be embedded with information, which tells the user what to do next.

Fogg (2003) states that a computing technology will have greater persuasive power if it offers suggestions at opportune moments. An important example for an opportune moment is that people can immediately take action (hot triggers).

Internal triggers as defined by Eyal (2014) have been removed. It is useful for users returning whenever they feel a particular emotion, on their own, without needing further prompts (Eyal, 2014). Since the sleep diary only needs to be used once in the morning and not multiple times a day it is not used here.



FILLING OUT THE SLEEP DIARY

The action phase, done in anticipation of a reward, consists of filling out the sleep diary. It is based on both the hook model and the FBM which state that simplicity is key. The FBM posits six elements of simplicity, with simplicity being the sum of the users scarcest resource at a particular point in time: time, non-routine, money, physical effort, brain cycles and social deviance.

CALCULATION SLEEP EFFICIENCY SCORES

The main variable reward chosen is to calculate the user's Sleep Efficiency (SE) – scores, the diary must display the users SE-scores immediately after completing the diary. The sleep efficiency is the reported time asleep relative to the amount of time spent in bed. This score is important because it gives the patients a good indication about their sleep complaints and how their treatment is progressing, since a high sleep percentage is an indication of a good sleeper. SE-scores are also used as an indication in sleep restriction therapy of when to increase the amount of sleep time allowed (when sleep efficiency exceeds 85%).



The Sleep Efficiency Score (SES) scores can also be calculated by patients in the current pen-and paper diary, but according to Laury from Kempenhaeghe, the therapists usually ends up calculating it after one or two weeks when meeting with the patient.

This reward is variable in a sense that it is different every day and the user can see how treatment is affecting them. There can be more rewards in the sleep diary, like offering compliments (principle of praise (Fogg, 2003)) but this is the most important one.

LONG-TERM DATA OVERVIEW

The value stored in the sleep diary is the overview of long-term data. The diary becomes more interesting with extended use, because it allows the user to assess how their homework, like relaxation therapy and stimulus control therapy is affecting their SE-scores over time. Based on those assessments the patient and therapist can decide with which components of CBT-I to continue and which to drop.

STAKEHOLDER INTERESTS

As mentioned earlier, the goal was to find an approach that would serve all stakeholders involved. The proposed model in this chapter aims to solve the problem statements defined by Dr. Overeem and it overlaps with the PhD thesis, as "data visualization to get insight into the therapy effect" is one of the active projects being worked on, see Appendix B - challenges from the coach. In addition, besides data visualisation, Begüm also expressed interest in explorations regarding preferred interaction for submitting time. Having defined a model that would serve all stakeholders involved, it was decided to continue with this approach.

DEVELOPING A MOBILE APPLICATION

Following the literature research and the definition of the model, it became clear that the choice for a mobile application has a lot of advantages compared to a stand-alone device. While the defined model could be applied to a stand-alone device (through a tangible interaction on a connected device and sending scores and data in an e-mail, e.g.), an app has a lot more flexibility in implementing these phases and other persuasive techniques.

AGUMENTS IN FAVOR OF AN APP

The most foremost argument in favor of an app, is the flexibility in applying multiple persuasive techniques. For example, an app offers more flexibility in tailoring it to the user's needs, interests, or other factors relevant to the individual (tailoring technology)(Fogg, 2003). Other examples include flexibility to offer compliments (principle of praise) and instructions (principle of tunnelling) through dialog boxes.

Another factor is that it fits in user's already existing routines. 79% of smartphone owners check their device within 15 minutes from waking up (Eyal, 2014), meaning immediate opportunities to show a trigger. Users carry their phone with them, so they could also see the notification again at a later time, decreasing the chance of forgetting to fill it out.

Other practical factors in favor for an app include that an app doesn't require an extra device and is thus cheap and easily scalable. If the developer would want to adjust components it could be easily done via an update.

Even other components of the CBT-I, like advice for sleep hygiene, instructional videos for relaxation technique, e.g. could be implemented into the application at a later stage becoming a deliverer of internet based-therapy. There is some evidence already, that interactive, online CBT-I may have beneficial effects that are comparable to face-to-face therapy (Espie, Hames, & McKinstry, 2013) A few axample of apps using (parts of) CBT-I already exist, including one being co-developed by Stanford School of Medicine (T2, 2016)

ARGUMENTS AGAINST AN APP

As stated earlier, sleeping problems in the Netherlands are especially prevalent among women and elderly. In that light, the choice for a mobile phone application may seem illogical, since elderly are not necessarily as skilled with smartphones as younger people or may not own one.

Furthermore, if a patient would have his or her phone on the nightstand, it could lead to filling out the sleep diary in bed when the user checks his or her phone. This would be against advice given in CBT-I for good sleep hygiene, so it would need to be stressed to not fill out the diary while still in bed.

CONCLUSIONS & DESIGN CHALLENGES

There are both positives and negatives about developing an app as the sleep diary, but the positives were deemed to outweigh the negatives, as it was felt that the app offers more opportunity and flexibility to succesfully influence the users behaviors and attitudes. Thus the decision was made to develop a mobile phone application.

The design challenges that flow from that decision are to design a simple user interface with understandable interactions, select and implement appropriate persuasive techniques, design and implement a clear data visualization and enable reminders and data extraction in the mobile application (See ficure 6).

MOBILE PHONE & SENSOR DATA

One of the biggest categories of sleep related apps, are apps that make use of the phone's accelerometer to track users sleep based on movement. In talks with Dr. Overeem, he indicated that an assessment of the sleep phases (like Rapid Eye Movement

sleep (REM)) of the patient based on movement, are not accurate enough. In the clinic this is done through all kinds of sensors on the body, called a polysomnography (PSG).

Other measurements, like when a patient is asleep and awake, is possible to measure to some extent using a phone. In talks with Laury, GZ-psychologist at Kempenhaeghe, it was indicated that she doesn't see added value in using sensor-support to help patients remember previous night's sleep.

She states that it's not reliable enough and that it should still be about the subjective experience, which the sensor data could even conflict with. For example: there is a risk that an insomnia patient feels bad about last night's sleep, while the app indicates it was really good, causing a disconnect between the patient and the technology

The danger of this disconnect is realistic, since one of the characteristics of insomnia is that subjective experiences of both the quality and quantity of sleep may be the cause the problem (Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008). Rather, Laury suggested an emphasis in the design on making sure that the patient understands that the data is about estimations and the patients subjective experience.



LAYOUT & INTERACTIONS

Figure 6 - Design challenges sleep diary app

Diary layouts & interactions - Iteration one

As defined in the conceptual model, filling out the diary is the so called "Action" phase in which simplicity is the most important factor.

The six elements of simplicity, as defined by B.J. Fogg (2009) are time (how fast is it done?), non-routine (routine behavior the user is already familiar with, is found more simple), money, physical effort, brain cycles (the amount of thinking required) and social deviance (a behavior that is socially deviant is not simple).

Taking these factors into account, simplicity is the sum of the users scarcest resource at a particular point in time.

Of these six elements time, brain cycles and non-routine are probably the scarcest in the morning routines of people. Social deviance and money are not applicable, since both diaries do not cost the user any money, nor do they require to break societal norms.



Physical effort can be a factor since users may find the text, buttons and icons, e.g. too small on a mobile device. Depending on the interaction, they may find it hard to do precise movements as well, which might also be defined as motorial effort.

Based on these factors, this first iteration of sketching and generating ideas focussed mostly on usability in terms of it being easy to use and understand. The idea generation was inspired by four different sources, for a more elaborate overview of all the findings, see Appendix E – Input diary layouts & interactions:

- 1. Previous user test with lo-fi prototypes (M2.1 semester)
- 2. Benchmarking
- 3. The EVE report (Development of a sleep diary, Thoolen & de Vogel, 2016)
- 4. The Consensus Sleep Diary (Carney et al, 2012)

Two design questions were defined for the first iteration of diary layouts:

Design question one: What is the preferred interaction for submitting time?

The sleep diary requires submitting times in every question, which can be done in a number of ways. The goal in this iteration is to generate ideas for how times could be submitted and consequently find out which is found most easy to do and understand.

Design question two: should the overview be presented after each step? Or after completion of the diary?

The second design question was defined during the idea generation of the possible interactions for the diary. One particular point of feedback on one of the prototypes of the M2.1 semester was that users liked the constant overview of the data filled out as it allowed them to see what they were doing (The ring diary, see Appendix E – Input diary layouts and interactions).

The same principle was adapted into the dial diary and in the neo-classical diary presented on the following pages, by adding an overview of the data submitted after each question. However, this is not possible in all diaries, like the Analog diary for example. Since there is also a sense of progress in the dial and neo-classical diary by progressing through the colored icons, this lead to the question whether the user would prefer an overview after each question, or rather at the end of the diary.

THE CONCEPTS

Following the idea generation, 3 different interactions to submit time were defined and turned into concepts: the dial diary, the analog diary and the neo-classical diary. The neo-classical diary was adapted to a version without an overview after each step (the classical diary) to be able to answer the research question whether to present the overview after each step or after completion of the diary

THE DIAL DIARY

The dial diary is inspired by the rotation diary and the ring diary of the M2.1 semester, as well as the EasySleep app (Sileci apps, 2016) (See Appendix E – Input Diary Layouts & Interactions).

The dial diary is a circle meant to depict a clock with a 24-hour timescale(See Figure 7). It has a shorter line to depict the clock hand for the hours and a longer line for the minutes. The hours are set first and consequently the quarters by tapping the clock hand and rotating it to the desired position. In all of the sleep apps, the user can only select quarters: zero, 15, 30, and 45 minutes, the same as the Kempenhaeghe sleep diary. Since the diary is about estimations, smaller times are not allowed, to prevent any stress caused by the tendency a user might have to try and fill out the diary too precisely.

The active clock hand is always displayed red and the color follows along with the clock hand, while the digital time is being displayed in the middle of the overview circle.

The icons all correspond to a question of the sleep diary, based on feedback from the M2.1 semester that users suggested icons for each element in the overview. With each question, the color of the corresponding icon becomes colored and the dial becomes the same color. The color of the icon and dial correspond with that segment of the overview that follows after each step. (See figure 8).



⊨ 🖇 🗯 🗘 💻 👁

00:00



Time to bed









Figure 9 - Neo-classical diary

THE NEO-CLASSICAL DIARY

The neo-classical diary is based on the default way of submitting time on an Android phone. The diary looks exactly the same as the dial diary, the difference, visually, is that there are no clock hands. The user taps the digital time within the circle and a pop-up box appears where the time can be submitted also by either tapping the arrows, or by



typing (a keyboard appears when hitting either of the numbers, see Figure 9). Each step is followed by an overview that looks exactly the same as the dial diary.

In the dial diary a circular overview was more logical because of the input mode. However, a circular overview has been chosen in all of the prototypes of the first iteration, since these iterations are about evaluating the interaction mostly and no eploration had been done yet for the data visualization. In addition, arguments can be made in favor of a circular overview, based on the EVE report, stating:

"a circular representation of time has a positive influence on people. This can be translated to the sleep diary in which time is the key element" (Thoolen & de Vogel, 2016)

This is based on findings that a circular time representation has been shown to help users focus more on the task at hand and think about activities more concretely in a saving plan (Tam, Lee, & Dholakia, 2012).

Thoolen & de Vogel (2016) also argue that a circular representation of time has the advantage that the circle circumference is larger than a linear representation of time in the same surface. Thus a smaller area is required for representing time, which is valuable on a smartphone screen.



23:30
 23 00 13 22 11 12 1 14 10 00 2

45 21 9 15 3 15 8 30 ð 20 16 7 5 б 19 17 18

Time to bed

WHAT TIME DID YOU GET INTO BED?

<u>@</u> 00:00

Figure 10 - Analog diary

Figure 11 - Classical diary

THE ANALOG DIARY

The analog diary is based on, as the name suggests, an analog clock. Some participants of the focus groups involved in developing the Consensus Sleep Diary suggested alternate graphical formats, such as clock faces or time charts (Carney et al,2012).

The analog diary features three rings of numbers. The outer two rings contain the 24 hours of the day. Once a number is tapped , that number becomes red and the inner third, most inner ring containing the quarters, appears. The quarters can be submitter in the same way, the time appears in the digital clock above the analog one as well (See Figure 10). The overview in the analog diary is not given until the diary is completed. This is because a ring around the analog diary would not fit on the screen or make the numbers too little and clustered.

THE CLASSICAL DIARY

The classical diary is, interaction wise, a copy of the neo-classical diary, it is made to answer the research question whether to present the overview after each step or after completion of the diary. The classical diary asks the questions step-by-step and shows the same overview as the other diaries upon completion of the diary (See Figure 11).

QUESTIONS IN THE DIARIES

The current Kempenhaeghe sleep diary is a graphical format and although it does include instructions on how to fill out the diary, it does not ask questions directly, like "What time did you try to go to sleep?" for example.

For the current prototypes, these questions are required however, thus the decision was made to use the relevant questions defined in the Consensus Sleep Diary. The advantage of using these items is that the construction and wording of the sentences has been developed iteratively through focus groups. Lexile analyses suggested that the Core diary instructions are at a sixth-grade reading level and the Core diary was written at a third-grade reading level(Carney et al,2012). Only the questions of the CSD are used that are also present in the Kempenhaeghe sleep diary.

Prototyping & Experiment Setup

To answer the design questions defined for this iteration, the designs were prototyped and evaluated through user testing.

All concepts were prototyped using Axure RP Pro, a rapid prototyping software tool for web and desktop applications. It allows for graphically designing interfaces and adding interactions to them, creating interactive prototypes for user testing, without having to write code (Axure, n.d.).

OBJECTIVES

The objectives of this user test were threefold:

- Gain insight into the usability and understandability of the prototypes.
- Answer the design questions defined for this iteration:
 - a) what is the preferred interaction for submitting time?
 - b) should the overview be presented after each step? Or after completion of the diary?
- Other qualitative input on the prototypes regarding what participants liked, points for improvement, preference for diaries, etc.

TEST SETUP

The setup of this test was a mixed-method approach, including the System Usability Scale (SUS) as a quantitative measure and semi-structured interviews as a qualitative measure. Furthermore the setup was a within subjects design in which all participants are exposed to every treatment or condition (Cherry, 2016), being the testing of all four prototypes.

This approach was chosen because it does not require a large pool of participants and individuals are exposed to all levels of a condition, so individual differences will not distort the results (Cherry, 2016). This approach also allows to solicit individual preferences for prototypes.

Participants were asked to add the four prototypes to their phones and to fill out each diary. Upon completion of each diary, participants were administered a post-task questionnaire, the SUS, for each prototype and a semi-structured interview was conducted. The interviews were audio recorded. After completion of all four diaries and the specific questions for each, a couple more general questions about the prototypes were asked. The bias caused by familiarizing with the diaries, and thus filling out the next one faster or more easily, was eliminated by each participant going through the diaries in a different order.

The overviews presented in the diaries were not responsive to the actual time submitted, but consisted of a series of images. Because of the time required to make responsive overviews and since the prototypes were about testing the interactions, the participants were asked to fill out predetermined times and durations to make the overview representative of the data.

Since the apps should be self-explanatory, the moderating technique chosen was Retrospective Probing (RP). This technique entails waiting until the testing of the sleep diaries is completed, the questionnaires filled out and then asking the participants about their thoughts and actions (Romano Bergstrom, 2013). This was to make sure that the ratings for usability and the opinions on the diary were not biased by help received from the researcher, but rather true reflections of the interactions with the apps.

PARTICIPANTS

Although the target group of the diary is insomnia patients, this user test was not targeting specific groups, as the evaluation of interactions were not deemed to differ for insomniacs and non-insomniacs. Instead, it was decided to recruit a convenience sample, participants were selected based on accessibility and/or proximity to the researcher ("Convenience sampling," 2016). Five participants were recruited for this user test.

Participants received and signed a consent form, containing the purpose, procedures, risk/benefits and confidentiality statements, among others, of this experiment (See Appendix F – Consent Form Interactions).

MEASURES & ANALYSIS

The System Usability Scale (SUS) was used to evaluate the subjective usability of the prototypes, see Appendix F - System Usability Scale. It allows it's user to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications. It has some additional advantages in that it can be used on small sample sizes with reliable results and it can effectively differentiate between usable and unusable systems (Usability.gov, 2013).

The semi-structured interviews (See Appendix H - Interview Guide) were analyzed using thematic analysis. Thematic Analysis is the analysis of textual material (newspapers, interviews and so forth) in order to indicate the major themes to be found in it. In thematic analysis the researcher does not identify the overall theme of the text, but digs deep into the text to identify a variety of themes which describe significant aspects of the text (Howitt & Cramer, 2011).



Thematic analysis is not a single, identifiable approach to the analysis of qualitative data. There is no accepted, standardised approach to carrying out a thematic analysis, so different researchers do things differently. The term "Thematic Analysis" refers to a wide range of different sorts on analysis (Howitt & Cramer, 2011).

There was some confusion as to which was the most appropriate method to analyze the interviews and even on what the exact name of the correct analysis was after completion of the analysis. This is because there are other methods of qualitative research which seem to compete with thematic analysis in the sense that they take text and, often, identify themes. Grounded theory is an example of this. If the basic processes involved in carrying out a grounded theory analysis are compared with those of thematic analysis then differentiating between the two is difficult. (Howitt & Cramer, 2011)

A discussion exploring differences between methods involving identifying themes from textual data, and an elaboration of why thematic analysis was chosen, can be found in Appendix I – Discussion analysis methods.

THE PROCESS OF THEMATIC ANALYSIS

In this project thematic analysis was done as proposed by Braun and Clarke (2006), which is probably the most systematic introduction to doing thematic analysis to date. It is a fully-fledged account of thematic analysis which seeks to impose high standards on the analyst such that more exacting and sophisticated thematic analyses are developed (Howitt & Cramer, 2011).

The entire process is summarised in Figure 12, note that there are many loops back to the earlier phases of the analysis meaning to depict that it is a back-and-forth process.



Figure 12 - Braun & Clarke 's model of thematic analysis (Howitt & Cramer, 2011)

The first step is familiarisation with the data, which means to do the interviews, transcribe them and read through the transcripts. As is usual in thematic analysis, a literal transcription of the text was generated, so without denoting pauses in speech, acceleration in speech, etc. This stems from the realist perspective on the text, the belief that the text represents a basic reality and so can largely be understood literally (Howitt & Cramer, 2011).

The second step is to give an initial code to a piece of text, meant to capture the essence of that segment of text (Howitt & Cramer , 2011). In this project, this was done physically, by printing the transcripts, cutting out pieces of text representing a single idea and writing a code, a few words, to describe the essence of that piece of text.

In this project the codes were generated using an inductive analysis, which entails a process of coding the data without trying to fit it into a pre-existing coding frame, or the researcher's analytic preconceptions (Braun & Clarke , 2006) So the codings are meant to flow from the data, rather than being preconceived, or based on existing theory.

The third step is searching for themes based on the initial coding. Themes identify major patterns in the initial codings and so are a sort of second level of interpretation of the text where the analyst focuses on the relationships between the codings (See Figure 13) (Howitt & Cramer, 2011). In this project this was done by physically move the cut-out pieces of text around to group similar codings and define an overarching theme for that group on a post-it note (See Figure 14).

The fourth step is to go over all the themes and to check whether the content of the themes accurately reflects the theme's description. This can lead to abandoning or modifying themes or split up themes into new ones.

Theme definition and labelling is the fifth step and is about refining the definition and labelling of the themes, de-



Figure 13 - Relationship between text, codings and theme (Howitt & Cramer, 2011)

fining what it is and what it is not. The analyst may find it appropriate here to identify sub-themes within a theme which adds to the task of defining and labelling these accurately (Howitt & Cramer , 2011).

The last step is report writing, which tells the story the researcher wants to tell about the data. The story being told relates back to the research question defined. The final report requires illustrating the analysis using extracts from the data (Howitt & Cramer, 2011).



Figure 14 - Defining themes in the interview data

Test Results - Iteration one

The user tests resulted in two types of data: The results of the SUS – questionnaire and the transcripts of the semi-structured interviews.

As mentioned, the data from the interviews was analyzed using a thematic analysis resulting in feedback on each of the prototypes individually, as well as more general topics like the overview, notifications and the preferred diary. For the full overview and quotes from the transcripts relating to the themes found in the analysis, see Appendix J – Thematic Analysis, First Iteration.

The SUS-scores range from 0-100, but are not percentages. In fact, despite the wide usage of SUS, there has been little guidance on interpreting SUS scores (Sauro, 2011). The scores were interpreted by comparing the score obtained with the average SUS score from all 500 studies conducted and then assess and classify the scores in terms of "poor" or "good", for example. For the process of calculating and interpreting the scores, see Appendix K – Interpretation SUS-Scores

This data was used to reinforce the participant's feedback or look for inconsistencies. Below is an overview of the results of the user test.



The neo-classical diary

SUS-SCORE: 57.5 ASSESSMENT USABILITY: Below average

The neo-classical diary scored below average, average being a SUS-score of 68 (Sauro, 2011). This seemed to be inconsistent however, with the interviews. In the interviews the prototype was found easy to use, which makes sense considering it is the exact same interaction as the classical diary, which scored a SUS-score of 93.125. The neo-classical diary was also the most preferred diary out of the prototypes. However, participants reported technical difficulties with overlapping text when moving to other questions via tapping the icons, so the low SUSscore was probably caused by technical difficulties with overlapping text, rather than the interaction itself.

Other themes found regarding the neo-classical diary was that the overview after each step was appreciated.



The classical diary

SUS-SCORE: 93.125 ASSESSMENT USABILITY: Good

The classical diary was assessed the best in terms of usability by the participants. The diary was found easy to use and understand, but also not very interesting to use. Time to bed

WHAT TIME DID YOU GET INTO BED?

____ 00:00∙



The analog diary

SUS-SCORE:61.875ASSESSMENT USABILITY:Below average

The analog diary also scored below average and was considered a polarizing diary, since the average score was calculated by a couple of very high scores, exceeding 90, and some average and very low scores. This is consistent with interview data, where there were polarizing opinions on the interaction. One group found the amount of numbers confusing, while the other group found it logical and fast.

The other theme discovered was that the way to add an awakening was not clear, for a variety of reasons (See below).



OTHER THEMES

PREFERRED DIARY

The preferred diary out of the three was the neo-classical diary for various reasions, See Appendix J - Themes interactions, first iteration

OVERVIEW IN THE APP

Two themes were discovered regarding the overview in the app. The first is that most participants prefer the overview after each step. This was indicated both when it was solicited as a general question after filling out the four prototypes, as well as unsolicited during after the use of the neo-classical diary.

The other entails the feedback that a legend, explaining the colors of the overview, and also more data in numbers, would clarify the overview.

NOTIFICATIONS

On the question what the preferred reminder would be for filling out the diary. Participants indicated that app-notifications, like Facebook, e.g., would be the preferred format. They also indicated that an alarm would be too intrusive.

CONCLUSIONS

The objectives of this user test were threefold:

- Gain insight into the usability and understandability of the prototypes.
- Answer the design questions defined for this iteration:
 - a) what is the preferred interaction for submitting time?
 - b) should the overview be presented after each step? Or after completion of the diary?
- Other qualitative input on the prototypes regarding what participants liked, points for improvement, preference for diaries, etc.

Insight into the usability and understandability of the prototypes was gained through participant feedback through semistructured interviews, backed up by the SUS-scores.

The first design question "What is the preferred interaction for submitting time?" cannot fully be answered yet. The dial diary was assessed the worst out three different interactions, while the interaction of the classical and the neo-classical diary showed the most promise. The opinions on the analog diary were divided among participants.

Following this data, the decision was made to develop a second iteration of prototypes of the neo-classical diary and the analog diary. The dial diary was discarded as it showed the least promise out of the prototypes. In addition, solving the issue of the interaction being hard to do motorial-wise, was deemed unlikely to be achieved because of small screen-sizes of some smartphones.

Since the analog diary was so polarizing, a second iteration was deemed to be appropriate to act on the point for improvement found in the data. The classical diary was also discarded, since it has the same interaction as the neo-classical diary. The second design question on whether the overview should be presented after each step of the diary, or upon completion, was answered in favor of the neo-classical diary.

Other qualitative input was also achieved through the interviews and included topics like the preferred diary, point for improvement regarding the overview and the preferred format of notifications, See Appendix J - Themes interactions, first iteration

Diary layouts & interactions - Iteration two

The results from the first iteration of prototyping and user testing was taken as the basis for the second iteration of prototyping, entailing new iterations for the analog diary and the neoclassical diary

Two diaries were discarded after the first iteration of user test, leaving two prototypes: the analog diary and the neo-classical diary. The themes discovered for these prototypes were improved upon with the goal of submitting them to another user test to get more qualitative input on the diaries and make a decision for a final prototype. Once again, the diaries were prototyped using Axure RP Pro.

The overviews were not adjusted yet in this iteration, since this was another quick iteration on the layouts and interactions of the prototypes and the idea generation on the data visualization was yet to be done.

The plan was to implement the feedback already received on the overviews, after the idea generation was complete and the visualizations to be implemented in the final diary were chosen. The same applies to the input on the preferred format of app notifications.

THE ANALOG DIARY

As found in the user test, the analog diary was quite polarizing in terms of usability: praised for it's fast interaction, but criticized for the confusing amount of numbers. The other theme discovered was that the way to add an awakening was not clear, for a variety of reasons. This has led to the following improvements:



The buttons for adding awakenings have been made more explicit. instead of hitting "confirm" to go to duration, the button now says "duration" (See Figure 16).



Figure 16 - Analog diary iteration 2



THE NEO-CLASSICAL DIARY

The interaction of the neo-classical diary, as witnessed in the classical diary, was found very easy to use. However, the technical difficulties with overlapping text dropped its SUS-score. The neo-classical diary was especially appreciated for the overview after each step. The points improved upon:



The overlapping text was fixed, by going through the questions in a predetermined order. The icons are still there, but the problem was caused by tapping the icons in a random order.

The confusion in the analog diary about the awakenings was, among other factors, that it was not clear what icon to hit to add another awakening. Although not indicated to be a problem in the neo-classical diary, adding another awakening is quite similar. It was decided to apply the same adjustment here: Instead of having to tap the eye-icon again, two buttons appear, with either "confirm & all done" or "confirm & add more".

Test setup - Iteration Two

The second iteration of user tests were also evaluated through user testing , using a similar approach as the first iteration.

The main objective of this user test was to make a choice for a final prototype. After the first iteration of user testing there were still a lot of points for improvement for the prototypes and their interactions, and it was deemed too early to make a choice for a final prototype.

This iteration has processed the identified points for improvement and the main goal is to find out which prototype participants would prefer to use if they were to track their own sleeping behaviors daily. The opportunity was also used to solicit more qualitative input, like what participants liked and disliked.

TEST SETUP

The setup of this test was a qualitative approach, applying semi-structured interviews and thematic analysis. Similar to previous test the setup was a within subjects design to allow for a smaller pool of participants (Cherry, 2016). This approach also allows to solicit individual preferences for prototypes.

Participants were asked fill out the analog diary and the neo-classical diary on the phone of the researcher. This approach was chosen because no adaptive views of the diaries were made yet meaning the diaries didn't fit on smaller screens in the first iteration of user tests. This was then solved by letting the participant use the researchers phone.

Upon completion of each diary, a semi-structured interview was conducted. The interviews were audio recorded. After completion of all both diaries and the specific questions for each, participants were asked which one they would rather use to track their sleep daily, and why. The bias caused by familiarizing with the diaries, and thus filling out the next one faster or more easily, was eliminated by each participant going through the diaries in a different order. The overviews presented in the diaries were still not responsive to the actual time submitted, so the participants filled out predetermined times.

The moderating technique chosen was Retrospective Probing (RP) to make sure that the opinions on the diaries were not biased by help received from the researcher, but true reflections of the interactions with the applications.

The SUS was not used this time, because the main objective of this experiment was to find out which diary the participants would rather use for extended periods of time, which may not be dependent on just usability, but also the fun of the interaction, e.g.

PARTICIPANTS

A convenience sample of eight people was recruited, participants were selected based on accessibility and/or proximity to the researcher ("Convenience sampling," 2016). Participants received and signed a consent form, containing the purpose, procedures, risk/benefits and confidentiality statements, among others, of this experiment (See Appendix L – Thematic Analysis - Second Iteration, for a Dropbox link to the experiment files, including the consent form, interview guide and transcripts).

MEASURES & ANALYSIS

The semi-structured interviews were analysed using thematic analysis in order to indicate the major themes to be found in It (Howitt & Cramer, 2011). As all thematic analyse in this project, it was executed according to the model as proposed by Braun and Clarke (2006), see Figure 12.
Test Results - Iteration two

As mentioned, the data from the interviews was analyzed using a thematic analysis, resulting in feedback on each of the prototypes individually, as well as a preference for one of the two.



For the full overview and quotes from the transcripts relating to the themes found in the analysis, see Appendix L – Thematic Analysis, Second Iteration.

ANALOG DIARY 2.0

The points for improvement seemed to have had a positive effect on the assessment of the prototype. No themes were found stating an overwhelming or confusing amount of numbers, nor were the awakenings found unclear. For some it was still harder to understand at first, because it was misunderstood that the numbers were supposed to be tapped, or the participant did not understand that the outer ring represented hours and the inner ring minutes. Remarkably, this was not found in the first iteration.

Recurring theme was the appreciation of the fast interactions, because the user only needs to tap the numbers. The opinions on the overview after each step on a separate screen were divided. Although the majority found the overview on a separate screen inconvenient a few participants felt that the overview on a separate screen helped them pay more attention to it and be more aware of it.

SLEEP DIARY 2.0

The technical difficulties were successfully resolved in sleep diary 2.0 as none of the participants experienced any overlapping text. Recurring theme for this diary was that the overview after each step was much appreciated because it gives a sense of progress and the user can see what he or she is doing.

One participant literally talked about the "overview on the same page", but it was also suggested by the results of analog diary 2.0, that the overview must be on the same page as the time input to be fully appreciated.

A side effect of resolving the technical difficulties was that the user was progressing through the questions (and thus icons) in a predetermined order, from left to right. Participants indicated they liked the sense of progress they got by progressing through the icons. A point for improvement here is that participants would like to be able to tap an icon to go back and adjust the data they submitted.

CONCLUSIONS & DISCUSSION

The main objective of this user test was to make a choice for a final prototype. Participants were asked is which prototype they would prefer to use if they were to track their own sleeping behaviors daily. The opportunity was also used to solicit more qualitative input, what participants liked and disliked for example.

The experiment resulted in six people with a preference for sleep diary 2.0 and two people with a preference for analog diary 2.0. The preferences for sleep diary 2.0 were mostly based on it being clear and straightforward to use, while advocates of analog diary 2.0 pointed out that tapping the numbers was faster. As a result of this experiment the decision was made that sleep diary 2.0 was going to be the final prototype.

DISCUSSION

The choice for sleep diary 2.0 was based on the preferences of the participants and that it was found the most straightforward to use. There were hardly any problems with using or understanding the prototype.

On the other hand, the interaction with analog diary 2.0 was found faster and even found more fun by some. One of the participants in the study, who preferred sleep diary 2.0, indicated that the choice would have been different if the overview could be on the same page in analog diary 2.0.

A case could be made that after extended use and familiarisation with the diary, participants would no longer require to have an overview after each step. And of course, there are those that liked the overview on a separate screen after each step.

So the ideal situation would be to implement both interactions in an application and make it customizable. Users could choose which interaction they like and could opt for an overview after each step, or upon completion of the diary. In this project, due to time constraints, it was not possible however to create a customizable diary with multiple input modes and thus the decision was made to go forward with sleep diary 2.0

Persuasive techniques Sleep Dlary

The next step in developing the application was to decide which persuasive techniques to implement throughout the app, as defined in the conceptual model of the sleep diary.



PERSUASIVE TECHNIQUES

This was done by making a user journey of a day of CBT-I, doing literature research on the patient experience in insomnia research, brainstorming with other students how persuasive techniques could be used, based on the findings and more idea generation, using the brainstorm cards with persuasive techniques, see Appendix D – Brainstorm Cards PT.

USER JOURNEY & PATIENT EXPERIENCE IN CBT-I

The target group of the sleep diary being developed, is insomnia patients. However, it is hard to contact this target group directly. It is not possible via Kempenhaeghe, because of the regulations about patient privacy, and attempts to contact insomnia patients via several online forums in the M2.1 semester, did not lead to any responses.

To gain more insights into the process and patient experience during CBT-I, a user journey was made based on the treatment process as defined by the GGZ protocol book (Verbeek & van de Laar, 2015), and a literature research on the patient experience was conducted.

THE PROCESS OF CBT-I

The structure of CBT-I, as defined by the GGZ protocol book includes seven sessions at the clinic with the therapist and two follow-up sessions. The time in between sessions varies from one up to two weeks. The follow-up sessions are one month and three months respectively after treatment completion,

To be treated at a sleep clinic, the patient first needs a referral from either their general practitioner or a specialist in a hospital. Before visiting the clinic for the first sessions, the patient receives forms in the mail to complete before the first session. These include a sleep questionnaire and a sleep diary.

In between each session the patient has some homework, which is build up progressively. It starts with the sleep diary, a sleep registration form and a "solution-oriented thinking" form and along the way forms and exercises are added, like relaxation techniques, sleep restriction therapy and stimulus control, as described in the "backgrounds" chapter. When treatment is done, the patient will have read roughly 31 pages of info and will have filled out 28 forms, of which at least eight are one-week sleep diaries.



LITERATURE RESEARCH USER EXPERIENCE

To get an idea of the patient experience, three papers were dissected on this topic. The first is called "The Insomnia Patient Perspective, a Narrative Review" (Cheung, Bartlett, Armour, & Saini, 2013). The paper explores how the patient perspective has been described within insomnia research literature, with the patient perspective including patient variables such as needs, expectations, preferences, satisfaction, or subjective experiences of people seeking and or using healthcare. 13 996 articles were retrieve from three databases in this literature review and submitted to various selection processes. A total of 72 papers were eventually read and 43 43 highly relevant articles were included in the paper.

The paper uncovered interesting aspects of the patient perspective, like a possible disconnect between patient's definition and the clinical definition of insomnia . Instead of quantifying hours, insomnia is mostly described by patients in terms of its disabling daytime impacts.Other examples, among many others, of the patient perspective include the stigmatization of insomnia, causing a feeling of isolation among insomnia patients and that maladaptive beliefs about insomnia and sleep are common among insomniacs and contribute to the maintenance of insomnia.

The second paper explores the experiences of insomnia patients in Sleep Restriction Therapy (SRT), focusing on clarifying possible side-effects, challenges to adherence and implementation and perceptions of benefit/impact (Kyle, Morgan, Spiegel-



User journey CBT-I

halder, & Espie, 2011). Some important conclusions of the paper included the side-effects of initiating SRT, reporting fatigue/ exhaustion (100%), extreme sleepiness (94%), reduced motivation/energy (89%) and headache/migraine (72%) Interviews also discovered the challenges to adherence, as experienced by the participants and their coping strategies to facilitate adherence.

The third paper discusses the relationship between the therapist and the patient as a predictor for the outcome of CBT-I (Constantino et al., 2007). The paper highlights that a therapist perceived as critically confrontive, leads to higher drop-out rates in therapy and less treatment satisfcation. Reversely, participants perceiving the therapist as higher in affiliation, showed a greater reduction in sleeping problems.

THE USER JOURNEY

To get a good overview of the patient experience/perspective and to relate it back to the treatment process, an illustration was made of one day in the life of an insomnia patient in an advanced stage of CBT-I, including filling out the forms, relaxation exercises, SRT and of course filling out the sleep diary (See figure 18). The illustration was then copied to an A format and all relevant insights of the papers regarding the patients experience were written on post-it notes and added to the illustration in corresponding spots. For example, the feeling of isolation and the stigmatization of insomnia was added to the spot in the day where the insomnia patient is lunching with his colleagues.

BRAINSTORMING & IDEA GENERATION

With the new insights on the user experience, a brainstorm with a group of four Tu/e students, also doing a project involving a sleep diary, was conducted (See figure 19). The goal of the brainstorm was to explore how the persuasive techniques as defined by B.J. Fogg (2003) could be applied to insights of the user journey.



Figure 19 - Brainstorm persuasive techniques

Other tools used in the brainstorm were the brainstorm cards, containing the definition of the persuasive techniques, along with an example of it's application, see Appendix D – Brainstorm Cards PT.

The brainstorm started with a couple of minutes to familiarize with the user journey and read the insights on the post-it notes. Consequently, a brainstorm card was read out loud and a timer was set for a couple of minutes to think about how that particular technique relates to the user journey and could be applied to the diary. Ideas were written or drawn on post-it notes and grouped on a separate paper. Once time expired, the results were discussed and the process was repeated until there were no brainstorm cards left.

IDEA GENERATION

The ideas from the idea generation were visualized through sketching, see figure 20, as most ideas were still scribblings on post-it notes. Then more time was spent on analysing the user journey for generating more ideas and identifying design opportunities for the sleep diary. For an elaboration on five design opportunities identified from the user journey, see Appendix M – Insights User Journey. Not all design opportunities can be applied in this project , because it is specific to SRT e.g., but are still discussed there for future development.



Figure 20 - Sketches persuasive techniques

Implementation Persuasive Techniques

Following the brainstorm, idea generation and identification of design opportunities for the sleep diary, the selected persuasive techniques were implemented in the app

This chapter presents an overview with the persuasive techniques implemented in the app, see figure 21, and an elaboration on each technque. The final prototype was renamed to something more commercial: "Sleep Buddy". The annotations in figure 21 correspond with the headers in the text:

INCREASE PERCEIVED CREDIBILITY

The first step applied was trying to make the app look as credible as being trustworthy and incorporating expertise. According to B.J. Fogg (2003), perceived credibility consists of two factors: perceived trustworthiness and perceived expertise. He goes on to state that computing technology that is perceived as trustworthy (fair or unbiased) will have greater persuasive powers.

Perceived expertise entails if the user view the technology as incorporating expertise. If the user of a technology perceives the developer of the technology as knowledgeable and competent on that specific subject, it will have increased powers of persuasion. Many cues lead users to view a source as inhabiting expertise (such as a white lab coat) (Fogg, 2003). An effort was made to optimize credibility within the app by conveying the expert sources behind the app (Kempenhaeghe logo, doctor icon)

CUSTOMIZED LOGIN

The user of the app is provided with their own log-in codes and sees their name upon login. This has a number of reasons behind it:

REDUCTION TECHNOLOGY

The first advantage of this approach is that the user doesn't need to create his or her own log-in codes and can login with the ones provided. This is an example of a reduction strategy. It increases the benefit/cost ration of a behavior by reducing the steps to log in.

THERAPEUTIC ALLIANCE

One of the design opportunities defined from the user journey was the opportunity to design the app in a way to strengthen the relationship between therapist and patient. Another word for this relationship is therapeutic alliance.

Studies found that perceiving the therapist as higher in affiliation results in a greater reduction in sleep problems, especially so among patients with low expectations for improvement. In contrast to that, perceiving therapists as critically confrontive was generally associated with less treatment satisfaction and people who dropped out of therapy experienced their therapist as more critically confrontive as well.

A quality therapeutic alliance was defined as affiliative, autonomy granting and devoid of hostile control or critical confrontation (Constantino et al., 2007)

The personalized log-in screen, in combination with a welcoming and supportive message from the virtual doctor is an effort to strengthen this therapeutic alliance.

INCREASE PERCEIVED CREDIBILITY





FIGURE 21 - OVERVIEW PERSUASIVE TECHN

IVIA



QUES FINAL PROTOTYPE SLEEP BUDDY

RECIPROCITY

People will feel the need to reciprocate (return the favor) when computing technology has done them a favor (Fogg, 2003). By providing the login codes to the patients, the clinic has done something for them. This is emphasized by the message on the second screen when asked to set an alarm: "We have set up your account for you". The goal of this setup is that the user of the app will repay the favor by setting a reminder for themselves.

Reciprocity is a social dynamic, which only works when users infers a social presence in a computing product. This can be done, among other possibilities, through physical cues, like a face or body and by adopting social roles like a teammate, opponent or doctor (Fogg, 2003). The sleep diary infers a social presence by presenting a physical cue that takes on the social role of a doctor.

SELF-SET REMINDERS

Notifications could be given automatically, most popular apps on a phone never ask explicitly to set notifications. However there are some advantages of a self-set reminder:

WE SEEK TO BE CONSISTENT WITH PAST BEHAVIORS

Research has shown that the past actions of a person is an excellent predictor of that persons future actions. In a study involving researcher asking people to place a "drive carefully" signs in their front yard, a difference of 59% was found between groups refusing to place a much smaller "be a safe driver" sign and those who accepted the first request. (Eyal, 2014)

So, little investments, such as setting a reminder, can lead to big changes in future behavior. Filling out the sleep diary in this case.

ABILITY TO DECLINE

As stated earlier, a quality therapeutic alliance is autonomy granting. So it was deemed better if the user would set his/her own reminders and also have the opportunity to decline.

CONTACT THERAPIST

The icon on the main screen with the doctor allows the user to send a message to their therapist when stuck or when they have a question. The message is then forwarded to the therapist and the users will receive an answer once the therapist has found time to do so. This has a couple of advantages:

THERAPEUTIC ALLIANCE

As mentioned, a quality therapeutic alliance is important. Constantino et al. (2007), mention that patients with low expectations for improvement may have a particular need to experience their group therapist as supportive tolerant and understanding while working through their prognostic doubts. Being able to send questions aims to help in that respect and improve the relationship between patient and therapist.

PERCEIVED CREDIBILITY

Research on web credibility shows that the more responsive to users, the greater the perceived credibility of a website is (Fogg, 2003). In this case it is up to the therapist who has to reply to the questions, but there is an opportunity here to increase credibility.

RE-CONTEXTUALIZE MALADAPTIVE BELIEFS

Research has shown that maladaptive beliefs about insomnia and sleep are common among insomnia patients and contribute to the maintenance of insomnia which can affect treatment responses (Cheung, Bartlett, Armour, & Saini, 2013). Being able to ask questions to the therapist might help re-contextualize some of those maladaptive sleep beliefs and positively influence treatment responses.

COMMENTS

Research has shown that patients sometimes experience a disconnect between the clinical definition of insomnia and their definition of insomnia. Patients define it mostly in terms of disabling daytime impacts, rather than quantifying their sleep. This often results in a felt need to convince their therapist of the seriousness of their problem (Cheung, Bartlett, Armour, & Saini, 2013).

The diary provides elaborate opportunity to leave comments about their night. How they feel, why they slept bad, etc. Requesting an opportunity to leave comments in a sleep diary was also one of the most consistently recurring themes in the development of the Consensus Sleep Diary (Carney et al,2012).

"ENTRY RECEIVED"

Fogg states that using technology to observe others' behavior increases the likelihood of achieving a desired outcome (Fogg, 2003). Crucial in surveillance technology however is that it must be overt and accepted. By letting the user know that their entry was received, the app lets the user know that their behavior is being tracked and something is done with it. Which is a form of accepted and overt surveillance.

FACTS & TRIVIA

As stated, maladaptive beliefs can affect treatment responses. Facts & trivia provided in the app are meant to re-contextualize some of these sleep beliefs. The idea is that these change daily, in which case it could also be seen as a type of reward, depending on how much the user appreciates them.

CALCULATION SLEEP EFFICIENCY SCORES

Although not conceived in this idea generation, calculating SE-score automatically, also increases the benefit/cost ration of a behavior and is thus an example of reduction technology

LONG-TERM OVERVIEWS

Fogg (2003) defines self-monitoring technology as follows:

"applying computing technology to eliminate the tedium of tracking performance or status helps people to achieve predetermined goals or outcomes"

The app allows the user to track their treatment progress and discover patterns in sleep behavior, feeding the natural human drive for self-understanding (Fogg, 2003).

(This particular PT was not implemented yet for this user test, but was implemented in the final prototype).

User Test - Persuasive techniques

After implementation of the persuasive techniques, the diaries were once again assessed using semi-structured interviews.

The objective of this user test was to gain insight into how different aspects of the persuasive techniques were perceived, as well as more general input on what participants liked and disliked. The results can then be used to improve the prototype

Most persuasive techniques cannot be asked directly, as it would happen unconsciously. It is impossible to ask "Since your app account was set up for you, do you feel the need to reciprocate and set an alarm?, for example. Some questions that could be asked included how trustworthy participants found the app, if they felt the app gave them enough support and how the presence of the virtual doctor was perceived.

TEST SETUP

The setup of this test was a qualitative approach, using semi-structured interviews and thematic analysis to discover themes in the data. Participants were asked to fill out Sleep Buddy on the phone of the researcher and upon completion, as semistructured interview was conducted. The interviews were audio recorded.

The moderating technique chosen was retrospective probing, which means not asking any questions until the task is complete (Romano Bergstrom, 2013). Usually this is done to avoid interfering with assessments of usability, which in this case would apply to the text to be read, if this was self-explanatory.

PARTICIPANTS

A convenience sample of five people was recruited. Participants received and signed a consent form, containing the purpose, procedures, risk/benefits and confidentiality statements, among others, of this experiment (See "Appendix N – Thematic Analysis Persuasive Techniques, for a Dropbox link to the experiment files, including the consent form, interview guide and transcripts).

MEASURES & ANALYSIS

The semi-structured interviews were analysed using thematic analysis in order to indicate the major themes to be found in It (Howitt & Cramer, 2011). As all thematic analyse in this project, it was executed according to the model as proposed by Braun and Clarke (2006), see Figure 12.

The anlysis of the data was slightly different this time, in terms of coding. In the other user tests, codes were generated using an inductive analysis, which entails a process of coding the data without trying to fit it into a pre-existing coding frame, or the researcher's analytic preconceptions (Braun & Clarke , 2006) So the codings are meant to flow from the data, rather than being preconceived, or based on existing theory.

This is true in this case again for the more general questions such as: "What did you like most about the diary?". On the other hand, some questions, like "Overall, how trustworthy did you find the application? why?", were based on existing theory that the Kempenhaeghe logo and the presence of the virtual doctor would positively influence the perceived credibility of the app. Thus that particular category was preconceived and an example of deductive coding.

TEST RESULTS

The user test resulted in feedback on different aspects of Sleep Buddy, such as the virtual doctor, personalization and the diary layout. For the full overview and quotes from the transcripts relating to the themes found in the analysis, see Appendix N - Thematic Analysis Persuasive Techniques.

THE VIRTUAL DOCTOR

One of the worries about the virtual doctor being present throughout Sleep Buddy was that it might be found intrusive by the users of the app. Upon data analysis, it was found that this was not the case. However, one participant was particularly irritated by a piece of text in the results section: "Your entries helps your therapist to track your progress and treat you better!"

The participant felt that if the diary would show that each day, it would become very annoying and even pushy. So the decision was made to remove that piece of text and leave it at: "Thank you! We have received your entry!" Furthermore, all participants understood that the virtual doctor was in fact a fictional, computer generated character and not representing an actual person.

PERSONALIZED WELCOME SCREEN

Before starting each user test, the prototype was quickly customized to contain the name of the particular participants. This personalized welcome screen was noticed and appreciated by participants, as participants generally reacted positively to seeing that the app knew their name.

DIARY LAYOUT

Remarks on the diary layout was that it looks trustworthy, for a variety of reasons, including: the company logo, being able to contact the therapist and the "nice symbols".

A point for improvement was that the available help in the app could be made more visible. One participant suggested to make the blue "info" button bigger, containing additional info on the questions. From observations it was also noted that none of the participants tapped the info button when indicating confusion about questions afterwards.

Another participant did not understand that the doctor could be tapped for help, which was indicated at the welcome screen of the diary. So the decision was made to make the blue info button bigger and the text on the welcome screen shorter, to improve chances of users carefully reading the info.

USE OF THE DIARY

Recurring theme from earlier iteration on the interactions, was that Sleep Buddy was found easy to user.

A few users did indicate that they did not understand the "awakenings" question, for varying reasons. One participant did not understand the wording of the question and the information underneath the "Info" button clarified it.

Most participants indicated they would like to see improvement in the "default times" displayed by the app. As a default option in this prototype, the current time of the day would be displayed. When you are filling out times of last evening in the morning, this is not optimal. Users would also expect that when a time is indicated that a person went to bed, the next question, when the lights were switched off, should at least start from the time that was filled out in the last question.

Participants who did set an alarm, indicated that they did so because filling out a diary is something that could be forgotten in morning routines.

CONCLUSIONS

The user test led to feedback on what is appreciated in Sleep Buddy, as well as points for improvement. These include adjustments to dialogs, making the blue "info" button bigger and adjusting the default times of the questions.

Idea Generation Data Visualization

he next step in developing the app, was the data visualization.

Both the daily overviews with the total sleep time and sleep efficiency, e.g. and the long-term overviews.





Figure 22 - Sketches Data Visualization

The data visualization development started with sketching possible ways how to visualize relevant data(See figure 22), inspired by examples of data visualization on Pinterest. All feedback from every user test on the overview was gathered and taken into account in the idea generation. Feedback included having a legend, making the range of the circle explicit and presenting the data in numbers as well.

After the initial idea generation, the sketches were discussed with Dr. Mathias Funk of the Tu/e and an expert on data visualizations. The notes of that meeting can be found in Appendix O – Feedback Data Visualization.

DATA VISUALIZATION IN SLEEP BUDDY

As mentioned earlier in the report, the plan for the overviews was to implement the feedback already received through the user tests, after the idea generation was complete and the visualizations to be implemented in the final diary were chosen.

Due to time constraints, it was not possible anymore to run a user test on the preferred visualizations and prototype a different, working, visualization. So the decision was made to keep the current visualization in Sleep Buddy and apply the feedback to that visualization.

Markers were added to indicate the scale of the ring, the icons were added to the overview in full color to serve as a legend (See figure 21) and each icon can be tapped to see the corresponding data in numbers (See figure 23). As a long-term data visualization a simple, one week, bar graph was added containing the SE-scores, together with info of what is considered a good SE-score.



Figure 23 - Data Overview

Prototyping Sleep Buddy

For the final user test, the final prototype of Sleep Buddy was assembled.

The persuasive techniques and reminders were already added to the diary framework as part of the PT user test, but many challenges remained to finalize the prototype.



PROTOTYPING

The main challenge to make a fully functioning prototype was making the overview responsive to the data submitted. Up until this point the overview had been a set of images, which was thus only representative of the data when the times were submitted as instructed by the user tests.

MAKING RESPONSIVE OVERVIEWS

The original plan was to remake the prototype in HTML and CSS, to that end two courses on CSS and HTML were completed during the semester. However, when the time came to make the final prototype, the skills and knowledge on the two programming languages was deemed insufficient.

Case Name	Case 1	Edit Condition	Clear Condition						
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⊿ Open I Cu	Enter text below. To insert variables or expressions, surround the variable name or expression with "[[" and "]]". For example, "[[OnLoadVariable]]" or "The sum is [[VarA + VarB]]". The current page name can also be inserted using [[PageName]].								
Ne	Insert Variable or Function								
Po	[[Time_in_bed-((((Duration_awakening_1+Duration_awakening_2+Duration_awakening_3)/15)*0.25) +								
Pa	((((Hours_degrees_Q2*15) + ((Quarters_degrees_Q2/15)*3.75)) - Startpoint_mask)/15) + (SOL * 0.25))]]								
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Figure 24 - Mathematics in Axure

Thus it was decided to make the final prototype in Axure as well, making use of math and functions (see figure 24) to make the overview rotate to the position corresponding with the time submitted and presenting accurate total sleep times and SE-scores. Once the updated data visualization was completed (including improvement points from the user tests), long-term overviews were also added to the prototype.

To make the data visualization of the week bar graph representative for the final user test, the data filled out would have needed to be stored locally or on a server. First it was attempted to make the prototype write the user-submitted data to a text file on a webserver, but this attempt failed.

So a workaround was created involving the sending of e-mails. Once the user would tap the "Confirm & all done!" button to go to the overview, a pop-up email message would appear. The email was addressed to the researcher and the body of the email contained the data submitted, so all the user would have to do is hit "send". The researcher would then adjust the overview for the previous day manually, making the week overview representative for the following day.

The same was applied to setting actual reminders. Once the user had decided whether he or she wanted a notification or not, that info, including at what time (if applicable) would appear in a pop-up email. The researcher would then send the participant automated text messages at their specified times to remind participants to fill out the sleep diary.

ADAPTIVE VIEWS

Another prototyping challenge was that of different screen sizes. In earlier iterations a problem occurred with the diary not fitting on smaller screen sizes. To solve that, some adaptive views were prototyped. This means that the diary automatically adjusts to different screen sizes.

OTHER POINTS FOR IMPROVEMENT

Some points for improvement still remained from earlier user tests, which were gathered in one document – See Appendix P – Improvement Points Final Prototype. Not all points could be implemented due to time constraints, but some examples that were implemented include adjusting the default times of questions, making a custom time-field (no pop-up) and adjusting the text in the diary.

TRANSLATION OF THE APP

In earlier iterations the questions of the consensus sleep diary were used because the construction and wording of the sentences has been developed iteratively through focus groups. Lexile analyses suggested easy reading levels(Carney et al, 2012).

For the final user test however, statistical comparisons are made between the current Kempenhaeghe sleep diary and Sleep Buddy.

Since the finalized product is going to be used in Dutch and to avoid any bias in comparing adherence and user experience results, the questions from the consensus sleep diary were translated to Dutch. To do so, two translators translated each item individually without them seeing each other's results. One completed, the translated items were compared, discussed, and a consensus was reached on the final translation of the item.

DIALOG BOX ESTIMATIONS

One of the underlying factors identified at the outset of this project was that patients don't fill out their sleep diaries, because it's hard to remember all relevant timespans of the previous night (and thus not quickly done). Since the decision was made to not use sensor data, users of the app cannot be helped via that way.

Alternatively, a dialog box was implemented stressing that the diary is about estimations and not exact numbers, if a user spends too much time in one particular screen. This is aimed at reducing pressure of trying to fill out exact numbers and making the diary faster and less stressful to fill out (see figure 25).





Final User Test

At the start of the project the following problems and underlying factors were identified:

- 1. Patients don't fill out their sleep diaries, because:
 - It's not done quickly. This is because it's hard to remember all relevant timespans of the previous night
 - Patients forget
- 2. Patients fill out their diaries too late or inaccurately, because:
 - Patients fill out their diary without thinking about it after they initially forgot in the morning

Another pain point of the pen-and-paper diary is that it's non-digital, thus only reviewable for medical staff whenever the patients visits them. Also, converting a paper diary to a digital one is a time consuming process.

The goal of the project therefore, was to develop a digital sleep diary that patients will fill out on time daily and consistently, benefiting insomnia treatment. An approach was sought to achieve this goal in a way that would be interesting to all stakeholders involved.

The developed sleep diary aims to achieve both of these goals through implementing a proposed conceptual model in a mobile application that features reminders, a simple and understandable interaction and both day- & long-term overviews of sleep data, including sleep efficiency scores as the most important score. Throughout the app persuasive techniques have been implemented in order to influence the attitudes and behaviors of the apps user. The application has been named Sleep Buddy.

OBJECTIVES & RESEARCH QUESTIONS

The main objective of the final user test is to assess whether the goal of increasing consistency of users filling out the diary daily and on time, has been achieved through the use of Sleep Buddy. This can be assessed by comparing the adherence, to filling out the diary daily, between a group using Sleep Buddy and a group using the Kempenhaeghe, pen-and-paper, sleep diary. The following research questions was identified:

"Does the use of Sleep Buddy lead to more consistently in filling-out the diary on time each day, compared to the Kempenhaeghe, pen-and-paper, sleep diary?"

The hypothesis for this research question is that the use of Sleep Buddy will indeed lead to a higher consistency in filling out the sleep diary daily, compared to the Kempenhaeghe sleep diary. Or in other words: the expectancy is that users of sleep buddy will have filled out the diary on time more days on average, then the users of the Kempenhaeghe sleep diary.

Secondary objectives of this research experiment is to assess the user experience of Sleep Buddy in order to see how the diary might be improved as well as having a benchmark for future iterations of the diary, and to solicit qualitative input on the diary to identify points of improvement.

EXPERIMENT SETUP

The setup of this experiment is a between-subjects or independent measures design, every participant is only subjected to a single treatment (Agresti & Franklin, 2007). The experiment consists of two groups assigned to fill out a sleep diary each morning. One group will be given the pen-and-paper sleep diary from sleep clinic Kempenhaeghe and the other group will be given the designed sleep diary application called Sleep Buddy.

This approach was chosen to limit a loss of interest in the experiment and boost completion rate. For example: if a group would enter a 7-day experiment with one sleep diary and then a 7-day experiment with the other sleep diary (within-subjects design), they might lose interest in the experiment and not fill out the questionnaire at the end of the experiment. Especially with Christmas and the related holiday then coinciding with the experiment.

Assignment bias, where groups have different characteristics but are compared as if similar, is limited by sampling from a homogeneous group.

Both groups will enter a seven-day experiment with the assignment to fill out their sleep diary within 60 minutes from waking up. The participants in the group that uses the Sleep Buddy, will have the opportunity to set reminders to fill it out. The group with the pen-and-paper diary from Kempenhaeghe will not receive any reminders.

At the end of the experiment participants filled out a questionnaire where they could submit the number of entries made on time, out of the seven days. The questionnaire also contained the insomnia severity index for screening purposes.

In addition, for the users of Sleep Buddy, the questionnaire also contained the user experience questionnaire to assess the user experience of Sleep Buddy and additional questions to solicit feedback on what participants (dis)liked about different aspects of the app, like the data visualization, e.g.

The experiment & questionnaire were first performed in a pilot test and adjusted prior to the actual experiment. For a link to the experiment files including consent forms and the filled out questionnaires, see Appendix P – Sleep Diary Questionnaire.

EXPERIMENT SETUP

Since insomnia patients are very hard to find and recruit for this study, the decision was made to test the prototypes on non-insomnia patients.

To ensure a homogenous group and limit assignment bias, a list of relevant criteria was made that each participant should match:

- 1. The participants should be ranging from 18 to 34 years old
- 2. The participants should own a smartphone and use it on a daily basis for at least a year prior to the experiment.
- 3. The participants should not be diagnosed or treated for any sleep disorders.

These criteria are meant to make sure that participants have about the same skill using mobile devices and that the amount of data to fill out the diary is roughly the same (people with sleep disorders may have a lot more awakenings to fill out, e.g.)

The age group is based on research indicating that millennials (aged 18 to 34) are much more likely to be smartphone users compared to those aged 35 and older (Poushter, 2016).

At first educational level was listed as a criteria, but research shows that although education is strongly related to people's health behaviors (Pampel, Krueger, & Denney, 2010), the influence of educational level on non-compliance is equivocal. It seems that educational level may not be a good predictor of therapeutic compliance (Jin, Sklar, Min Sen Oh, & Li, 2008).

Participants were recruited through personal contacts and on the campus. Potential participants were asked about their age, smartphone use and if they had any sleep disorders. If all the criteria were met, the potential participant was given a consent form with the information regarding the study, confidentiality, among other aspects. A participant agreed to take part in the study by signing the consent form.

A total of 34 participants were recruited for this study. Participants were randomly assigned to either the group using the Kempenhaeghe sleep diary or the Sleep Buddy group.

MEASURES & INSTRUMENTS

An online questionnaire was composed using Qualtrics, were participants could submit the number of days they had actually filled out the diary on times. Other components of the questionnaire were the Insomnia Severity Index (ISI), the User Experience Questionnaire (UEQ) and additional questions to solicit feedback on different aspects of the app. For the full questionnaire, see Appendix P – Sleep Diary Questionnaire.

THE INSOMNIA SEVERITY INDEX

The ISI, developed by Morin, Vallieres & Bastien, is a questionnaire used to assess the "nature, severity, and impact of insomnia and monitor treatment response in adults" (American Thoracic Society, 2016). It is a seven-item questionnaire with a five-point Likert scale (from zero, meaning no problem and four meaning very severe problem).

To make sure that the amount of data filled out by users is roughly the same, people without any diagnosed or treated sleeping problems were recruited. In this experiment the ISI was used as a post-experiment screening tool to validate if a participant indeed didn't have any sleep disorders. Any participant with an ISI score of 15 or higher, indicating clinical insomnia with moderate severity, was considered an outlier. Their data was not used further in the analysis.

THE USER EXPERIENCE QUESTIONNAIRE

The UEQ allows for a quick assessment of the user experience of interactive products (Hinderks, 2016). The UEQ measures different aspects of classic usability and user experience aspects, divided over six scales (Schrepp, 2015):

- Attractiveness: Overall impression of the product. Do users like or dislike the product?
- Perspicuity: Is it easy to get familiar with the product? Is it easy to learn how to use the product?
- Efficiency: Can users solve their tasks without unnecessary effort?
- Dependability: Does the user feel in control of the interaction?
- Stimulation: Is it exciting and motivating to use the product?
- Novelty: Is the product innovative and creative? Does the product catch the interest of users?

The UEQ is a 26-item questionnaire with seven-point semantic differentials, which means that each item is represented by two terms with opposite meanings. The order of the items is randomized, so half of the items start with the positive term, en vice versa, in order to detect any participants that might have filled out the scale carelessly.

Three typical application scenarios of the UEQ are to compare the user experience of two products, to assess if the product has sufficient user experience and to determine areas of improvement.

In this experiment the data is used to determine areas of improvement and to establish an overall assessment of the user experience which can be compared with future iterations of Sleep Buddy.

Quantitative Data Analysis

The quantitative data regarding the adherence scores between the groups was analysed using SPSS Statistics, following instructions from the SPSS Survival Guide by Julie Pallant (2007). These are the global steps that were followed:

A) WRITE CODEBOOK FOR ANALYSIS IN SPSS

Quantitative analysis was done in the program SPSS Statistics. Before the information from the questionnaires can be entered, it is necessary to prepare a codebook. This is a summary of the instructions used to convert the information obtained from each subject or case into a format that SPSS can understand (Jullie Pallant, 2007) In a codebook the full variable name is listed, as well as the SPSS variable abbreviation and the coding instructions. Which informs the reader and other researchers working with the data, which number has been assigned to what answer, see figure 26 – Codebook SPSS

Full variable name	SPSS variable name	Coding instructions
Identification number	ID	Subject Identification number
Insomnia Severity Index	ISI	Insomnia Severity Index Score
Diary Version	Version	1 = Pen and Paper 2 = Phone
Amount of diary entries	Total_fill	Amount of days the diary was filled out
Did the user set a notification	Notification	1 = Yes 2 = No

Figure 26 - Codebook SPSS

B) SET UP DATA FILE, SCREEN AND CLEAN THE DATA

After the codebook had been completed, the data file was set up in SPSS. The SPSS variable names, as defined in the codebook, were entered into SPSS and the variable types are defined (categorical, continuous, e.g.) after that the data is screened for so called "outliers", or extreme scores as well as impossible score (score of 6 on a 5-point Likert scale e.g.) In this case there was also a threshold for the ISI. Two cases were removed because of a score of 15 on the ISIS, indicating a clinical insomnia with moderate severity.

C) ASSESS THE NORMALITY OF THE VARIABLES & CHOOSE SUITABLE STATISTICAL ANALYSIS

Many of the statistical techniques, so called parametric tests, assume that the distribution of scores on the dependent variable is "normal". Normal is used to describe a symmetric, bell-shaped curve, which has the greatest frequency of scores in the middle, with smaller frequencies towards the extremes.

Before being able to make a decision on which statistical analysis to perform, the normality of the variables has to be assessed. A Shapiro-Wilk test was used to assess the normality of the variables, since empirical testing has found that Shapiro–Wilk has the best power for a given significance (Razali N & Wah Y B, 2011) and it is more suitable for smaller sample size (<50) ("Testing for Normality using SPSS Statistics," 2013). After assessing the normality of the variables, an informed decision can be made on which statistical analysis to use to answer the research questions.

D) RUN TESTS, INTERPRET RESULTS & DRAW CONCLUSIONS

After running the tests, the outcomes are interpreted and reinforced with graphs, histograms, boxplots, etc. to visualize the outcomes. As a last step, conclusions are drawn from the results, research hypothesis are retained or rejected and research questions answered.

OVERALL DATA OBSERVATIONS

After further analyses two participants from the 'phone' group were removed from the data. These participants had a score of 15 on the Insomnia Severity Index, indicating clinical insomnia with moderate severity. Consequently after removing these participants, the 'phone' group consisted of 12 participants.

To give some insights into the data collected, some overall data observations are listed here. The observations make distinctions between the group that used the Kempenhaeghe sleep diary and the group that used Sleep Buddy.

EXPERIMENT COMPLETION RATE

Of the 34 participants recruited for this experiment, 25 filled in the questionnaire (73,5%). Of the 'pen and paper' group, 11 participants filled in the questionnaire (64,7%) and of the Phone group, 14 participants filled in the questionnaire (82,4%).





The histograms show the amount of days the participants filled out their sleep diaries, including the mean of the groups and the standard deviation (see figure 27 – Histograms diary versions). Upon inspection of the histograms it seems that the Sleep Buddy group did not result in higher adherence than the pen-and-paper sleep diary.

CHOOSING A SUITABLE STATISTICAL ANALYSIS

An important factor in being able to choose the right statistic is the normality of the variables. the normality of the variables was assessed through Shapiro-Wilk tests. A non-significant value on the Shapiro-Wilk test (value of more than 0.05) indicates normality.

Tests of Normality										
		Kolmogorov-Smirnov ^a			Shapiro-Wilk					
	Which version	Statistic	df	Sig.	Statistic	df	Sig.			
Total days of filling in the	Pen and Paper	,290	11	,010	,761	11	,003			
diary	Phone	,300	12	,004	,847	12	,034			

a. Lilliefors Significance Correction

Table 1 - Tests of normality

A Test of Normality was conducted to assess the normality of the distribution of scores separately for both groups. The Shapiro-Wilk statistic was significant for both groups suggesting violation of the assumption of normality, see table 1 - Tests of Normality

INDEPENDENT-SAMPLES T-TEST.

To compare the effects of the version (pen-and-paper/phone) on the amount of days the diary was filled outs, an independentsamples t-test can be used.

An independent samples t-test is used when the researcher wants to compare the mean score, on some continuous variable, for two different groups, which would fit the description above. However, this is a parametric test and in this case, not all of the data is normally distributed.

For the normally distributed data the t-test would seem like the way to go, since there is one categorical independent variable (pen-and-paper/phone) and there is one continuous dependent variable (amount of diary entries). For the non-normal distributed data, a non-parametric alternative must be used, which would be the Mann-Whitney U Test.

MANN-WHITNEY U TEST.

This technique is used to test for differences between two independent groups on a continuous measure. Instead of comparing means of the two groups, as in the case of the t-test, the Mann-Whitney U test actually compares medians. It converts the scores on the continuous variable to ranks, across the two groups.

It then evaluates whether the ranks for the two groups differ significantly. As the scores are converted to ranks, the actual distribution of the scores doesn't matter. For the analysis of the data, Mann-Whitney U tests were used.

RUN TEST, INTERPRET RESULTS & DRAW CONCLUSIONS

As discussed, the Mann-Whitney U test was used to check for significant differences in the amount of diary entries between the pen-and-paper and the Sleep Buddy group. The test returned a non-significant result:

A Mann-Whitney U test revealed no significant difference in the amount of days the sleep diary was filled out between the 'pen and paper' group (Md = 6.00, n = 11) and the 'phone' group (Md = 6.00, n = 12), U = 55.50, z = -0.67, p = .51, r = .14.

ADDITIONAL TESTS

Next to the main research question a test was run to check for significant differences in the amount of diary entries between the phone group that did set a notification and those that didn't

A Test of Normality was conducted to assess the normality of the distribution of scores separately for both groups. The Shapiro-Wilk statistic was significant for the 'no notification' group suggesting violation of the assumption of normality. The Shapiro-Wilk statistic was non-significant for the 'notification' group indicating no violation of the assumption of normality.

Since both variables need to be normally distributed to safely use a parametric technique, a Man Whitney U test was used:

A Mann-Whitney U was conducted to compare the amount of days the sleep diary was filled in for the 'notification' and the 'no notification' group. There was no significant difference in the amount of days the sleep diary was filled in between the 'notification' group (Md = 5.50, n = 6) and the 'no notification' group (Md = 6.00, n = 6), U = 15.50, z = -0.42, p = .68, r = .12.

CONCLUSIONS

The performed statistical analyses conclude the testing of the hypothesis for the main research question:

"Does the use of Sleep Buddy lead to more consistently in filling-out the diary on time each day, compared to the Kempenhaeghe, pen-and-paper, sleep diary?"

The results of the comparisons between the pen-and-paper and phone groups did not return any significant results, which means the hypothesis that the use of Sleep Buddy will indeed lead to a higher consistency in filling out the sleep diary daily, compared to the Kempenhaeghe sleep diary, can be rejected.

In addition, differences in adherence between those that set a notification and those that didn't in the phone group was assessed. No significant difference was found between the groups, suggesting setting a notification does not lead to a higher amount of entries.

To get more inight into the reason for this result, the data as to why participants did not fill out the diary a specific day was inspected:

The Sleep Buddy group missed a total of 33 diary entries (37,1%). Of the entries missed, a total of seven were missed because it was forgotten (21, 2%), five because the participant was in a hurry (15,1%), three because it was forgotten the experiment had started (9,1%), one was forgotten and missed the notification (3%) and one was distracted by other apps and then thought it was done already (3%). 15 missed entries were unspecified (45,5%).

The pen-and-paper group missed a total of 22 entries (28,6%). Of the entries missed, a total of three were missed because it was forgotten (13,6%), three were forgotten because the participant was too busy in the morning (13,6%) and 16 missed entries were unspecified (72,7%).

Analysis User Experience Questionnaire

Secondary objective of this research experiment was to assess the user experience of Sleep Buddy in order to see how the diary might be improved as well as having a benchmark for future iterations of the diary.

The data from the UEQ was analyzed using the Excel tool provided by the authors of the UEQ. The tool allows it's user to enter the data of the test after which, the scale means, standard deviation, confidence intervals, etc. are calculated automatically. In addition, the tool provides visualizations and it offers a benchmark of 246 product evaluations with the UEQ (Schrepp, 2015). The tool is freely available to download at: ueq-online.org.

DATA SCREENING

The first step was to check for inconsistencies in the data. Sometimes participants answer randomly, but since all items in a scale should measure a similar construct, this can be detected by comparing how much the best and worst evaluation of on item in a scale are different. A big difference is seen as an indicator for a problematic data pattern.

If it happens for one or two scales, it does not have to be a problem, since it can also be cause by wrong item-interpretation. In the current analysis however, five instances of problematic data patterns were found in one response (out of a possible six). That participant was considered an outlier and was removed from further analysis.

RESULTS & BENCHMARK

The excel tool calculates the means of the different scales automatically. Values > 0,8 represent a positive evaluation and values < -0.8 represent a negative evaluation. The tool also provides a more visual way of displaying the means with an evaluation whether it's bad or good, see figure 28 – Scale means Sleep Buddy



The benchmark function of the tool entails that the measured scale means are set in relation to existing values from a benchmark data set. This data set contains data from 9905 persons from 246 studies concerning different products (business software, web pages, web shops, social networks).



Figure 29 - Benchmark Sleep Buddy

The mean results for all scales and the comparison of the results for the diary to the data in the benchmark allows to evaluate the relative quality of the prototype, as well as assess which points of the diary need the most work. For a graph on the comparison, see figure 29 – Benchmark Sleep Buddy

The results in numbers:

Attractiveness has a mean of .67 (SD = 1.06, 95% CI [0.09, 1.24], N = 13). This is labelled 'bad' compared to benchmark. Perspicuity has a mean of .98 (SD = 1.14, 95% CI [0.36, 1.60], N = 13). This is labelled 'below average' compared to benchmark. Efficiency has a mean of .98 (SD = 1.16, 95% CI [0.35, 1.61], N = 13). This is labelled 'above average' compared to benchmark. Dependability has a mean of .69 (SD = 0.67, 95% CI [0.33, 1.06], N = 13). This is labelled 'bad' compared to benchmark. Stimulation has a mean of .37 (SD = 1.01, 95% CI [-0.19, 0.92], N = 13). This is labelled 'bad' compared to benchmark. Novelty has a mean of .08 (SD = 0.94, 95% CI [-0.43, 0.59], N = 13). This is labelled 'bad' compared to benchmark.

CONCLUSIONS

The user experience of Sleep Buddy was assessed on six different scales: attractiveness, perspicuity, efficiency, dependability, stimulation and novelty. The goal was to assess in which areas the diary could improve as well as have a benchmark dataset to compare future iterations with.

The conclusion of the analysis is that all aspects of the diary still need a lot of work. Notable are the especially low scores on the stimulation and novelty scales, both of which are hedonic quality aspects (Schrepp, 2015). This suggests that participants did not associate the interactions with the diary with aspects of pleasure.

The data can be used to compare to future iteration of the sleep diary.

Analysis Diary Feedback

Another secondary objective of this experiment was to solicit qualitative input on the diary to identify points for improvement

The data was obtained through an online questionnaire this time, instead of semi-structured interviews. The questions soliciting input on Sleep Buddy were exported from the questionnaires and analyzed using thematic analysis. codes were generated using an inductive analysis, which entails a process of coding the data without trying to fit it into a pre-existing coding frame, or the researcher's analytic preconceptions (Braun & Clarke , 2006).

For the full overview and quotes from the transcripts relating to the themes found in the analysis, see Appendix Q - Thematic Analysis Sleep Buddy

THE WEEK OVERVIEW

The week overview was appreciated by participants, since it allowed them to compare different days. One participant indicated to compare nights and link those to particular activities of that day.

On the other hand, two participants found the overview deceiving, indicating they felt tired or sleepy, while their overview told them otherwise. Obviously, since the overview is based on their own data, it is not deceiving, but it should be a point of further investigation.

If people will perceived the overview as deceiving it will hurt the perceived credibility of the app. Options to solve this, might be to stress that the overview is based on their estimations or maybe a better option would be to enable the user to indicate the quality of their sleep and how rested they feel. This could then be presented as part of the overview.

THE DAY OVERVIEW

The daily overview was appreciated by the majority of participants and was found clear. A smaller sample does require some more explanation, indicating they didn't understand what everything meant.

THE QUESTIONS

One theme identified in the data was that the first two question of the diary caused confusion. The first question asks what time the user went to bed and the second question asks at what time the lights were switched off. For people with bad sleep hygiene habits these times might be quite different, but participants indicated that it took them a while to understand that those two were in fact not asking the same question.

The other theme was that some participants found it limiting that they could only fill out quarters, rather than minutes. They felt submitting a block of 15 minutes would be too much if they were only awake for a couple of minutes.

The reason that only quarters are possible, is that it's aimed to reduce the stress of participants trying to fill out too exact times. A possible solution here would be to clearly indicate in the app beforehand, why this is so and instructions on what to do when lying awake for only a couple of minutes.

IMPROVE ON TECHNICAL DIFFICULTIES

The experiment encountered some technical difficulties involving the pop-up emails and lphone users, unfortunately influencing the experiment negatively. So justly given feedback was to improve on those issues.

STATISTICAL ANALYSIS MAIN RESEARCH QUESTION & THE UEQ

It could not be proven that the Sleep Buddy does indeed lead to more diary entries on average, compared to the Kempenhaeghe sleep diary.

DURATION OF THE EXPERIMENT

Limitations of the study included that the experiment lasted only one week, while the actual sleep diary is usually filled out for a minimum of eight weeks in CBT-I. It would be interesting to repeat this experiment with a longer duration to see if the diaries do differ in adherence compared over longer periods of time.

TECHNICAL DIFFICULTIES SLEEP DIARY

Another factor that could have biased the results for both the adherence as well the user experience of Sleep Buddy, was the technical problems experienced by a majority of the participants. This stemmed from the workaround created for gathering the data, involving the pop-up emails.

In the case of Iphone users, the pop-up would appear, and the "send" button would be tapped, but then it would return to the start screen of the app, prompting the same pop-up email and thus making it impossible to progress to the next screen.

SAMPLING METHOD

For this experiment a homogeneous sample was recruited to account for individual differences. Important to note however, is that one effect of choosing such a specific population could be that the results cannot be generalised to a wider populations. Also a different group was recruited then insomnia patients. Since adherence to filling out a sleep diary and the user experience are the subjects of investigation, the estimation was that the being an insomniac wouldn't affect the research significantly, but this cannot be known for certain. There is a risk that the results won't correspond with the actual target group of the application.

INTERNAL CONSISTENCY DEPENDABILITY

The excel tool calculates the Cronbach's alpha for all the scales, which measures the reliability or consistency of a scale. Dependability has poor internal consistency, with a Cronbach alpha coefficient reported of .26, which could be an indication that some items of this scale were misinterpreted by some participants in the given context. Thus the scale should be interpreted carefully.

THEMATIC ANALYSIS

The approach of this thematic analysis and in this project was to do quick iterations of user testing in order to complete more iterations. This means concessions in effort made to enhance the quality of the thematic analyses, which may have affected the results. This section addresses techniques that could have been used to improve the quality and which techniques have been used.

Qualitative research is fundamentally interpretive, and interpretation represents personal and theoretical understanding of the phenomenon under study (Zhang Y & Wildemuth B M, 2009). This basically means is that different researchers might come to different results with the same data and maybe even the same codebook being used. Lincoln and Guba proposed four criteria for evaluating interpretive research work: credibility, transferability, dependability and confirmability (RWJF, 2008).

CREDIBILITY

Credibility refers to the adequate representation of the constructions of the social world under study. A set of activities have been recommended to improve the credibility of the study:

- a) Prolonged engagement in the field
- b) Persistent observation
- c) Triangulation (application and combination of several research methods in the study of the same phenomenon)
- d) Negative case analysis (investigation of elements that do not seem to support or even contradict patterns or explanations that are emerging from data analysis)
- e) Checking interpretations against raw data
- Peer debriefing (the researchers reasoning about all or parts of the research process is assessed by a peer that is not involved in the research project)
- g) Member checking (interpretations and conclusions are tested with the members of which the data was originally obtained from)

TRANSFERABILITY

Transferability refers to the extent to which the researcher's working hypothesis can be applied to another context. It's not the researcher's task to provide an index of transferability; rather, he or she is responsible for providing data sets and descriptions that are rich enough so that other researchers are able to make judgments about the findings' transferability to different settings or contexts.

DEPENDABILITY

Dependability refers to the coherence of the internal process and the way the researcher accounts for changing conditions in the phenomena.

CONFIRMABILITY

Confirmability refers to the extent to which the characteristics of the data, as posited by the researcher, can be confirmed by others who read or review the research results.

The major technique for establishing dependability and confirmability is through audits of the research processes and findings. Dependability is determined by checking the consistency of the study processes and confirmability is determined by checking the internal coherence of the research product, namely, the data, the findings, the interpretations and the recommendations. The materials that could be used in these audits, include raw data, field notes, theoretical notes and memos, coding manuals, process notes, and so on.

CONCLUSIONS

To summarize: transferability and confirmability were taken into account, since research materials and transcripts were made available in a dropbox folder. In the current project triangulation was done on one occasion, using semi-structuered interviews and the system usability scale in the first iteration of the layouts & interactions experiment. This improves credibility for that

Conclusions & Future Work

The goal of this project was to develop a digital sleep diary that patients will fill out on time daily and consistently. A sleep diary application was developed iteratively, with multiple idea generations & user testing on multiple aspects of the diary.

The developed sleep diary aims to achieve the goal stated above through implementing a proposed conceptual model in a mobile application that features reminders, a simple and understandable interaction and both day- & long-term overviews of sleep data. Throughout the app persuasive techniques have been implemented in order to influence the attitudes and behaviors of the apps user.

It could not be proven that the use of the developed sleep diary did indeed lead to a higher consistency in filling out the sleep diary daily, compared to the Kempenhaeghe sleep diary.

The user experience of the sleep diary was also assessed using the user experience questionnaire and feedback on different aspects was solicited through an online questionnaire. The findings resulted in a benchmark dataset which can be compared with future iterations of the sleep diary and points for improvement on the sleep diary developed.

Regarding stakeholder benefits: for sleep clinic Kempenhaeghe, a prototype for a digital sleep diary application was made and user tested iteratively forming a basis for further development towards a fully functional application which could be used in treatment.

For PhD Begüm Erten-Uyumaz insights were obtained regarding diary inputs and an exploration of data visualization. A collaboration has been initiated to write a paper together which, if published, will be added to her thesis as initial exploration on diary input.

FUTURE WORK

As for future work, first recommendation would be to do a user study on the data visualizations developed in this project. The preferred visualization and other remarks for a clear visualization could then be implemented in a following iteration.

Regarding that iteration, second recommendation would be to remake the app through coding in HTML, CSS and JavaScript. Since then there is no need for the e-mail pop-ups and the diary will become less susceptible to technical difficulties or bugs. For this remake, the points for improvement found in the final user test should be taken into account, as well as those that were found earlier, but were not implemented yet, see Appendix O – Improvement Points Final Prototype

Third recommendation would be to run an extended user test for a prolonged period of time to see re-assess the research question defined in the final user test:

"Does the use of Sleep Buddy lead to more consistently in filling-out the diary on time each day, compared to the Kempenhaeghe, pen-and-paper, sleep diary?"



I chose the project on developing a sleep diary, because it covers topics like persuasive technology, health related lifestyle and self-treatment, all aspects that suit my personal vision and identity as a designer. In addition, the project was an opportunity for me to work with a team of experts, consisting of a doctoral candidate, a therapist and a sleep doctor.

TEAMWORK AND COMMUNICATION (TC)

The M2.2 semester followed a very cumbersome M2.1 semester in which too much time was spend in defining the direction of the project, even changing the direction 12 weeks into the project. The lack of progress, bad communication and bad management of the project on my part did take its toll on me both mentally and physically. So I was determined to learn from that experience and show improvement for this semester, as defined in my PDP.

The approach in the M2.2 semester was to define a problem statement and a project direction, relevant to all stakeholders, as soon as possible and run a lot of iterations in the development of the sleep diary. Communication was improved by planning weekly progress meetings at the outset of the semester and providing the coaches with meeting notes after each meeting. I feel like I did learn from the M2.1 semester and this semester was a lot better!

USER AND SOCIETY (US)

As defined in my PDP, my goal was to learn about and apply the psychology of enhancing motivation, forming habits and persuasive technology. I feel like I have achieved that goal with learning more about the hook model, persuasive technology, the behavioral model and persuasive systems design.

The methods were analyzed and a conceptual model that could be applied to the sleep diary was developed. Furthermore, brainstorms and an idea generation on persuasive techniques was completed and suitable techniques implemented in the sleep diary.

DESIGN & RESEARCH PROCESSES (DRP)

I think the biggest learning curve regarding the project was in DRP. Maybe partly because of the fast pace of the project, I made some mistakes in conducting different experiment and analyses.

One example was that for the first two iterations of user tests regarding the interactions, I conducted some interviews over the phone, which may probably was not the optimal approach. The participants added the prototypes to their phones after which I called them to conduct the interview. Since I chose for retrospective probing, I figured it didn't matter if I would see them interact with the prototype. Later I realized that although I wouldn't' have said anything, it would have been more educative if I did see how participants interacted with the prototypes. This was adjusted for the PT iteration of user testing.

Another learning point involved the technical difficulties with the app in the final user test. Although a pilot test was run, it focussed mostly on the understandability of the instructions provided to do the user test and it involved just one participant, who didn't happen to have an Iphone. So that is a lesson to be learned for the future, especially when testing mobile applications, to recruit more participants in the pilot tests.

I also learned a lot about analysis techniques exploring differences between methods like grounded theory, thematic analysis and qualitative content analysis, as well as applying thematic analysis.

TECHNOLOGY & REALIZATION (TR)

Another goal defined in my PDP was to improve in prototyping. The original plan was use sensors and actuators, develop in processing and learn CSS and HTML. After a while the conclusion was made that it would be more beneficial for this project to learn Axure, a prototyping tool for mobile websites, to develop the initial prototypes.

The goal was to develop the final prototype in CSS/HTML and to that end two courses on that subject were completed on CodeAcademy.com

Although the knowledge of these languages was deemed insufficient to develop Sleep Buddy, and the fact that JavaScript would also be needed, by coding it from scratch, a lot was still learned from doing these courses and I consider it a valuable skill for my professional career. I do intend to develop it further.

CONCLUSION

Overall, I am happy with the process I went through this semester. It was a shame that the hypothesis of the research project could not be accepted and that a prototype could not be created from code. However, I learned a lot through the process and I think I have learned a lot of valuable skils for my professional career.





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IMAGES

Cover page, sleeping woman

http://www.womenshealthmag.com/sites/womenshealthmag.com/files/images/0604-cant-sleep-0717.jpg

Page 12, woman filling out a sleep diary

http://sixtypull.sixtyandmellc.netdna-cdn.com/wp-content/ uploads/2015/09/Sixty-and-Me-How-Using-a-Sleep-Diary-Can-Help-You-to-Sleep-Better-After-60-740x416.jpg

Page 13, Figure 3 - Fogg's Behavior Model (FBM) http://www.behaviormodel.org/

Pages 6 + 7, desk with laptop

https://www.flickr.com/photos/todolisthacks/15016079000

Page 13, Figure 2 - Fogg's Functional Triad of

Computer Persuasion

http://heidi.ee/HCI/wp-content/uploads/2015/03/Screen-Shot-2015-03-22-at-20.09.41.png

Page 14, Figure 4 - The Hook Model

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Page 25, Figure 3 - Woman checking her phone

http://az616578.vo.msecnd.net/fil es/2015/11/27/635842504728946558-1285149006_100.jpg
Appendix A - Sleep Diary Kempenhaeghe

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Invullen van de slaap/waakkalender

Instructie

Met deze kalender brengt u uw slaappatroon in kaart. Dit is een zeer belangrijk instrument om inzicht te krijgen in uw slaapprobleem. Mogelijk heeft u deze kalender al eerder ingevuld. Het is echter belangrijk deze nu opnieuw in te vullen.

Het weekschema op de kalender loopt van dag 1 tot en met dag 7. De hele uren zijn aangegeven met een verticale streep en onderverdeeld in vier hokjes van elk een kwartier. De balk loopt van 's avonds 18.00 tot de volgende dag 18.00 uur.

Belangrijk is dat u de kalender pas 's ochtends invult. Kijk 's nachts niet op de wekker; het gaat om een schatting.

De kalender vult u als volgt in:

- de tijd dat u slapend in bed doorbrengt, kleurt u geheel in
- de tijd die u in bed doorbracht zonder te slapen, geeft u aan door die vakjes te arceren (schuine streepjes)
- het tijdstip waarop u het licht uitdoet, geeft u aan met een verticale streep
- elk hokje staat voor 1 kwartier
- de tijd waarop u naar bed gaat, in slaap valt, wakker wordt en in bed ligt, of blijft liggen, rondt u af op kwartieren
- Vul het schema in vanaf het moment dat u het vragenlijstenpakket binnen heeft en stuur de kalender samen met de vragenlijsten pas op als u het schema voor een volle week ingevuld heeft. Sla alstublieft geen dagen over.

Ter verduidelijking een voorbeeld:

Op dag 1, 5 januari, bent u om 22.30 uur naar bed gegaan. Om 23.00 uur hebt u het licht uitgedaan, waarna u vervolgens om 23.30 in slaap bent gevallen. Op 6 januari werd u om 8.00 uur wakker, maar u bent nog een uurtje blijven liggen en om 9.00 uur opgestaan. Van 14.00 tot 14.30 uur bent u in slaap gevallen. Hetzelfde gebeurde om 17.00 uur. Deze laatste keer duurde de slaap echter naar tien minuten.



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Appendix B - Challenges from the Coach



Insomnia

Problems with initiating and maintaining sleep.
Inability to obtain restorative sleep.
Adverse consequences on daytime activities.
Factors for Insomnia are inappropriate sleep habits and unhealthy thoughts about sleep.

Insomnia becomes chronic if symptoms are more than_ three times a week and present at least previous three months.

Sleep State Misperception



Insomniacs perceive sleep time as less than the actual time passed. The current sleep measurement tools cannot measure sleep-state misperception.

Inaccurate sleep time judgement may reduce the effect of Insomnia therapy.

"Sleep Scheduling" to improve sleep quality

"Sleep Scheduling" consist of two components of Cognitive Behavioral Therapy for Insomnia (CBT-I): *Sleep Restriction(SR)* and *Stimulus-Control (SC)*. SR aims to limit bedtime in bed to build sleep pressure and improve sleep quality.

SC is to associate bedroom environment with sleeping.

"Sleep Scheduling" is considered to be the most effective part of Insomnia therapy for regulating bedtime habits.

CHALLENGE 1: EDUCATIVE GAME

To Overcome Sleep State Misperception

- An innovative solution to help Insomniacs to overcome their disorder by increasing awareness on their sleep state misperception.
- The ultimate goal is to educate the patients to make accurate judgements about their sleep time in a playful way.



CHALLENGE 2: DATA VISUALISATION



To Get Insight into the Therapy Effect

- Informative and visually pleasing visualisations of the therapy effect.
- The ultimate goal is to persuade Insomniacs that "Sleep Restriction" is an effective method to heal their sleep disorder.

CHALLENGE 3: SMART TANGIBLE PRODUCT

To Track the Progress of "Sleep Scheduling"

- A tangible smart product that would help Insomniacs to grasp the progress of therapy before sensing the outcome.
- The ultimate goal is to stay motivated and pass the initial therapy phase (usually the most frustrating) smoothly.



Appendix C - Theories behavior change

As mentioned briefly in the "Technology & Behavior Change" chapter, a couple of therories regarding technology and behavior change have been explored. Those theories are described more elaborately here. In the later stages of the project, Persuasive Systems Design by Harri Oinas-Kukkonen was discovered. Although they could not be implemented anymore at that stage of the project, they are described here as well to present some alternatives for the theories used here.

However, as can be read in this appendix, there is quite some overlap between the models still. Harri Oinas-Kukkonen has based his model on the functional triad by B.J. Fogg and both B.J. Fogg and Nir Eyal use parts of Cialdini's ideas.

PERSUASIVE TECHNOLOGY

B.J. Fogg defines Persuasive Technology (PT) as "any interactive computing system designed to change people's attitudes or behaviors". Captology, the study of computers as persuasive technology, focus on human-computer interaction (HCI), not on computer-mediated communication (CMC). Specifically, captology investigates how people are motivated or persuaded when interacting with computing products rather than through them (Fogg, 2003)

Technology can persuade on two levels: macro and micro. If persuasion and motivation are the sole reasons a products exists (like a simulation to avoid teenage pregnancies) it is called macrosuasion to describe this overall persuasive intent of the product. (Fogg, 2009)

Some computing products, such as email programs, do not have an overall intent to persuade, but they could incorporate smaller persuasive elements to achieve a different overall goal. This is called microsuasion. For example, in educational software applications, microsuasion technique – such as offering praise or giving gold starts for completing a task – can lead to staying on task longer. (Fogg, 2009).

FOGG'S FUNCTIONAL TRIAD OF COM-PUTER PERSUASION

A notable distinction has been made between three basic ways that persuasive computers function: as tools, as media, or as social actors, as can be seen in the Functional Triad of Computer Persuasion (See figure A1). As a tool, a computer application or system can provide humans with new abilities allowing people to do things more easily. As a medium, a computer will provide simulations and virtual environments as well as sensor input to prompt insights into cause-effect relationships.



Figure A1 - Fogg's functional triad of computer persuasion

Finally, as a social actor the persuasive technology aims to change attitudes and behaviors by providing social support or leveraging other social rules and dynamics. (Fogg, 2003)

Persuasion strategies applied in products will differ depending on whether a computing technology is functioning as a tool, a medium, or a social actor. Each corner of the functional triad comes with its own set of persuasion techniques. A few general

techniques can be seen in the functional triad, like making target behavior easier to do or rewarding people with positive feedback.

A full list of all persuasive techniques as defined by B.J. Fogg in his book "Persuasive Technology – using computers to change what we think and do" (2009), with an example can be found in Appendix D - Brainstorm cards PT.

FOGG'S BEHAVIOR MODEL (FBM)

The FBM is a model for understanding human behavior. In this model, behavior is a product of three factors: motivation, ability and triggers, each of which has subcomponents. The FBM asserts that for a person to perform a target behavior, he or she must (1) be sufficiently motivated (2) have the ability to perform the behavior, and (3) be triggered to perform the behavior. These three factors must occur at the same moment, else the behavior will not happen (Fogg, 2009).

As can be seen in Figure A2, motivation and ability can trade off. In other words: if the behavior is very easy to do (and thus the ability is high), not a lot of motivation is required for the trigger to be effective and spark the intended behavior, en vice versa. A trigger can be anything like an alarm, a text message, etc.l



Figure A2 - Fogg Behavior Model (FBM)

According to the FBM, as defined by B.J. Fogg (2009), posits that both motivation, ability and trigger have several sub-components:

MOTIVATION

motivation has three core motivators, each with two sides:

- PLEASURE/PAIN Humans seek pleasure and avoid pain, it is a primitive response that functions adaptively in hunger, sex and other activities related to self-preservation
- HOPE/FEAR Hope is the anticipation of something good happening. Fear is the anticipation of something bad, often the anticipation of loss
- SOCIAL ACCEPTANCE/REJECTION people are motivated to do things that win them social acceptance. Perhaps even more dramatically, people are motivated to avoid being socially rejected.

<u>ABILITY</u>

The FBM posits six elements of simplicity, with simplicity being the sum of the users scarcest resource at a particular point in time:

- TIME If a desired action costs more time than the person has available, then the behavior is not simple.
- MONEY For people with limited financial resources, a target behavior that requires too much money, is not simple.
- PHYSICAL EFFORT Desired actions that require a lot of physical effort may not be simple.
- BRAIN CYCLES If performing a behavior causes us to think hard, that behavior might not be simple, especially so if the mind is consumed with other things. Thinking deeply or thinking in new ways can be difficult.
- SOCIAL DEVIANCE Social deviance is going against the norm, breaking the rules of society. If a target behavior requires to be socially deviant then that behavior is no longer simple.
- NON-ROUTINE People tend to stick to their routines, which is found more simple, even if a routine is harder to do than an alternative solution. When people face a behavior that is not routine, they may not find it simple

TRIGGERS

A trigger is something that tells people to perform a behavior now. The FBM describes three types of triggers:

- SPARK AS TRIGGER When a person lacks motivation to perform a target behavior, a trigger should be designed in tandem with a motivational element (e.g. videos that inspire hope)
- FACILITATOR AS TRIGGER This type of trigger is appropriate for users that have high motivation but lack ability. This trigger also makes the behavior easier to do.
- SIGNAL AS TRIGGER A signal works best when people have both the ability and the motivation to perform the target behavior. It just serves as a reminder.

THE HOOK MODEL (Eyal, 2014)

Cognitive psychologists define habits as "automatic behaviors triggered by situational cues": things we do with little or no conscious thought. The hook model uses triggers, an action, variable rewards and investment (See Figure A3) to engage people and make them return as well. Through consecutive hook cycles, successful products reach their ultimate goal of unprompted user engagement

Research has not yet found a timescale for forming a habit. However, a 2010 study found that some habits can be formed in a matter of weeks while others can take more than five months (Lally, van Jaarsveld, Potts, & Wardle, 2010). Researchers also found that the complexity of the behavior and how important the habit was to the person greatly affected how quickly the routine was formed. Let's take a closer look at the model:

EXTERNAL TRIGGERS

Habit-forming technologies start changing behavior by first cueing users with a call to action, the external trigger, which is delivered through any number of things in our environment like sound, an alarm, a notification, etc. External triggers are embedded with information, which tells the user what to do next.

Let's take Facebook as an example: the external trigger could be an e-mail from a friend to join Facebook. Since triggers should be embedded with info on what to do next, the e-mail contains a big "Sign Up Now!" button.



Figure A3 -The Hook Model

<u>ACTION</u>

The action is the behavior done in anticipation of a reward. In this phase, two factor are important: the ease of performing an action and the psychological motivation to do it. That means that the more effort – either physical or mental – required to perform the desired action, the less likely it is to occur.

For example, clicking the "Sign Up Now!" button would take the person to a sign up page, where he or she is required to fill in personal details. The anticipated reward is to see the timeline of the friend that sent the invitation.

VARIABLE REWARD

The variable reward phase, is the phase in which users are rewarded, reinforcing their motivation for the action taken in the previous phase. variability increases activity in the nucleus accumbens and spikes levels of the neurotransmitter dopamine, driving the hungry search for rewards.

After signing up to Facebook, the reward would be to see the timeline of the friend who sent the invitation. The variability is found in that each post is different, and each time the user comes back, the posts are different. The investment increases the odds that the user will make another pass through the hook cycle in the future, which happens when the user puts something into the product, such as time, data, effort, social capital or money.

INVESTMENT

The investment implies an action that improves the service for the next go-around. For example, the investment on Facebook would be the effort to search and invite more friends, inproving the experience with more and varied content.

INTERNAL TRIGGERS

Through successive hooks, users begin to form associations with internal triggers, which attach to existing behaviors and emotions. For example, Facebook can be associated with the need for social connections. Anytime a user feels lonely, the automatic

PERSUASIVE SYSTEMS DESIGN (PSD)

Fogg's work on PT has been adapted by Harri Oinas-Kukkonen, who calls it Persuasive Systems Design and defines it as "computerized software or information systems designed to reinforce, change or shape attitudes or behaviors or both without using coercion or deception" (Oinas-Kukkonen & Harjumaa, 2009).

Oinas-Kukkonen and Harjumaa proposed a systematic method to develop persuasive systems based on Fogg's strategies. Their Persuasive Systems Design (PSD) model contains three steps: designers should understand the key issues behind persuasive systems (step 1), designers should analyse the persuasion context (step 2), and designers should consider the system qualities (step 3). The system qualities (step 3) are described comprehensively; the underlying principles of the system qualities are described, and the belonging software requirements and examples of implementation are given.(Horsch, Brinkman, van Eijk, & Neerincx, 2012)

The system qualities are divided into four categories: task-, dialogue-, credibility-, and social support. The strategies within the first two categories (task and dialogue support) are based on the strategies of B.J. Fogg. There are no fundamental differences. the descriptions deviate in the level of details. The underlying idea of credibility, the third category, is that a system that is more credible is more persuasive. Fogg discussed credibility as well, however did not include as a category in his functional triad.

The last category is social support, which describes how to use social influence strategies to persuade the coachee, like social comparison, competition and cooperation. These social strategies could be used in a virtual sleep coach by connecting the coachees with peers.(Horsch, Brinkman, van Eijk, & Neerincx, 2012)

In this point PSD also differentiates from PT, as this category is about computer-mediated communication and PT focuses on human-computer interaction (HCI). However, Fogg (2003, pp. 183 -210) does touch on these categories and explains how they can be applied to connected persuasive technologies. Again, there is no seperate category for computer-mediated communication in Fogg's functional triad of computer persuasion.

Although credibility and computer-mediated communication in PSD are not included into the functional triad, for anyone who is familiar with the entire book by Fogg (2003), their ideas are very similar. Thus to conclude, the main differences then lie in the described systematic method to develop persuasive systems.

Appendix D - Brainstorm Cards PT

These PT cards explain the persuasive principles as described by B.J. Fogg (2003). Each card has a front (left row) and a back (right row), containing the definition of the principle and an example. Blue cards means their category is PT as a took, red is as a simulation and green is as a social actor. The grey card explains how PT can convey a social presence to use PT as social actor.



Tailoring technology

Persuasion through customization

Information provided by computing technology will be more persuasive if it is tailored to the individual's needs, interests, personality, usage context, or other factors relevant to the individual

Example

A word processing application might suggest that youincrease your working vocabulary by learning a new word each day.

You might be more motivated to follow up on this suggestion if the application prvided information showing the limited range of your working vocabulary

Suggestion Technology

Intervening at the right time

A computing technology will have greater persuasive power if it offers suggestions at opportune moments

Example

SMART is a portable trailer that can be placed by the roadside to monitor the speed of oncoming vehicles.

As a driver approaches the trailer, it displays it's speed on a large screen as well as displaying the speed limit for the street

Self-monitoring technology

Taking the medium out of tracking

Applying computer technology to eliminate the tedium of tracking performace or status helps people to achieve predetermined goals or outcomes.

Example

Heart rate monitors are devices that monitor a person's heart rate during exercise

Heart rate monitors help people modify their physical behavior so their heart rate stays within a predetermined zone

Surveillance technology

Persuasion through observation

Applying computer technology to observe others'behavior increases the likelihood of achieving a desired outcome

Example

Hygiene guard is a system which monitors hand washing in employee restrooms to make sure employees follow hygiene rules. It makes use of sensors in the employee's ID badge and in the restroom

*Note: surveillance must always be overt!

Conditioning technology

Reinforcing target behaviors

Computing technology can use positive reinforcement to shape complex behavior or transform existing behaviors into habits

Example

A video game is a good game when a player wants to keep on playing.

Computer games reinforce behavior through sounds and visuals, points accumulated, progression to next levels, ranking in high scores, etc.

Cause-and-effect simulations

Offering exploration & insight

Simulations can persuade people to change their attitudes or behaviors by enabling them to observe immediately the link between cause and effects

Example

HIV-roulette is a kiosk where people can sit down and play a game which gives them insights into how their sexual behavior can affect their HIV-status

Virtual rehearsal

Creating spaces for persuasive experiences

Providing a motivating simulated invorenment in which to rehearse a behavior can enable people to change their attitudes or behavior in the real world

Example

Drivers simulations allow aspiring drivers to get used to the dynamics of driving without exposing them to the dangers of actual driving

Virtual rewards

Providing experiences in everyday context

Computer simulations that reward target behaviors in a virtual world, such as giving virtual rewards for exercising, can influence people to perfom the target behavior more frequently and effective in the real world

Example

The fitness VR rowing machine depicts the user in a boat rowing past scenery, distance markers and landmarks.

You can also race against a virtual competitor, who helps set a pace fo you.

Real-world simulations

Providing experiences in everyday context

Portable simulation technologies designed for use during everyday routines can highlight the impact of certain behaviors and motivate behavior or attitude change

Example

"Baby think it over" is an infant simulator, used as a part of many school programs.

It is a doll with a simple computer inside that cries until you give it attention and it raises awareness of the attention a baby requires

Explanation

When perceived as social actors, computers can leverage principles of social influence. A social actor can be persuasive by:

 Rewarding people with positive feedback
 Modeling a target behavior or attitude
 Providing social support

Principle of attractiveness

Computers as social actors

A computing technology that is visually attractive to target users is likely to be more persuasive as well

Principle of similarity

Computers as social actors

People are more readily persuaded by computing technology products that are similar to themselves in some way

Explanation

When perceived as social actors, computers can leverage principles of social influence. A social actor can be persuasive by:

- Rewarding people with positive feedback
 Modeling a target behavior or attitude
- 3. Providing social support

Principle of reciprocity

Computers as social actors

People will feel the need to reciprocate when computing technology has done a favor for them

Explanation

When perceived as social actors, computers can leverage principles of social influence. A social actor can be persuasive by:

- 1. Rewarding people with positive feedback
- 2. Modeling a target behavior or attitude
- 3. Providing social support

Principle of authority

Computers as social actors

Computing technology that assumes roles of authority will have enhanced powers of persuasion

Explanation

When perceived as social actors, computers can leverage principles of social influence. A social actor can be persuasive by:

- 1. Rewarding people with positive feedback
- 2. Modeling a target behavior or attitude
- 3. Providing social support

Principle of praise

Computers as social actors

By offering praise, via words, images, symbols, or sounds, computing technology can lead users to be more open to persuasion

Explanation

When perceived as social actors, computers can leverage principles of social influence. A social actor can be persuasive by:

- 1. Rewarding people with positive feedback
- 2. Modeling a target behavior or attitude
- 3. Providing social support

Social Cues

That infere social presence

 Physical: Face, eyes, body, movement
 Psychological: Preferences, humor, personality, feelings, empathy, "I'm sorry"
 Language: Interactive language use, spoken language, language recognition
 Social dynamics: turn taking, cooperation, praise
 social roles: doctor, teammate, opponent, teacher

Appendix E - Input diary layouts & interactions

As mentioned, the idea generation of the first iteration of diary layouts was inspired by four different sources:. More details on the findings in the following sources are desribed in this appendix:

- Previous user test with lo-fi prototypes (M2.1 semester)
- Benchmarking
- The EVE report (Thoolen & de Vogel, 2016)
- The Consensus Sleep Diary (Carney et al, 2012)

EXPERIMENT M2.1 SEMESTER

In the M2.1 semester, three low-fidelity (lo-fi) prototypes of sleep diaries were made and a user test was done to get qualitative input on the interactions. Since two of the three lo-fi prototypes were stand-alone devices and not apps, not all user input is transferable to the phone app.

To get a global impression, starting with the phone and proceeding clockwise (See figure E1): the phone app works by tapping and dragging segment borders to set the times. The ring diary works by rotating the ring and confirming set times with the buttons. The rotation diary works by rotating the entire device, like a clock hand.

Below is the user feedback that can be taken into account in the development of a sleep diary app:



Figure E1 - Prototypes M2.1 semester

ROTATION

- Rotation of a device, like a clock hand, is easy to understand (rotation diary). But the shape of the device didn't evoke any associations with a clock hand. So rotation could be a good idea for the app, but the shape has to evoke a clock.
- Participants noted that having a 12-hour time span in quarters, distributed over a 360 degrees angle would make it very hard to fill out the diary with precision (rotation diary).
- Rotation of the ring diary, was found intuitive, because the lights (overview) follow along with the rotations so you can see what you are doing. En vice versa, it was disliked in the rotation diary that there was now overview and the user couldn't see what he or she was doing.

PHONE APP DIARY

In the phone app diary there was some confusion about the interaction, what the user was supposed to do. It is probable that this was caused by it being a low-fidelity prototype, rather than it being a bad interaction, since the user doesn't get any feedback on the interaction.

A useful insight for future iterations is that users really liked the icons used to explain the components of the overview. Users suggested more icons for all elements in the overview.

BENCHMARKING

There are a lot of different sleep diaries used by therapists, there is not yet a consensus diary that is universally used. However , an effort has been made to present an expert consensus, standardized, patient-informed sleep diary (Carney et al,2012). An exploration was done to see what kind of mobile applications of sleep diaries are already on the market. For reasons discussed earlier, apps that use sensor-based sleep info were excluded from this exploration.

THERAPY APPS

Three apps were found that include a sleep diary as would be used by a clinic. The two that are found combine a sleep diary with other components of CBT-I treatment, like advice for sleep hygiene. In addition, an app of the Consensus Sleep Diary (CSD) was found (Carney, 2017), but upon requesting to pilot test it, it was unavailable because it is currently being redesigned. Notable is that the other two apps present the sleep diary component as a list of questions, much like a questionnaire,

InsomniaFix

InsomniaFix (NOVOS Behavioral Health Solutions, 2016) is an app with advice for sleep hygiene and offers a prescribed sleep schedule after filling out a short questionnaire about the user's sleep habits. It also includes sleep analysis with graphs to monitor progress based on a daily sleep diary (See figure E2).

You have 0 of 28 diary entries required to recalculate your prescribed sleep schedule.	Your Sleep Prescription
Mean Diana Mintana	Your Bed Time: Out-of-Bed Time:
view biology matory	12:15 AM 8:15 AM
ate:	👌 Adjust Sleep Schedule 🔶
6-01-2017	
	Total Time in Bed Every Nightx:
. What time did you get into bed and attempt to leep last night?	8 hrs 0 mins
	Please follow your Sleep Prescription and your Sleep
Approximately how many minutes did it take ou to fall asleep?	instructions everyday:
Approximately how many minutes did it take ou to fall asleep?	Your Sleep Instructions
Approximately how many minutes did it take ou to fall asleep? Approximately how many times did you wake up uring the night?	Your Sleep Instructions
Approximately how many minutes did it take bu to fall asleep? Approximately how many times did you wake up uring the night?	Your Sleep Instructions →
Approximately how many minutes did it take ou to fall asleep? Approximately how many times did you wake up uring the night? Between the time you first fell asleep and the me you got out of bed in the morning, how many OTAL minutes were you awake?	Your Sleep Instructions → Your Alerts are On
. Approximately how many minutes did it take ou to fail asleep? . Approximately how many times did you wake up uring the night? . Between the time you first fell asleep and the me you got out of bed in the morning, how many OTAL minutes were you awake?	 Your Sleep Instructions → Your Alerts are On

Figure E2 - In-app screenshots Insomniafix

CBT-I Coach

The CBT-I coach provides a structured program that teaches strategies proven to improve sleep and help alleviate symptoms of insomnia. CBT-I coach is intended to augment face-to-face care with a healthcare professional. It can be used on its own, but is not intended to replace therapy for those who need it (T2, 2016).

The application provides features like self-assessment using the Insomnia Severity Index (ISI) and the sleep need questionnaire. It contains tools to quiet the mind, contains sleep hygiene information and provides a sleep diary (See Figure E3).

- 2 2	a 🗑 😤 📶 70% 🖬 10:45	■ 20 2 × 3 2 ml	/9% 🖬 10:45
Home	① ? 苹	New Entry	
HOME	TOOLS	vrijdag, januari 6, 2017	٢
0	1 00	Did you nap or doze yesterday?	No
		What time did you get into bed yesterd	ву?
My Sleep	Tools	no data	0
		What time did you try to go to sleep?	
		no data	0
		How long did it take you to fall asleep?	
Learn	Reminders	0 hours: 0 minutes	0
Slee	p Prescription	How many times did you wake up, not o your final awakening?	counting
Your Sleep Prescrip have complete	otion will appear here once you eted 5 sleep day diaries	0	

Figure E3 - In-app screenshots CBT-I Coach

Notable is that both apps share the same way of submitting the time, through scrolling wheels (See figure E4).

EasySleep

More visual ways of tracking sleep in a subjective way also exist, although none were found that actually ask the questions relevant to a sleep diary. An example is EasySleep, an app to help you track your sleep in hours and the sleep quality (Sileci apps, 2016). The app features two dials to indicate the number of hours slept and the subjective sleep quality (See Figure E5).



EasySleep

THE EVE REPORT

The EVE report is a project by two industrial design students of the Tu/e, also developing a digital sleep diary. A lot of that input is not applicable in this case, since they developed a stand-alone device. They combined that device with an app, however, in which they opted for a circular representation (See figure E6) of time for the following reasons:

"a circular representation of time has a positive influence on people. This can be translated to the sleep diary in which time is the key element" (Thoolen & de Vogel, 2016).

This is based on findings that linear time presentation is more future oriented (it has a past, present and future), while circular time representation is more present oriented (same patterns are repeated according to a cyclical pattern). A circular time representation has been shown to help users focus more on the task at hand and think about activities more concretely in a saving plan (Tam, Lee, & Dholakia, 2012).

Thoolen & de Vogel (2016) also argue that a circular representation of time has the advantage that the circle circumference is larger than a linear representation of time in the same surface. Thus a smaller area is required for representing time, which is valuable on a smartphone screen



Figure E6 - App EVE project

THE CONSENSUS SLEEP DIARY

The consensus Sleep Diary (CSD) has been developed iteratively through collaborations with insomnia experts and potential users. In the process the following points were found relevant for the digital sleep diary being developed:

- The core CSD would be designed to fit on a single page. This is a practical solution and it would seem less daunting for users.
- The wording of the diary would be in past tense since they are most often completed in the morning after the night being reported upon.
- All questions are written in 2nd person so that it would appear as though the researcher/clinician was inquiring about the sleep behaviors
- There are CSD instructions on what to do if the respondent misses a day, as well as item-specific instruction(good for under the "Info" button) to enhance likelihood of correct item interpretation
- Some participants suggested alternate graphical formats, such as clock faces or time charts. Some advocated electronic formats
- The first draft was too complicated & overwhelming. Participants would have preferred a single-day format. Important to express some method for adding comments regarding important influences on a particular night of sleep
- Adjusted after first draft: eliminating blank lines to fill in times, A.M./P.M. check boxes, text with units following participant response (minutes, hours, e.g.) & added comments field (which was still found little opportunity to describe specific aspects of sleep).
- The most consistent overall theme was the need to express personalized comments regarding sleep & wakefulness (Ability to describe their sleep experience in some detail).

Appendix F - Consent Form Interactions

TU/e Technische Universiteit Eindhoven University of Technology

Eindhoven University of Technology

Informed consent for participants in research projects involving human subjects

Title of the project:	Sleep diary 2.0
Student :	Lester Moorman
Coaches:	Jun Hu & Begum Erten-Uyumaz

I. Purpose of this research/project

The current project is called "Sleep Diary 2.0" and it is about developing an application of a so called "sleep diary". Sleep diary 2.0 is a tool for medical specialists and patients to both diagnose, track and treat sleep disorders like insomnia. Sleep diary 2.0 is to gather subjective sleep data of patients under treatment and covers elements like *time to bed, time you fell asleep, etc.*

This experiment aims to investigate people's preferences and experience regarding the use of different sleep diary applications.

II. Procedures

In this study participants will test four prototypes of sleep diary applications. As a participant you will first be asked to add the diaries to their phones. On completion, you will be asked to fill out each diary. After each diary, you will be administered a post-task questionnaire and a semi-structured interview will be conducted. The audio of the interview will be recorded. The entire duration of the experiment is estimated to be 30 minutes.

III. Risks

There will be no more risk involved than the risk encountered in everyday life. Adding the apps to the smartphone will be done by adding a shortcut on the home screen to a web URL. Nothing will be downloaded, thus eliminating the risk of viruses.

IV. Benefits

Your participation in the study can provide insight on preferences and experience regarding the use of different sleep diary applications. This insight will contribute to the development of a sleep diary application.

Your personal benefits are independent of the benefits of this study. You may contact the conductor of this study at a later time for a summary of the research results.

V. Extent of anonymity and confidentiality

Participants in this study are guaranteed confidentiality. Personal data will not be collected at any point during the study. Distinction between participants will be made with a number code

VI. Freedom to withdraw

Participation in this study is voluntary and you have the right to withdraw from the study at any point. You have the right not to answer any question you may be uncomfortable with.



VII. Subject's responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities: add the application shortcuts to the home screen on my phone, fill out each diary and answer the post-task questionnaires and semi-structured interview to the best of my ability.

VIII. Subject's permission

I have read the consent form and conditions of this experiment. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Participant signature:

Date:

In case of questions about this research or its conduct, I may contact:

Lester Moorman +31616201907 I.f.moorman@student.tue.nl

Appendix G - System Usability Scale

System Usability Scale

© Digital Equipment Corporation, 1986.

- 1. I think that I would like to use this system frequently
- 2. I found the system unnecessarily complex
- 3. I thought the system was easy to use
- 4. I think that I would need the support of a technical person to be able to use this system
- 5. I found the various functions in this system were well integrated
- 6. I thought there was too much inconsistency in this system
- 7. I would imagine that most people would learn to use this system very quickly
- 8. I found the system very cumbersome to use
- 9. I felt very confident using the system
- 10. I needed to learn a lot of things before I could get going with this system

Strongly disagree				Strongly agree
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5

Appendix H - Interview Guide

Semi-structured interviews

Participant ID:

Name

Diary questions per diary (5x4)

- 1. Where you able to complete the diary as instructed?
- 2. Overall, how easy is it for you to use the prototype?
- 3. What do you like most about the prototype?
- 4. What do you like least about the prototype?
- 5. If you could change one thing about the prototype what would it be and why?

Diary questions to round up (1)

- 6. Which input mode did you like most? And why?
- 7. Would you prefer to see the overview on the main screen or as an individual screen?
- 8. How hard was it for you to understand the overviews? Why so?
- 9. Which diary type motivates you most to take action and why?
- 10. Which version of the diary helps you to track your progress better? Why?
- 11. If the diary where to give notifications as reminders, what kind of notifications would you prefer? (alarm, icons, e.g.)
- 12. What features would make the diary more engaging?

Appendix I - Discussion Analysis Methods

As stated in the report, the semi-structured interviews were analysed using thematic analysis. Thematic Analysis is the analysis of textual material (newspapers, interviews and so forth) in order to indicate the major themes to be found in it. (Howitt & Cramer, 2011)

There was some confusion as to which was the most appropriate method to analyze the interviews and on what the exact name of the correct analysis was even after completion of the analysis. This is because there are other methods of qualitative research which seem to compete with thematic analysis in the sense that they take text and, often, identify themes (Howitt & Cramer, 2011).

To solve this, papers on each method were read and because of a lack of clarification, a forum thread was started on Researchgate to discuss it with researchers and professors around the globe.

This appendix aims to take a look at other methods of qualitative research that are easily confused with thematic analysis, and discuss the differences.

AFFINITY DIAGRAMMING

The first impression was that the technique to apply was affinity diagramming, which was done before to analyze interviews in the "Designing for the User Experience" course.

UsabilityNet (2006)defines it as follows: Affinity diagramming is used to sort large amounts of data into logical groups. Existing items and/or new items identified by individuals are written on sticky notes which are sorted into categories as a workshop activity.

Through reviewing affinity diagramming, it became clear that it is rather a technique for grouping information as a group to gain consensus of how the information should be grouped. Apart from the lack of depth of the method, the analysis did not involve a group process, thus this method could be discarded as the method of choice.

GROUNDED THEORY

Grounded theory methods consist of systematic inductive guidelines for collecting and analyzing data to build middle-range theoretical frameworks that explain the collected data. Throughout the research process, grounded theorists develop analytic interpretations of their data to focus further data collection, which they use in turn to inform and refine their developing theoretical analyses (Howitt & Cramer , 2011)

If the basic processes involved in carrying out a grounded theory analysis are compared with those of thematic analysis then differentiating between the two is difficult. But there is a crucial difference: grounded theory is intended as a way of generating theory which is closely tied to the data. Theory development is not the intention of thematic analysis. Of course, any process which leads to a better understanding of data may lead subsequently to the development of theories (Howitt & Cramer , 2011).

Other sources highlighting the differences between the methods, go on to state that thematic analysis is less "theory" oriented and a more light-weighted and practical. many claimed having used grounded theory method, but only used coding/categorizing part of the process, which is more like thematic analysis (Chapman, Hadfield, & Chapman, 2015).

Since theory development is not the goal of the experiments, rather to get input on prototypes, grounded theory was also deemed inappropriate as the method of choice.

QUALITATIVE CONTENT ANALYSIS

Qualitative content analysis (QCA) is defined as s research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns.

In one particular type, conventional content analysis, researchers avoid using preconceived categories, instead allowing the categories to flow from the data. Researchers immerse themselves in the data to allow new insights to emerge, also described as inductive category development (Hsieh & Shannon, 2005).

The paper goes on to state that: "At most, the result of a conventional content analysis is concept development or model building"

CONCLUSIONS

Thus far it's still quite hard to differentiate between QCA and thematic analysis. According to one response in the thread by David Morgan of Portland University this is because QCA is poorly defined as a method:

"thematic Analysis overlaps heavily with Content Analysis, but part of reason for that is that CA is so poorly specified as a method" (Morgan D L, 2016)

One advantage of thematic analysis is that it is well-defined in the Braun & Clarke version, while there is no definitive version of QCA, so it harder to nail down. Another advantage of using thematic analysis is that the original Braun & Clarke (2006) article has over 20,000 citations on Google Scholar, which indicates how widely accepted it is (Morgan D L, 2016).

For these reasons, the choice was made to use thematic analysis to analyze the interviews conducted in this project:

Appendix J - Thematic Analysis, First Iteration

Theme	Sub-themes	Example quotes
Use of the classical diary	Easy to use & understand	"It works very easily. It's fast, it's responsive and it's clear" "You instantly understand what you are supposed to do!" "5 was most easy and I rated it 5. It was clear and did what I wanted."
	Not very Interesting	"It is kind of boring, but it is easy" "It's quite dry, but I guess that all sleep diaries are. So it was straight-forward but also not very interesting"
Use of the neo-classical	Easy despite technical issues	"I get a lot of overlapping text, but that doesn't have anything to do with functionality. I think the functionality is fine." (On how easy it was to use the prototype) "I didn't find this one hard, it was easy" "I thought it was easy to do" "If you filled on out and went to the next and wanted to check the previous then the numbers would overlap"
	Feedback after Each step is Appreciated	"I like that you get the results in the circle, a little bit of progress" "That you immediately see what you are doing." (On what the participant liked about the prototype). "You can see the build-up at once, which I like."
Use of the Analog diary	Polarizing opinions on use of the diary	 "Too many numbers, it's not clear for me" "I would prefer something more intuitive and less overwhelming in the morning" "I don't like this prototype, I wouldn't choose this version" "I really liked that it was so logical, it doesn't require any explanation" "I liked this one the best! Because I could just click the times, I didn't need to scroll" "That it was so fast!" (On what the participant liked about the prototype).
	Filling out Awakenings unclear	"No, the awakenings part I didn't understand at first" "Ok, I didn't understand that I was supposed to hit the "plus" to add another awakening. Now I understand, but I didn't understand it earlier" "With awakening you need to hit "confirm" before you can fill out the duration. That was not immediately clear. I was looking for it, but couldn't find it at first."

Theme	Sub-themes	Example quotes
Use of the dial diary	Movements are too precise	"You need a little bit preciseness with your hands to fill it out correctly, it's easy to get it wrong" "I found it very hard. Because the discrete values are too small. You need to cover a large range of values in a small area. I didn't find that nice to use"
	Minutes & duration Not self-explanatory	"It was not instantly clear to me what I was supposed to do. I had no idea that I had to do hours first and then minutes." "I think an explanation would be beneficial, like: click for the hours and click for the minutes or something" "it wasn't clear that there are 2 clock hands for both hours and minutes, maybe you can accentuate that more, so you know instantly that the minutes come a step later."
Preferred Diary	Neo-classical: III	"I think neo-classical. Because with a little bit of info beforehand you can fill it out. And I like that everything is one page and you get feedback after each step." "The neo-classical diary" (on the participants preferred diary)
	Classical: I	"The classical one. Also the most boring, but I think it's most effective."
	Analog: I	"I liked the analog diary the best, because it worked very well and it was clear"
Overview In the app	Preferred after each step	"I like to see the overview after every step because it looks nice & clarifies what you entered and if you did it correctly." "if you can implement it that you see it after each step, it would be something extra"
	Legend and Numbers would Make it clearer	"What is the range of the circle? What are the colors?" "The percentages don't mean anything to me (Sleep efficiency) so maybe that would need some clarification." "I think it would be clearer if there was a chart which tells you the times in numbers and which color is what."
Notifications	App-notifications are the preferred format	"I would like a pop-up reminder." "I think a notification like Facebook would be good"
	Alarms are too Intrusive	"I am not so fond of alarms." "An alarm would be intrusive"

FOR ACCESS TO THE FULL INTERVIEW TRANSCRIPTS, SEE: https://www.dropbox.com/sh/icmgz48qqxf0vqw/

AAAsl1fsW4cIh3Me0KZgtgxCa?dl=0_

				Dry	Boring	Experience	understandable	Instantly	No-nonsense	Fast	Responsive	Functionality	Classical Diary
				Progress	After each step	Feedback			Confirm redundant?	Overlapping text	Easy to use	Functionality	<mark>Neo-Classical Diary</mark>
Too many numbers	Confusing	Overwhelming	Easy	Fast	Clear	Polarizing opinions				Awakenings unclear	Duration hidden	Functionality	Analog diary
						Duration hidden	Awakenings unclear	Clockhands unclear	Minutes hidden		Too precise	Functionality	Dial diary
		Notifications	Triggers	cii cie i alige	Circle mage	Time indicators	Overview		Overview after	Classical: I	Neo-clasiccal: III Analog: I	Preffered diary	General

Appendix K - Interpretation SUS-Scores

The System Usability Questionnaire was administered and from them, a SUS -score was calculated. This is done by subtracting 1 from the users response for odd questionnaire items, while for the even-numbered items the responses are subtracted from 5. The converted responses are then added up and multiplied by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40 (Sauro, 2011). The Scores for the sleep diary prototypes were as follows:

Dial diary:	31.25
Neo-classical diary:	57.5
Analog diary	61.875
Classical diary:	93.125

Although the scores are 0-100, these are not percentages. The System Usability Scale is not diagnostic, but it will give an indication of how badly the usability of a product, website, e.g. needs work. Despite the wide usage of SUS, there has been little guidance on interpreting SUS scores (Sauro, 2011).

One way to interpret the scores is by normalizing them. That way they can be converted to a percentile rank (See Figure K1). However, normalizing the scores is a complex process done by specialized, paid, software ("SUS Guide & Calculator Package," 2017).

Because of the explorative nature of the experiment and the sample size it was decided to interpret the scores in another often done way, which is to compare the score obtained with the average SUS score from all 500 studies conducted, which is a 68 (Sauro, 2011).





This means that a SUS score above 68 is above

average and anything below 68 is below average. A raw SUS score of a 74 converts to a score of a B-, scoring at the mean score of 68 makes a C and anything below a 51 is an F (The bottom 15%), see Figure K1 (Sauro, 2011).

The exact grades for the prototypes cannot be determined without the software, but a general assessment can be made that the usability of the prototypes. Given the information above, the dial diary was classified as poor, since anything below a score of 51 is considered an F (Fail).

The Neo-classical diary and the analog are classified as below average, both are under the average of 68 to differing degrees. And the classical diary is considered "good", posting a score of 93.125.

Appendix L - Thematic Analysis, Second Iteration

Theme	Sub-themes	Example quotes
		Sleep diary 2.0
Overview on the main page	Sense of progress	"I like that you can see your progress in the overview of what you are submitting" "I also like the overview, that you can see where you are"
	See what you are doing	"You instantly see what you are doing with the overview on the same page" "I think the circle is interesting. I like that you see the transitions visually"
The lcons	Sense of progress	"I found this one easier. I think because of the icons and because you can see what is still to come" "I also really like the symbols and that the symbol you are at lights up"
	Enable correcting Data	"I would like to be able to tap the icons to go back and correct any mistakes I made" "I'd like to be able to go back, tap the icon and adjust the data."
		Analog diary
Overview on separate page	More awareness	"I was also better aware of the overview. In the other one it appeared in the background and here it was on a separate screen, so it jumps out more. "I was much more aware of my progression because of the separate screen of my progress. At first, I didn't really pay attention to it. So the overview is clearer."
	Less convenient	"When I have to do this quickly, that separate screen is really annoying, because I have to click through a lot of screens" "It is also kind of confusing because you have the separate screen for the overview and then return to the questions" "I would try to implement the circle in the main overview, so that it's not on a separate screen"
Input mode	Harder to under- stand at first	"I was turning it at first, then I understood that I had to tap the numbers" "First, I have to search and after a while I understand that the outer ring are the hours and the inner ring the minutes"

Theme	Sub-themes	Example quotes					
	More fun and faster	"I feel this one is faster to fill out, because you can simply tap the clock" "I do think tapping the numbers like it is a funny way of filling out the diary. This may be a faster input than the other app. I think just tapping the numbers is quite easy"					
Preferred Diary	Sleep diary 2.0: VI	"Sleep diary 2.0 because it I very s just like my alarm clock" "Sleep diary 2.0, I think it's clearer	traight-forward, it works "				
	Analog diary 2.0: II	"Analog diary 2.0, because tapping more fun" "Analog diary 2.0. I thought it was and you can complete it faster. I a separate screen, because it makes	g the numbers is faster and a little more easy to fill out lso like the overview in the s you more aware."				
Sleep Diary 2	2.0	Analog diary 2.0	General				
Overview on mai	in page	Overview on separate page	Preffered diary				
Sense of prog	gress	More awareness	Sleep Diary 2.0: IIII				
See wat you are	doing	Less convenient					
Question icc	ons	Input mode					
Sense of prog	ress	Harder to understand at first					
Enable correctin	g data	More fun & faster					

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z48qqxf0vqw/

Appendix M - Insights User Journey

Insights User Journey

The user journey is based on the GGZ-protocol book, which entails protocols for therapists on how to conduct Cognitive Behavioral Therapy for Insomnia (CBT-I), and papers that cover the experience of patients undergoing CBT-I. One paper was about the patient perspective (Cheung, Bartlett, Armour, & Saini, 2013) and the other about patients experiences during sleep restriction therapy (Kyle, Morgan, Spiegelhalder, & Espie, 2011).

Following are the insights of the user journey that may be relevant for (future iterations of) the sleep diary:

1. Clinical definition of insomnia

Patients experience a feeling of isolation from a perceived and/or actual lack of understanding from personal, social, workplace and medical relationships. This may result in self-blame.

In addition, some patients experience a disconnect between the clinical definition of insomnia and their definition. Patients tend to define it in terms of disabling daytime impacts, resulting in a need to convince therapists of the seriousness of the problem.

When judging sleep quality, researchers found that feeling restored upon waking up and feeling alert throughout the day were rated most important.

"If one is sleeping poorly, I'm not sure that quantifying the hours slept is as important as the results of sleep deprivation" (Cheung, Bartlett, Armour, & Saini, 2013)

<u>Design opportunities</u>: The data visualization in the diary could play a role in patients feeling understood, by presenting values in a way that is relevant to the patient

Another way the diary could help is providing elaborate opportunity to leave comments about their night. How they feel, why they slept bad, etc. This may be done through voice recordings, e.g.

2. Therapeutic alliance

Perceiving the therapist as higher in affiliation results in a greater reduction in sleep problems. In contrast to that, perceiving therapists as critically confrontive was generally associated with less treatment satisfaction and people who dropped out of therapy experienced their therapist as more critically confrontive. A quality therapeutic alliance is affiliative, autonomy granting and devoid of hostile control or critical confrontation (Constantino et al.,2007) <u>Design opportunities</u>: The sleep diary application could be used to strengthen the relationship between therapist and patient. This could be done by personalized messages, offering help when needed, etc.

3. Maladaptive beliefs

Maladaptive beliefs about insomnia and sleep can affect treatment responses. Educating patients and re-contextualizing sleep beliefs facilitates informed goal setting, which translates into positive health behaviors.

In sleep apnea researchers found that better pre-treatment beliefs results in better adherence. (Cheung, Bartlett, Armour, & Saini, 2013)

<u>Design opportunities</u>: The app can give facts & trivia about sleep, to educate users. Although the therapists has a certain role here as well, it is not clear what would be appropriate. Also, the timing when filling out the diary in the morning might be perceived as annoying or intrusive.

The app could contain videos featuring 'graduates' that speak about treatment experience & implementation. It is done in sleep apnea that way.

4. Feeling of isolation

Patients may feel isolated from social relationships among friends, family and in the workplace. Insomnia is a sleeping disorder that is often trivialized. Patients may react by "normalizing" themselves

"No one understands what it's like, because they once had a bad night's sleep they think they know what it's like and tell you to 'just get over it'" (Cheung, Bartlett, Armour, & Saini, 2013)

<u>Design opportunities</u>: The app might provide opportunities to provide personalized stories based on long-term sleep data. In a way that others can get a better feel for what insomnia really does. This is closely related with the patient definition of insomnia, as discussed earlier.

5. Impact Sleep Restriction Therapy (SRT)

Maybe more relevant when the entire CBT-I process, not just the sleep diary were to be supported by an app. The problem here is that SRT has a big impact on daytime functioning. The first two weeks of SRT are described as "extremely difficult"

The side-effects of SRT are: fatigue/exhaustion (100%), extreme sleepiness (94%), reduced motivation /energy (89%) and headache/migraine (72%). For patients, spending less time in bed may feel counterintuitive (Kyle, Morgan, Spiegelhalder, & Espie, 2011).

<u>Design opportunities</u>: The app may play a role in warning patients for the difficulties of SRT, assist in supporting strategies to cope with the extra time forced to spend awake and give relevant info on results.

Appendix N - Thematic Analysis Persuasive Techniques

Theme	Sub-themes	Example quotes				
Use of the diary	Easy to use	"It is very easy and almost everyone has a smartphone these days"				
·		"I did find it user-friendly"				
	Awakenings	"I would expect here that I would have to fill out the number				
	less clear	of awakenings first."				
		"What do you mean with awakenings? During the night? Or				
		after the alarm sounded?"				
	Notifications convenient	"I thought it would be convenient, because you have your routines in the morning and then it's easy to forget. So it's good to have a notification"				
		"These are things you might forget sometimes, especially in the morning and this would be easy. It's the same as an alarm clock it's nice to be reminded."				
	Sufficient	"Yes, it is explained well." (on whether the app offers				
	Support	sufficient support)				
		"Yes! Especially when you know you can hit the blue info button and that when you don't know something you can ask a question to your therapist" (on whether the app offers sufficient support)				
	Improve	"It's a shame that there is no 'the same' button for when you				
	default times	want to fill out the same thing" "It would be nice if the app would display the time you filed out last time as default option, rather than the current time. It would be nice if the default option would stay close to the times you usually fill out." "I would expect that when you say 00:00 for time to bed, the default value for the next question should be the same or				
		higher and not the current time."				
The virtual Doctor	Computer generated	"Yes, that was quite clear for me" (on if it was clear that the doctor was a virtual character) "Yes, I did understand" (on if it was clear that the doctor was a virtual character)				
	Non-intrusive	"I definitely didn't find the doctor too intrusive" "I didn't find it intrusive, except for the piece of text I mentioned earlier" (text: Your entries helps your therapist to track your progress and treat you better!)				
Personali- zation	Noticed & appreciated	"I see it's personalized, so that's interesting" "Ah, nice!" (on explaining how the app would know the user				
		name)				
Diary layout	Looks trustworthy	"Yeah, trustworthy! Because it looks nice. And I don't know what this logo is, but I thought it was the logo of a company?" "Also because you can contact your therapist, it gives a feeling of trust" "Quite trustworthy, it just gives me that impression, it looks trustworthy with the nice symbols and so on."				
--------------	------------------------	---				
	Help more prominent	"I would make the blue info button bigger" "No, was that indicated at the beginning? I didn't quite understand that. Pity I missed it" (on whether the participant understood he could tap the doctor for help)				



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z48qqxf0vqw/

Appendix O - Improvement Points Final Prototype

Improvement Points Final Prototype

1) Applied in the final prototype?: Yes

- a) **The problem:** When clicking the time, a pop-up appears, after which the time is filled out. Then the "set time" button is hit, after which the pop-up closes. The confirm button on the page then takes the user to next question. The users find one of these buttons redundant.
- b) **The solution:** Create a custom time-field that doesn't open in a pop-up, effectively removing the "set time" button.

2) Applied in the final prototype?: Yes

- a) **The problem:** The default times in the text fields are always set to the current time, which most often are not close to the times being filled out. Users find the extra effort to reach the correct time unnecessary.
- b) **The solution:** Set default times to expected values, either based on previous questions or last nights "time to bed", e.g.

3) Applied in the final prototype?: No

a) **The problem:** Users expressed the wish to be able to fill out the same time as the previous question or day.

The solution: Add a button that enables the users to fill out the same as previous days, or maybe a customizable button with a user-set time.

4) Applied in the final prototype?: No

- a) **The problem:** Users expressed frustration with not being able to go back to previous question by tapping the icon and check or correct their data.
- b) The solution: Make the icons clickable and enable users to go back and correct their data.

5) Applied in the final prototype?: Yes

- a) **The problem:** Users did not click the blue info button with more info when they did not understand a question because they did not see it.
- b) **The solution:** Make the blue info button more prominent by making it bigger or putting it in a different place. The virtual doctor can refer to the button as well.

6) Applied in the final prototype?: Yes

- a) **The problem:** Some users did not understand that they could tap the virtual doctor to ask their therapist a question because they did not read the explanatory text at the beginning.
- b) **The solution:** Explain the virtual doctor in a pop-up dialog box, or with less other text on one page to ensure it is read.

- 7) Applied in the final prototype?: Sort of, translated to Dutch
 - a) The problem: The phrasing of the question caused some participants to think that they were supposed to fill out the number of awakenings first, before filling out the time and duration. In the app it's the time and duration of each awakening individually, after which the user can add another awakening.
 - b) **The solution:** Either rephrase the question, or enable the user to fill out the number of awakenings first.
- 8) Applied in the final prototype?: Yes, Dutch.
 - a) The problem: The application will be used by Dutch people, however, this project is in English.
 - **b) The solution:** Decide, after consulting with coaches, which language to use in the final prototype and stick to that.
- 9) Applied in the final prototype?: Yes
 - a) **The problem:** One user was very annoyed with the text: "Your entries help us to track your progress and treat you better." It was found pushy.
 - b) The solution: Remove that text
- 10) Applied in the final prototype?: Yes
 - a) **The problem:** The overview is not clear to some users, while other users find that it could contain more details, like a scale, legend, etc.
 - b) **The solution:** Refine the overview of the night, during filling out the diary and after. (scale, legend, etc.)

Optional for future development:

- 11) Allow users to choose between the classical input mode or that of the analog diary.
- 12) Enable users to change the order of the icons and thus questions.

Appendix P - Sleep Diary Questionnaire

Sleep Diary Questionnaire

This section asks some questions about your sleeping patterns.Note that the questionnaire says "severity of insomnia", and how noticeable your "sleep problem" is.This questionnaire is used among insomniacs a lot, but is also suited to be used otherwise. It's usage here doesn't mean to imply you have insomnia or sleeping problems!

Q4 Please rate the CURRENT (i.e. last 2 weeks) severity of your insomnia problem(s).

	0. None	1. Mild	2. Moderate	3. Severe	4. Very severe
Difficulty falling asleep	О	О	0	О	O
Difficulty staying asleep	О	О	0	О	О
Problems waking up too early	0	0	0	0	О

Q5 How satisfied/dissatisfied are you with your current sleep pattern?

- O 0. Very satisfied
- O 1. Satisfied
- O 2. Moderately satisfied
- O 3. Dissatisfied
- **O** 4. Very dissatisfied

Q6 How noticeable to others do you think your sleep problem is in terms of impairing the quality of your life?

- **O** 0. Not at all noticeable
- O 1. A little
- O 2. Somewhat
- O 3. Much
- O 4. Very much noticeable

Q7 How worries/distressed are you about your current sleep problem?

- 0. Not at all worried
- O 1. A little
- O 2. Somewhat
- O 3. Much
- O 4. Very much worried

Q8 To what extent do you consider your sleep problem to interfere with your daily functioning (e.g. daytimefatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) currently?

- **O** 0. Not at all interfering
- O 1. A little
- O 2. Somewhat
- O 3. Much
- O 4. Very much interfering

Q10 Dear participants, Thank you again for taking part in my research experiment and the effort made the last seven days! This survey is meant to collect the results of the week and also, if you used it, to ask you about your impressions with the app. There will be some additional screening questions about your sleep in general, to help me perform relevant statistical analysis. Thank you!Lester

Q2 Out of the seven days, which days did you fill out the diary within 60 minutes from waking up? PLEASE NOTE: Only tick the boxes when you filled out the diary withing 60 minutes from waking up, even if you did submit it later. Please DO count any unfinished entries due to technical difficulties (in case of using the app), e.g.

- Saturday
- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday

Q3 Please indicate on any day that you didn't fill out the diary, what the reason was for not filling out the diary that day (forgotten, in a hurry, e.g.)

Saturday Sunday Monday Tuesday Wednesday Thursday Friday

Q1 Which version of the sleep diary did you use?

- **O** Pen-and-paper sleep diary
- O Mobile phone application

If Pen-and-paper sleep diary Is Selected, Then Skip To End of Survey

Q12 For the assessment of the prototype, please fill out the following questionnaire. The questionnaire consists of pairs of contrasting attributes that may apply to the prototype. The circles between the attributes represent gradations between the opposites. You can express your agreement with the attributes by ticking the circle that most closely reflects your impression. This response would mean that you rate the application as more attractive than unattractive. Please decide spontaneously. Don't think too long about your decision to make

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sure that you convey your original impression. Sometimes you may not be completely sure about your agreement with a particular attribute or you may find that the attribute does not apply completely to the particular product. Nevertheless, please tick a circle in every line. It is your personal opinion that counts. Please remember: there is no wrong or right answer!

	1	2	3	4	5	6	7
Annoying:Enjoyable	0	0	0	0	0	0	0
Not understandable:Understandable	О	О	О	О	О	О	О
Creative:Dull	О	О	О	О	О	0	Ο
Easy to learn:Difficult to learn	О	О	О	О	О	0	Ο
Valuable:Inferior	О	О	О	О	О	О	О
Boring:Exciting	О	О	О	О	О	0	Ο
Not interesting:Interesting	О	О	О	О	О	О	Ο
Unpredictable:Predictable	О	О	О	О	О	О	Ο
Fast:Slow	О	О	О	О	О	О	Ο
Inventive:Conventional	О	О	О	О	О	О	Ο
Obstructive:Supportive	О	О	О	О	О	0	Ο
Good:Bad	О	О	О	О	О	О	Ο
Complicated:Easy	О	О	О	О	О	О	Ο
Unlikable:Pleasing	О	О	О	О	О	О	Ο
Usual:Leading edge	О	0	О	О	О	0	Ο
Unpleasant:Pleasant	О	0	О	О	О	0	Ο
Secure:Not secure	О	О	О	О	О	0	Ο
Motivating:Demotivating	О	О	О	О	О	О	Ο
Meets expectations:Does not meet expectations	0	0	О	О	0	0	О
Inefficient:Efficient	О	0	О	О	О	0	Ο
Clear:Confusing	О	0	О	О	О	0	Ο
Impractical:Practical	О	0	О	О	О	0	Ο
Organized:Cluttered	О	0	О	О	О	0	Ο
Attractive:Unattractive	О	О	О	О	О	0	О
Friendly:Unfriendly	0	0	Ο	О	0	0	Ο
Conservative:Innovative	О	0	0	О	О	0	Ο

Q9 Please assess the prototype now by ticking one circle per line.

Q13 What did you like most about the diary?

Q14 1. If you could change things about the prototype what would it be and why?

Q19 Were there any questions that you weren't sure about what they meant? How did you interpret it?

- Q15 Did you set a notification in the app?
- O No
- O Yes

Q16 Why didn't you set a notification?

- Q17 What did you think about the overview of the day?
- Q18 What did you think about the overview of the week?

FOR ACCESS TO THE FILLED OUT QUESTIONNAIRES, CONSENT FORM AND DATA ANALYSIS FILES, SEE: https://www.dropbox.com/sh/icmg-

z48qqxf0vqw/

Appendix Q - Thematic Analysis Sleep Buddy

Theme	Sub-themes	Example quotes
The week overview	Nice to reflect on the week	"It is also nice that you can compare days to each other" "It was nice to have an overview and to know which days I slept well and which I didn't" "Nice, could see that I didn't sleep that well some nights compared to other nights & link that to the activities of those day."
	Can be found Deceiving	"My score was nearly the same every day and still I felt much more rested on some days and more sleepy on others. It was interesting to see that I had still slept well on the days that I felt less awake." "Bit deceiving as I knew how tired I was, but it said I had a great sleeping week. It did not take in account how many hours I slept."
The day overview	Appreciated & clear	"I really liked the circle, it is very clear and easy" I liked it, it was clear, and it motivated me to fill in the whole app every day, as I could see change after each question" "I liked that I could see my answers visually in the circle"
	More explanation Required	"Nice, but I don't know what everything means "I would have liked some more explanation on what everything meant" "The design, app looks boring and the filled in results are not visualized in a clear way"
The questions	Questions one and Two cause confusion	"Maybe add one practice round, to understand the difference between going to bed and turning off the light" "The first time I thought question 1 and 2 were the same, all the times after that I understood the difference." "I think I were able to find out, but for example for me when I go to bed, I turn off the light. So the question about what time going to bed and what time I tried to get a sleep made no sense, this is the reason I go to bed, you see. Also so previous answer."

Theme	Sub-themes	Example quotes
	15 minutes feels limiting	"Sometime you are only awake for a very small moment (a minute or so), but then it's zero or 15 minutes" "You can only indicate the moments that you are awake in quarters. Sometimes you are only awake for a couple of minutes. So the possibility to also indicate this in blocks of five minutes for example" "Also I usually wake up several times for 1 minute only (so if feels) instead of 15 minutes. But maybe those are too short to count anyways?"
Prototype	Improve on technical difficulties	"Make sure that the application is working and available by every kind of Iphone" "Make it an actual app" "The time input element felt clunky and i would try to improve that. I would also store data in a database instead of the emails and use real notifications"

FOR ACCESS TO THE FILLED OUT QUESTIONNAIRES, CONSENT FORM AND DATA ANALYSIS FILES, SEE: https://www.dropbox.com/sh/icmg-

z48qqxf0vqw/

BETTER SLEEP

This document contains the report of the Final Masters Project (FMP) of Lester Moorman, it documents the process and results of the "Sleep Buddy" project, executed between February 2016 and February 2017. The project is aimed at the development of a digital sleep diary that helps patients fill out the diary consistently.

CREATED BY :

Lester ster Moorman

LESTER MOORMAN +31 6 16 201 907

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