The effects of Smartphone use on Sleep quality and Chronotype

Final year project

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Abstract

Smartphone use is ubiquitous in modern day society however, its prevalence is a factor in increased light-at-night exposure. This light exposure before sleep has negative implications for sleep such as increasing alertness, delaying the onset of sleep and reducing sleep-promoting hormones. This study aimed to address the inconsistently in the literature by using a Smartphone application to track phone use, and using a student population as they are largely effected by both new emerging technology and poor sleep quality. This study examined whether smartphone use was associated with poor sleep quality using a direct measure of phone use Secondly it set out to examine whether an individual's Chronotype was associated smartphone. To examine this, 29 students downloaded the smartphone application "Quality time" which provided an objective measure of smartphone use and competed questionnaires on sleep quality (Pittsburgh Sleep Quality Index) and Chronotype (Morningness Eveningness Questionnaire). Results found that neither Chronotype nor overall sleep quality impacted on levels of smartphone usage. However, higher smartphone usage was correlated with higher daytime dysfunction. In conclusion, the current study indicates that smartphone does not have a negative effect on overall self-reported sleep quality but does impact on daytime dysfunction. Future research could use even more objective measures to collect sleep information to measure each variable to the highest levels of reliability.

Introduction

The recent advancements over the last 20 years in handheld technology have allowed people to be in constant contact and never with a source of entertainment. The emergence of the Smartphone has changed everybody's way of life, 2.5 billion people have a Smartphone with internet access worldwide. Whilst Smartphones have improved lives a great deal, they have also been found to have negative effects on sleep if used before bed (Chang, Aeschbach, Duffy, & Czeisler, 2015). 90% of the adult population use their Smartphone an hour before sleep (National Sleep Foundation, 2008). The use of such devices before sleep effects ones circadian rythem, delaying tiredness, circadian rhythm refers to the body's biological clock, influencing when one feels tired or awake. The use of a blue light emitting device before sleep, such as a TV or Smartphone, delays the onset on Chemical messengers that prepare the body and mind for sleep (Roenneberg, & Merrow, 2016). Students are a demographic largely affected by phone use (Massimini &Peterson, 2009). Blue light interferes with the body's natural circadian cycle, delaying the onset of sleep promoting hormones delaying the feeling of tiredness thus keeping one up longer. Students often have the choice to attend their lectures, with a lack of a long standing routine and a consistently changing schedule (Buboltz, Soper, Brown, & Jenkins, 2002), only 29.4% of students get the recommended amount of sleep (Lund, Reider, Whiting, & Prichard, 2010). Which raises concerns since the brain is still developing till the age of 25.

Circadian rhythm is governed by many interactions in the brain, the neurotransmitter melatonin, which is a sleep promoting hormone, is released from the pineal gland to signal the brain to prepare for the biological night, when the eye perceives a reduction in light the circadian

clock is signalled to start releasing melatonin. Melatonin isn't solely produced in the pineal gland, melatonin synthesis has also been found to occur in the retina followed by the reduction of light in one's environment, although melatonin synthesis in the retina hasn't been found to circulate through-out other regions of the brain, hindering this process can lead to a dysregulation of the circadian clock and reduced dopamine excretion, a key neurotransmitter in mood regulation (Tosini, 2000). The SCN system is connected directly to the retina in the eye. Exposing the retina to light past the natural cycle of night and day will delay the onset of chemical messengers to signal sleep (Dijk, & Archer, 2009).

Sleep is essential to proper cognitive functions, Lim and Dinges (2010) conducted a meta-analysis of over 70 studies and found that short term sleep deprivation (48 hours) had negative implications in speed processing and accuracy in cognitive tasks related to simple and complex attention, working memory, processing speed, and short term memory. Sleep deprivation does not have to be as long as 48 hours to bestow negative effects on cognitive function. Pilcher and Walters (1997) compared students who were sleep deprived for 24-hours against those who had 8-hours sleep on a range of cognitive tasks. They found that the sleep deprived group performed worse on all cognitive tests, however they reported higher levels of attention and estimated performance on the cognitive tests when compared to the control group. Pilcher and Walters (1997) concluded that these findings indicate that college students are not aware of the severity of sleep deprivation on their own cognitive abilities and do not perceive themselves as greatly affected by a lack of sleep .This could affect the reliability of any self-reported sleep questionnaires when interviewing a student sample . Studies have repeatedly shown that students have high levels of night time phone use (Sharkey, Carskadon, Figueiro, Zhu, & Rea, 2011). A study showed that students are only achieving adequate sleep duration approximately 29% of the time (Lund, et al, 2010). With many studies showing the connection

between light exposure and reduced sleep quality, a study conducted tested the effects off artificial light on sleep quality and duration, five light conditions were tested in relation to the level of salivary melatonin suppression. The five types of light participants were exposed were to Red light (660nm), Amber light (595nm), Green (525nm), Blue/Green (497nm) and Blue (470nm). Lower (of a lower frequency) wavelength light resulted in greater melatonin suppression from 65% to 81 %. Lower wavelengths also showed a greater Dim Light Melatonin onset (DLMO) ranging from 27 to 36 minutes (Wright, & Lack, 2001). This study shows the effects of blue light specifically. Blue light is also the most used light frequency on Smartphone devises.

Blue infused white light has been implemented in the workplace to increase alertness and productivity (Viola, James, Schlangen, & Dijk, 2008). The uses of devices that emit blue light at night have been recorded to interfere with the body's biological clock. The process of releasing melatonin takes time with a gradual reduction of light perceived by the eyes, however in this technologically advanced age, 90% of people will expose themselves to blue light right up until they go to sleep (National Sleep Foundation, 2008), especially students. (Massimini &Peterson, 2009), this interferes with the natural production of melatonin making it harder to fall asleep. The brain of mammals follow certain circadian rhythms that are advantageous to the organism, (e.g. mice hunt at night). The process that keeps track of the daily fluxuations in light is known as the "Pacemakers". Many of thousands of neural connections govern this process in the suprachiasmatic nuclei (SCN) located in the anterior hypothalamus.

Kimberly et al, (2009) found blue light blocking glasses 3 hours before sleep to have a better effect on sleep quality and mood when compared to wearing yellow light blocking glasses, the researchers hypothesised that with constant exposure to blue light up until sleep, by blocking

blue light it could create a form of psychological darkness which would allow the SNC to work properly in the hours approaching sleep. In this study twenty participants were randomly allocated into either the blue-blocking group or the yellow tinted group and were instructed to wear them 3 hours prior to sleep. Baseline measures were taken for each participant by having them complete a one-week assessment of recording their sleep quality, duration and time in a sleep diary. The study lasted two weeks. At the end of the study participants who wore the blue light blocking glasses experienced significant improvement in sleep quality. Researchers also found a significantly higher frontal NREM sleep power density in an EEG, although all-night REM sleep didn't significantly differ in each light condition. (Chellappa, Steiner, Oekhafen, & Cajochen, 2017). These findings may explain the reduction in sleep quality we see in individuals with high levels of smartphone use. This would be even prevalent in individuals without a set bed time. Chellappa and colleagues didn't measure how much light exposure each participant experienced during the experiment, to improve this study a direct measure of light exposure could be used, however it would be difficult to measure all blue light exposure.

The effect of blue light on circadian rhythm could also support the theory of delayed sleep onset due to light exposure. When investigating the effects of E-books such as the Kindle on sleeping habits, Chang and colleagues (2015) found that reading on an electronic device in the hours before sleep reduced melatonin secretion as well as a longer time spend falling asleep and effected morning alertness when compared to non-users. A critique with this study is the measure of only the time of use but and not amount of use through the day. Melatonin is gradually released throughout the evening and night so the problem of melatonin being supressed isn't only keeping someone awake longer but also delaying the circadian clocks wind down phase. These finding match with Van den Bulck's 2004 paper demonstrating the effects of screen based devise use before bed. Van den Bulck (2004) saw greater levels of tiredness and

symptoms of daytime dysfunction in a sample of children that use screen based devices before sleep (Van den Bulck, 2004), furthermore this is common practice for all ages to use screen based technology prior to sleep (Tazawa, & Okada, 2001). The consistent free use of a smartphone during the day leads its self to habit forming behaviours such as the repetitive inspection of content on the device, e.g. checking social media. This repetitive inspection leads into other actions on with the devise, increasing overall usage. As these behaviours become more apparent, the probability of problematic behaviours increase and carryover to over aspects of life (Oulasvirta, Rattenbury, Ma, & Raita, 2012). In a paper looking at predictors of good sleep hygiene in adolescents, the use of a mobile phone during the day was related to reduced sleep duration, quality and a delayed sleep onset (Bartel, Gradisar, & Williamson, 2015). From these study's it can be deduced that habitual mobile behaviours precede high levels of phone use, for this reason it can hypothesised that overall phone use could be a predictor of problematic mobile behaviours at night as it is seen in Böhmer and colleagues study, Smartphone use increases for the general population from 9pm to 1am (Böhmer, et al, 2011). It is only plausible that this behaviour is even more apparent in a high phone use group.

With the age of the smartphone, the number of mobile users has drastically increased. According to the Digital 2016 report, 3.5 billion people worldwide own a phone, 2.5 billion have internet access on their device and 2 billion are active social media users. 90% of people are also exposed to blue light right up until sleep (National Sleep Foundation, 2008), The function of a mobile phone has also changed as the surrounding field of cyber technology becomes more advanced. Many functions of a smartphone rely heavily on internet access with internet and free information now being a human right (Elhai, Levine, Dvorak, & Hall, 2016), the field of cyber psychology have taken a big interest in the effects of handheld devices, ranging from the effects on attention, life satisfaction and sleep quality. Many psychological issues have been correlated

to Smartphone use, such as high levels of perceived stress and poor academic performance have been found to correlate with higher levels of Smartphone use (Samaha, & Hawi, 2016). However Samaha and Hawi's experiment was correlational in methodology, it is unclear if the relationship between academic performances is directly caused by Smartphone use or if the relationship is caused by other variables since many variables are correlated with high levels of Smartphone use, controlling for such variables would give researchers a clearer view of this relationship.

Personal gratification through social media has been found to only account for 28% of the variance in Phone addiction tendency (Songm, Larose, Eastin, & Lin, 2004). These finding split the assumption that smartphones are only addictive due to social media accessibility, however a study looking at the applications used on a Smartphone, many applications are used and at different times of day (Böhmer, Hecht, Schöning, Krüger, & Bauer, 2011). Smartphones have endless downloadable applications, sites to visit, and operations such as "Maps" for directions. It is evident that Smartphone dependency is a problem, with research suggesting high-risk individuals to be young extraverted adults. (Bianchi, & Phillips, 2005). This could be due to the time of which the smartphone is used. Massimini and Peterson (2009) investigated the effects of phone use on sleep quality and duration in third level students. They found 62.9% of the sample used text messaging as their preferred method of communication, but considered texting to have become an obstruction in aspects of their lives. The majority of the participants reported to have had lost sleep over the last week due to using a mobile device. In relation to sleeping patterns, 66% of the participants claimed to regularly text between the hours of 1pm to 1:59am. The link was strengthened further by a correlation between symptoms of phone addiction and lower sleep quality (Massimini &Peterson, 2009). In recent years new technology has allowed researchers to more accurately assess Smartphone use through the use of one's own phone. In 2011 a large scale research study was conducted looking at smartphone application use in the sample

(Böhmer, Hecht, Schöning, Krüger, & Bauer, 2011). Over a period of 163 days, data was collected by a smartphone application called "AppSensor" to get an accurate measure from the phone of how much it was being used. Findings found Smartphones to be used for communication every hour of waking time with increased usage from 11am to 10pm. During the evening, gaming apps were found to have the highest likelihood of use.. Social applications such as Facebook have the highest probability of use during the night from 9pm to 1am.These finding match with Massimini, and Peterson's (2009) finding of 66% of their sample admitting to using phones for social interaction between the hours of 10pm to 1:59am. The location of multimedia based applications such as music based apps were found to have be 2.26 times more likely to be used when moving at a speed that exceeds 25kph (i.e. while traveling). Social applications were used more frequently at home. (Böhmer, Hecht, Schöning, Krüger, & Bauer, 2011). The findings of both these studies show increased phone use from the evening through the night till approximately 2am. The use of social applications can be problematic for sleep hygiene as conversations online don't have an agreed upon end point. Outside of extraversion, a possible variable that has yet to be studied in relation to Smartphone use is Chronotype.

The concept of chorotype aims to explain the variation in circadian rhythm and is defined by patterns of wakefulness, sleeping habits, highest time of alertness and an individual's sleeping preference. Morning types wake early and have their maximum levels of wakefulness at 11am to 1pm, in between there is a Neither type, this type is dictated by a result that fell between Morning and Evening types. Evening Chorotypes wake later, experience their max alertness between 5pm-7pm and go to sleep late. Evening type is correlated with increased risk of alcohol consumption and overall substance (Adan,1994). A study investigated the connection between the big 5 trait personality index, age, sex and internet addiction in relation to Chronotype. Results found Evening types as well as males to score higher on levels of internet addiction (Randler,

Horzum, & Vollmer, 2014). Randler hypothesised that personality styles that lend them self's to addiction are related to the Eveningness Chronotype such as extroversion, thus making evening types more susceptible to internet addiction .However it is unclear whether it is the addictive tendency's that lead to higher phone use or if it is a result of increasing the amount of night time hours one is awake for.

The assumption of Evening Chronotypes being more prone to additive behaviours is backed up by study conducted with a sample of 537 participants, researchers found Evening Chronotypes consumed more alcohol, nicotine and cola than morning types (Adan, 1994). However Randler's (2014) study does not specify how participants accessed the internet hence these finding can't imply any correlations with Smartphone use. In 2016 Demirhan, Randler and Horzum followed up on Randler's 2014 paper, investigating the relationship between problematic smartphone use, personality, and Chronotype, their results indicated higher levels of problematic phone use to correlate with Eveningness Chronotype, furthermore there were no sex differences in levels of problematic phone use (Demirhan, Randler, & Horzum, 2016), however a study investigating the effects of Chronotype on sleep quality and demographics in a student population found a connection between sex and Chronotype with females scoring higher, indicating morning type, Evening types were also found to have worse sleep quality and duration within the sample (Vitale, et al, 2015). The use of a self-report questionnaire in Randler and Demirhan's studies could be changed out for a Smartphone screen time tracker to get a more accurate and credible measurement of phone use to measure with Chronotype .The research published on Chronotype and phone use us weak with a reliance on subjective measures of phone use.

Growing up with the emergence of internet and wireless based technology, the college population is a strongly effected demographic by the technological age. In White and colleague's

(2011) paper , 350 psychology students, 45.1% male and 53.7% female, reported their overall sleep quality, filled out the SMS Problematic use Scale, an adaption of the Internet Addiction Questionnaire, the Mobile Use scale, the Mini IPIP and the Mobile Phone Use Questionnaire. The Results indicated the majority of students spend over 5 hours a day on their mobile phone and slept 7.5 hours. No significant correlation was found between sleep disturbances or perceived lower sleep quality and phone use. However there was a significant correlation between pathological text messaging and lower sleep quality, and a significant correlation between addictive text messaging and worse sleep quality. Measuring phone use doesn't need to be self-report anymore as there are smartphone applications that can now track a person's phone use through their own device, this would be the most accurate of a measure for phone use (White, buboltz, & Igou, 2011). The Pittsburgh Sleep Quality Index (PSQI) is the gold standard subjective measure of sleep quality in sleep research. The high internal homogeneity and simplistic question style helps researchers to uncover the sleeping habits of participants, however the PSQI is mostly used in research to measure levels of sleep hygiene, Scores on the PSQI are suitable to be used instead of a sleep diary and in turn is a less intrusive method of data collection. (Gradner,Kripke, Yoon, & Youngstedt, 2006). Using the PSQI and other reputable questionnaires, more than just perceived sleep quality can be measured. The PSQI contains seven components influencing Sleep quality research could be conducted to discover the influence of phone use on each of the seven components to see where people are being negatively influenced most.

The common use of questionnaires and scales for Smartphone use has given researchers critical data on the connection between phone use and many variables such as sleep, depression and anxiety disorders, however using Smartphone applications to track phone use is providing objective measure of phone use thereby giving greater validity to findings. Christensen and

colleagues (2016) investigated the relationship between Smartphone screen time, demographics and sleep with the use of a smartphone application to measure the amount of screen time participants spend over a 30-day period. A cross-sectional analysis was conducted with 653 participants. Sleeping habits were measured using the Pittsburgh Sleep Quality Index (PSQI). Screen time had a median of 38.4 hours per month, calculating at 3.7 minutes per hour. Self-reported younger age was associated with increased screen time. Higher levels of screen time were also significantly associated with shorter sleep duration, lower sleep quality, and longer sleep onset latency (Christensen, et al, 2016). A review of the effects of electronic media on sleep onset in adolescents was published in 2010 by Neralie, Cain and Michael Gradisar. In a review of 36 papers, they found a consistent relationship between media use and delayed bed time (Cain, & Gradisar, 2010). Since 2010 many forms of electronic media are now accessible by a Smartphone, music , GPS systems and even books are now available on a Smartphone device. Evening Chronotypes experience later bed times and more erratic sleeping patterns and thus are more susceptible to be awake during problematic times where delayed sleep onset can manifest.

With the increasing levels of smartphone use seen in recent years, a corresponding reduction in sleep quality has been observed in individuals with higher levels of smartphone use (White, buboltz,& Igou, 2011). The increasing surge of literature on the maladaptive effects correlated to smartphone use, uses mostly self-reporting questionnaires to assess participant's smartphone use, these readings are not as accurate as they could be. With the topic of smartphone use, researchers can take advantage of the item they are researching. Applications have been made for smartphones to track screen time as seen in Christensen et al's 2016 paper, giving researchers the most valid measure they could ask for. Certain demographics such as being male or a college student may make someone more susceptible to develop problematic

smartphone behaviours, however the real issue that will be addressed in this paper is the effect of Smartphone use on sleep quality. This study will also investigate the role Chronotype has on phone use and if Evening Chronotypes are more at risk of negative phone use. The results from this study should shine light on the role Chronotype has on problematic phone use. Furthermore the results from this study will expand on the current knowledge know about students phone use in Ireland.

This current paper will use the participant's smartphone device to track their phone use over seven days instead of a self-report questionnaire and compare the results to scores on the Pittsburgh sleep quality index (PSQI). (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). This paper will investigate only college students from the ages of 18 to 31 because of the inconsistency of the findings in this population in regards to phone use and sleep. This sample has also been chosen because of the impact a lack of sleep can have at this age when pursuing an academic degree. The effects of new technologies for the future generations can first be observed in a student population since they are technologically aware and will be the first to grow up in a society with Smartphones. Additionally this study will ask the question of what Chronotype is more likely to have higher levels of phone use. Since studies have found Evening Chronotypes to be more at risk of developing addictive behaviours, it is hypothesised Evening Chronotypes will have higher levels of smartphone use than Morning or Neither types. The studies done on Chronotype and phone use to this point have used subjective measures for phone use, a weak methodology for accessing time spend on a phone. This study will make use of the object being studied and use a Smartphone application to objectively measure phone use. Chronotype will be determined through the use of the Morningness Eveningness Questionnaire (MEQ) (Home,& Ostberg, 1974). This research will investigate the following hypotheses'.(1) High levels of

objective smartphone usage u will results in poor sleep quality in the student population, (2) Evening Chronotypes will be correlated with high levels of smartphone use.

Methods

Participants

Twenty-seven young adult college students ages aged 18 to 30 (M=21.41, SD= 1.76) were recruited through a convenient sampling method. In the sample, 59.3% were male and 41.7% were female. Exclusion criteria included being outside the age bracket and not currently pursuing a third level degree. Lastly no vulnerable population are used for this study.

Materials

The Pittsburgh Sleep Quality Index (PSQI) is a 19 item self-report questionnaire that measures peoples sleep quality. The PSQI can be categorized into seven Components, “Sleep quality”, “sleep latency”, “Sleep duration”, “Sleep efficacy” ,”Need for sleep medication”, “Daytime Dysfunction due to sleepiness ” and “Sleep disturbances”. The Total overall scores on the PSQI range from 0 to 21, with lower scoring (below 5) indicating good sleep and high scores (above 5) indicating bad sleep. Each component can be calculated by adding scores from different questions,(e.g. question 1 and 9 for subjective sleep quality). The PSQI has been found to have high internal homogeneity. Scores on the PSQI have been shown to correlate with sleep diaries, giving this scale high reliability. (Gradner,Kripke, Yoon, & Youngstedt, 2006).

The Morningness Eveningness Questionnaire(MEQ) is a self-report, multiple choice questionnaire with answers varying from a 4-5 Likert scale. The MEQ provides a measure of individual’s time of day preference by assessing peoples waking time, sleeping time and highest point of alertness throughout the day. The scores from the MEQ range from 16 to 86. Scores under 41 indicate Evening type, 42 to 58 indicate Intermediate or Neither types, and above 58 indicates Morning type. The reliability of the MEQ in relation to sleeping habits has been investigated. Tailard et al (2004) found a correlation between sleeping preferences (i.e. preferred

time to wake and sleep) and scores on the MEQ (Taillard, Phillip, Chastang, & Bioulac, 2004), giving the MEQ adequate reliability in gauging an individual's Chronotype.

To measure smartphone use, the Android Smartphone application "Quality Time" was used. The application was invented by developers in N-Computing Global Inc. The application "Quality Time" is downloaded onto participant's smartphone devices and will provide an objective measure of smartphone use. The total screen time will be calculated by adding up the minutes of seven days of screen time.

Procedure

Participants were given an information sheet with a full overview of the study, listing the benefits and risks as well as what will be required of them if they choose to consent, this sheet also informed them that their involvement with study will be confidential and voluntary. A consent form was then given to each participant, requiring them to indicate that they understand their rights and requirements moving forward. Participants were then instructed to download the "Quality Time" application onto their smartphones, Researchers asked each participant if they had adequate phone storage to download the application, if so, they proceeded to download the application and were instructed how to set up the application. Once the application was successfully downloaded participants were given two questionnaires, first the PSQI was given to participants and filled out, and then the MEQ was given and completed. Eight days later, participants sent seven screenshots representing the last seven days of phone use to the researcher.

Results

Screen time was split into quartile ranges with low levels of screen time being the medium of the lower half of the data, medium being the median of the data and high levels being the median of the higher half of the data. Descriptive statistics reveal the mean score on the Pittsburgh Sleep Quality Index was 8.4, indicating that the majority of participants have poor sleep quality. The variable Sleep Score was used to group participants into either a “good”(0) or a “bad”(1) score on the PSQI. The mean screen time revealed an average of 29 hours and 55 minutes (1786.6 minutes) per week equating to 4 hours and 16 minutes a day. The seven components of the Pittsburgh Sleep Quality Index (indicate each of these) are added together to form the global score are scored 0-3. The seven components add up to the total Global score.

Figure 1.

Descriptive statistics for nominal and scale variables

	N	Mean	Median	Range	Std. Deviation
AGE	27	21.41	21	9	1.716
SEX	27				
Male	16(59%)				
Female	11(41%)				
MEQ	25	43.32	42	26	7.022
Morning	1(4%)	60	60	0	0
Neither	14(56%)	47.7	46.5	16	4.85
Evening	11(40%)	39	38.5	16	4.297
PSQI	27	8.4074	8	13	3.53291
Good	6(22%)	4.17	4.5	3	1.17
Bad	21(78%)	9.62	9	9	2.99
Sleep Quality	27	.4444	0	3	.97402
Sleep Latency	27	1.78	2	3	.892
Sleep Duration	27	1.26	1	3	1.196
Sleep Efficacy	27	1.30	1	3	1.295
Sleep Medication	27	.48	0	3	1.051
Daytime Dysfunction	27	1.37	1	3	.688
Sleep Disturbances	27	1.78	2	3	.698
Screen time(Min)	27	1796.5926	1731	3353	768.41
Low	9(33%)	1035	1155	1119	405
Medium	11(41%)	1809.36	1744	576	188
High	7(26%)	2755.71	2496	1522	580

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Effect of Sex on Phone Use

An independent samples t-test was conducted to compare the levels of Phone use between males and females. There was no significant different in scores between the two groups, t(19.85) = .055, p = .957, two-tailed with males (M = 1802.5, SD =972.9) scoring higher than females(M =1743.9, SD =651.9) (see figure 1). The magnitude of the differences in the means (mean difference =237.3, 95% CI:-963.6 to 1438.2) was small (Cohen's d = 0.075).

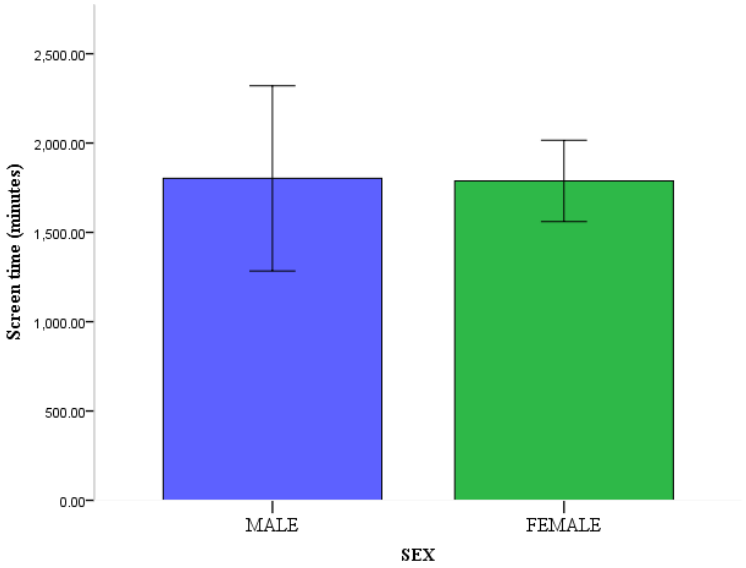

Figure 1. Mean scores of Screen time for each sex

Effects of Smartphone Use on Sleep Quality.

The Relationship between Phone Use and Sleep Quality was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscasticity. There was a no correlation between the two variables ($r = .058$, $n = 27$, $p < .776$). This indicates that the two variables share approximately 3% of variance in common. Results indicate no correlation between Phone use and Sleep Quality scores on the PSQI.

(Table1)

Correlation table for the 7 components of PSQI and Phone use.

	0	1	2	3	4	5	6	7
(0)Phone use								
(1)Sleep Quality	-.219							
(2)Sleep Latency	.021		.251					
(3)Sleep duration	.094		-.004	.417				
(4)Sleep efficacy	.181		.075	.592	.197			
(5)Medication	-.167		.008	-.046	-.225	-.109		
(6)D Dysfunction	.251		.032	.265	.346	.217	-.043	
(7)Disturbances	.078		.207	.227	.302	.033	.151	.418

Note. Variables listed across the horizontal axis refer to variables listed e.g Phone use=0, Sleep Quality=1.

The relationship between the seven components of the PQSI and phone use was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscasticity. All correlations between the variables were weak. No result was statistically significant.(See table 2).

The relationship between levels of Phone use and Daytime Dysfunction was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscasticity. There was a moderate correlation between the two variables (r= .41, n=27, p=.033). This indicates that the two variables share approximately 17% of variance in common. Results indicate a significant correlation between levels of Phone use and Daytime Dysfunction (see figure 2)

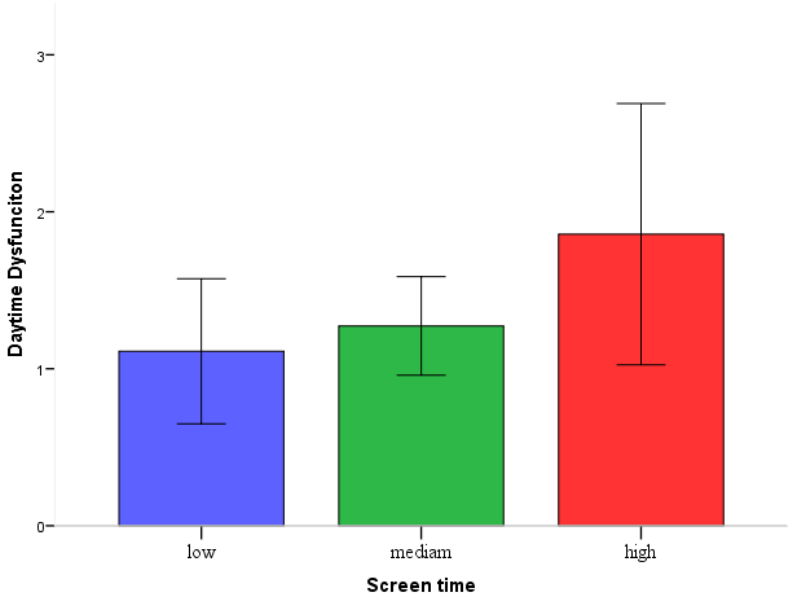

Figure 2. Mean scores of Daytime Dysfunction and Screen time

A one-way between groups ANOVA was conducted to determine if there were Daytime Dysfunction differences between Chronotype.

There was no statistically significant difference in levels of daytime dysfunction for the three groups F(2, 22) =.159, p =.854. The effect size indicated a very small difference in sleep quality (eta squared = .086).

Post-hoc comparisons were not performed since the Group Morning type has fewer than two cases.

An independent samples t-test was conducted to compare the levels of Phone use between good and bad sleepers. There was no significant different in scores between the two groups, t(5.951) = .484, p = .645, two-tailed with good sleepers (M = 1981.2, SD =1148.1) scoring higher than bad sleepers (M =1788, SD =339.6). The magnitude of the differences in the means (mean difference =14.5, 95% CI: -536.2 to 565.2) was small (Cohen's d = 0.026).

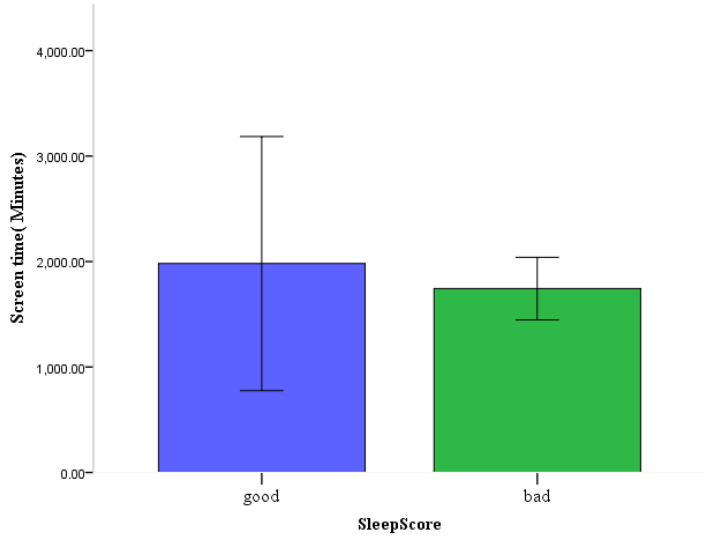

Figure 3. Mean score of screen time for good and bad sleepers on the PSQI

A one-way between groups ANOVA was conducted to determine if there were sleep quality differences in the level phone use. Participants were divided into three groups according to where they fell in the quartile range (high, medium and low. There was no statistically

significant difference in levels oh phone use for the three groups F(2, 24) =.044, p =.957. The effect size indicated a very small difference in sleep quality (eta squared = .0057.

Post-hoc comparisons using the Tuckey HSD test indicated that the mean scores for low Phone use (8.11, SD = 3.51) was not significantly higher (P = .963) than medium Phone use (8.45, SD = 3.50) or high Phone use (p = .966; M = 8.57, SD = 4.11). There was no statistically significant difference in mean scores between medium and high levels of Phone use (P = 1.00).

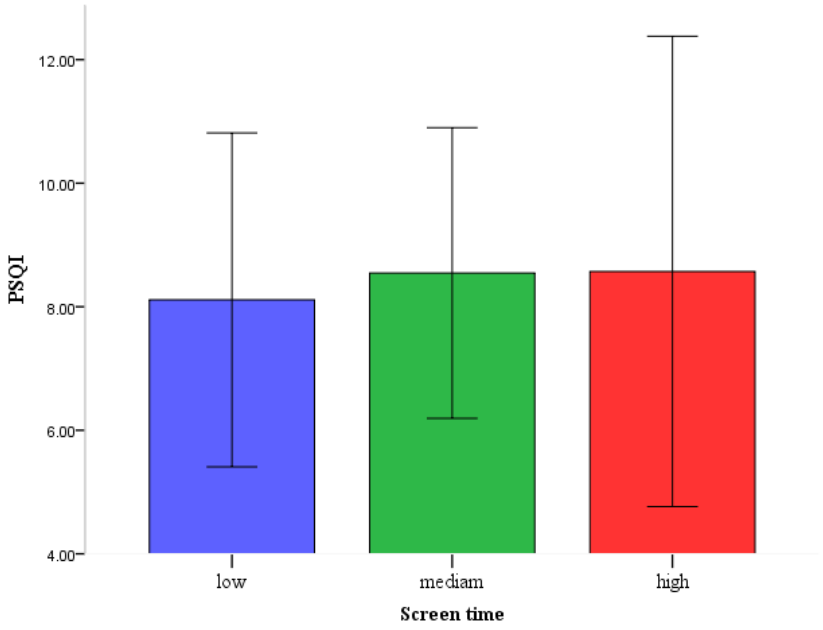

Figure 4. Mean scores of the PSQI and screen time

Effects of Phone use on Chronotype

An independent samples t-test was conducted to compare the levels of Phone use between Evening and Neither Chronotypes, since there was only 1 morning type. There was no significant difference between the two groups of Chronotypes, t(21.58) = 1.38, p = .181, two-tailed with Evening Chronotypes (M= 2019, SD= 852) not scoring significantly higher than Neither Chronotypes (M = 1584, SD = 6880). The magnitude of the difference in the means (Mean

difference = 435.1, 95% CI: -219.-07 to 1089.27) was weak to medium (Cohen's d = .446) (See figure 5).

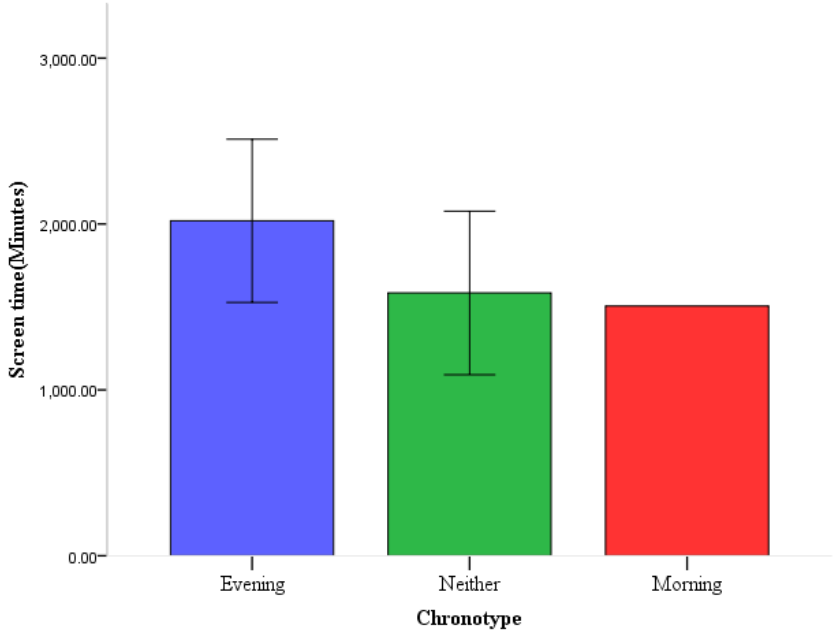

Figure 5. Mean scores of screen time for each Chronotype

An independent samples t-test was conducted to compare the Chronotype between males and females. There was no significant difference between the two sexes, t(19.22) = -1.096, p = .286, two-tailed with Females (M= 45.09, SD= 7.73) scoring higher than Males(M= 41.93, SD= 6.34) the magnitude of the difference in the means (Mean difference = -3.62, 95% CI: --9.194 to 2.869) was weak (Cohen's d = .44695).

A two-way between group's analyses of variance was conducted to explore for: (1) differences in sleep quality, and Chronotype, on levels of phone use (2) to examine if the effect of sleep quality on phone use depends upon the Chronotype of the participants.

Initial findings indicated no violation of the assumptions of homogeneity of variance (.60). The interaction effect between Sleep quality and Chronotype was not statistically significant, F(1,20) =1.166, p= .293. The main effect for Chronotype was not significant and of a small magnitude

(F(1,20) = .1.552,p = .236 eta squared =.134). The main effect for Sleep quality was not statistically significant and of a small magnitude (F(1,20) = .331, P = .571, eta-squared = .016).

Findings

The Results from the statistical tests performed did not find any significant finding for the main hypotheses'. There was no significant correlation between Smartphone use and sleep quality nor was there an effect found for Chronotype or sex. Out of the seven components of the PSQI, daytime dysfunction was the only variable to have a significant relationship with Smartphone use, indicating high levels of Smartphone use are related to higher levels of Daytime dysfunction.

Discussion

This study aimed to investigate the relationship between Smartphone screen time and sleep quality and to examine the effects of Smartphone use on Chronotype. Results from this study did not find any significant effects between screen times on sleep quality, nor was any effect in relation to screen time and Chronotype. Findings were contrary to the hypothesis, but not uncommon in the current academic literature.

Findings from Christensen and Colleagues (2016) found a relationship between higher phone use and worse sleep quality, measured using the PSQI and a Smartphone screen time tracker, which this study did not replicate. In the study by Christensen (2016), a Smartphone application was used to measure the amount of active screen time a participant spent on their phone, the median screen time for the sample was one hour 22 minutes a day. This average is considerably lower than the average screen time found in this study (4 hours and 16 minutes), the difference could be due to the amount of time the study collected data for, in Christensen's study Screen time was tracked for 30 days, compared to the seven days data was collected for in this study, although White and colleague's (2011) study with a student population, found an average of proximately 5 hours a day, The amount of phone use found by White is consistent with the finding of this study. White and colleagues (2011) also did not find a significant effect between levels of phone use and disturbances in sleep quality or duration. The technology of phones in 2011 however was much less advanced with internet browsers on phones being inefficient and internet rates unaffordable for the average college student (White, et , al, 2011). This effect could be due to the sample used in this study since college students are a population with changing sleeping patterns and the highest level of technology use in the general public. This would result in making it hard to find a relationship between the variables. It could be hypothesised that this relationship should

be found in the general public, and to be a less common finding in a student population, there may be a case for this since Christensen used an adult population and White (2011) found no relationship using a student sample. Further studies could split a pre-existing data set into a between groups design to investigate the differences seen the adult population compared to a solely student sample.

The second aim of this study was to investigate the relationship between Screen time on a Smartphone and Chronotype. It was hypothesised Evening types will score higher on phone use than Morning or Neither types. Finding from this study did not find a significant relationship between Eveningness and phone use. The non-significant result could be due to the small sample size and the poor distribution seen in Chronotype in the sample. A study conducted by Randler and Horzum (2016) found that higher levels of problematic phone use was significantly related to the Eveningness Chronotype. However the differences seen in the results of this study could be due to a difference in problematic phone use and over all phone use. Differences could also be due to the bias seen in participants when answering self-report questionnaires. This result was surprising to see no difference between each Chronotype since Evening types have a propensity to addictive behaviours (Adan, 1994). However this study only investigated the relationship between Neither and Evening types, it is possible that Evening and Neither types score around the same range for phone use, with Morning types scoring differently.

When comparing Smartphone screen time to the seven components of the PSQI, there was a significant relationship between Screen time and Daytime dysfunction within the sample, indicating that participants with increased screen time had higher levels of daytime dysfunctional symptoms. These finding have been found elsewhere in the literature (Exelmans, & Van den Bulck, 2016).. In a study comparing the seven components of the PSQI to smartphone use after

lights out found those who used their Smartphone in bed has greater levels of sleep latency, sleep disturbances and daytime dysfunction the following day (Exelmans, & Van den Bulck, 2016). However in Exelmans' study a full adult population sample was used, the age of the participants in this study could be a protective factor for other negative aspects related to sleep quality such as sleep latency.

When comparing sex differences in the sample, there was no significant difference seen in Smartphone screen time between males and females. This is also the case in many of the studies in this area (Brown, et al, 2002). There was also no difference seen in reports of Chronotype between sex's, this is uncommon in the literature when looking at the adult population with several studies finding males to have significantly higher levels of Evening types (Lehnkering, & Siegmund, 2007). However when comparing sex differences in young adults a study also found no significant difference in Chronotype between sexes (Mongrain, Carrier, & Dumont, 2005). Even studies that found an effect within a student population found a relatively small difference (Vitale,et al, 2015). This could be due to the young age of the sample since Evening type is correlated to being of a younger age (Roennberg, et al, 2004), hence making it difficult to find any difference is relation to sex.

The implications of Smartphone screen time not being directly related to a reduction in sleep quality implies it's not how much a Smartphone phone is used, but how it is used that effects sleep, however the relationship found between Screen time and Daytime dysfunction implies no matter the function or time, excessive Smartphone use can induce high levels of daytime dysfunction. Exelmans and Van den Bulck (2015) conducted an experiment to examine the propensity to use a phone after lights out and sleep the components of sleep quality on the PSQI. They found that reported phone use in after lights out strongly predicted scores on the

PSQI, higher levels of daytime dysfunction, lower sleep quality and more frequent sleep disturbances (Exelmans, & Bulck, 2015). It is inconclusive if high levels of Smartphone use effects a participant in the same day or if it is a knock on effect to the next day, although if Chang and colleagues (2015)'s findings that an using an e-reader before sleep effected participants next day alertness, this could apply to all blue light devises, if this is the case then 90% of adults using their phone before bed (National Sleep Foundation, 2008) becomes a concerning figure. However this study's finding of Daytime dysfunction being realed with high phone use could be due to the high number of bad sleepers (78%) in the sample.

The implication of the second tested hypothesis of higher levels of screen time being related to Evening Chronotype is harder to deduce from the data found in this study, as there was only one Morning type, however this data does show that there is a substantial lack of Morning types in the student population as well as many people who fall into the Neither category, implying a lack of a preference. Although these finding are not unusual, with college students known for changing sleeping schedules (Brown, Buboltz Jr, & Soper, 2002), it seems the longer a person stays up at night, the higher there phone use becomes. It would be plausible to hypothesis this if Evening types have higher phone use than neither types and slightly worse, although not Significant, sleep quality, that the extra time spent on the phone was at night thus leading to greater sleep onset. A future study could measure when participants used their phones during the day to try measure lights effect on sleep more accurately.

This study contributes to the current knowledge of the topic of Smartphones effects on sleep by gathering an objective measure of Smartphone use in an Irish college population, most the study's measuring screen time are conducted in the United States of America or Asian country's including Japan, South Korea and China so little is known about the digital habits of

Irish youths. Furthermore the astoundingly low levels of sleep quality found in the students in this sample is a common thread through the literature and country's alike. As these results add up from many academic sources, greater awareness for the importance of technological hygiene will become apparent, changing the perception of persistent Smartphone use.

This study has a number of strengths by addressing the correlational issues of Demirhan, Randler, & Horzum's (2016) study. A novel finding in this study is the impact of phone use on Daytime dysfunction, whist Christensen (2016) and Abbey (2011) used the PSQI to measure sleep quality, neither of them reported a link between the component of the PSQI Daytime dysfunction and phone use, however this finding does resemble the increased levels of tiredness seen in Chang et al's E-reader study. This is an important finding because it could explain the relationship between phone use and other tested variables such as academic performance (Samaha, & Hawi, 2016). Future research could investigate the relationship between academic performance and phone use mediated by the presents of daytime dysfunction in the student population.

The limitations of this study could be the presents of only one Morning Chrnotype, reducing the tests than could be used to investigate the relationship between phone use and Chronotype, this however could be due to the lack of Morning types in the student population. The use of the MEQ could be changed to a different questionnaire since the MEQ measures common practice, treating a week as a whole, a possible improvement would be to use the Munich Chronotype questionnaire since it measures week day and weekend sleeping practices. The data gathered for screen time spanned seven days whist Christensen and colleague's gathered data for screen time over thirty days, if this experiment was to be re-modelled, it would be of benefit to gather data for screen time over a 30 day period as well. Potentially there could

be been reductions in screen time for participants due to the ability the “Quality time” application gave to participants of being able to observe the data being collected on a daily basis, this could lead to participants being more aware of how much they are using their phones. Additionally another limitation is the use of a self-report sleeping measure as many people don’t understand the difference between bad sleep quality and good sleep quality, to get around this, further research could “Acti watches” to objectively measure the sleep quality of participants and compare to a direct measure of phone use using an application such as “Quality time, thus making the results far more creditable and less likely of finding a type one error.

The relationship between phone use, sleep quality and Chronotype was investigated in this study using the new methodological measure, a Smartphone application, to gauge how much each participant uses their phone for a week, giving strength and efficacy to the measure of Smartphone use. Findings were inconclusive in relation to any interaction between Smartphone use, Sleep quality and Chronotype. It is hypothesised that the lack of an interaction is due to the sample being taken from a student population, a demographic that consistently shows poor sleep quality and higher levels than the general public of technology use, hence making it difficult to distinguish any variability within the sample.

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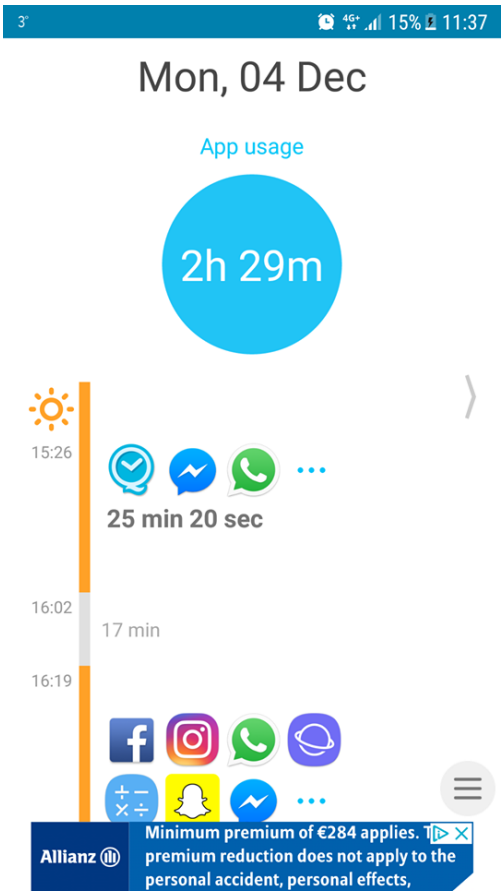
Appendix A

Quality time application sample screenshot

Participants sent 7 screen shots from inside the Quality time application to the research.



Appendix B

Pittsburgh Sleep Quality Index

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

INSTRUCTIONS: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?

   USUAL BED TIME _____

2. During the past month, how long (in minutes) has it usually take you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, when have you usually gotten up in the morning?

   USUAL GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)

   HOURS OF SLEEP PER NIGHT _____

INSTRUCTIONS: For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...cannot get to sleep within 30 minutes	☐	☐	☐	☐
(b) ...wake up in the middle of the night or early morning	☐	☐	☐	☐
(c) ...have to get up to use the bathroom	☐	☐	☐	☐
(d ...cannot breathe comfortably	☐	☐	☐	☐
(e) ...cough or snore loudly	☐	☐	☐	☐
(f) ...feel too cold	☐	☐	☐	☐
(g) ...feel too hot	☐	☐	☐	☐
(h) ...had bad dreams	☐	☐	☐	☐
(i) ...have pain	☐	☐	☐	☐

(j) Other reason(s), please describe

_____

_____

	Very good	Fairly good	Fairly bad	very bad
6. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐

	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

	No bed partner or roommate	Partner/ roommate in other room	Partner in same room, but not same bed	Partner in same bed
10. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...loud snoring	☐	☐	☐	☐
(b) ...long pauses between breaths while asleep	☐	☐	☐	☐
(c) ...legs twitching or jerking while you sleep	☐	☐	☐	☐
(d) ...episodes of disorientation or confusion during sleep	☐	☐	☐	☐
(e) Other restlessness while you sleep; please describe	☐	☐	☐	☐

_____

_____

SCORING INSTRUCTIONS FOR THE PITTSBURGH SLEEP QUALITY INDEX:

The Pittsburgh Sleep Quality Index (PSQI) contains 19 self-rated questions and 5 questions rated by the bed partner or roommate (if one is available). Only self-rated questions are included in the scoring. The 19 self-rated items are combined to form seven "component" scores, each of which has a range of 0-3 points. In all cases, a score of "0" indicates no difficulty, while a score of "3" indicates severe difficulty. The seven component scores are then added to yield one "global" score, with a range of 0-21 points, "0" indicating no difficulty and "21 " indicating severe difficulties in all areas.

Scoring proceeds as follows:

Component 1: Subjective sleep quality

Examine question #6, and assign scores as follows:

Response	Component 1 score
"Very good"	0
"Fairly good"	1
"Fairly bad"	2
"Very bad"	3

Component 1 score: _____

Component 2: Sleep latency

1. Examine question #2, and assign scores as follows:

Respo\nse	Score
≤15 minutes	0
16-30 minutes	1
31-60 minutes	2
> 60 minutes	3

Question #2 score: _____

2. Examine question #5a, and assign scores as follows:

Response	Score
Not during the past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Question #5a score: _____

3. Add #2 score and #5a score

Sum of #2 and #5a: _____

4. Assign component 2 score as follows:

Sum of #2 and #5a	Component 2 score
0	0
1-2	1
3-4	2

Component 3: Sleep duration

Examine question #4, and assign scores as follows:

Response	Component 3 score
> 7 hours	0
6-7 hours	1
5-6 hours	2
< 5 hours	3

Component 3 score: _____

Component 4: Habitual sleep efficiency

1. Write the number of hours slept (question #4) here: _____
2. Calculate the number of hours spent in bed:

   Getting up time (question #3): _____

   Bedtime (question #1): _____

   _____

   Number of hours spent in bed: _____

3. Calculate habitual sleep efficiency as follows:

   (Number of hours slept/Number of hours spent in bed) X 100 = Habitual sleep efficiency (%)

   (_____/_____) X 100 = %

4. Assign component 4 score as follows:

Habitual sleep efficiency %	Component 4 score
> 85%	0
75-84%	1
65-74%	2
< 65%	3

Component 4 score: _____

Appendix C

Morningness Eveningness Questionnaire

Instructions:

Please read each question very carefully before answering.

Please answer each question as honestly as possible.

Answer ALL questions.

Each question should be answered independently of others. Do NOT go back and check your answers.

1. What time would you get up if you were entirely free to plan your day?

5:00 – 6:30 AM	5
6:30 – 7:45 AM	4
7:45 – 9:45 AM	3
9:45 – 11:00 AM	2
11:00 AM – 12 NOON	1
12 NOON – 5:00 AM	0

2. What time would you go to bed if you were entirely free to plan your evening?

8:00 – 9:00 PM	5
9:00 – 10:15 PM	4
10:15 PM – 12:30 AM	3
12:30 – 1:45 AM	2
1:45 – 3:00 AM	1
3:00 AM – 8:00 PM	0

3. If there is a specific time at which you have to get up in the morning, to what extent do you depend on being woken up by an alarm clock?

Not at all dependent	4
Slightly dependent	3
Fairly dependent	2
Very dependent	1

4. How easy do you find it to get up in the morning (when you are not woken up unexpectedly)?

Not at all easy	1
Not very easy	2
Fairly easy	3
Very easy	4

5. How alert do you feel during the first half hour after you wake up in the morning?

Not at all alert	1
Slightly alert	2
Fairly alert	3
Very alert	4

6. How hungry do you feel during the first half-hour after you wake up in the morning?

Not at all hungry	1
Slightly hungry	2
Fairly hungry	3
Very hungry	4

7. During the first half-hour after you wake up in the morning, how tired do you feel?

Very tired	1
Fairly tired	2
Fairly refreshed	3
Very refreshed	4

8. If you have no commitments the next day, what time would you go to bed compared to your usual bedtime?

Seldom or never later	4
Less than one hour later	3
1-2 hours later	2
More than two hours later	1

9. You have decided to engage in some physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 7:00 – 8:00 am. Bearing in mind nothing but your own internal "clock", how do you think you would perform?

Would be in good form	4
Would be in reasonable form	3
Would find it difficult	2
Would find it very difficult	1

10. At what time of day do you feel you become tired as a result of need for sleep?

8:00 – 9:00 PM	5
9:00 – 10:15 PM	4
10:15 PM – 12:45 AM	3
12:45 – 2:00 AM	2
2:00 – 3:00 AM	1

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last for two hours. You are entirely free to plan your day. Considering only your own internal "clock", which ONE of the four testing times would you choose?

8:00 AM – 10:00 AM	4
11:00 AM – 1:00 PM	3
3:00 PM – 5:00 PM	2
7:00 PM – 9:00 PM	1

12. If you got into bed at 11:00 PM, how tired would you be?

Not at all tired	1
A little tired	2
Fairly tired	3
Very tired	4

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following are you most likely to do?

Will wake up at usual time, but will NOT fall back asleep	4
Will wake up at usual time and will doze thereafter	3
Will wake up at usual time but will fall asleep again	2
Will NOT wake up until later than usual	1

14. One night you have to remain awake between 4:00 – 6:00 AM in order to carry out a night watch. You have no commitments the next day. Which ONE of the alternatives will suite you best?

Would NOT go to bed until watch was over	1
Would take a nap before and sleep after	2
Would take a good sleep before and nap after	3
Would sleep only before watch	4

15. You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own internal "clock" which ONE of the following time would you choose?

8:00 AM – 10:00 AM	4
11:00 AM – 1:00 PM	3
3:00 PM – 5:00 PM	2
7:00 PM – 9:00 PM	1

16. You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 10:00 – 11:00 PM. Bearing in mind nothing else but your own internal "clock" how well do you think you would perform?

Would be in good form	1
Would be in reasonable form	2
Would find it difficult	3
Would find it very difficult	4

17. Suppose that you can choose your own work hours. Assume that you worked a FIVE hour day (including breaks) and that your job was interesting and paid by results). Which FIVE CONSECUTIVE HOURS would you select?

5 hours starting between 4:00 AM and 8:00 AM	5
5 hours starting between 8:00 AM and 9:00 AM	4
5 hours starting between 9:00 AM and 2:00 PM	3
5 hours starting between 2:00 PM and 5:00 PM	2
5 hours starting between 5:00 PM and 4:00 AM	1

18. At what time of the day do you think that you reach your "feeling best" peak?

5:00 – 8:00 AM	5
8:00 – 10:00 AM	4
10:00 AM – 5:00 PM	3
5:00 – 10:00 PM	2
10:00 PM – 5:00 AM	1

19. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

Definitely a "morning" type	6
Rather more a "morning" than an "evening" type	4
Rather more an "evening" than a "morning" type	2
Definitely an "evening" type	0