Eindhoven University of Technology

MASTER

Enlighten your sleep
the effect of a dawn-dusk simulation on the sleep onset, quality of sleep and waking up of people with psychosis and schizophrenia

van den Akker, M.K.H.

Award date:
2015

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ENLIGHTEN YOUR SLEEP

The effect of a dawn-dusk simulation on the sleep onset, quality of sleep and waking up of people with psychosis and schizophrenia.

Marianne van den Akker
0732290

In partial fulfillment of the requirements for the degree of

Master of Science
in Human Technology Interaction

of the department of Industrial Engineering and Innovation Sciences

Supervisors
Dr. Ir. Y.A.W. de Kort (Yvonne) | TU/e
Dr. Ir. F. Beute (Femke) | TU/e
Dr. M. van der Zwaag (Marjolein) | Philips Research

Eindhoven, June 2015
PREFACE

The upcoming pages describe my master thesis of Human Technology Interaction at the University of Technology, Eindhoven. With this project I was able to develop my interests and experience in lighting, healthcare and usability into further depth. The specific user group really challenged me to combine my skills as a researcher with my soft skills in empathizing, listening, being patient and careful formulation.

I want to take the opportunity to thank my supervisors Yvonne de Kort, Femke Beute, and Marjolein van der Zwaag for supporting me in this project, sharing their knowledge with me and giving me valuable lessons.

Furthermore, I want to thank Els Møst for sharing her knowledge on analyzing sleep data with me. I also want to thank Toine Lamberts, Edwin Cornelissen and Miranda de Weijer from GGzE Center of Psychosis, for giving me this wonderful opportunity to conduct research in their units.

I also want to thank my family and friends who supported me through highs and lows. And to Robin: thank you for being there for me and supporting me so greatly.
ABSTRACT

Many psychiatric disorders are accompanied by sleep problems. These sleep problems can increase the severity of the psychiatric disorders and possibly complicate the recovery process, leading to a vicious circle. Sleep is highly controlled by the biological clock, which regulates the timing of periods of sleepiness and wakefulness throughout the day. Light is the major synchronizer of our biological clock and can therefore potentially support the treatment of psychiatric disorders. Prior studies have shown that dawn and dusk light has positive and improved effects on sleep, recovery of depressions, and daytime activity. To our knowledge however, no research of dawn-dusk light on the effect of sleep has been conducted with psychiatric patients suffering from psychosis and schizophrenia. In this field study we investigated the effect of simulating dawn and dusk light with a Wake-up light in the bedrooms of psychotic patients on sleep onset, sleep quality and waking up. A randomized cross-over design was conducted, with a baseline condition, one experimental dawn-dusk condition, and a waiting list/follow-up condition as control. Sleep patterns of the clients were daily measured through Actiwatch data, sleep diary data and weekly interviews. The participants felt more alert upon waking up with the dawn-dusk simulation as compared to the baseline and control condition. Furthermore, the participants thought that the dawn-dusk simulation improved the quality of their sleep. In addition of these results, the qualitative research rendered valuable insights on experience with the dawn-dusk simulation. The results indicated that the dawn-dusk simulation worked out for some, but not for others. Half of the clients were positive about the dawn-dusk simulation and noticed beneficiary effects. This research proposed new insights in the methodology of dawn-dusk studies and the effects of dawn-dusk light on sleep of psychotic and schizophrenic patients.

Keywords
Dawn-dusk light, Circadian rhythm, Sleep (disorders), Psychosis, Schizophrenia.
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1. INTRODUCTION

Russell Foster (TED talk, 2013) – a prominent circadian neuroscientist - states that if you are an average sort of person, over one third of your life is spent on sleep. This means that if you become ninety, more than 30 years of your life are entirely spent on sleep. What those 30 years tell us is that sleep at some level must be important, Foster argues. He reflects how society developed quite different opinions about sleep over the centuries and illustrates this with a number of quotes. Around the 1600’s and 1700’s sleep was our inspiration: “Sleep is the golden chain that ties health and our bodies together.” - A quote by Thomas Dekker (1611). “O sleep, o gentle sleep, nature's soft nurse, how have I frightened thee” – A quote by William Shakespeare (1710). However, in the 1900’s we began to think differently about sleep: “Sleep is for wimps.” – Margaret Thatcher (around 1985). Thomas Edison (around 1900) also had a different opinion: “Sleep is a criminal waste of time, inherited from our cave days”. What Edison made possible by developing the light bulb, was to make humans able to extend the day and dominate the night. And nowadays, Foster contends, we seem to tolerate sleep, but still we treat it as something negative, perhaps because we think that we are not doing a lot while we are asleep. However, sleep is of great influence on our concentration, creativity, social skills, and mood, and in addition on diabetes, obesity, cancer and mental health as also confirmed by Russell Foster in his TED talk.

There is a strong connection between sleep and mental health. Many psychiatric disorders are accompanied by sleep problems (e.g., Costa e Silva, 2006; Lee, Cho, Cho, Jang, & Kim, 2012; Widakowich, Neu, Nagant, Steegen, & Verbanck, 2010; Sutton, 2014; Monti et al., 2013; Wulff, Gatti, Wettstein, & Foster, 2010). These sleep problems can increase the severity of the psychiatric disorders and possibly complicate the recovery process, leading to a vicious circle.

Sleep is for a large part controlled by the biological clock, which regulates the timing of periods of sleepiness and wakefulness throughout the day. Light is the major synchronizer of our biological clock and can therefore potentially support the treatment of psychiatric disorders (Wirz-Justice et al., 2005). Different studies explain that bright white light in the evening can result in delaying the biological clock, which can result in worsening, amongst others, mood (Kondo et al., 2009). Furthermore, natural day light changes gradually over the day. Kondo et al. (2009) investigated the effect of abrupt changes from light to dark versus twilight light change in the morning and evening on sleep. They suggest that light during dusk and dawn (with light gradually decreasing in the evening and increasing in the morning) could promote sleep in people with dementia, but also healthy people. Mimicking the dawn signal with artificial light in the morning can result in an increased ease of awakening, reduced inertia with more alertness and energy, and can have an antidepressant effect (Wirz-Justice et al., 2005).

The current study aimed at gaining knowledge on improving the sleep onset, the sleep quality and waking up of patients with psychosis and schizophrenia, by a dawn and dusk simulation. The study was conducted at the Centre of Psychosis and sub-department High Intensive Care (HIC) at the mental healthcare institution in Eindhoven (Geestelijke Gezondheids zorg Eindhoven or abbreviated: GGzE). Previously, a combined effort of the GGzE and Philips resulted in co-creating the HIC unit. This department helps the most ill patients by creating a healing environment that is pleasant and enhances their well-being, subsequently accelerating the
recovery process. Currently, the use of light at this centre at the GGzE (white bright light at all times) is not programmed to optimize the synchronization of the biological clock of clients to the day-night period. Through simulating the natural dawn and dusk in the bedrooms of the clients, we hypothesize that sleep onset, sleep quality and waking up (inertia) could be improved.
2. CONTEXT

Literature concerning the user group of this study will be described in the next sections. First the background of the user group is described in the next sections explaining the disorders and emphasizing the severity. Last the situation concerning sleep and the use of lights at GGzE will be explained, to give more rise to the importance of this study in this particular user group.

2.1 Psychosis

Psychosis is often used to describe mind-affecting or psychiatric symptoms. ‘Psychotic’ refers to ‘not having contact with the real world’, meaning that people with psychosis have difficulties with distinguishing the real world from their ‘own’ imaginary world. People with psychosis are in a state of being in which they lose themselves in illusions, hallucinations and incoherent thoughts (Lezy, 2007).

The onset of psychosis is partly through genetic liability, exposure to environmental stressors (e.g., childhood trauma) and urban upbringing (van Os, 2008). Cannabis also acts as a component cause of psychosis, increasing the risk of psychosis in people with certain genetic or environmental vulnerabilities (Parakh, 2013). Apart from Cannabis, alcohol, nicotine, and use of hard drugs can cause substance induced psychoses as well (Howard et al., 2004). The ‘primary symptoms’ of psychosis include delusions, hallucinations, disorganized speech, abnormal psychomotor behaviour, and being negative (World Health organization, 1992). Psychotic experiences are generally thought to be distributed along a spectrum/continuum (van Os, 2008): an episode can differ in strength, experience, and duration. The severity of the symptoms can predict the degree of cognitive and neurological deficits (American Psychiatric Association, 2013).

2.2 Schizophrenia

Several mental disorders (schizophrenia, depression, mania) include the primary symptoms of psychosis. According to Stanghellini and Raballo (2015), the characteristics of psychotic symptoms vary across different mental disorders. The difference between the mental disorders lays in the origin of the delusions. Different feelings and different experiences result in variations of those delusions. Schizophrenic delusions arise from a breakdown of the person’s total awareness of reality (Parnas, 2004, 2011, 2012). The person is struck with ‘something’ that opens up a new, more personal understanding of the world (Stanghellini & Ballerini, 1992). With this new, more personal, understanding of the world, comes poor social functioning. The social impairments associated with schizophrenia may result from deficits in social cognition (Langdon, 2014) – ‘the mental operations that underlie social interactions, including perceiving, interpreting, and generating responses to the intentions, dispositions and behaviours of others’ (Green et al, 2008, p.1).

2.3 GGzE Centrum Psychose and High Intensive Care

The Centre for Psychosis (‘GGzE Centrum Psychoze,’ 2015) is a building with several units. All clients have psychosis and most clients suffer from both psychosis and schizophrenia. The High Intensive Care (HIC) in this building of GGzE is a closed clinic with a maximum of 20 clients. People with different diagnoses enter the HIC on forced admission and stay for one to several weeks. Clients have their own bedroom and they have unsupervised access to the three living rooms and the fenced yard of the accommodation. The other units have a similar outlook with three living rooms, however accommodating different clients. These clients
suffer from prolonged psychiatric issues as consequence of psychoses and usually stay in the centre for a longer period up to years. Moreover, these clients are allowed to go outside without supervision of the staff. One of the units with prolonged admissions of clients is called the Dintel, accommodating a maximum of 20 clients. The research will be conducted in this unit, as well as in the HIC.

2.3.1 Light conditions at the Dintel and HIC
Downlighters are mounted in the ceilings of the living rooms with an illuminance between 100 and 300 lux (Figure 1). This meets the requirements of ‘General lighting on the Intensive Care Unit’ according to Table 5.47 of NEN-EN 12464-1. From 21:00 hours onwards, the light automatically drops to half of its capacity for the remainder of the evening: half of the lights go off, the other half remain at the same intensity. During onsite visits of the researcher, the clients were asked how they feel about the lighting. They report that the lighting is alright, but they don’t like that half of the lights go out at 21 o’clock sharp. Also they report that more atmosphere lighting is preferred, especially in the bedrooms. The patients have three lamps in their bedrooms: two downlighters in the ceiling and one bed lamp. They prefer to have the bed lamp switched on; however they also report that this light is too bright.

2.3.2 Sleep at the Centre of Psychosis and HIC
During visits at the Centre of Psychosis and HIC, the nurses and psychiatrists were asked what they consider to be difficult issues at the unit. Sleep was indicated to be one of the most important issues at this centre. Subsequently, clients were asked about the quality of sleep. The clients reported that their sleep was very light and restless. Some of them experience more problems in falling asleep at night and some of them have more trouble to get up in the morning. They unintentionally wake up at night at different times.

The staff report that the circadian rhythm of the clients is disturbed oftentimes. Some clients wake others at night by noises they make. Especially clients with mania and psychoses have a lot of trouble with sleeping: their illness negatively impacts their sleep experience (bothered by fear and bustle). It is noticed that there is a correlation between the quality of sleep and the severity of the illness. The sleep improves when the health improves and vice versa.

In the following section, the relation between psychiatric disorders and sleep will be discussed. Next, an explanation about the pathways of light and characteristics of light teach us how light can aid in reducing sleep related problems.
3.1 Sleep
Sleep is a physiologic state that is essentially governed by two processes. The first process that controls sleep is a homeostatic process that produces sleep, based on time elapsed since the last sleep. The second and most influencing process that controls sleep is our circadian rhythm (Stewart, 2002). Sleep is therefore strongly controlled by the biological clock, governed by the suprachiasmatic nucleus (SCN) as visible in Figure 2. The SCN is connected with ip-RGCs (light sensitive ganglion cells). These cells contain a photopigment (melanopsin) that is sensitive for the blue spectrum of light and especially sensitive for dawn and dusk light. The light during dawn and dusk therefore activates the ipRGCs to regulate sleep, wakefulness, mood and alertness. The SCN produces melatonin intrinsically. This melatonin production can be interrupted by a light signal, slowing the melatonin production down. When it becomes lighter (during dawn) the SCN is interrupted by this light and tells the brain to make less melatonin so you get awake. When it becomes darker (during dusk) the SCN tells the brain to make more melatonin so you get drowsy (Pinel, 2010). Furthermore, when the social time deviates from the circadian rhythm, it might result in suboptimal mood, alertness and sleep and wakefulness.

Sleep is an active state that is critical for our physical, mental and emotional well-being (Wirz-Justice et al., 2005) and cognitive functioning. Problems with sleeping impair our well-being and functioning. The most common sleep disorder is insomnia, particularly prevalent in psychiatric disorders (Coleman,
The causes of insomnia are mood, panic and anxiety disorders, and dementia (Saddock, 2002). People with insomnia have difficulty in initiating sleep, maintaining sleep, or suffer from non-restorative sleep. The consequences that patients typically report occur during daytime, and include fatigue, irritability and/or an impaired memory, and problems with performance (American Psychiatric Association, 2005). Most studies show that about half of the patients with insomnia have this sleep disorder because of a psychiatric disorder. Moreover, sleep disorders can increase the severity of psychiatric disorders and complicate the recovery process (e.g., Costa e Silva, 2006; Lee et al., 2012; Widakowich et al., 2010; Sutton, 2014; Monti et al., 2013). Gathered insights (through conversations with the staff and clients of the HIC at GGzE) have indicated that especially falling asleep and waking up are problematic for the clients at this unit. Sleep remains one of the key methods to understanding psychiatric disorders and to treating the patients who have them (Costa e Silva, 2006).

3.2 Light

The importance of sleep for psychiatric patients was highlighted in the previous paragraph. It was also highlighted that sleep is partly controlled by our homeostatic process but mainly by our circadian rhythm. Light is the main controller of this circadian rhythm. In this section the functioning of light will be explained, including how light controls our circadian rhythm.

Light can have influence on the visual, but also on the physical and psychological functioning. The psychological impacts of light, for example, play an important role in the perceived atmosphere of an environment, influencing experiences and creating associations with light. Next up, first the different pathways of light will be explained, then dawn-dusk studies will be highlighted, and the last section explains how light influences our experiences, mood, and associations.

3.2.1 Different pathways of light

Only twenty-five years ago, it was thought that the human eye’s only function was to give us the ability to see. This process of seeing could be explained by light detecting photoreceptors (rods and cones) of the retina in the eye. The cells in the inner retina subsequently provided the initial stages of visual processing. Evidence for other functions of the eye however, came later from researchers concerned with the circadian rhythm. Next to the eye’s function of enabling us to see by means of light, the eye also contains a third photoreceptor which causes light to align our biological clock to environmental time (Foster, 2005).

The framework presented in Figure 3 describes the different pathways through which light can influence humans. This framework is inspired by models developed by Boyce (2003) and Veitch, Newsham, Boyce and Jones (2008) and literature overviews by Warthen and Provenzio (2012) and de Kort and Veitch (2014). Light can influence humans through the image forming pathway and through the non-image forming pathway. The image forming pathway takes care of visual experience, visual comfort and visual performance (like object recognition, size, contrast and colour perception) with light coming through the rods and cones in the eye (e.g. Chhajed, Xi, Li, Gessmann, Schubert, 2005; Valberg, 1995; Bergum & Bergum, 1981, Chan & Courtney, 2001; Govén, Laike, Pendse, & Sjöberg, 2007). The non-image forming pathway is divided into long term (circadian) effects and direct (acute) effects. The effects of these non-image forming pathways are caused by light...
entering through the intrinsically photosensitive retinal ganglion cells (ipRGCs) located in the eye. The long term (circadian) effects influence for a large extent the mood, sleep and wakefulness but also cognition and alertness (Vandewalle, Maquet & Dijk, 2009). Furthermore, misalignment of the biological clock can cause cardiovascular problems, sleep disorders and cancer (Escobar et al., 2012). The direct effects of light through the ipRGCs cause changes in mood and cognition, but also alertness and wakefulness, and behaviour (Becker, 2005; Veitch et al., 2008; Cajochen, 2007; Barkmann, 2012; Sleegers et al., 2013). Furthermore, light can also influence humans through the skin: sun-exposed skin produces Vitamin D (Holick, 2008; Landsdowne & Provost, 1993). This can be attributed to UVB radiation of sunlight (Figure 4).

3.2.2 The effect of light on the circadian rhythm

As mentioned, the visual system is based on the perception of light via the rods and cones of the retina and subsequent processing in the visual centers of the brain. In addition to the rods and cones, as mentioned, a third type of receptor is active: the intrinsically photosensitive retinal ganglion cells (ipRGCs) which govern the non-image forming pathway (Berson, Dunn, & Takao, 2002; Brainard et al., 2001; Hattar, Liao, Takao, Berson, & Yau, 2002). Figure 5 shows a visual of the eye and the retina, with the placement of the rods, cones and ipRGCs. This paragraph will specifically go into the long term (circadian) effects of the non-image forming pathway. As also noted, the non-visual system is based on light innervating the ipRGCs. This light falls on the ipRGCs located in the retina, travelling via the retinohypothalamic tract through the optic nerve and optic chiasm to the suprachiasmatic nucleus (SCN). The SCN is the primary clock responsible for the regulation of alertness, mood, sleep and wakefulness and other circadian body functions, controlling these functions through the hormones melatonin and cortisol (Wright, Lowry, Lebourgeois, 2012; Pinel, 2010). Neurons in the SCN have a genetic basis for the circadian rhythm generation, resulting in a rhythm of about 24 hours (Gachon et al., 2004). Circadian is derived from the Latin ‘circa diem’ which means ‘approximately a day’ (thus 24 hours). Differences in this rhythm exist between individuals, but for each individual the endogenous period has precision in variability of only several minutes from day to day (Meijer, Michel, Vansteensel, 2007). Environmental factors are responsible for larger differences between individuals and deviations from the natural biological rhythm. Deviations from the circadian rhythm because of environmental factors might result in suboptimal mood, alertness and sleep and...
wakefulness. Furthermore, the circadian pacemaker in the SCN is also involved in the adaptation to changing day-length between seasons (Ralph, Foster, Davis, & Menaker, 1990; Schwartz, Iglesia, Zlomanczuk, & Illnerova, 2001). A schematic overview of the circadian cycle is depicted in Figure 2.

### 3.2.3 Light at Dawn and Dusk

The ipRGCs in the retina contain the photopigment melanopsin that is sensitive for the blue spectrum of light and specifically to dawn and dusk light, as shortly highlighted in Paragraph 3.1 about sleep. The activation of melanopsin at dawn and dusk is a primary cause for the effects of the non visual system (Hankins, Peirson, & Foster, 2008). Melanopsin photopigment shows peak spectral sensitivity at near 480 nm (Qiu et al., 2005; Panda et al., 2005) which is in the blue spectrum of light. The melanopsin in the ipRGCs is thus maximum active when it absorbs blue light. Furthermore, 480 nm light appears to dominate the wavelengths at dawn and dusk (Foster, 2005). This means that the ipRGCs are responsible for detecting dawn and dusk as well as encoding day-length (Meijer et al., 2007). Besides the response of the SCN to light with a wavelength of 480 nm, SCN cells also code for light intensity. There is a threshold at around 0.1 lux, which is high as compared to the threshold of vision (which is around 0.00001 lux). Above 0.1 lux, SCN cells code almost linear for increments in light intensity until they are saturated at a maximum of 1000 lux. SCN neurons are therefore not able to discriminate between a cloudy and sunny day (10⁵ lux) and also not between a cloudy and a bright night. The cells can only differentiate between day and night. The large possible range of illumination levels in the environment is translated into an electrical activity that falls in the range of the SCN cells, with the transition of light intensities around dawn and dusk.

The synchronization / entrainment of the circadian rhythm with the environmental cycle can be achieved with daily adjustment of the phase and period of the circadian os-
cillator (Daan, 2000). Light pulses can lead to adjustments in the phase of the circadian rhythm. The generation of phase shifts is dependent on the time when the light pulses are given. Phase delays of the rhythm occur after light exposure during early night (dusk) and phase advances can be seen as a result of light pulses during the late night (dawn). There is no phase response to light pulses during the day or at night, they occur thus during dawn and dusk (Pittendrigh, 1988).

The light during dawn and dusk can thus affect the circadian rhythm through the SCN cells. Since the SCN is located just above the optic nerves, which transfer information from the eyes to the brain, the SCN receives information about incoming light. When there is less light (during dusk) the SCN tells the brain to make more melatonin so you get drowsy (Pinel, 2010). When it becomes lighter (during dawn) the SCN tells the brain to make less melatonin so you get awake. During winter and early spring, the natural light in the Netherlands is in most cases not aligned to the natural bedtimes of humans. Especially psychiatric patients are disadvantaged by this phenomenon (e.g. Costa e Silva, 2006; Lee et al., 2012; Widakowich et al., 2010; Sutton, 2014; Monti et al., 2013).

Furthermore, the dim light melatonin onset (DLMO) is the best characterisation of the 24-h melatonin rhythm, which is strongly associated with the circadian sleep-wake rhythm. (Sack, 2007; Lewy, 2010; Lewy, 1999; Nagtegaal, 2002; Pandi-Perumal, 2008). Kondo et al. (2009) studied the influence of gradually changing twilight (dawn-dusk) on core body temperatures and melatonin secretion compared to abrupt changing light. They found that dawn dusk light is physiologically significant in increasing the core body temperature earlier in the morning and increasing melatonin secretion at 2 o’clock in the night. Also it was found that the morning drowsiness was lower in the dawn dusk condition.

By using artificial dawn and dusk light aligned to the bedtimes of the patients, their objective sleep and subjective sleep experience might improve. A dawn-dusk simulation can thus potentially support the treatment of psychiatric disorders. The anticipated benefit from this study of simulating the dawn and dusk in the bedrooms of the clients, is that sleep onset, sleep quality, and waking up can be improved resulting in reduced inertia, more alertness and energy during the day on short term and a reduction of symptoms on the longer run. The dusk simulation implies that the light in the bedrooms will gradually decrease in brightness (from 250 to 0 lux) and colour temperature (from 2700 to 1000 K) supporting the onset of melatonin production. The dawn simulation implies that the light in the bedrooms will gradually increase in brightness (from 0 to 250 lux) and colour temperature (from 1000 to 2700 K) supporting the termination of melatonin production.

Research on dawn and dawn-dusk studies reveal positive and improved effects on sleep, recovery of depressions, and daytime activity (e.g. Avery, Bolte, Wolfson, & Kazaras, 1994; Avery et al., 2001; Gabel et al., 2013). In a study from Gabel et al. (2013) with seventeen healthy participants, three different light settings (dawn-simulation, dim light, and blue LED light) separated by two weeks were administered each morning after two 6h sleep restricted nights. The results indicate that subjective mood, tension, cognition, and well-being were all improved in the dawn condition only. The influence of a dawn simulation using a Wake-up light for one week (and one control week) was tested on 103 healthy children and adolescents in
a study from Fromm, Horlebein, Meergans, Niesner, & Randler (2011). The participants reported that alertness and wake-up time were improved. Avery, Bolte, Wolfson, & Kazaras (1994) conducted a study in which nineteen participants with winter depression were treated with either a week dawn simulation or a week red dawn signal. The results indicate that depressions were less after the dawn simulation, but not after the red dawn signal. Leppämäki, Meesters, Haukka, Lönnqvist, & Partonen (2003) tested the effect of a dawn simulator on SAD with 77 volunteer subjects from a community-based trial. Subjective quality of sleep was improved after six days of dawn simulation, however with modest benefits. In a study from Gasio et al. (2003) a dawn-dusk simulation was compared to a dim red light condition in a protocol of 3 weeks each of baseline, treatment and follow-up, completed by 13 demented participants. The two conditions were compared using actimetry-determined sleep variables. The results of the Actiwatch data showed that the participants in the dawn-dusk condition had shorter sleep latency, longer sleep duration, more nocturnal immobility, and less nocturnal activity compared to the dim red light group. Viola et al. (2015) tested the effect of a dawn simulation and a control condition (darkness during sleep and dim light during wakefulness) on cardiovascular vulnerability with 17 healthy participants. It was observed that the dawn simulation significantly impacted the parasympathetic cardiac activity. The data revealed that the dawn simulation resulted in a significant gradient reduction in heart rate during the transition from sleep to wakefulness compared to the control condition. During the transition from sleep to wakefulness, parasympathetic cardiac activity is maintained stable only when participants are exposed to dawn simulation light, while a drastic decrease is observed under dim light (the control condition). Dawn light exposure may therefore minimize the sharp decrease in parasympathetic cardiac control, so that the heart rate is more stable during the transition from sleep to wakefulness. These studies have been conducted with several user groups, however, to the researcher’s knowledge not yet with psychiatric patients suffering from psychoses and schizophrenia. Since this group of people suffers severely from sleep related problems, a dawn and dusk simulation might be an effective way to ameliorate sleep related issues and experiences. Therefore, this paper will describe a study exploring the effects of a dawn and dusk study on sleep of patients with psychoses and/or schizophrenia. This study is an explorative study to investigate if there are noticeable effects in this user group, and if the methods work on the patients.

3.2.4 Atmosphere perception and associations with light

Apart from the influence of (dawn and dusk) light on the circadian system, light also has an impact on how we perceive the atmosphere of an environment. The atmosphere of an environment has a large effect on human beings. It can influence mood, well-being and behaviour (e.g. Veitch & Gifford, 1993; Aan ‘t Rot, Moskowitz & Young, 2006). The impact of light on the atmosphere can therefore also affect the psychiatric patients in other ways than their sleep or even contribute to the sleeping experience of the clients. It is therefore relevant to include atmosphere perception in the study. Atmosphere is described as the ‘subjective impression of the environment related to the expected (and not necessarily actual) effect on mood’ (Vogels, 2008). Atmosphere perception can be used to determine the psychological effect
of environments, rather than mood because mood is also affected by other than environmental factors like cognition. It was demonstrated by experiments from Vogels (2008) that atmosphere can be described by four underlying dimensions: Coziness, Liveliness, Tenseness, and Detachment. The atmosphere can be characterized as high or low scores on these dimensions, together giving an impression about the expected impact on mood, well-being and behaviour. Apart from the expected effect of atmosphere on mood, people's mood can also be directly affected by light (e.g., through illumination, color, and color temperature of light), as a result of people's personal preference (Veitch et al., 2008). People prefer daylight (Boyce, Hunter, & Howlett, 2003) and environments that are sunny and bright (Beute & de Kort, 2013). Bright light is often associated with sunlight, but bright light can also come from artificial sources. Since the artificial dawn and dusk light applied in the study emits bright light at its peak, it can potentially influence the clients in other ways than improving sleep. The clients might prefer the lamp with the dawn and dusk simulation as compared to the existing light-dark situation at GGzE, as result of the bright light from this lamp. Brightness (natural as well as artificial) can also give and impression of heat: the brighter the light, the warmer the room appears (Quinn, 1981). On the other hand, rooms with low and warm illumination are associated with homelike environments, and rooms with high and cool illumination are associated with offices and hospitals (Baron & Rea, 1991). The clients might either prefer the simulated light because of the warmer appearance of the room, or they do not prefer the light above the existing situation because they potentially relate it to the hospital like environment they are in. Although, the latter is questionable since the light from the dawn-dusk simulation is in the range of lower (warm) colour temperatures. Overall, people generally believe that exposure to daylight is beneficial for many aspects of wellbeing, such as health, mood, and performance (Veitch & Gifford, 1993). Therefore, there is a possibility that the artificial dawn and dusk light might not give rise to beliefs of beneficial effects or preferences of this light. Furthermore, preferences of light are also dependent on the environment. Light enables us to view the environment and being able to see this environment gives us a feeling of control and safety of the environment (Koskela & Pain, 2000). The clients might therefore perceive the atmosphere of their bedrooms different with the dawn-dusk simulation than in the existing light-dark situation. Furthermore, the association with light is also influenced by past experiences in a certain environment. Warm white light is often related to positive memories, whereas cool white light is related to more negative or less pleasant memories. As the light from the dawn-dusk simulation emits warm white light, it potentially evokes positive memories. In sum, preferences of light are dependent of associations with light.

3.3 Rationale

Gathered insights (through conversations with the staff and clients) have indicated that falling asleep, sleeping and waking up pose substantial problems for the clients of the Centre of Psychosis and HIC at GGzE. Through simulating the natural dawn and dusk in the bedrooms of the clients, sleep onset, sleep quality and waking up (inertia) may be improved, in line with results reported for a range of other populations.
3.3.1 Primary and secondary objectives

The research question of this evaluation is the following:

Does a dawn-dusk simulation improve the day-night rhythm - sleep onset, sleep quality and the ease of waking up - of people with psychosis and/or schizophrenia, as compared to the existing white light/darkness transition?

The following hypothesis is posed:

Through application of the dawn-dusk simulation, the experienced sleep quality - duration of sleep, and sleep efficiency, fragmentation of sleep, nocturnal wakefulness and nocturnal activity - will improve relative to the existing situation, measured through subjective reporting and objective data. The sleep onset latency and ease of waking up - measured through morning feelings - will improve as well, relative to the existing situation, measured through subjective reporting and objective data.

This primary objective will be achieved by comparing subjective sleep data acquired via a sleep diary, of the existing light situation with the dawn-dusk simulation. Also, objective sleep data from the Actiwatch will be compared between the existing light-dark situation and the dawn-dusk simulation. Subjective and objective sleep data will be compared within and between participants. The secondary objective is to investigate the satisfaction of clients with the lamp and the dusk-dawn simulation as compared with the existing situation; and the experience of the staff about the satisfaction of the clients. This will be achieved by comparing the evaluation questionnaire (obtained during the interview) between the two conditions: the condition with the existing dark-light situation versus the condition with the dawn-dusk situation. An evaluation questionnaire will also be administered to the staff, to compare the interview results of the clients with the experience of the staff.

It must be highlighted that this study is an exploratory study, to investigate whether there are noticeable effects on this group of people or not, and to explore whether the effort of participating in the study is burdensome for the clients. In addition, this study explores the potential of conducting a larger dawn-dusk study in a group of psychotic and/or schizophrenic patients.
### 4. METHOD

#### 4.1 Design

In this field study a randomized cross-over design was conducted, with a baseline condition, one experimental dawn-dusk condition, and a waiting list/follow-up condition as control. An overview of the study design is depicted in Figure 6. The duration of the study was fifteen days, each condition lasting for five days. During the first five days baseline measures were conducted in order to determine how the participants sleep under the existing light conditions. During day 5-10 study group 1 received the experimental condition, while waiting list group 1 remained in the original light-dark situation. This was immediately followed by a switch in conditions between the two groups. The baseline condition was included to compensate for interpersonal differences between the participants and to determine bedtimes of the participants, which are used to synchronize with the onset time of the dawn and dusk simulation. Furthermore the participants were expected to naturally recover over time, so the baseline condition checked for differences in severity of sleep problems between participants. The control condition allowed us to control for general recovery trajectories. Furthermore a follow-up condition was included to measure a possible wash out effect: the influence of the DD on the sleep could either fade out or even continue to have an effect (Lieverse et al., 2011).

#### 4.2 Participants

##### 4.2.1 Sample

Thirteen participants of both sexes started with the study. During the study, two of the thirteen participants dropped out because of an unexpected dismissal. Eight males and three females completed the study (mean age = 40.38, SD age = 11.27, and an age range of 20-60). As many clients as possible –who wanted to participate- were included in the study. Six participants were clients of the HIC with a residential duration ranging from 2 days to a couple of weeks, and five participants were clients of the Dintel with residential durations ranging from a couple of months to years (all sub-departments of the Centre of Psychosis at GGzE). All participants suffered from psychoses and/or schizophrenia. Treatment and medication prescription were not influenced. Participants that had a dismissal date within the duration of the study were excluded from the study. The Actiwatch sleep data from participants that did not wear the Actiwatch for more than three subsequent days was excluded as well. Eight staff members (three males and five females) of the Centre of Psychosis were interviewed at the end of the evaluation. One of the interviewed staff members was a nurse specialist, the other staff members were nurses.

![Figure 6 | Design of the study.](image-url)
4.2.2 Sample size justification
The sample size was predominantly determined by the number of clients available at the Centre of Psychosis having a planned duration of stay longer than the study period. It appeared to be conventional to include 10 - 18 participants to perform the study, according to research on dawn and dusk-dawn studies (Thorn, 2004; Gabel, 2013; Avery, 1994; Gasio, 2003). The sample size of the staff is also predominantly determined by the number of staff available at the Centre of Psychosis. All available staff members were included in the final evaluation interview.

4.3 Setting and apparatus
The study was conducted in the Centre of Psychosis including the sub-department High Intensive Care. The study took place in the individual bedrooms of the client participants. A Philips Wake-up light (HF3510/01) was placed on the nightstand next to the clients’ bed at eye height and at approximately 50 centimeters from the pillow. The lamp was given one-quarter turn away from the client so that the light did not directly shine into the eyes (Figure 7).

4.3.1 Extra: creating a light theme to get the unit involved
Based on the idea of the staff a ‘light theme’ was created in the Centre of Psychosis during the pilot study. It was assumed that this would increase adherence to the pilot. The theme was realized by providing Philips Living Color lamps (Figure 8) to the unit. The lamps were used to create different atmospheres in the living rooms in the evening. Also information brochures about the pilot were provided and put in the living room. The staff switched on the Living Color lamps in the evening. The lamps were used on top of the normal white light in the living room. The Living Color lamps did not disturb the study.

4.4 Manipulations
4.4.1 Wake-up light
In the experimental condition, the clients received a lamp, which they were asked to use during one week of the study (Figure 9). The Philips Wake-up light (Koninklijke Philips Electronics NV, Amsterdam, the Netherlands), is an alarm clock with an integrated dawn and dusk simulation. The lamp is CE-marked. Lighting switched on 30 minutes before waking and gradually increased from 0 to 250 lux, measured at 50 centimeters from the source, and from 1000 to 2700 K. The opposite effect was generated before going asleep: the lighting decreased from 250 to 0 lux and from 2700 to 1000 K in 30 minutes. The dusk simulation was scheduled to decrease when the participant lay in bed, and was fully dimmed at sleep time.
In the dawn simulation the light gradually increased in brightness and increased in colour temperature, and started half an hour before the preferred waking time of the participant. In the dusk simulation the light gradually decreased in brightness and decreased in colour temperature half an hour before going to sleep. Furthermore, the preferred bedtime and wake-up time of the participants was asked during the intake questionnaire. The answers on these two questions were used to synchronize the preferred bedtimes with the individual onset time of the dawn and dusk simulation.

4.5 Measurements

4.5.1 Actiwatch
During the 15 days of participation, all clients were asked to wear an Actiwatch Spectrum Pro (Figure 10). The Actiwatch Spectrum Pro (Philips Respironics, Pittsburg, USA) is a wrist worn accelerometer and light recorder. It is waterproof (IEC Standard 60529 IP52), CE marked and a medical device class II. Actigraphy is the standard method of collecting rest-activity rhythms in the field.

4.5.2 Intake questionnaire
On the start of the participation, the clients were asked to fill in an intake questionnaire. This questionnaire included 19 multiple choice questions about morningness/eveningness (Morning-Evening Questionnaire; Horne and Ostberg, 1976). The questions were answered on either a four or five point scale describing different activities on different times. Furthermore two questions were added about the preferred bedtime and wake-up time of the participants. The answers on these two questions were used to synchronize with the onset time of the dawn and dusk simulation. The intake questionnaire can be retrieved in Appendix A.

4.5.3 Sleep diary
The participants were asked to fill in a sleep diary, every morning upon awakening and every evening before bedtime. Because some of the participants were unable to fill in the sleep diary by themselves, and others needed motivation to fill in the sleep diary, the participants were assisted by the researcher in filling in the sleep diary, every day of the study. The morning questionnaire of the sleep diary included 11 questions with space for additional comments. The questions were from the Consensus Sleep Diary (Carney et al., 2012) asking about the quality of sleep of last night rated on a 5 point Likert scale, feelings of rest upon awaking rated on
4.5.4 Interview clients

At the end of the week, after every five days of participation, the clients participated in a brief interview. This interview contained multiple choice questions about the atmosphere in the ward during the five past days (Atmosphere Metrics, Vogels et al., 2008), the subjective quality of sleep (whether it improved, worsened or stayed the same compared to the week before), and current arousal and mood valence (Thayer, 1986). All questions were answered on a 5 point Likert scale. The items that were added from Atmosphere Metrics (Vogels, 2008), were ‘pleasant atmosphere’, ‘vivid atmosphere’, ‘tense atmosphere’, ‘formal atmosphere’, and satisfaction about ‘light of the atmosphere’, ‘temperature of the atmosphere’ and ‘privacy’. Extra atmosphere items about ‘atmosphere in the bedroom’ and ‘atmosphere in the ward’ were added since both spaces (bedroom and ward) could influence the clients. The items added from Thayer (1986) were ‘energetic’, ‘sleepy’, ‘calm’, ‘tense’, ‘sad’, and ‘happy’. The amount of the items included in the interview was restricted, because of the condition and attention span of the clients. Adding more items would have led to overloading the clients and possibly less reliable results. Furthermore, after the week of the dawn-dusk light intervention, the participants were asked three questions about their experience with the lamp. The first question was: ‘On a scale from 1 to 10, to what extent would you advice the lamp to your friends/family?’ The second question was: ‘Would you like to continue to use the Wake-up light at home? Yes/No, Why/Why not?’ The third question was: ‘Would you like to continue to use the Wake-up light here? Yes/No, Why/Why not?’ The clients’ interview can be retrieved in Appendix C1.

4.5.5 Interview staff

After the study, the nurses and nurse specialist were asked to participate in a short interview, about the atmosphere in the ward during the study time, the sleep pattern of the clients, and the influence of the Wake-up light. The items that were added from Atmosphere Metrics (Vogels, 2008), were ‘pleasant atmosphere’, ‘vivid atmosphere’,
‘tense atmosphere’, ‘formal atmosphere’, and satisfaction about ‘light of the atmosphere’, ‘temperature of the atmosphere’ and ‘atmosphere in the building’. The following extra questions were added: ‘How did the quality of sleep of the clients change during the study?’ ‘How do you rate the effect of the Wake-up light on the clients?’ ‘How did you experience the Wake-up light at this unit?’ and ‘Would you choose to have the Wake-up lights at the unit in near future?’ The interview with the staff can be retrieved in Appendix C2.

4.6 Procedure
Participants started either on the 2nd or the 9th of March with the study (BL-DD-FU or BL-WL-DD). Since the minimum sample size was not achieved, a second pilot was started on the 7th of April, a week after the clock was switched to summer time. The participant could decide to stop at any moment during the pilot. Their motivation for leaving the evaluation was asked, with explicit emphasis on the fact that the participant was not required to give any reason.

Several measurements were taken during the 15 days: Firstly, during an intake session demographic information (sex and age) was gathered from the participants, as well as the chronotype. During the intake session participants were asked to wear an Actiwatch (see Figure 10) in order to measure activity and sleep parameters. The Actiwatch was worn continuously during the duration of the evaluation, meaning three weeks. Because the Actiwatch is a valuable device, the Actiwatch was handed in to the staff when participants left the unit. Secondly, participants were asked to fill in a sleep diary (see Appendix B) every evening before bedtime and in the morning after getting up. The participants were assisted by the researcher every day in filling in the sleep diary. The sleep diary measured the subjective sleep duration, subjective quality, morning inertia and general questions on daytime activities. Thirdly, after finishing each of the 5 days the participants were being interviewed (see Appendix C) about their sleep experience and atmosphere at the unit. After the study was finished, the staff was interviewed about their experience with the study and satisfaction with the lamps.

Staff members were only be asked to participate in an interview at the end of the pilot study: see Figure 6, the last interview box. The interview took ten minutes at most.

4.7 Statistical analysis
The analyses were conducted using IBM SPSS 20. In order to assess the influence of dawn-dusk light on sleep, Hierarchical Linear Models (HLMs) were conducted comparing the influence of dawn-dusk light versus the normally used light-dark situation on sleep. No significant effects resulted from the analyses of dawn-dusk versus the control condition, corrected by the baseline condition. Therefore different analyses were conducted, where the baseline condition, waiting list, and follow-up condition were each separately compared against the dawn-dusk condition. The first HLM was conducted comparing the baseline week versus the dawn-dusk week, specifying first the participants as subjects and adding the conditions (baseline week and dawn-dusk week) as fixed factors to the model. The sleep onset, sleep quality, and waking up variables were each analyzed separately as dependent variable. The second HLM was conducted comparing the dawn-dusk week versus the waiting-list week. The third HLM was conducted comparing the dawn-dusk week versus the follow-up week (control week) to investigate the effect of order and possible wash-out effects of the dawn-dusk.
week. An outlier analysis was conducted, where standardized z-scores below -3 or above 3 were excluded from further analysis. The standardized z-scores with removed outliers were used in further analyses. Separate HLM models were used with the diary and interview questions as dependent variables and the conditions (baseline versus dawn-dusk; waiting list versus dawn-dusk; and dawn-dusk versus follow-up) as fixed factors to the model.
The sleep patterns of the clients were measured daily through objective Actiwatch data and subjective sleep diary data. To analyse these sleep patterns, first the Actiwatch data was pre-processed to determine the sleep intervals from the Actiwatch data. The data from this pre-analysis were used in the main analysis, together with the data from the sleep diaries. In the main analysis we investigated the effect of dawn-dusk light on the sleep onset, sleep quality and waking up of the clients. Next, the answers on the weekly interview questions about the atmosphere at the unit, quality of clients’ sleep and clients’ mood were examined. After the analysis of the interview answers, the answers on the interview questions about the experience with the Wake-up lamp and comments during the study were described. In addition, the answers of the interviews with the staff about clients’ sleep, atmosphere at the unit and experience with the Wake-up lamp were described. Last, the personal experiences of the researcher are shared, to inform on the special level of expertise required in this group of participants.

5.1 Pre-analysis: setting Actiwatch intervals
First, the Actiwatch data were analyzed by looking at the actigraphy of each participant. An actigraph basically shows the activity levels of each participant for each day. Based on the activity levels, sleep intervals

Figure 11 | actigraphy of one participant. The areas marked in light blue represent the time the participant is in bed but not asleep. The areas marked in darker blue represent the sleep time of the participant. The light purple areas represent the off-wrist times of the participant. The activity levels are represented in black.
were determined which were used by the software to calculate sleep data. There are three different methods to determine these intervals. The first one is an automatic function built into the Actiwatch software, which makes the distinction between sleeping and awake, however this function seemed not specific enough for the complex sleep data of this group. The Actiwatch sleep data showed almost no visible distinction between sleeping and being awake at some moments, making it difficult to determine the sleep intervals. The second method to set the sleep intervals was to use the data of the diaries, filled in by the participants. Even healthy people struggle with remembering at what time they fall asleep, let alone people with psychosis and other mental illnesses. The sleep intervals from the diaries did not seem reliable enough for most of the participants. Therefore, together with an expert on analyzing sleep data we determined consistent, more specific rules to establish the sleep intervals. These rules (Appendix D) were based on the activity levels of the participants. The sleep interval data from the diaries were compared with our own determined sleep interval data; and the sleep intervals determined with our own set of rules seemed indeed more reliable. Therefore, the data generated by the Actiwatch software based on our own set of rules were used in the main analysis. Figure 11 shows an example of the actigraphy of one participant (see Appendix D for all the actigraphy and an explanation of the rules that were used to determine the intervals).

Together with an expert on analyzing sleep data, the sleep intervals of both the Actiwatch and the diary was looked at on a daily level for each week first, to see whether there was a regular pattern of change in each week (possibly indicating an improvement or deterioration during a condition). The sleep intervals of all patients differed greatly each day, with no recognizable pattern of duration of sleep, time of sleep onset and wake-up time over the week. As no patterns were found in changing sleep duration, time of sleep onset and wake-up times from day to day, the averages and standard deviations were calculated for each variable, per week, per participant. These averaged data were used in the further analysis.

5.2 Main analysis: sleep
Our hypothesis was that through application of the dawn-dusk simulation the experienced sleep quality, sleep onset, and ease of waking up would improve relative to the existing light-dark situation. In order to assess the influence of dawn-dusk light on sleep, Hierarchical Linear Models (HLMs) were conducted comparing the influence of dawn-dusk light versus the normally used light-dark situation on sleep. The results of the first HLM comparing the baseline week versus the dawn-dusk week, can be retrieved in Table 2. The second HLM was conducted comparing the dawn-dusk week versus the waiting-list week (Table 3). The third HLM was conducted comparing the dawn-dusk week versus the follow-up week (control week) to investigate the effect of order and possible wash-out effects of the dawn-dusk week. The results of the third HLM analysis can be retrieved in Table 4. The means and standard errors of the parameters in each condition are shown in Table 1. The Actiwatch data of two participants were excluded from the analysis, since half or even more of the actigraphy was missing because of an high off-wrist percentage. In addition, two outliers were found: one outlier in the onset latency variable, and one in the average awake time variable. The outliers were from different participants, however
both in the dawn-dusk week. Furthermore, the diary data of one participant were excluded from the analysis, since only three days were filled out by the participant.

Table 1 | Means and SEs of the parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline M (SE)</th>
<th>Dawn Dusk M (SE)</th>
<th>Control M (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective Actiwatch data on daily basis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset latency</td>
<td>4.20 (1.82)</td>
<td>6.63 (3.98)</td>
<td>5.71 (2.56)</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>504.02 (75.47)</td>
<td>536.90 (63.41)</td>
<td>494.28 (62.10)</td>
</tr>
<tr>
<td>Sleep efficiency</td>
<td>79.40 (9.24)</td>
<td>78.68 (30.17)</td>
<td>80.59 (9.00)</td>
</tr>
<tr>
<td>Wake time after sleep onset (WASO)</td>
<td>50.85 (10.96)</td>
<td>43.78 (8.95)</td>
<td>44.76 (7.90)</td>
</tr>
<tr>
<td>Average awake time</td>
<td>2.48 (0.28)</td>
<td>3.42 (0.93)</td>
<td>2.39 (0.28)</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>24.30 (5.52)</td>
<td>22.83 (5.16)</td>
<td>24.94 (4.98)</td>
</tr>
<tr>
<td>Total activity counts</td>
<td>8607.28 (2203.74)</td>
<td>7649.89 (2211.72)</td>
<td>6962.28 (1390.46)</td>
</tr>
<tr>
<td><strong>Subjective Sleep diary data on daily basis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of sleep</td>
<td>3.45 (0.15)</td>
<td>3.29 (0.15)</td>
<td>3.31 (0.26)</td>
</tr>
<tr>
<td>Feeling rested after awakening</td>
<td>3.67 (0.25)</td>
<td>3.64 (0.27)</td>
<td>3.49 (0.30)</td>
</tr>
<tr>
<td>Alertness after awake</td>
<td>5.12 (0.45)</td>
<td>3.31 (0.73)</td>
<td>3.81 (0.64)</td>
</tr>
</tbody>
</table>

5.2.1 Sleep onset measured by Actiwatch data

The sleep onset was measured by the Actiwatch software through subtracting the time when the client was in bed trying to sleep (indicated by lower activity levels than being awake) and the time of falling asleep (indicated by even lower activity levels when sleeping). The hypothesis was that the sleep onset would improve with the simulated dawn-dusk light versus the existing light-dark situation. No significant effect of the condition (Baseline versus Dawn-Dusk, Waiting List versus Dawn-Dusk, and Dawn-Dusk versus Follow-up) on the sleep onset latency was found, not confirming our hypothesis.

5.2.2 Sleep quality

Sleep quality was measured through sleep parameters from Actiwatch data: the duration of sleep, the WASO (total wake time after sleep onset and before the last time of waking up), the sleep efficiency (average of continuous sleep hours), the fragmentation (amount of times being awake at night), and the average amount of time per being awake. Furthermore the total activity counts (amount and height of movements during sleep) were measured with Actiwatch data. Last, the subjective quality of sleep was measured through data from the sleep diary.

5.2.2.1 Sleep quality measured with Actiwatch data

The hypothesis was that the experienced sleep quality would improve through applica-
tion of the dawn-dusk simulation, relative to the existing situation without the dawn-dusk simulation. This experienced sleep quality was measured through Actiwatch data (by indicators of duration of sleep, sleep efficiency, WASO, fragmentation of sleep, nocturnal wakefulness, and nocturnal activity). A positive significant effect was found of the condition (Dawn-Dusk versus Waiting List) on fragmentation of sleep. This meant that the participants woke up fewer amount of times at night during the week of the dawn-dusk simulation compared to the waiting list week. This indicated a better and less disturbed sleep. This effect was not found for the baseline week versus the dawn-dusk week, nor for the dawn-dusk week versus the follow-up week. No additional significant effect of the condition (Baseline versus Dawn-Dusk, Waiting List versus Dawn-Dusk, and Dawn-Dusk versus Follow-up) on the duration of sleep, WASO, sleep efficiency, average awake time per being awake, and total activity counts were found (Table 2-4). Apart from the positive significant effect of the dawn-dusk light on the amount of times that the participants woke up at night, the results were not in line with the hypothesis.

5.2.2.2 Sleep quality measured with Sleep diary data

The experienced sleep quality was also measured through sleep diary data (by the question about subjective quality of sleep). No effects were found on the condition (Baseline versus Dawn-Dusk, Waiting List versus Dawn-Dusk, and Dawn-Dusk versus Follow-up) on the subjective quality of sleep (Table 2-4). This was not confirming our hypothesis.

| Table 2 | Baseline week versus Dawn-Dusk week. |
|---|---|---|
| **Baseline week versus Dawn Dusk week** | **F (df, df error)** | **p-value** | **Estimate (β)** |
| Objective Actiwatch data on daily basis | | | |
| Onset latency | (1, 4.40) = 0.45 | 0.53 | -0.15 |
| Sleep duration | (1, 8) = 0.73 | 0.42 | 0.17 |
| Sleep efficiency | (1, 8) = 0.12 | 0.73 | -0.03 |
| Wake time after sleep onset (WASO) | (1, 8) = 0.73 | 0.42 | 0.26 |
| Average awake time | (1, 8) = 0.96 | 0.36 | 0.54 |
| Fragmentation | (1, 8) = 0.17 | 0.69 | -0.10 |
| Total activity counts | (1, 8) = 0.41 | 0.54 | -0.18 |
| Subjective Sleep diary data on daily basis | | | |
| Quality of sleep | (1,9) = 1.25 | 0.29 | -0.28 |
| Feeling rested after awaking | (1,9) = 0.00 | 0.94 | -0.03 |
| Alertness after awake | (1,18) = 4.39 | 0.05* | -0.90 |

* is significant at p < .05.
5.2.3 Waking up measured by Sleep diary data

The feelings of waking up (feeling refreshed after awaking and alertness after awaking) were measured through qualitative data from the sleep diaries. The hypothesis was that through application of the dawn-dusk simulation, waking up will improve relative to the existing light-dark situation.

No significant effect of the condition (Baseline versus Dawn-Dusk, Waiting List versus Dawn-Dusk, and Dawn-Dusk versus Follow-up) on how refreshed participants were upon awaking was found (Table 2-4).

A significant effect was however found for the condition (BL/DD) on the alertness after just waking up positive for the Dawn-Dusk week (see Table 2). This meant that most people mentioned that they were more alert in the mornings during the dusk-dawn week, compared to the baseline week, in line with the hypothesis.

<table>
<thead>
<tr>
<th>F (df, df error)</th>
<th>p-value</th>
<th>Estimate (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective Actiwatch data on daily basis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset latency</td>
<td>(1, 6) = 0.13</td>
<td>0.74</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>(1, 3) = 0.29</td>
<td>0.63</td>
</tr>
<tr>
<td>Sleep efficiency</td>
<td>(1, 3) = 0.30</td>
<td>0.62</td>
</tr>
<tr>
<td>Wake time after sleep onset (WASO)</td>
<td>(1, 3) = 0.72</td>
<td>0.46</td>
</tr>
<tr>
<td>Average awake time</td>
<td>(1, 3) = 0.46</td>
<td>0.55</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>(1, 3) = 15.93</td>
<td>0.03*</td>
</tr>
<tr>
<td>Total activity counts</td>
<td>(1, 3) = 0.71</td>
<td>0.45</td>
</tr>
<tr>
<td>Subjective Sleep diary data on daily basis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of sleep</td>
<td>(1, 3) = 0.22</td>
<td>0.67</td>
</tr>
<tr>
<td>Feeling rested after awaking</td>
<td>(1, 3) = 0.90</td>
<td>0.41</td>
</tr>
<tr>
<td>Alertness after awake</td>
<td>(1, 3) = 2.08</td>
<td>0.25</td>
</tr>
</tbody>
</table>

* is significant at p < .05.
Table 4 | Dawn-Dusk week versus Follow-up week.

<table>
<thead>
<tr>
<th>Objective Actiwatch data on daily basis</th>
<th>F (df, df error)</th>
<th>p-value</th>
<th>Estimate (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Onset latency</strong></td>
<td>(1, 7) = .97</td>
<td>0.36</td>
<td>-0.56</td>
</tr>
<tr>
<td><strong>Sleep duration</strong></td>
<td>(1, 4) = 3.73</td>
<td>0.13</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Sleep efficiency</strong></td>
<td>(1, 4) = .24</td>
<td>0.65</td>
<td>-0.09</td>
</tr>
<tr>
<td><strong>Wake time after sleep onset (WASO)</strong></td>
<td>(1, 4) = .56</td>
<td>0.50</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Average awake time</strong></td>
<td>(1, 8) = 1.77</td>
<td>0.22</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>Fragmentation</strong></td>
<td>(1, 4) = 0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total activity counts</strong></td>
<td>(1, 4) = 0.71</td>
<td>0.45</td>
<td>0.44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subjective Sleep diary data on daily basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quality of sleep</strong></td>
</tr>
<tr>
<td><strong>Feeling rested after awakening</strong></td>
</tr>
<tr>
<td><strong>Alertness after awake</strong></td>
</tr>
</tbody>
</table>
5.3 Interview data: sleep, atmosphere perception and mood

The questions of the weekly interviews consisted of multiple choice questions, which were filled in by the participant, assisted by the researcher. The data of these questions were added to the Hierarchical Linear Model analyses. Again three HLM analyses were conducted. The first HLM was conducted comparing the baseline week versus the dawn-dusk week. The interview answers were each explored separately as dependent variable. The second HLM was conducted comparing the dawn-dusk week versus the waiting list week, the third HLM was conducted comparing the dawn-dusk week versus the follow-up week. No outliers were found in the interview data. The means and standard errors of the interview answers in each condition are shown in Table 5.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Baseline M (SE)</th>
<th>Dawn Dusk M (SE)</th>
<th>Control M (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasant atmosphere</td>
<td>3.10 (0.41)</td>
<td>2.55 (0.25)</td>
<td>2.18 (0.26)</td>
</tr>
<tr>
<td>Vivid atmosphere</td>
<td>3.45 (0.37)</td>
<td>2.91 (0.39)</td>
<td>2.91 (0.39)</td>
</tr>
<tr>
<td>Tense atmosphere</td>
<td>3.20 (0.47)</td>
<td>2.09 (0.42)</td>
<td>2.73 (0.33)</td>
</tr>
<tr>
<td>Formal atmosphere</td>
<td>2.60 (0.50)</td>
<td>2.09 (0.25)</td>
<td>2.00 (0.19)</td>
</tr>
<tr>
<td>Light atmosphere</td>
<td>2.64 (0.24)</td>
<td>2.90 (0.35)</td>
<td>2.82 (0.30)</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.91 (0.16)</td>
<td>3.00 (0.47)</td>
<td>3.09 (0.25)</td>
</tr>
<tr>
<td>Privacy</td>
<td>3.64 (0.43)</td>
<td>3.90 (0.41)</td>
<td>4.00 (0.33)</td>
</tr>
<tr>
<td>Atmosphere bedroom</td>
<td>3.36 (0.28)</td>
<td>2.91 (0.25)</td>
<td>2.64 (0.20)</td>
</tr>
<tr>
<td>Atmosphere ward</td>
<td>3.36 (0.31)</td>
<td>2.91 (0.16)</td>
<td>3.09 (0.32)</td>
</tr>
<tr>
<td>Current sleep</td>
<td>3.70 (0.37)</td>
<td>3.00 (0.19)</td>
<td>3.27 (0.23)</td>
</tr>
<tr>
<td>Improvement of sleep</td>
<td>4.00 (0.37)</td>
<td>2.45 (0.34)</td>
<td>2.45 (0.28)</td>
</tr>
<tr>
<td>Energetic mood</td>
<td>3.90 (0.35)</td>
<td>3.09 (0.25)</td>
<td>3.09 (0.34)</td>
</tr>
<tr>
<td>Sleepy mood</td>
<td>3.70 (0.42)</td>
<td>2.82 (0.40)</td>
<td>3.27 (0.33)</td>
</tr>
<tr>
<td>Calm mood</td>
<td>3.18 (0.35)</td>
<td>3.09 (0.39)</td>
<td>2.64 (0.20)</td>
</tr>
<tr>
<td>Tense mood</td>
<td>2.50 (0.43)</td>
<td>2.82 (0.33)</td>
<td>2.36 (0.24)</td>
</tr>
<tr>
<td>Sad mood</td>
<td>2.73 (0.49)</td>
<td>2.55 (0.41)</td>
<td>2.73 (0.38)</td>
</tr>
<tr>
<td>Happy mood</td>
<td>3.67 (0.47)</td>
<td>2.73 (0.27)</td>
<td>3.09 (0.34)</td>
</tr>
</tbody>
</table>

A significant effect of the condition (Baseline versus Dawn-Dusk) on Improvement of sleep was found in advantage of the dawn-dusk week (M = 2.45, SE = 0.34) compared to the baseline week (see Table 6). This indicated that more participants mentioned that their sleep improved during the dusk-dawn week compared to the baseline week. Another trend was found for Current sleep, in advantage of the dawn-dusk week compared to the baseline week, meaning that the quality of sleep of the participants was to be found better in the dawn-dusk week compared to the baseline week. A trend for Tense atmosphere was found of the condition (BL/DD) positive for the dawn-dusk week, indicated by the lowest mean of this variable in the dawn-dusk week com-
pared to the baseline week (see Table 6). This indicated that the atmosphere was less tense in the dawn-dusk week compared to the baseline week. Another trend was found on the condition (WL/DD) positive for the waiting list week. This meant that participants indicated that the atmosphere at the unit was less tense in the waiting list week as compared to the dawn-dusk week (see Table 7). In addition, a trend was found on the perceived atmosphere in the bedrooms. Participants indicated that the atmosphere in the bedroom was better in the waiting list week as compared to the dawn-dusk week. No other significant effects or trends were found for the perceived atmosphere.

Three more trends were discovered on mood of the participants. The participants indicated that they felt more energetic, less sleepy during daytime, and happier in the dawn-dusk week as compared to the baseline week. Apart from the significant effect of improved sleep and pleasant atmosphere, and trends for current sleep, tense atmosphere, atmosphere of the bedroom, energetic mood, sleepy mood, and happy mood, no other significant effects or trends of the condition (Baseline versus Dawn-Dusk, Waiting list versus Dawn-Dusk, and Dawn-Dusk versus Follow-up) on the quality of sleep, perceived atmosphere or mood were found (see Table 6-8 for the results of the interview answers).

### Table 6 | Interviews: Baseline week versus Dawn-Dusk week. Interview Data is on weekly basis.

<table>
<thead>
<tr>
<th></th>
<th>Baseline week versus Dawn Dusk week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F (df, df error)</td>
</tr>
<tr>
<td>Pleasant atmosphere</td>
<td>(1, 9.04) = 1.86</td>
</tr>
<tr>
<td>Vivid atmosphere</td>
<td>(1, 10) = 1.96</td>
</tr>
<tr>
<td>Tense atmosphere</td>
<td>(1, 19) = 3.18</td>
</tr>
<tr>
<td>Formal atmosphere</td>
<td>(1, 9.99) = 1.21</td>
</tr>
<tr>
<td>Light atmosphere</td>
<td>(1, 19) = 0.40</td>
</tr>
<tr>
<td>Temperature</td>
<td>(1, 10.19) = 0.17</td>
</tr>
<tr>
<td>Privacy</td>
<td>(1, 9.61) = 0.2</td>
</tr>
<tr>
<td>Atmosphere bedroom</td>
<td>(1, 20) = 1.47</td>
</tr>
<tr>
<td>Atmosphere ward</td>
<td>(1, 20) = 1.69</td>
</tr>
<tr>
<td>Current sleep</td>
<td>(1, 9.30) = 4.68</td>
</tr>
<tr>
<td>Improvement of sleep</td>
<td>(1, 9.22) = 10.37</td>
</tr>
<tr>
<td>Energetic mood</td>
<td>(1, 19) = 3.66</td>
</tr>
<tr>
<td>Sleepy mood</td>
<td>(1, 9.53) = 3.99</td>
</tr>
<tr>
<td>Calm mood</td>
<td>(1, 20) = 0.03</td>
</tr>
<tr>
<td>Tense mood</td>
<td>(1, 9.48) = 0.41</td>
</tr>
<tr>
<td>Sad mood</td>
<td>(1, 10) = 0.09</td>
</tr>
<tr>
<td>Happy mood</td>
<td>(1, 8.96) = 3.61</td>
</tr>
</tbody>
</table>

* is significant at p < .05.
* is a trend at p < .10.
Table 7 | Interviews: Dawn-Dusk week versus Waiting List week. Interview Data is on weekly basis.

<table>
<thead>
<tr>
<th></th>
<th>Dawn Dusk week versus Waiting List week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F (df, df error)</td>
</tr>
<tr>
<td>Current sleep</td>
<td>(1, 8) = 0.89</td>
</tr>
<tr>
<td>Improvement sleep</td>
<td>(1, 8) = 0.23</td>
</tr>
<tr>
<td>Pleasant atmosphere</td>
<td>(1, 4) = 10.00</td>
</tr>
<tr>
<td>Vivid atmosphere</td>
<td>(1, 4) = 1.00</td>
</tr>
<tr>
<td>Tense atmosphere</td>
<td>(1, 8) = 0.87</td>
</tr>
<tr>
<td>Formal atmosphere</td>
<td>(1, 4) = 0.29</td>
</tr>
<tr>
<td>Light atmosphere</td>
<td>(1, 7) = 1.54</td>
</tr>
<tr>
<td>Temperature</td>
<td>(1, 3.81) = 3.04</td>
</tr>
<tr>
<td>Privacy</td>
<td>(1, 3.20) = 0.40</td>
</tr>
<tr>
<td>Atmosphere bedroom</td>
<td>(1, 4) = 6.00</td>
</tr>
<tr>
<td>Atmosphere ward</td>
<td>(1, 4) = 1.00</td>
</tr>
<tr>
<td>Energetic mood</td>
<td>(1, 4) = 0.35</td>
</tr>
<tr>
<td>Sleepy mood</td>
<td>(1, 8) = 0.53</td>
</tr>
<tr>
<td>Calm mood</td>
<td>(1, 8) = 2.13</td>
</tr>
<tr>
<td>Tense mood</td>
<td>(1, 4) = 2.67</td>
</tr>
<tr>
<td>Sad mood</td>
<td>(1, 4) = 0.19</td>
</tr>
<tr>
<td>Happy mood</td>
<td>(1, 8) = 0.60</td>
</tr>
</tbody>
</table>

* is significant at p < .05.
\(^{\vee}\) Is a trend at p < .10.
5.4 Qualitative results: comments from participants and staff

Next to the quantitative Actiwatch, sleep diary and interview data, interview questions about the Wake-up light delivered qualitative insights on the experience with the lamp. In addition, answers on the diary questions about day time naps, sleep times, medicine, caffeine, and drugs usage delivered more qualitative insights on the sleep and daytime habits of the participants. All qualitative data were collected from the answers on the sleep diary questions, additional comments of participants in the diaries, and answers on the questions about the user experience with the Wake-up lamp. These data were subsequently written down by the researcher and first categorized in different topics, and then connections were made between the comments of participants in different topics. Furthermore, the answers of the staff from the evaluation interview at the end of the study delivered additional qualitative insights. Last, the personal experiences of the researcher gave extra insights on how to handle this special group of participants.

5.4.1 Wake-up light

In the next paragraphs, the answers on the interview questions about the experience with the Wake-up light at the end of the dawn-dusk week will be described. The participants rated their experience with the Wake-up light and explained why they would or would not want to continue using the Wake-up light at the unit and at home. Most participants gave similar reasons for (not) continuing to use the lamp at the unit, or at home.

Roughly half of the participants reported
positive comments about the experience with the Wake-up light, the other half of the participants reported more negative experiences with the Wake-up light. These comments were described below.

The positive experiences with the dawn-dusk light differed amongst the participants, from very general comments about the lamp and atmosphere, to more specific comments about falling asleep or waking up with the lamp, or even changing the sleep rhythm. More general comments about the experience with the lamp were ‘I find it a good lamp’ (noted by Male 1, HIC). He rated the lamp with an 8 or 9 on a scale from 1 to 10, although he did not mention any specific reasons why he liked the lamp. Male 3 from the HIC noted that he found the atmosphere with the lamp nice and rated his experiences with a 7, although he did not mention how it influenced his feelings concerning his sleep. Male 5 from de Dintel mentioned that he liked the light and would rate it with a 9. After that, he said: ‘I cannot do without the lamp anymore’. How the light was influencing him in a positive way was hard to unravel. Apart from the general comments about the lamp and atmosphere, some participants described their experience more specifically related to the actual function of the Wake-up light. One participant mentioned that the lamp helped her with falling asleep: Female 2 from the HIC rated the lamp with an 8 or 9 and noted that the lamp was calming and helped her falling asleep. She also mentioned that this effect depended on the medication she was taking. Another participant mentioned having positive experience with waking up with the lamp: Male 4 from the Dintel mentioned that he liked waking up with the lamp but not falling asleep with it, rating the lamp with a 7.5. One participant even mentioned that her sleep rhythm had changed: Female 1 from the HIC mentioned that she found the lamp relaxing, rating its effect with a 6. She also said that the lamp ‘changed my rhythm in a positive way’ which is a clear indicator of the intended function of the dawn-dusk light. The dawn-dusk simulation might have worked out for the participants with positive comments about the Wake-up light.

The reasoning behind the negative comments concerning the experience with the dawn-dusk light was more specific than the reasoning behind the positive comments. The same participant (Male 4) from the Dintel mentioned that he would continue to use the lamp at this unit, but not at home: ‘If I have to buy it, I wouldn't use the lamp because it is too expensive’. Female 3 from the HIC would rate the lamp with a 1: ‘I sleep with earplugs and blanket over my head so I don't notice environmental sounds and light’. She was very clear about being unintentionally woken up by sounds and light from the environment. She slept with earplugs and her head covered under a blanket to avoid unintentionally waking up, and therefore the lamp would not have had an effect on her. Male 6 from the Dintel said that he liked the lamp in the beginning but not after a while, mentioning that he preferred a ‘normal’ alarm clock, because he was afraid to sleep through the light of the lamp. Although he did not like the lamp in the end, he would still rate his experience with a 7.

Male 8 from the HIC in general liked the lamp but would not use it because the buttons on the side are unclear when it's dark. He did not mention if the dawn-dusk light affected him, only said that he liked the lamp because of its size and the radio function. Male 9 from the HIC said ‘I do not need the lamp’. From his comments it was not clear why he would not like the lamp, although looking at his sleep interval data made it clear. He had a very stable sleep rhythm, falling asleep and
waking-up around the same times each day, and waking up every night an equal amount of times to go to the toilet (as he mentioned in his diary). Last, Male 7 from the Dintel simply said that the lamp does not work on him, rating it with a 1.

During the Dawn-Dusk week, some participants already (informally) commented on the Wake-up lamp. From these comments, the reasons behind the experiences with the Wake-up lamp became clearer. Male 7 from the Dintel only mentioned that the lamp did not work on him, giving a very low rate. During the Dawn-Dusk week, he already mentioned: ‘The lamp does not help me, my psychoses –the voices in my head- control when I fall asleep and wake up’ explaining the very low rating of his experience with the lamp. Furthermore, Female 1 from the HIC mentioned that she had to get used to the lamp first. Looking at her positive comments on the one hand and the fact that she had to get used to the lamp on the other hand, explained her relatively low rating of the lamp. The dawn-dusk simulation might not have worked out well for the participants with negative comments about the Wake-up light.

5.4.2 Sleep

In addition to the experiences with the dawn-dusk light, answers on the diary questions about day time naps, sleep times, nightly occurrences delivered more qualitative insights on the sleep and daytime habits of the participants, as well as medicine, caffeine, and drugs usage. In the next paragraph, evident and repetitive answers on the diary questions about day time naps, sleep times and nightly occurrences are mentioned.

A number of participants had a lot of day time naps (Female 1 and Male 3 from the HIC, and Male 6 and Male 9 from the Dintel). On top of that, Female 1 had a lot of irregular sleep times, which could be in connection with the day time naps. The day time naps might have shifted her sleep rhythm in such a way, that her sleep times were irregular. A couple of participants missed a night of sleep (Male 1 and 2 from the HIC) or even multiple nights of sleep (Male 4 from the Dintel). Male 4 from the Dintel also mentioned to have a lot of irregular sleep times for the times he did not missed a night of sleep. During the baseline week, some participants were woken up by loud noises from the neighbours (Female 1, Female 3 and Male 1 from the HIC). These three participants mentioned this in the same week. Since all three participants were from the same department (HIC) and at the same floor and side of the building, it was probably the same client who woke them up.

One participant (Male 8) from the HIC always slept with the light on and he also tried to stay awake for some nights in the dawn-dusk week to challenge himself. He also commented that he liked the Wake-up light especially for its size and radio function, not mentioning the light. The dawn-dusk simulation did probably not affect him. Furthermore, Male 1 from the HIC mentioned that the first night of the dawn-dusk week gave him nightmares. These findings indicate that nearly all participants had on the one hand similar problems with sleep (irregular sleep times and day time naps) and on the other hand very different reasons for the sleep problems. There was one exception between the participants: one participant (Male 9 from the Dintel) had a very regular sleep at night, apart from his daytime naps. He always got up five or six times at night to visit the toilet. He was the only participant that seemed to have a very stable sleep/wake rhythm. The dawn-dusk simulation
might not have worked for him, since he also mentioned in that he did not need the Wake-up light. Last, especially new clients at the HIC needed to get accustomed to their new surroundings, as they were not living and sleeping in their ‘usual’ surroundings. As an attempt to cover those factors, questions about the atmosphere in the sleeping room and in the ward were added to the weekly interview sessions. In addition, in the diary was a question about the atmosphere at the unit. The baseline week was also intended to be a week of acclimatization to the study.

5.4.3 Use of sleep medication, late night caffeine and drugs
Numerous comments about medicine, caffeine, and drugs usage were made in the diaries. First the comments of the medication usage will be described, then the caffeine usage and last the usage of alcohol and other drugs will be described.

Only participants from the HIC (all women and one man) mentioned that they used extra sleep medication almost every day (Female 1, 2 and 3, and Male 1). Three participants mentioned in the same week that they had restless nights because of a noisy neighbour waking them up. Furthermore, all three participants used extra sleep medication on regular basis. It might be that those participants are light sleepers in general. One of the clients, who mentioned to be woken up by neighbours and used sleep medication, also rated the experience with the Wake-up light very low. She mentioned that the lamp did not work on her because she sleeps with earplugs and a blanket over her head to filter out the environmental sounds and light. For her, the dawn-dusk simulation would probably not work. From the Dintel, only one man (Male 4) reported that he sometimes used sleep medicines. Apart from the comments in the sleep diaries, one man (Male 5 from the Dieze) mentioned that he got new heavy sleep medicines after the baseline week, improving his sleep but making him less happy. The clients from the HIC enter this unit in a crisis moment of psychosis and stay on an average a number of weeks, the clients from the Dintel are staying for a long time at this unit and sometimes even years. The medication is possibly more stable at the Dintel as compared to the HIC, and in general the clients at the Dintel were not requiring additional sleep medication.

In addition, only men, again mostly from the HIC reported late night caffeine usage. Male 3 (HIC) reported drinking three cups of caffeinated drinks every late evening. This participant also reported to have either a very irregular sleep (or missing nights) or multiple daytime naps, reported in their sleep diaries. Male 1 (HIC) reported that he sometimes drank a lot of caffeinated drinks late in the evening in the baseline and waiting list week, but not in the dawn-dusk week. In the beginning this participant asked why particular questions were in the sleep diary (also about caffeine usage), so the researcher told him that caffeine usage could influence the study. Possibly he did not drink caffeinated drinks in the dawn-dusk week on purpose, because of curiosity of the working of the dawn-dusk light. Male 8 (HIC) reported that during the whole study period he sometimes drank around 7 cups of coffee, cola or tea. This participant reported that he always slept with the light on and he also tried to stay awake for some nights in the dawn-dusk week to challenge himself. Furthermore he reported to sit behind a computer screen late in the evening and drinking a lot of caffeinated drinks. The combination of sleeping with the light on, drinking a lot of caffeinated drinks, and sitting behind a computer screen late in the evening pos-
sibly had a negative influence on his sleep pattern. Therefore the dawn-dusk simulation had possibly little effect on him. Male 6 from the Dintel reported that after the baseline week he sometimes drank a lot of caffeinated drinks. He also reported to have a lot of daytime naps. A lot of participants that reported irregular sleep times and daytime naps, also reported to drink plenty caffeinated drinks in the evening. The caffeine usage possibly had a negative influence on their sleep patterns.

Again only men (both from the HIC and the Dintel) commented about drugs usage (speed, heroin, dope, weed, cannabis and alcohol). The participants from the HIC mostly used hard drugs, and the participants from the Dintel only consumed soft drugs and alcohol. Male 2 from the HIC reported that he took different drugs during the whole study period: speed, cannabis, beer (after two weeks this client was dismissed from the unit and could not participate in the study anymore). Male 1 from the HIC used different hard drugs like speed, dope and heroin during the whole study period. Male 4 from the Dintel often smoked cannabis during the whole study period. Three of four participants which used drugs on a regular basis, also missed nights of sleep (usually it were the same nights that they used drugs and missed nights of sleep). One participant who used drugs on a regular basis also indicated that the Wake-up light caused nightmares in the first night. It was likely that the drugs influenced the sleep patterns and induced the nightmares.

5.4.4 Light at the ward and use of electronic media
As explained in the Context of this study, the light at the unit was automated and at nine o’clock, half of the lights turned off. The other half of the lights were still on at full brightness. This was resulting in clients sitting in the fully lit areas. Furthermore, one client (Male 8, HIC) reported to sit behind the computer screen late in the evening and at night. Bright light from the lamps and electronics late in the evening possibly made the clients more active and therefore a possible confound for the effect of the dawn-dusk simulation on sleep.

5.4.5 Informal comments about contact with researcher
Apart from comments about the experience with the dawn-dusk light, comments about sleep, and comments about medicine and drugs usage, additional comments were made about the contact with the researcher. Some participants mentioned that they liked filling in the diary together and doing the interviews. The comments that were made were all from men and participants from the HIC. Male 2 mentioned: ‘I like to fill in the diary together and to do the interviews. It gives me rest’. Male 3 said that he liked to do the interviews and that it brings his mind to rest. Two participants thus explicitly mentioned that participating in the study gave them rest.

5.5 Comments by staff from the end-interviews
In the next paragraphs, the answers of the staff from the evaluation interview at the end of the study will be described. The staff commented about their experiences with the Wake-up light in the clients’ bedrooms, the atmosphere at the unit and the quality of sleep of the client participants. The answers of the staff gave interesting insights, in line with the participants’ comments.
5.5.1 Wake-up light
All staff members said they liked to have the Wake-up lights at the unit. Furthermore, all staff members mentioned they would like to have the Wake-up lamps at the unit in near future. Most of them noted that it would have an effect on some of the patients, but not on all patients. The last comment was in line with the comments of the participants that were divided in two camps. One member said: ‘the lamp would have a nice effect, if they first can get used to it’. Indeed some of the clients mentioned that they had to get used to the lamp. Another staff member noted: ‘it might be better to have the lamp for waking up the patients, instead of the staff waking up the patients’. In addition, one member noted that the effect of the wake up light might be greater when the lights of the general spaces are also in dawn-dusk modus. The last comment was interesting, since many clients were hanging around in the general spaces in the evenings, in the fully lit areas. Since the light was automated, it was not possible to adjust.

5.5.2 Atmosphere at the unit
From the interviews with the staff, it was clear that the atmosphere either improved or stayed the same during the whole study period. Some members noted that the atmosphere had improved. Others mentioned that they thought the atmosphere had not changed. None of the staff members mentioned that the atmosphere deteriorated. This was partly in line with what the participants mentioned, as the results indicated that some participants rated the atmosphere more pleasant as the study progressed.

5.5.3 Quality of sleep
Most staff members were unsure about the changes in the quality of the sleep of patients. It was said that they heard of some patients that they liked the lamp, but the staff did not notice significant differences in the dawn-dusk week. The nurse specialist noted: ‘the quality of sleep of the clients was improved and the presence of the lamp made the clients more aware of their sleep patterns’. Possibly the impact of the study (including the presence of the lamp) and the researcher at the units made the clients more aware of their sleep patterns, explaining the positive effects of the subjective experiences on quality of sleep and sleep improvement.

5.6 Experiences at the Center of Psychosis
The group of participants required a special level of human-related qualities from the researcher. The ability of empathizing, listening and patience were needed in order to fulfill the study. Therefore a special section is added here, to take the opportunity to share the personal experiences from the researcher with this group and to inform on what it takes to conduct a study on this group of people. Due to probable negative experiences in the clients’ past, trust played an important role in participating in the study. They either did not trust how the Actiwatch gathered data, the effect of the Wake-up light or the anonymity of the information they reported in the diaries. Together with the fact that they suffered from mental illnesses, motivation played an important role as well. The clients had their hands full of their illnesses, which made it hard to motivate them to continue participating. The illnesses also made the reported data less reliable. First the experiences concerning trust and motivation will be shared, next, privacy related issues, then the experiences concerning the time investment of the researcher, and last the experiences with conducting the specific methods at GGzE and contact with
the clients. It must be highlighted that this study was an exploratory study, to investigate whether there were noticeable effects on this group of people or not, and to explore whether the effort of participating in the study was burdensome for the clients. In addition, this study explored the potential of conducting a larger dawn-dusk study in a group of psychotic and/or schizophrenic patients. The experiences described in the next paragraphs were really personal experiences, not per definition applicable to other researchers.

5.6.1 Trust and motivation
The participants that took part in the study were all people with difficult personal backgrounds and mental illnesses, taking different kinds of medication. In order to let them participate in the study (and keep them participating for several weeks), it required to develop a trust relationship with each of them and to empathize, but also being positive and light-headed around them. Because of their illness and medication, they sometimes forgot what you as a researcher had been telling them or sometimes even who you are (and why they are participating). Being patient and motivating them seemed to be highly important. Showing up every day to check how the participants were doing and having a short (sometimes long) motivational talk, kept them wanting to continue with the study. In addition, it required to choose the words carefully on why it was helpful for them to participate. Only when they had specific (trust-related) questions, they were informed with fair answers. Furthermore, the study required to work with ethical guidelines about including clients and information about the study. Some clients for example had a really strong opinion about the study and did not want to be involved in any way. Other participants did not trust any electronics (the Actiwatch they were asked to wear). I tried to tackle the trust about the Actiwatch by saying that it only measured if they are sleeping or awake. If they asked how it measured, I explained them. Sometimes a participant wondered whether the Actiwatch could know about the dreams or thoughts he or she had. Then I tried to answer the question by visualizing what I see when I connect the Actiwatch to the computer: the number of the Actiwatch (no names or personal information) and a curving line that indicates when being active or awake. Some participants that did not trust the Actiwatch or the Wake-up light, or participants who wanted to know very detailed what the Actiwatch or Wake-up light could do, were given a manual of the devices.

5.6.2 Privacy
Sometimes a participant asked how the GGzE would use this information and if they could get different medication based on the study outcome. Whenever this happened, as a researcher it seemed best to comfort the participant and to tell that it is okay. The participant was then asked and motivated to wear Actiwatch again. Also it was checked with the staff if they noticed something about the participant.

5.6.3 Time investment
The investment of conducting the study was high for the researcher. It took a couple of hours per day to check with the participants on site and help them filling in the diary. The group of participants was split into two groups of six participants (six in March, six in April) which was just enough for one researcher to check on the morning questions (which should be filled in as soon as they wake up). Not all participants were able to fill in the answers by themselves, and were therefore assisted. In addition, not all clients
of the unit were able to participate in the study (because of planned dismissals and inability to speak or write due to their illness). With more participants, it would have been more time consuming and not feasible for one researcher to check on all participants upon awaking or before bedtime.

5.6.4 Conducting the study
The reliability of the data was questionable, especially the diary data. Even healthy people struggle with remembering at what time they fell asleep, how often they woke up at night, how many cups of coffee they drank or reporting about their sleep quality, let alone people with psychosis and other mental illnesses. Apart from the difficulty in remembering what to report, it took a lot of effort for most of the clients to participate. Some of the participants mentioned that they found it too effortful to fill in the diary data. Others were fine with filling in the diary data but had difficulties with the intake procedure. Reading the informed consent, filling in chronotype questionnaire and after that listening to an explanation of how to participate in this study was a true investment for the participants, even causing two clients to quit with participation in the study. Explaining the procedure of the study required a special level of attention as well, in particular for the clients that received the dawn-dusk simulation in the last study week (and thus had to wait for two weeks). The waiting list condition was included because it is not recommended to exclude people to a condition (dawn-dusk), when this condition is expected to have beneficiary effects. Because the study design required a control condition, the creation of a waiting list condition still let the people had the dawn-dusk simulation. First, jealousy was prevented as people who wanted to be included in the dawn-dusk situation could simply be told that there were not enough lamps and that because of that they had to wait for a couple of days. Secondly, the participants were expected to naturally recover over time; by including a waiting list condition, the impact of the dawn-dusk simulation on the dependent variables when being less ill allowed us to control for general recovery trajectory. All in all, most participants wore the Actiwatch as intended and filled in the diaries almost completely. All participants completed the interviews.

Furthermore, the required investment of the staff was too much at some points. The staff was asked to motivate the clients in participating and to pay attention to the Actiwatches whenever a participant left the unit for a walk. Sometimes it was very chaotic at the unit, even causing one Actiwatch to be lost at the final day of the study; moreover it had never been retrieved. In addition, the night shift started at 10 o’clock PM which implied that I had to leave the unit before 10 PM, being sent away the first nights. Since most participants went to sleep well after 10 PM, it was not possible to assist the clients with filling in the evening questions of the diary. This made the answers less reliable, as some of the participants only filled in the evening questions in the morning, upon arrival of the researcher. In addition, based on the idea of the staff a ‘light theme’ was created in the Centre of Psychosis during the pilot study. It was assumed that this would increase adherence to the study. The theme was realized by providing Philips Living Color lamps (Figure 8) to the unit. The controllers of these lamps were in hands of the staff, since they have experience with clients ‘borrowing’ materials from the unit and hiding them. These lamps evoked curiosity and were liked by most clients, however specifically one client really did not like the lamps. He even hid one lamp which made it effortful for the staff to retrieve the lamp.
5.6.5 Manipulation of the clients
Some of the clients appeared to be very manipulating. Once during the study when the staff was not in near presence, it occurred that a client tried to get my attention and talked for half an hour about his or her story and why he or she is hospitalized in this unit. This happened to me several times (with heavy stories to process). Once a client tried to manipulate me -through telling his story to me and how he is secluded from the outer world and not allowed to contact anyone- to call his brother, since that would really help him. Handling this situation was difficult for me since I did not want to lose his trust or make him tell other clients that my study was worthless (this person had great manipulative skills). Instead, I told him that I was really not allowed to involve in any clients’ situation (amongst other words) because I would risk their situation and mine. I said I was hoping the best for him to happen.

5.6.6 Peculiar and positive contact with the clients
Another time in the beginning, I was looking for a client participant for ten minutes and nobody (staff and other clients) seemed to know where she was. I was asked if I already had taken a look in the closet of her room, because at times she hid herself in there. Of course I had not taken a look in there, as this was not the first place that had come to mind. However, by showing up every day at the unit, I knew more what to expect later on. Another client seemed to be very kind and relaxed when I installed the Wake-up light in his room, however when I walked away, I heard him scream being upset about a button on the lamp. During the recruitment of the participants there were several clients that changed their mind a couple of times within a couple of hours about whether or not participating. During an explanatory talk of five minutes about the study, one client changed her mind four times. First she was enthusiastic, then she excused and walked away, then she came back to participate because she felt sorry and wanted to help in the study, and then again decided that she did not want to take part. On the other hand, some participants were very enthusiastic about their participation and participated for the full three weeks. They really wanted to share their feelings about the study. Also they were looking forward to receiving the Wake-up light: ‘Can I be first, please? I really want to try the lamp!’ Others even said that they find the research very important and that they did not care for any compensation. Some were also curious about the outcomes and wanted to get information on their personal sleep data. When I arrived at the institution in the mornings, some clients who sat outside already said ‘Hey, Marianne has arrived again! Hi there!’ and they waved and said goodbye when I left on my bicycle.
6. DISCUSSION

In this study we investigated whether sleep onset, sleep quality and waking up (inertia) of psychotic patients may be improved, through simulating the natural dawn and dusk in the bedrooms of the clients. Prior studies (e.g. Avery, Bolte, Wolfson, & Kazarakas, 1994; Avery et al., 2001; Gabel et al., 2013) have shown that dawn-dusk light has positive and improved effects on sleep, recovery of depressions, and daytime activity. To our knowledge however, no research of dawn-dusk light on the effect of sleep has been conducted with psychiatric patients suffering from psychoses and schizophrenia. Since this group suffered severely from sleep related problems, we investigated the effect of dawn-dusk light on sleep, measured through objective Actiwatch data and subjective data of diaries and interviews.

6.1 Sleep measured with objective Actiwatch data

We only found one effect in the results of the objective Actiwatch data, however the qualitative data from the diaries and interviews resulted in more significant effects. The sleep of the participants appeared to be less fragmented (meaning that the participants woke up fewer amount of times at night) with the dawn-dusk simulation as compared to the waiting list condition, indicating a better and less disturbed sleep. Since only one effect was found in the Actiwatch data, this could implicate that apart from the single significant effect, either the Actiwatch data were unreliable, or there was no further effect of the dawn and dusk simulation on the sleep onset and sleep quality of the clients. The Actiwatch data could have lacked in reliability because of three reasons. The first was the analyzeability of the actigraphy, because the sleep data of most participants was complex with almost no visible distinction between sleeping and being awake. This data made it difficult to reliably determine sleep intervals. The second reason of not finding effects in the Actiwatch data, could have been the group size. Since the group was small, the effect sizes were also small. The third reason was the amount of time the clients wore the Actiwatches. The intention was that the clients would wear the Actiwatches at all times during the study, however issues related to trust or their illness made the off-wrist percentage high for some of the participants, resulting in incomplete data.

Previous research using a dawn-dusk simulation with a protocol of 3 weeks baseline, treatment and follow-up, completed by 13 demented participants, compared the conditions using actigraphy-determined sleep variables (Gasio et al. 2003). The results of the Actiwatch data showed positive and significant effects for the dawn-dusk condition on sleep: the participants had a shorter sleep latency, longer sleep duration, more nocturnal immobility, and less nocturnal activity compared to the control condition. Most dawn and dawn-dusk studies however (Gabel et al., 2013; Fromm et al., 2011; Avery et al., 1994; Leppämäki et al., 2003; Viola et al., 2015) used subjective sleep data only. The use of subjective sleep data only, could have been valuable for measuring the effect of a dawn-dusk simulation on a group of healthy people or in any case people with no issues regarding remembering. Nevertheless, as mentioned earlier, even healthy people struggle with remembering at what time they fall asleep, let alone people with psychosis or other mental illnesses. The discrepancy between subjective and objective sleep data was assessed in a study from Most, Aboudan, Scheltens and Van Someren (2012) with 55 Alzheimer Disease patients and 26 healthy subjects. The results show that the value of sleep questionnaires...
6.2 Sleep quality and waking up measured with sleep diary data

One effect was found in the sleep diary data. The participants appeared to be more alert upon waking up in the dawn-dusk week as compared to the baseline week. However, no other significant effects were found. Either there was an actual effect of the light on the alertness but not on the subjective quality of sleep, and feelings of rest upon waking up, or the data was unreliable. Potentially the clients had difficulties with rating their feelings of subjective sleep quality and waking up. Therefore the ratings did potentially not correspond to their actual feelings. An alternative explanation for the effect of the dawn-dusk simulation on alertness but not on other feelings of subjective sleep quality and waking up can be potentially attributed to the acute effects of light. The light sensitive ganglion cells in the eye (ipRGCs) are involved in the long-term effects of regulation of sleep and wakefulness, mood and alertness (Vandewalle, Maquet & Dijk, 2009). The direct effects of light coming through the ipRGCs include improvement of alertness, performance on several cognitive tasks (Vandewalle et al., 2009). The intervention time of the dawn-dusk light was only one week, potentially declaring the findings of alertness but not of feelings related to the quality of sleep and rest. Furthermore, exposure to bright artificial light - 1000-2000 lux - has been found to directly increase vitality (Partonen & Lönqvist, 2000) and increase positive mood (aan het Rot, Moskowitz & Young, 2008). This indicates that exposure to bright light might improve the feelings of rest upon waking up. The light intensity of the dawn-dusk simulation was potentially not high enough to result in significant effects of feelings of rest. It is recommended for future studies to conduct more research on the brightness of the dawn and dusk simulation and possibly increasing this. In addition, it is advised to conduct more research on the duration of the intervention and potentially increasing this.
6.3 Sleep, atmosphere perception and mood measured with interview data

Several effects of the dawn-dusk simulation were uncovered in the interview data. Most participants thought that their sleep had improved and that their quality of sleep in general was better during the dawn-dusk simulation week as compared to the other weeks. An explanation could potentially be attributed to preferences and associations with light. People prefer environments that are sunny and bright (Beute & de Kort, 2013) and bright light is often associated with sunlight. In addition, people generally believe that exposure to daylight is beneficial for many aspects of wellbeing, such as health, mood, and performance (Veitch & Gifford, 1993). As the light of the Wake-up lamp simulated the natural dawn and dusk, it might have been associated with actual daylight and the beneficial effects of daylight. However, these effects of quality of sleep were not found in sleep diary and Actiwatch data. This could be explained by a bias in favour of the intervention (placebo effect) since all clients were looking forward to receive a nice lamp for a week, or the clients actually thought that the quality of their sleep had improved in the dawn-dusk simulation week as compared to the other weeks. Additional questions about the lighting preferences of participants are recommended to be added in future dawn-dusk studies, to compensate for the placebo effect. Another option to compensate for the placebo effect is to include a lamp with a different light simulation in the baseline and control conditions.

Light also has an impact on how we perceive the atmosphere of an environment and therefore it was thought that light also affected the psychiatric patients in their atmosphere perception or even contributed to the sleeping experience of the clients. Participants perceived the atmosphere in the unit less tense during the week they received the Wake-up lamp, as compared to the other weeks. Either the perceived tense-ness could be assigned to the effect of the dawn-dusk simulation, or the atmosphere of the unit was actually less tense because of different (attitudes of other) clients, fewer incidents and different staff members. However, the general atmosphere and the atmosphere in the bedroom were perceived more pleasant in the waiting list week than with the dawn-dusk simulation. Either the participants perceived the atmosphere not as pleasant with the dawn-dusk simulation, or the atmosphere of the unit was actually more pleasant in the waiting list week because of different (attitudes of other) clients, fewer incidents and different staff members. The lack of other effects on perceived atmosphere could potentially been attributed to the brightness of the dawn-dusk simulation. The maximum brightness of the dawn-dusk light was 250 lux, and as discussed above, exposure to bright artificial light - 1000-2000 lux - had been found to directly increase positive mood (aan het Rot, Moskowitz & Young, 2008). The brightness of the dawn-dusk simulation was therefore potentially not high enough for noticeable effects of atmosphere perception. Another reason for the few effects of the dawn-dusk simulation on the perceived atmosphere in this study could be that the light simply had little impact on the perceived atmosphere of the clients. In order to find out whether the dawn-dusk light had additional effects on the perceived atmosphere or not, it is recommended for future studies to conduct more research on the brightness of the dawn and dusk simulation and possibly increasing this.

Apart from the expected effect of atmosphere on mood, people’s mood can also be
directly affected by light (Veitch et al., 2008). Three trends were found in favour of the effect of the dawn-dusk simulation on mood. These effects could be attributed either to the actual effect of the light on participants’ mood, natural recovery of the clients, or the positive associations with the dawn-dusk light. Earlier it was mentioned that people prefer environments that are sunny and bright (Beute & de Kort, 2013). Bright light is often associated with sunlight, but bright light can also come from artificial sources. Since the artificial dawn and dusk light applied in the study emitted warm bright light at its peak, it could potentially have influenced the participants’ mood. No other effects of the dawn-dusk simulation were found. Either there was no actual effect of the dawn-dusk light on how calm, tense and sad participants felt in the dawn-dusk week as compared to the other weeks, or participants found it difficult (potentially too personal) to determine their mood on these items.

6.4 Qualitative measures
In the next paragraphs, the experiences of the participants with the dawn-dusk light will be discussed, as well as their behaviours regarding sleep, medication, and caffeine and drug usage. Note that this was an exploratory study, to investigate whether there were noticeable effects on this group of people or not, and to explore whether the effort of participating in the study was burdensome for the clients. In addition, this study explored the potential of conducting a larger dawn-dusk study in a group of psychotic and/or schizophrenic patients.

6.4.1 Dawn-Dusk simulation
The study results indicated that the dawn-dusk simulation was preferred by roughly half of the participants, but not by the other half of the participants. Based on the experiences with the dawn-dusk light, as analysed in the results, the participants had either positive experiences with the dawn-dusk light, or negative and neutral experiences. The reasoning behind the positive or negative experience with the dawn-dusk simulation differed between the participants as well. The discrepancy between the participants and their illnesses was presumably high, explaining the differences in experiences with the light. Next to psychosis, the participants also suffered from other diseases (e.g. schizophrenia, bipolar disorder and/or autism). In addition, the strength and elaboration of the diseases differed amongst the subjects. The complexity of the compound diseases made it difficult to determine for whom the dawn-dusk simulation might have helped and for whom not. It is recommended for future research in this user group to let the staff determine the use of the dawn-dusk simulation for each individual client, and the expected result of the dawn-dusk simulation. Since the institution is relatively small and the client-staff ratio is high, it is realistic to let the staff determine for who it is beneficial to use the dawn-dusk simulation. Furthermore, for some of the clients, a week was too short to get accustomed to the lamp. In order to let the clients get accustomed to the lamp, the intervention period should increase. Future research could also consider to start with a larger group of participants and to apply a different selection process of clients with a trial dawn-dusk week. Subsequently, client participants that seem to have no benefit from the light can be excluded, and others can continue with the second dawn-dusk week. In this way, the clients are able to get used to the dawn-dusk simulation and it might also result in more long-term (circadian) effects of the light. Furthermore, no effects of the follow-up week sleep were found. The follow-up condition
was included to measure a possible wash out effect: the influence of the dawn-dusk simulation on the sleep could either fade out or even continue to have an effect (Lieverse et al., 2011). In addition, it was expected that the participants would naturally recover over time. Since no effects of the follow-up condition were found, this can either be explained by the fact that the group size was too small to notice any wash out effects or effects of natural recovering (because only half of the participants had the follow-up condition), or there was no wash out effect of the dawn-dusk simulation. Increasing the intervention period of the study might result in measurable effects of natural recovery and wash out effects. In this way, we can investigate whether the dawn-dusk simulation has long-term effects on the sleep and recovery of the clients.

However, increasing the duration of the study might reduce the amount of participants. Keeping up the diary amongst others, also appeared to be an investment for the clients. In addition, a lot of clients at the HIC unit did not stay long enough to participate in the study. When increasing the intervention time, it should be considered to conduct the study merely at a unit where clients stay longer, like in the Dintel.

### 6.4.2 Sleep patterns
The sleep patterns of the participants were very irregular, with different sleep times, day time naps and other nightly occurrences. Mainly this could have been attributed to their illness since many psychiatric disorders are accompanied by sleep problems (e.g., Costa e Silva, 2006; Lee, Cho, Cho, Jang, & Kim, 2012; Widakowich, Neu, Nagant, Steegen, & Verbanck, 2010; Sutton, 2014; Monti et al., 2013; Wulff, Gatti, Wettstein, & Foster, 2010). For a remaining part, sleep issues could have been attributed to other factors, like noises from neighbours at the unit. These patterns of irregular sleep times and day time naps did not seem to improve in the week of the dawn-dusk simulation. The intervention time might have been too short to have noticed really improved sleep patterns. However, participant mentioned in the interviews that they personally experienced that their sleep improved and that the quality of their sleep was better in general. This information is still valuable and a reason to continue with the dawn-dusk simulation in order to investigate further beneficial effects on the experienced quality of sleep.

### 6.5 Limitations and lessons of the study
This was an exploratory study, to discover whether the effort of participating in the study was burdensome for the clients, and to learn what is needed to conduct a similar study in a larger user group. Limitations concerning the study are discussed below, as well as the lessons we learned from this study. In addition, recommendations are discussed giving suggestions for future research.

#### 6.5.1 The complexity of the group
Patients with psychiatric disorders had appeared to be a very challenging group to conduct research on. The client participants were unpredictable and had a low feeling of trust towards taking part in the study at some moments during their participation. The amount of clients in the unit was relatively small and the variance between the clients was very big. At the HIC unit, the duration of admittance is relatively short. The clients come in at the crisis moment of their illness, often not able to communicate, let alone take part in a study of three weeks. Therefore it usually takes a couple of days or even longer to let them come to senses. However, when they start to feel better, they were soon to be dismissed. At the Dintel
(the center of Psychosis where people stay for a longer time due to their illness) people are easier to approach from the start of the study because they are not at crisis moment of their illness. However, the feeling of trust towards the research is very low, and the approachability of the clients does not ameliorate over time as much as at the HIC. The only advantage comparing to the HIC unit, is that there is a smaller change of dismissal during the study period. Furthermore, the investment of conducting the study was high for the participants and the researcher. It took a couple of hours per day to check with the participants on site and help them filling in the diary. With more participants, it would have been too time consuming and not feasible to check on all participants upon awaking. However if the research was conducted in a bigger unit with more clients to participate, it should be considered to assist the participants with more researchers. Due to the trust and habituation (bonding) factors with the clients, it is a recommendation to divide the group of participants and allocate one researcher per group for the rest of the study. Apart from the difficulty in remembering their day and night patterns, it was too effortful for some of the clients to participate, as they personally indicated this. Future research must consider to merely include the questions which are deemed most relevant and to facilitate the intake procedure.

6.5.2 Bias prevention
It could not have been eliminated that the sample was biased towards clients who were more self-sustained and/or had less severe disabilities at hospitalization. The clients that were asked to participate understood the informed consent procedure and the study objectives and procedures while other clients that were not recruited did not, and/or had a lower estimated benefit/burden ratio. To maximize the possible number of participants, clients were asked to participate during the whole duration of their stay, if enough time remained to complete the study procedure. A wide variety of clients was staying at the Centre of Psychosis. Also the duration of admittance varied amongst the clients. Therefore, recruitment of participants with more specific characteristics in the two conditions (an even amount of female and male participants and evenly spread in age within the age range) was not realistic. The common factor of the group was that they all had psychosis and/or schizophrenia. As mentioned earlier, the complexity of the diseases made it difficult to determine for whom the dawn-dusk simulation might have helped and for whom not. It is recommended for future research in this user group to either let the staff determine the use of the dawn-dusk simulation for each individual client, and the expected result of the dawn-dusk simulation, or to use a different selection procedure as discussed in 6.4.1.

6.5.3 Medicines, late night caffeine, and drugs usage
The usage of medication changed multiple times, and sleep medication was used on top of the ‘normal daily’ medication, especially in the HIC unit. The use of caffeine, drugs and different medication probably seemed to have influenced the sleep patterns of. Furthermore, the caffeine and drugs usage added up to the difficulty of observing the effect of the Wake-up light. Future dawn-dusk studies in this user group are recommended to use a caffeine and drugs policy, in order to increase the possible effects of the dawn-dusk simulation. When doing so, one must be cautious to not intervene too much in the habits of the clients, so that they still want to participate in the study. In addition, it might be valuable for the unit in general to create
a policy on the use of caffeine and drugs, in order to stimulate better sleep patterns and to avoid escalating situations as result of this usage.

6.5.4 Waking time
In the dawn-dusk week, the participants were woken up by the dawn-dusk simulation at their personally preferred time (related to their chronotype). In the other weeks, participants were woken up by the staff, in certain 'waking rounds'. The staff took the preferred waking times of the participants as much as possible into account, however it depended on the daily situations in the unit if the preferred waking times were adhered. In the dawn-dusk simulation week, these times were more strictly adhered to the preferred times and therefore slightly different as compared to other weeks. The Wake-up light was therefore a good solution for some of the clients to wake up individually, but other clients needed the presence of somebody motivating them to wake up and have breakfast. In addition, the Wake-up light is probably a less stressful method of waking up compared to a normal alarm clock as used by some of the clients. A way to test for stress in different methods of waking up is to include an extra diary question in future research, about feelings of stress upon waking up.

A suggestion for future research to settle for the discrepancy between the intervention and control week, would be to wake up the participants at the same time during the whole study period, either by the staff, or by a placebo lamp.

6.5.5 Automation versus Control
In this study we gave the participants high experimental control over the Wake-up lamp. They were trusted that they kept the alarm on while the staff and experimenter were not there, and that they used the Wake-up light as explained. Also they were trusted to leave the Wake-up lamp at the same location and position during the dawn-dusk week. This resulted in little experimental control of the study. Perhaps participants forgot to put on the dusk simulation (or did this on purpose), or turned the button for the dawn simulation off. The researcher was not allowed to be at the unit after 10 o'clock, and the staff was not always able to control for the dawn-dusk simulation. There was no option available to automate the Wake-up lights in a way that the participants would not have any control (so that it can be trusted that the lamps would be used as intended). However, it is questionable if fully automated lamps would work in any user group (and especially this user group). The clients were often suspicious of what happened. Taking away any control would have a negative effect on their trust and the likability of the usage of the lamps. It is therefore recommended for future research to perform a study on the level of control of the dawn-dusk simulation. One group could have a high control over the lamp, another group could have low (or no) control over controlling the lamp. The effect of control on motivation and trust could then be investigated, and the outcome could subsequently be used in new dawn-dusk studies with psychiatric patients. Another option is to let the staff control more for the dawn-dusk simulation; however this might be too stressful or effortful for the staff.

6.5.6 Light at the ward and use of electronic media
The light at the unit was automated and at nine o'clock, with half of the lights in the ward turning off. The other half of the lights were still on at full brightness. This was resulting in clients sitting in the fully lit areas. Bright white light in the evening can result in delaying the biological clock, which can result in worsening amongst others mood (Kondo et
Bright light from the lamps and the use of electronics late in the evening made the clients possibly more active. The effect of the dawn-dusk simulation could have more potential when the other areas in the unit are adapted to the light of the dawn and dusk simulation. The latter was also suggested by a staff member, however since the light was automated, it was not possible to adjust. Future dawn-dusk studies in this user group are recommended to use a policy on electronic media in the evenings and at night, in order to increase the possible effects of the dawn-dusk simulation. When doing so, one must be cautious not to intervene too much in the habits of the clients, so that they still want to participate in the study. Furthermore, it might be valuable for the unit in general to create a policy on the use electronic media in the evenings and at night, in order to stimulate better sleep patterns. In addition, other areas in the unit should be adapted to the light of the dawn and dusk simulation (or at least decrease in brightness levels) if feasible.

**6.5.7 Effect of seasons**

The study was conducted in late winter and early spring. The effect of seasons also played a role in dawn-dusk studies. Especially in midwinter, the natural light in the Netherlands is in most cases not aligned to the natural bedtimes of humans. Especially psychiatric patients are disadvantaged by this phenomenon (e.g. Costa e Silva, 2006; Lee et al., 2012; Widakowich et al., 2010; Sutton, 2014; Monti et al., 2013). The dawn-dusk simulation might have the most effects on the clients when the natural light is least aligned to the natural bedtimes (as in midwinter), since the difference of the timing of the natural light and the dawn-dusk light is highest. Future research is therefore recommended to perform dawn-dusk studies in midwinter, to increase the potential effect of the light on sleep.

**6.5.8 Nightmares**

Another lesson we learned from this study, is to check for nightmares. When people have nightmares, they move a lot at the end of their sleep. Moving during sleep will present spikes in the Actigraph data and give the impression that the client is awake. It is recommended to include an extra variable in the diary to check for nightmares in further research. In this way it can be checked if the participant is already awake or still asleep (having nightmares).

**6.5.9 Weekend pattern**

Some of the clients did not always stay at the unit during the weekends. It might have been the case that they had a different sleep-wake pattern in those weekends. It is recommended for future research to ask the participants whether they had a different sleep-activity pattern during the weekends as during the week. Different weekend patterns of clients could influence how they recovered during the week, and therefore having a confounding effect on the dawn-dusk simulation.

**6.5.10 Day program**

The unit provided daily activities, for the clients to decide on whether to participate in them or not. As mentioned in the method, a question about participation in these activities was added later in the diaries. It would have been relevant to include this question from the beginning into the diaries. Participation could mean that a client has a specific reason to get up in the morning. However, this question was added later in the diary, when only the last five participants were included in the study. These were too few clients to find an effect of participation.
7. CONCLUSIONS AND RECOMMENDATIONS

This study proposed new insights in the methodology and the effects of dawn-dusk light on sleep of psychotic patients. The quantitative analyzes resulted in a single measured effect on sleep, but the qualitative analyzes resulted in many effects. The staff as well as the participants were positive about the effect of the dawn-dusk simulation. Furthermore, the qualitative research opened up valuable insights on experience with the methods. However the methods were time consuming for the clients as well as the researcher, most clients managed to fully participate in the study. A different selection procedure of the clients is recommended, to include only the clients who are thought to benefit from the dawn-dusk simulation. Regarding the small sample size and challenges of the data gathering process, current study must be considered as a pilot study.

Future studies using a dawn-dusk simulation are recommended to increase the intervention period, so that it increases the potential results in more long-term (circadian) effects of the light, and for the clients to habituate to the dawn-dusk simulation. Furthermore, it is recommended for future studies to conduct more research on the brightness of the dawn and dusk simulation and possibly increasing the maximum brightness, as the intensity of the dawn-dusk simulation was potentially not high enough, and exposure to bright artificial light might improve the feelings of rest upon waking up.

Last, it is recommended to increase the experimental control over the dawn-dusk light, by either applying a higher level of automation, or by letting the staff control more for the dawn-dusk simulation.

Since there were positive effects found in the subjective sleep experience of the clients and positive experiences with the dawn-dusk light, it is recommended to conduct research in larger groups to explore the effects of dawn-dusk simulation light on the sleep of psychotic patients. As the sample size increases, it is expected that more effects will result from the quantitative as well as additional effects from the qualitative analyzes.
REFERENCES


sources based on light-emitting diodes. Journal of Applied Physics, 97, 5.


Schwartz, W.J., Iglesia, de la, H.O., Zlomanczuk, P., & Illnerova, H. (2001). Encoding Le Quattro Stagioni within the mam-


APPENDICES

Appendix A: Intake Interviews

Ben je een vroege vogel of een nachtuil?
Beantwoord onderstaande vragenlijst* en volg de volgende instructies:

1. Lees elke vraag aandachtig vooraleer je erop antwoordt.
2. Beantwoord de vragen in de juiste volgorde.
4. Zet een kruisje vóór het antwoord dat bij jou past en bereken vervolgens je score.

Stel dat je volledig vrij je dag zou mogen plannen.
Om hoe laat zou je dan opstaan?

<table>
<thead>
<tr>
<th>Tussen 11u en 12u</th>
<th>Tussen 6u30 en 7u45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tussen 9u45 en 11u</td>
<td>Tussen 5u en 6u30</td>
</tr>
<tr>
<td>Tussen 7u45 en 9u45</td>
<td></td>
</tr>
</tbody>
</table>

Stel dat je volledig vrij je dag zou mogen plannen.
Om hoe laat zou je dan gaan slapen?

<table>
<thead>
<tr>
<th>Tussen 1u45 en 3u ’s morgens</th>
<th>Tussen 21u en 22u15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tussen 00u30 en 1u45 ’s morgens</td>
<td>Tussen 20u en 21u</td>
</tr>
<tr>
<td>Tussen 22u15 en 00u30</td>
<td></td>
</tr>
</tbody>
</table>

Als je op een precies uur moet opstaan, heb je dan een wekker nodig?

<table>
<thead>
<tr>
<th>Helemaal niet</th>
<th>Vrij vaak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soms</td>
<td>Heel vaak</td>
</tr>
</tbody>
</table>

Geraak je ’s morgens gemakkelijk uit je bed?

<table>
<thead>
<tr>
<th>Helemaal niet gemakkelijk</th>
<th>Vrij gemakkelijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niet echt gemakkelijk</td>
<td>Heel gemakkelijk</td>
</tr>
</tbody>
</table>

Hoe voel je je in het halfuur nadat je wekker is afgegaan?

<table>
<thead>
<tr>
<th>Helemaal niet wakker</th>
<th>Vrij wakker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niet echt wakker</td>
<td>Heel erg wakker</td>
</tr>
</tbody>
</table>

Heb je veel honger in het halfuur nadat je wekker is afgegaan?

<table>
<thead>
<tr>
<th>Helemaal geen honger</th>
<th>Vrij veel honger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niet veel honger</td>
<td>Heel veel honger</td>
</tr>
</tbody>
</table>
Hoe voel je je in het haluuur nadat je wekker is afgegaan?

Heel moe ○
Vrij moe ○
Redelijk in vorm ○
Heel erg in vorm ○

Als je de volgende dag geen verplichtingen hebt, op welk uur ga je dan slapen in vergelijking met je normale uur?

Meer dan 2 uur later ○
1 à 2 uur later ○
Minder dan een uur later ○
Zelden tot nooit later ○

Je hebt beslist om te gaan sporten. Een vriend(in) stelt voor om tweemaal per week samen een uur te sporten van 7u tot 8u’s morgens. In welke vorm denk je te verkennen?

In goede vorm ○
In redelijke vorm ○
Je vindt het moeilijk ○
Je vindt het heel moeilijk ○

Rond welk uur voel je je ’s avonds zo moe dat je in slaap zou kunnen vallen?

Tussen 2u en 3u’s morgens ○
Tussen 00u45 en 2u’s morgens ○
Tussen 22u15 en 00u45 ○
Tussen 21u en 22u15 ○
Tussen 20u en 21u ○

Je moet een examen afleggen waarvoor je twee uur een intensieve intellectuele inspanning moet leveren. Als je zo goed mogelijk in vorm wilt zijn, op welk uur van de dag zou je het examen dan het liefst afleggen?

Van 19u tot 21u ○
Van 15u tot 17u ○
Van 11u tot 13u ○
Van 8u tot 10u ○

Als je zou gaan slapen om 23u, hoe doe je dan zijn?

Heelmoal niet moe ○
Een beetje moe ○
Vrij moe ○
Heel erg moe ○

Om de een of andere reden ga je enkele uren later slapen dan normaal, maar je bent de volgende dag niet verplicht om op een bepaald uur op te staan. Welke optie zou je kiezen?

Je wordt wakker op je normale uur en valt niet weer in slaap ○
Je staat op op je normale uur, maar kruipt weer in je bed ○
Je wordt wakker op hetzelfde uur, maar je valt weer in slaap ○
Je wordt later wakker dan normaal ○
1. Hoe laat zou je naar bed willen gaan om te slapen?
2. Hoe laat zou je graag wakker willen worden?
Appendix B: Sleepy Diary

Morning
1. What time did you get into bed? Write the time that you got into bed. This may not be the time that you began "trying" to fall asleep.
2. What time did you try to go to sleep? Record the time that you began "trying" to fall asleep.
3. How long did it take you to fall asleep? Beginning at the time you wrote in question 2, how long did it take you to fall asleep.
4. How many times did you wake up, not counting your final awakening? How many times did you wake up between the time you first fell asleep and your final awakening?
5. In total, how long did these awakenings last? What was the total time you were awake between the time you first fell asleep and your final awakening. For example, if you woke 3 times for 20 minutes, 35 minutes, and 15 minutes, add them all up (20+35+15= 70 min or 1 hr and 10 min).
6. What time was your final awakening? Record the last time you woke up in the morning.
7. What time did you get out of bed for the day? What time did you get out of bed with no further attempt at sleeping? This may be different from your final awakening time (e.g. you may have woken up at 6:35 a.m. but did not get out of bed to start your day until 7:20 a.m.)
8. How often did you turn on the lights at night?
9. How restful did you feel when you woke up for the day? (5-point Likert Scale).
10. How would you rate the quality of your sleep? “Sleep Quality” is your sense of whether your sleep was good or poor. (5-point Likert scale).
11. How do you feel at this moment? (9-point Likert scale from 1 extremely alert to sleepy, much trouble to stay awake).
12. Comments

Evening
1. How many times did you nap or doze? A nap is a time you decided to sleep during the day, whether in bed or not in bed. “Dozing” is a time you may have nodded off for a few minutes, without meaning to, such as while watching TV. Count all the times you napped or dozed at any time from when you first got out of bed in the morning until you got into bed again at night.
2. How many caffeinated drinks (coffee, tea, soda, energy drinks) did you have after 21 o’clock? Enter the number of caffeinated drinks (coffee, tea, soda, energy drinks) you had where for coffee and tea, one drink = 6-8 oz; while for caffeinated soda one drink = 12 oz.
3. How many drinks containing alcohol did you have after 21 o’clock? Enter the number of alcoholic drinks you had where 1 drink is defined as one 12 oz beer (can), 5 oz wine, or 1.5 oz liquor (one shot).
4. Did you take cannabis after 21 o’clock?
5. Did you take any over-the-counter or prescription medication(s) to help you sleep? If so, list medication(s), dose, and time taken: List the medication name, how much and when you took EACH different medication you took tonight to help you sleep. Include medication available over the counter, prescription medications, and herbals (example: “Sleepwell 50 mg 11 pm”). If every night is the same, write “same” after the first day.
6. How do you feel at this moment? (9-point Likert scale from 1 extremely alert to sleepy, much trouble to stay awake).

7. Did you use electronic media after 21 o’clock? (television, tablet, laptop, smartphone).

8. How would you rate the atmosphere in the ward this evening? (very relaxed --- very tense, 5-point likert scale).

9. Did you participate to the scheduled activities (dagprogramma) today?
Appendix C1: Interview client
Vul bij elk woord het bolletje in, wat het best bij je past.

Licht/Atmosfeer in de slaapkamer: vond je het...

<table>
<thead>
<tr>
<th>Prettig/Gezellig</th>
<th>Levendig</th>
<th>Gespannen</th>
<th>Strikt/Veel regels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
</tr>
<tr>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
</tr>
<tr>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
</tr>
<tr>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
</tr>
</tbody>
</table>

Tevredenheid in deze ruimte:

<table>
<thead>
<tr>
<th>Licht</th>
<th>Temperatuur</th>
<th>Privacy</th>
<th>Sfeer (deze ruimte)</th>
<th>Sfeer in dit gebouw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heel ontevreden: o</td>
<td>Heel koud: o</td>
<td>Niet privé: o</td>
<td>Heel onprettig: o</td>
<td>Heel onprettig: o</td>
</tr>
<tr>
<td>Ontevreden: o</td>
<td>Koud: o</td>
<td>Neits onprive: o</td>
<td>Onprettig: o</td>
<td>Onprettig: o</td>
</tr>
<tr>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
</tr>
<tr>
<td>Tevreden: o</td>
<td>Warm: o</td>
<td>Privé: o</td>
<td>Prettig: o</td>
<td>Prettig: o</td>
</tr>
<tr>
<td>Heel tevreden: o</td>
<td>Heel warm: o</td>
<td>Heel prettig: o</td>
<td>Heel prettig: o</td>
<td>Heel prettig: o</td>
</tr>
</tbody>
</table>

Slaap:

<table>
<thead>
<tr>
<th>Hoe veranderde je slaap in deze 5 dagen?</th>
<th>Hoe beoordeel je je slaap nu?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbeterd: o</td>
<td>Heel slecht: o</td>
</tr>
<tr>
<td>Enigszins verbeterd: o</td>
<td>Slecht: o</td>
</tr>
<tr>
<td>Hetzelfde: o</td>
<td>Neutraal: o</td>
</tr>
<tr>
<td>Niet verbeterd: o</td>
<td>Goed: o</td>
</tr>
<tr>
<td>Helemaal niet verbeterd: o</td>
<td>Heel goed: o</td>
</tr>
</tbody>
</table>

Ik voel me*:

<table>
<thead>
<tr>
<th>Energiëk</th>
<th>Slaperig</th>
<th>Kalm</th>
<th>Gespannen</th>
<th>Somber</th>
<th>Blij</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
</tr>
<tr>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
<td>Nauwels: o</td>
</tr>
<tr>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
</tr>
<tr>
<td>Heel erg: o</td>
<td>Heel erg: o</td>
<td>Heel erg: o</td>
<td>Heel erg: o</td>
<td>Heel erg: o</td>
<td>Heel erg: o</td>
</tr>
</tbody>
</table>

*A combination of the Thayer Activation Deactivation Checklist (Thayer 1986) and the UWIST Mood Adjective Checklist (UMACL) (Matthews, 1990) was used, measuring the arousal (energy and tension) and mood valence (hedonic-tone) on a 5-point scale (not at all – hardly – somewhat – pretty much – very much).
End of the study: UX questions about the experience with the Wake-up light.
1. On a scale from 1 to 10, to what extent would you advice the lamp to your friends/family?
2. Would you like to continue to use the Wake-up light at home? Yes/No, Why/Why not?
3. Would you like to continue to use the Wake-up light here? Yes/No, Why/Why not?

Appendix C2: Interview staff

Atmosfeer in het gebouw: vond je het ...

<table>
<thead>
<tr>
<th>Behagelijk/prettig</th>
<th>Levendig</th>
<th>Gespannen</th>
<th>Formeel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
<td>Helemaal niet: o</td>
</tr>
<tr>
<td>Nauwelijks: o</td>
<td>Nauwelijks: o</td>
<td>Nauwelijks: o</td>
<td>Nauwelijks: o</td>
</tr>
<tr>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
<td>Redelijk: o</td>
</tr>
<tr>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
<td>Heel veel: o</td>
</tr>
</tbody>
</table>

Tevredenheid in het gebouw: vond je het ...

<table>
<thead>
<tr>
<th>Licht</th>
<th>Temperatuur</th>
<th>Sfeer in dit gebouw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heel ontevreden: o</td>
<td>Heel koud: o</td>
<td>Heel onprettig: o</td>
</tr>
<tr>
<td>Ontevreden: o</td>
<td>Koud: o</td>
<td>Onprettig: o</td>
</tr>
<tr>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
<td>Neutraal: o</td>
</tr>
<tr>
<td>Tevreden: o</td>
<td>Warm: o</td>
<td>Prettig: o</td>
</tr>
<tr>
<td>Heel tevreden: o</td>
<td>Heel warm: o</td>
<td>Heel prettig: o</td>
</tr>
</tbody>
</table>

Slaap:

<table>
<thead>
<tr>
<th>Hoe veranderde de kwaliteit van slaap van de cliënten tijdens het onderzoek?</th>
<th>Hoe beoordeel je het effect van de WakeUp lampen op de cliënten?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbeterd: o</td>
<td>Heel slecht: o</td>
</tr>
<tr>
<td>Enigszins verbeterd: o</td>
<td>Slecht: o</td>
</tr>
<tr>
<td>Hetzelfde: o</td>
<td>Neutraal: o</td>
</tr>
<tr>
<td>Verslechterd: o</td>
<td>Goed: o</td>
</tr>
<tr>
<td>Veel verslechterd: o</td>
<td>Heel goed: o</td>
</tr>
</tbody>
</table>
Lampen:

<table>
<thead>
<tr>
<th>Hoe vond je het om de WakeUp lampen hier te hebben?</th>
<th>Zou je snel in de toekomst de lampen hier willen hebben? (Kies ja of nee)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heel fijn: o</td>
<td>Ja, want</td>
</tr>
<tr>
<td>Fijn: o</td>
<td>Nee, want</td>
</tr>
<tr>
<td>Neutraal: o</td>
<td></td>
</tr>
<tr>
<td>Niet fijn: o</td>
<td></td>
</tr>
<tr>
<td>Helemaal niet fijn: o</td>
<td></td>
</tr>
</tbody>
</table>

Zijn er andere veranderingen geweest ten tijde van het onderzoek? (Bijvoorbeeld medicatie verandering van de participaten):

Eventuele Opmerkingen:
Appendix D: Sleep intervals

Two actigraphs per participant are shown on the next pages. Every time, the first one is the actigraph based on our set of rules, the second is the actigraph based on the diary data. Every day of the study is presented as one horizontal bar with activity lines on it. The areas marked in light blue represent the time the participant is in bed but not asleep. The areas marked in darker blue represent the sleep time of the participant. The light purple (or very dark blue) areas represent the off-wrist times of the participant.

The rules that were used to set the intervals were the following:

- The first minute when the activity was $> 100$, the participant is awake.
- The first minute when the activity was $< 100$, the participant is in bed.
- If more than 15 minutes before being awake, the activity was $> 100$ for less than 30 minutes, the participant is still asleep.
- The end of the sleep is marked when there is an active period (with an activity of $> 100$) of at least 30 minutes.
Actigraph of participant 1, based on our own set of rules.
Actigraph of participant 1, based on the diary data.
Actigraph of participant 2, based on our own set of rules.
Actigraph of participant 2, based on diary data.
Actigraph of participant 4, based on our own set of rules.
Actigraph of participant 4, based on diary data.
Actigraph of participant 5, based on our own set of rules.
Actigraph of participant 5, based on diary data.
Actigraph of participant 6, based on our own set of rules.
Actigraph of participant 6, based on diary data.
Actigraph of participant B, based on our own set of rules.
Actigraph of participant B, based on diary data.
Actigraph of participant 9, based on our own set of rules.
Actigraph of participant 9, based on diary data.
Actigraph of participant 10, based on our own set of rules.
Actigraph of participant 10, based on diary data.
Actigraph of participant 11, based on our own set of rules.
No Actiwatch data was available for participant 7 and 12.

Actigraph of participant 11, based on diary data.

No Actiwatch data was available for participant 7 and 12.