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Inconsistencies in the Alertness Dimensions within Measures of Sleepiness.

by

Katharine Elizabeth Jordan

A Master of Philosophy Thesis
Submitted in partial fulfilment of the requirements for the award of Master of Philosophy of Loughborough University.

May 2012
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This research investigates whether there is any significant relationship between four commonly used measures of sleepiness; the Multiple Sleep Latency test (MSLT), the Psychomotor Vigilance Task (PVT), the Epworth Sleepiness Scale (ESS) and the Karolinska Sleepiness Scale (KSS) in a group of healthy alert individuals, and to what extent the individual factors of sex, morningness-eveningness disposition and personality variables are related to these measures of sleepiness.

Fifty normal sleepers (26 females, 24 males) aged between 21-40 years of age (mean age 25.18 years) volunteered undergo a standard research MSLT. All participants had attained 7-8 hours of sleep prior to participation. Between the sleep opportunities they completed a practice and experimental session of the PVT, the Eysenck Personality Questionnaire (Adult EPQ-R) and the State-Trait Anxiety Inventory version (STAI Form Y). Subjective levels of sleepiness were collected using the KSS before each sleep opportunity of the MSLT, and either side of the PVT sessions. The Horne-Ostberg Morningness-Eveningness disposition questionnaire and ESS scores were collected prior to the testing day.

There was no significant correlation between the measures of sleepiness using the whole data set. Relationship between the measures of sleepiness was not improved by time of day. When the data was split by latency on the MSLT, a significant negative correlation was found between the MSLT and ESS, but only in nine participants. Sex of the participant was only significantly related to the ESS. The MSLT was the only measure of sleepiness found to be significantly related to the morningness/eveningness disposition of the participants. Personality characteristics were not significantly related to the ESS or PVT. A significant positive relationship between neuroticism score and latency on the MSLT was found when those participants who did not sleep in the MSLT were excluded from analysis. Scores on the KSS were significantly related to levels of neuroticism, state and trait anxiety and scores on the Lie scale of the EPQ.

It is concluded that although these measures of sleepiness are commonly used together, they do not have a significant relationship to each other in a group of healthy alert individuals. This suggests that each measure of sleepiness may be measuring a different component of the alertness-sleepiness spectrum, therefore no one measure can be relied upon to replace another in the measurement of alertness or sleepiness.
Some significant relationships between the alertness dimensions of certain measures of sleepiness and the individual differences within the participant group have been revealed, yet as no single individual difference measured in this investigation was significantly related to all of the measures of sleepiness, it is unlikely that these particular individual differences in the participant group are solely responsible for the inconsistencies in the alertness dimensions of these measures of sleepiness. Further investigation is required in order to further establish why there are inconsistencies in the alertness dimensions of these measures of sleepiness.
2. Introduction.

This literature review contains the previous research conducted into the measures of sleepiness, the level of concordance between the measures of sleepiness, and the effect that individual differences plays on these measures. The majority of this research has focussed on either clinical populations who suffer from excessive daytime sleepiness and have been diagnosed with a sleep disorder, or healthy sleepers who have been sleep deprived or had their sleep restricted prior to participation.

2.1. Why measure sleepiness?

Sleeping is an important feature of a person’s day to day existence with research indicating that the average adult will sleep between seven to eight hours a night (Tune 1969). A survey of 2000 people conducted in 2004 indicated that 58% of the British public reported sleep problems on one or more nights during the week (Groeger et al 2004) and sleep disorders have been found to be one of the most undiagnosed groups of medical conditions (Dead Tired Report. Weber Shardwich Visual Communications published in the “Sleep SOS report” Sleep Alliance 2004).

Furthermore, suffering from excessive daytime sleepiness has been seen to have a negative impact on many areas of an individual’s life. Research has indicated it can disrupt an individual’s personal relationships (Cartwright et al 1987) and their career as excessive sleepiness is linked to an increased risk of accidents at work (Lindberg et al 1997). However, untreated excessive sleepiness can have more dire consequences, as research has indicated that if left untreated excessive sleepiness is highly and significantly related to having an accident whilst driving (Findley et al 1988) and furthermore, the mortality rate for accidents caused by sleepiness is three times higher than accidents caused by alcohol or substance abuse (Royal Society for the Prevention of Accidents (ROSPA) 2001). There is also an implication for society as well as for the individual, as evidence shows that the cost of just one untreated sleep disorder is £432,000,000 a year to the NHS. (MacKay 2003).

As we spend such a proportion of our day asleep and because our waking hours can be vastly affected by the quality and/or quantity of our sleep, it is important research is conducted into the measurement of sleep and sleepiness. By gathering normative data on the population by measuring their sleepiness, sleep researchers and clinicians are also able to start to define where the line between normal and abnormal levels of sleepiness occurs.
Evidence gained from this research into the measurement of sleepiness can be used in a widespread manner in clinical settings as the ability to identify abnormal levels of sleepiness to aid diagnosis of sleep disorders, and monitoring of treatment. This in turn helps to prevent the considerable risks associated with untreated excessive sleepiness.

Measures of sleepiness fall into two distinct categories – those which are measured objectively with physiological or behavioural methods and subjective methods which measure a person’s perceptions about their sleepiness.

2.2. Objective Measures of Sleepiness

2.2.1 Multiple Sleep Latency Test (MSLT)
The Multiple Sleep Latency test is a physiological measure of sleepiness and was devised by Richardson et al in 1978, and standardised by Carskadon and Dement in 1982 at Stanford University, USA. It is based on the hypothesis that the sleepier a person is, the less time they will take to fall asleep.

In order to conduct this test, the participant has a number of electrodes placed on their scalp according to the 10-20 system of electrode application (Jasper 1958). This montage involves electroencephalography (EEG) to monitor brainwaves in the central and sometimes occipital areas of the brain, electrooculography (EOG) to monitor eye movements, and electromyography (EMG) to measure muscle tone. Glue or other adhesives are used to place further electrodes onto the forehead and behind the ears to act as a ground and references for other electrodes.

Once this montage is applied, the participant is taken to a quiet and darkened bedroom and asked to “lie quietly and relax, close your eyes, and try to go to sleep” at two hour intervals throughout the day, resulting in four or five sleep opportunities. The first sleep opportunity takes place 1.5-3 hours after awakening. These sleep opportunities are recorded on computer software and are scored by trained research or clinical staff for sleep onset and clinical MSLTs are also scored for sleep onset REM periods, which are indicative of narcolepsy. Rechtschaffen and Kales devised the first guide to scoring an EEG recording of sleep in 1973. Iber et al on behalf of the American Academy of Sleep Medicine (AASM) published an updated scoring manual in 2007.

In a research MSLT, sleep onset is scored from lights out to the first three consecutive epochs of stage 1 sleep or one epoch of any other stage of sleep. When this criterion is
met, the sleep opportunity is terminated and the patient is woken up to prevent the cumulative effect of any sleep that may have occurred at that point. However, in a clinical MSLT, sleep onset is scored as one epoch of stage 1 or any other sleep stage and when this is established, the patient is allowed up to 15 minutes of uninterrupted sleep, in order to look for REM onset which is indicative of Narcolepsy.

In either a research or clinical MSLTs, if sleep is not seen in any epoch, the test is terminated at 20 minutes. The sleep onsets from each of the sleep opportunities are averaged in order to get a single MSLT score. This value indicates the individual’s level of sleepiness which is scored to a set of guidelines first proposed by Thorpy et al (1992). An average latency on the MSLT of less than five minutes is said to indicate pathological sleepiness. Six to nine minutes is a diagnostic grey area as latencies of this length indicate the individual has a sleep latency which is quicker than that considered to be the normal range of sleep latency, but their latency is not within a pathological range. A latency of between ten to twenty minutes is considered to be within the normal range of sleepiness.

Wichniak et al (2002) advise that the MSLT can only be considered accurate if a number of criteria are met and as such the MSLT is often preceded by a nocturnal polysomnography to verify the quality and length of sleep on the night prior to the test. Previous research such as that of Carskadon and Dement (1979) has found that the MSLT can be affected by quality of sleep from up to a week before the test. The night before testing, caffeine and alcohol are prohibited. A urine sample is given on the testing day to ensure that the participant is clear of recreational and prescriptive drugs which may affect the results of the MSLT. In a clinical population, patients may be advised to stop any medication known to affect the test.

The MSLT is considered to be the “Gold Standard” of the current measures of sleepiness. Research has indicated that the MSLT is an effective method for measuring the sleep propensity of the individual. The test has been shown to be sensitive to circadian rhythms by showing a time of day effect. The shortest latencies on the MSLT are typically found in the 2pm sleep opportunity, a point in the day where there is a known circadian dip, seen in early research into the MSLT such as Richardson et al (1982) and more recently by Danker-Hopfe et al (2001).

Zwyghulzen-Doorenbos et al (1988) investigated the test-retest reliability of the MSLT in fourteen healthy individuals who had two MSLTs consisting of 4 sleep opportunities, on two occasions a minimum of four months apart. They found a high reliability between the two tests, with a very highly significant correlation between the
two tests. Richardson et al (1978) found the MSLT was able to accurately
differentiate between clinical and control populations as the narcoleptic patients in the
study significantly had shorter latencies and therefore fell asleep faster than the
control subjects who were healthy sleepers. This finding is supported by Steinberg et
al (1996) whose research examined a clinical population with a variety of sleep
disorders and found that the MSLT was able to accurately discriminate between those
patients who suffered from excessive daytime sleepiness from those who did not.
Steinberg’s study also indicated the MSLT was sensitive to whether patients with
obstructive sleep apnoea had received treatment and or not.

Research has also focused on the reliability of the staff that score the MSLT. Drake et
al (2000) examined the reliability of scoring sleep onset on the MSLT between scorers
and within the individual scorer in a group of clinical MSLTs. Several staff of
different grades scored the tests, and a number of the staff then rescored the same tests
30 days later. Drake et al found a statistically significant high level of reliability in
both the interrelations between colleagues and the intrarelations within an individual
scorer. Nevertheless, this research is yet to be repeated using non-clinical populations.

Previous research has also found a high level of consistency between the individual
tests on the MSLT. Golish et al (2002) found that in certain circumstances, such as the
first three sleep opportunities having a latency within the normal range, or the
participant having a latency of 20 minutes and therefore not falling asleep in any of
the first three sleep opportunities, then the mean sleep latency will be normal, and the
accuracy of this prediction was 100%.

Nevertheless, the MSLT is not without its limitations. Johns (2000) has criticised the
MSLT for being expensive and time consuming. This is because a MSLT can take up
to eight or nine hours to complete and requires the funding to pay a trained and
experienced member of staff to carry out this test. Furthermore, Johns argues that a
weakness of the MSLT is that it only measures sleep propensity in one situation and
one which lacks real world validity. This is because the test is performed in a
laboratory and requires the application of electrodes, which is not a situation an
individual will encounter in their daily life. Carskadon (1982) supports this comment
and explains that the participants have to be comfortable and familiar with their
surroundings in order for the test to be accurate.

Despite the test-retest reliability found by Zwyghulzen-Doorenbos et al (1988) in
healthy subjects, Jahnke and Aldrich (1990) have found that repeated MSLTs on
thirteen clinical subjects showed inconsistent results, where some patients have had
latencies in the normal range on one MSLT followed by a repeat MSLT where the latency was in the pathological range.

Results of the MSLT are also affected by elements such as what the individual has been doing in the minutes before the test (Bonnet and Arand 1998). Twelve individuals who had no complaints of excessive daytime sleepiness took part in two MSLTs. Participants either took a five minute walk or watched 5 minutes of television in bed before a sleep opportunity. These situations were counterbalanced within the participant group. Those that had been asked to take a walk before a sleep opportunity had significantly longer latencies than those who had watched television in bed. This result has real world validity as many laboratories and sleep centres encourage the individual to visit the toilet before the sleep opportunity begins, which may then have an effect on their scores.

Other researchers have criticised the premise that the MSLT measures an individual’s manifest sleepiness as the underlying assumption is that the sleepier they are the faster they will fall asleep. Harrison and Horne (1996) took healthy individuals who did not report excessive daytime sleepiness and who normally took 7-8 hours sleep a night and gave them the opportunity to sleep for up to ten hours a night for two weeks. These individuals came into the laboratory to undergo MSLTs, vigilance performance testing and subjective sleepiness ratings. Two individuals had sleep latencies in the pathological range on the MSLT yet there was no significant difference between their subjective sleepiness ratings or performance on the vigilance task with other individuals who had latencies within the “normal” range. Harrison and Horne concluded that these individuals had “high sleepability with no sleepiness” – that these two individuals were no sleepier than those individuals with latencies in the range considered to be normal but were able to relax and fall asleep in the MSLT. Although it is questionable to extrapolate from just two participants, this phenomenon has been seen in other research such as Geisler et al (1998) who argue that the MSLT cannot distinguish between those people who fell asleep in the MSLT because they are sleepy during the day, and those who fell asleep in the test because they are simply able to fall asleep in the daytime.

The results of the MSLT have also been seen to be affected by the individual’s attitude towards participating in the test. This issue was first reported in research by Blagrove and Horne (1991). Fourteen participants spent 32 hours awake in which they completed an MSLT at the varied hours of 20.00 to 15.00 the next day. Participants also completed subjective sleepiness ratings and a reaction time test. Seven of the participants were offered a financial incentive to stay awake for longer in the MSLT, whereas the remaining seven participants were offered no incentive. Those who had
been offered the financial incentive were able to stay awake 52-63\% longer than those who have no incentive, despite being equally sleepy on the subjective ratings and reaction time test. This suggests that the motivation of an individual can affect the MSLT despite the participant being sleep deprived.

More recently, Bonnet and Arand (2005) investigated the impact of motivation further by giving a bonus to those that could either stay awake the longest in the MSLT or go to sleep the fastest in order to receive a bonus. Participants were monitored to ensure they weren’t using any wake promoting activities such as jaw clenching or tapping. Their results supported that of Blagrove and Horne’s study, in that participants were able to significantly extend their latency on the MSLT with incentive to do so. However, they were not able reduce their latency on the MSLT.

Curcio et al 2001 criticises the MSLT for not being developed on clinical evidence instead of a population of healthy sleepers. In the same line of thought, Wise (2006) encourages sleep clinicians not to rely solely on the result of the MSLT but to use the test in conjunction with the clinical history of an individual to make a diagnosis. This is especially important in light of the research conducted by Bishop et al (1996) where MSLTs were conducted on 139 participants with normal sleep patterns and no excessive daytime sleepiness. Nevertheless 17\% of the participants had two or more sleep onset REM periods – one of the key features in the diagnosis of narcolepsy. Had the emphasis been solely on this result, and not in the context of a clinical history and a lack of excessive daytime sleepiness shown by subjective scales, then these participants may have been diagnosed with the sleep disorder.

Research into the MSLT has shown much individual variation seen on the test. One such element of individual variation is the effect of personality on the MSLT. Previous researches into the relationship between personality and the MSLT have had contrasting results.

Kronholm et al (1995) hypothesised that psychological elements would have a relationship with the MSLT. Seventy seven participants completed the MSLT and filled out the Beck Depression Inventory (BDI) and Karolinska Scales of Personality (KSP). Their results indicate a significant positive relationship between latency on the MSLT and psychological distress, indicating the higher level of psychological distress the higher sleep latency an individual had. This supports the criticisms made against the MSLT about the effect of the laboratory and electrodes on the participant – those who are have higher levels of anxiety find the MSLT an anxious situation and this is reflected in them taking longer to fall asleep in the sleep opportunities.
This result is supported from Kayumov et al (2000) who compared the MSLT results of participants with obstructive sleep apnoea and people suffering with depression. As expected, within the group of patients with sleep apnoea, the more fragmented the preceding nights’ sleep, the faster they fell asleep in the MSLT. However in the case of the depressed participants, the more the previous nights’ sleep was disturbed, the longer they took to fall asleep in the MSLT. Kayumov et al suggest that this is due to the participants feeling tense and therefore more alert. Furthermore, Shealy et al (1980) found a significant relationship between higher levels of neuroticism and problems with sleep onset.

Contrasting evidence about the relationship between elements of personality and the MSLT comes from Roehrs et al (1990) who conducted overnight polysomnography and MSLTs on 38 men who reported no sleep complaints. These participants were asked to fill out a number of measures of personality including the Minnesota Multiphasic Personality inventory (MMPI), Jenkins Activity Measures of Personality, and the Institute of Personality and Anxiety testing Anxiety Scale (IPAT). Latencies of less than six minutes or over 16 minutes were examined. The results indicated that there was no significant relationship between the MSLT score and the MMPI or Jenkins Activity Measures of personality. However, shorter latencies (<6 minutes) on the MSLT had significantly higher scores on the anxiety and suspiciousness elements of the IPAT. This is in contrast to the findings of Kronholm et al (1995) and Kayumov et al (2000), as the results suggest the more anxious you are, the faster you fall asleep on the MSLT.

The limitation of using correlations to analyse a relationship between two factors is that cause and effect are unable to be distinguished. Danielsson et al (2010) aimed to separate cause and effect in the relationship between levels of neuroticism and sleep onset. They conducted a study on 217 participants from adolescence to midlife. Though having higher levels of neuroticism as a teenager did not predict problems with sleep onset, having problems with sleep onset during their teenage years was significantly related to higher levels of neuroticism when the participants reached 37 years of age. This result would indicate that having issues initiating sleep leads to neuroticism, not that an individual’s neurotic personality traits lead to issues in their sleep.

Nevertheless, other research has found there to be no relationship between the MSLT and psychological factors. Olson et al (1998) completed overnight polysomnography and MSLT tests in healthy sleepers and asked them to complete the Symptom Checklist 90 Revised (SCL-90). This questionnaire asks the respondent to rate how frequently a list of symptoms has distressed them in the last week. Responses range
from “not at all, to extremely”. Results indicated there was no significant relationship between the psychological scales of the SCL-90 and the latencies on the MSLT. This was supported by more recent research by Watson et al (2004) who recruited 41 monozygotic twins who were discordant for chronic fatigue syndrome and these participants underwent MSLT testing. As part of the screening process, participants were given the Diagnostic Interview Schedule in order to measure psychiatric issues such as depression. They found no significant relationship between the mean sleep latency on the MSLT and incidences of depression within their sample. Furthermore, Manni et al (1991) found no significant correlation between relationship between the anxiety levels in healthy university students who completed the State-Trait Anxiety Inventory and sleep latency.

Research into the MSLT has also focussed on sex differences within the test. Geisler et al (1998) reported significantly longer sleep latencies in women than men. Gender differences were also seen in Punjabi et al (2003). Furthermore, some research has indicated that whether an individual is more of a morning or evening person can affect the MSLT. Volk et al (1994) found that those individuals with a more “evening disposition” reported feeling more sleepy on the subjective sleepiness scales, and were significantly more likely to fall asleep in the morning sleep opportunities of the MSLT than those participants who had a “morning disposition”. However there was no significant difference in overall sleep latency between the two groups.

2.2.2 The Psychomotor Vigilance Task (PVT)
The Psychomotor Vigilance task was first developed by Wilkinson and Houghton in 1982 and further formalised by Dinges and Powell in 1985. It is a measure of sustained attention which is widely used in sleep research to measure performance at various levels of sleepiness and in the use of different countermeasures to sleepiness. Performed on a computer, the individual is asked to watch a screen with a rectangle in the centre. At various intervals a rolling digital clock appears in the rectangle and the participant is asked to press a button as soon as they see the clock appear in the rectangle.

The PVT is usually performed in bouts of 10 to 30 minutes, and a visual analogue scale (VAS) of “Sleepy” to “Alert” is completed prior to and after the PVT is completed. The resulting data is scored for a number of elements. The speed at which the participant presses the button after the numbers appear gives a reaction time in milliseconds, and the data is also scored for false positives where the participant has pressed the button before the stimulus is on the screen, errors where the participant has responded to the stimulus but this action has not been picked up on the computer,
and lapses where the individual failed to respond within 500 milliseconds of the stimulus appearing on the screen. After the false positives, errors, and lapses have been removed from the data, a mean reaction time is then calculated.

The PVT is widely used in a variety of sleep research studies because of its many advantages. Firstly, the task has a very sharp learning curve which comes to peak between 1-3 sessions on the PVT (Dinges and Kribbs 1991). Kim, Dinges and Young (2007) argue that the PVT is not subject to a learning effect – that the participant’s score doesn’t improve depending on how many times the participant has completed the task. This is advantageous as it means a practice session on the PVT before the experimental procedure is normally enough to control for the effects of learning on the measurement, and therefore scores collected within the experiment are not confounded by practice effects. Loh et al (2004)’s results indicate that the PVT is sensitive to the time of day as the scores of PVT sessions reflected the circadian dips and troughs in the testing sessions.

Furthermore, research has indicated that the PVT is sensitive to the environment in which it is performed. Dinges et al (1997) have shown the PVT is sensitive to experimental measures such total sleep deprivation and sleep restriction, with reaction times slowing and number of lapses rising as the hours without sleep increase. Lighting has been seen to affect performance. Phipps-Nelson et al (2003) found that when participants were exposed to bright light (>1000 lux), they had faster reaction times compared with participants who were not exposed to the bright light when performing the PVT. However, contrasting results come from Kaida et al (2006) who found bright light only improved subjective measures of sleepiness, not performance on the PVT.

The posture sleep deprived participants assume whilst performing the task has also affected scores on the PVT, with those completing the PVT whilst standing having significantly less lapses and a faster reaction time than those who took that the PVT whilst sitting (Caldwell et al 2003).

Lastly, the PVT is able to reflect changes in sleepiness resulting from using countermeasures against sleepiness, with Wright et al (1997) finding significantly improved performance after administration of caffeine to participants.

However, like all measures of sleepiness, the PVT has its limitations. Loh et al (2004) have found that sessions of less than ten minutes result in less sensitivity to time of day effects and lapsing. Furthermore, the PVT has shown a lack of sensitivity to sleep disorders. For example, although Kim, Dinges and Young (2007) found a significant
correlation between the participants’ apnoea-hypopnoea index and the number of false positives on the PVT, the PVT was not associated with any other element of the PVT, and furthermore no association between sleep disordered breathing and a score on the PVT was found in participants younger than 65 years of age. This is a limitation because it is those with continual excessive daytime sleepiness who are most likely to suffer detriments in performance perhaps in the workplace, or whilst driving due to their sleepiness.

A key assumption of the PVT is that lapses are due to sleepiness and may represent a participant having “microsleeps”. However, research by Anderson and Horne (2008) has indicated that this is not necessarily the case. Participants restricted their sleep to five hours on the night prior to the experiment, and then completed two 30 minute sessions of the PVT in the following afternoon, either in the presence of an interesting distraction, or without a distraction, and these conditions were counterbalanced. Participants were filmed to measure head turns. Anderson and Horne found that participants who completed the PVT with an interesting distraction present scored significantly more lapses on the PVT and head turns than those participants who completed the PVT with no distraction present. Interestingly though, there were also frequent head turns even when the distraction was not present in the first ten minutes of testing. This suggests that some lapses on the PVT are not solely due to sleepiness but may also be the product of boredom.

Furthermore, Anderson et al (2010) used video equipment monitor participant’s lapses on the PVT. Lapses were categorised by whether the participant’s eyes were open but focused on the task, eyes closed during the lapse indicating a microsleep or the participant’s gaze was diverted away from the task. Lapses where the participant’s eyes were open but not diverted were the most common, a result which further indicates that lapses on the PVT are not purely down to microsleeps.

The PVT has also been shown to be affected by unwanted confounding variables such as the individual differences of age and gender. Research has frequently found men to have faster reaction times but higher levels of false positives (Blatter et al 2006, Kim, Dingess and Young 2007) and this result has been replicated in adolescents by Beijamini et al (2008). A possible explanation for this has been given by Kim, Dingess and Young (2007) who hypothesise that men aim for faster scores, whereas women aim for accuracy. Nevertheless, other research such as Frey et al (2004) has found no gender differences on the PVT.

Furthermore, Blatter et al (2006) found significant age differences on PVT performance. Under normal sleep patterns older participants had significantly lower
reaction times on the PVT. However, under sleep deprivation where the level of sleep pressure is high younger participants have worse performance on the PVT compared with their older counterparts.

Lastly, some previous research has indicated that the PVT and other behavioural measures of sleepiness can be affected by the personality of the individual performing the task. Manni et al (1991) found that a higher level of trait anxiety on the State-Trait Anxiety Inventory was related to poorer performance on a battery of tests measuring similar components to the PVT. Furthermore, Vrignon et al (2007) found that participants with higher levels of extraversion on the Eysenck Personality Questionnaire performed much better in terms of mean reaction time and percentage of lapses on the PVT than those participants who had lower levels of extroversion.

2.3. **Subjective Measures of Sleepiness.**

2.3.1. **Trait Subjective Measures of sleepiness.**

Trait subjective measures of sleepiness aim to measure an individual’s level of sleepiness as a global aspect – how sleepy the person generally has felt in recent times.

2.3.1 a) **The Epworth Sleepiness Scale**

The Epworth Sleepiness scale was devised by Johns at the Epworth hospital in Melbourne, Australia in 1991. It is a trait measure of sleepiness in that it records the individual’s level of sleepiness as a whole, and in general at the present time.

To do this, the person is asked to rate how likely they would be to doze in eight different situations which are frequently encountered in everyday life:

The Epworth Sleepiness Scale. (Johns 1991)

1. Sitting and Reading.
2. Watching TV.
3. Sitting, inactive in a public place (e.g. a theatre or meeting).
4. As a passenger in a car for an hour without a break.
5. Lying down to rest in the afternoon when circumstances permit.
6. Sitting and talking to someone.
7. Sitting quietly after a lunch without alcohol.
8. In a car, while stopped for a few minutes in traffic.

The scale measures the individual’s sleep propensity- their tendency to fall asleep and consists of situations which vary in “sophoricity” – the likelihood a person will doze. Items 6 and 8 are the most sophorific and item 5 is the least sophorific situation (Johns 1992).
All eight answers are then added together to get a final ESS score, with a range of 0-24. If a numerical score is not given for each of the eight situations the measurement is said to be invalid. Johns recommends that where half scores are given as answers, the answer should be rounded up to nearest number. Scores of less than ten are considered to be within the normal range, whereas scores above ten indicate excessive daytime sleepiness.

The ESS has many known advantages. The scale was first tested by Johns (1991) by examining a group of 30 controls who had no sleep related complaints, and 150 patients with a variety of sleep disorders. The ESS was filled in after the initial consultation, and a polysomnography and MSLT were carried out. Results indicated a statistically significant difference in the mean ESS scores between the patients and the controls, with the patients having a significantly higher score than controls. Johns argues that this means that the ESS is able to be used to distinguish between healthy and a clinical population of people, however this conclusion is questionable as the participants in the “patient” group had come specifically to the centre for their sleepiness. They were aware they were sleepy in the first place.

Furthermore, Johns argues that the Epworth sleepiness scale has a higher level of real world validity compared to the MSLT which has to take place in the laboratory and requires extensive equipment to be applied to a person for the test to take place. Also in contrast to the MSLT, it very cheap to administer, and can be completed very quickly. Further research by Johns (1992, 1994) has indicated that there are no significant differences in scores whether the patient completes the scale themselves or whether a relative completes the scale on the patients’ behalf. Statistics have indicated by factor analysis that sleep propensity is the only element measured in the ESS.

Johns administered the ESS to 87 third year medical students on two occasions approximately five months apart. The average ESS score was 7.7 and therefore within the range considered to be normal, and there was no significant difference and a very high correlation between the scores on both occasions, indicating the scale has a high test-retest reliability and level of consistency. Also examined were 54 patients with obstructive sleep apnoea (OSA), who were asked to complete the ESS before and after three months treatment on nasal continuous positive airway pressure (CPAP). Scores were significantly lower and in the normal range after CPAP treatment when compared to before treatment began. This indicates that the ESS is effective in measuring the effect of treatment.

Chervin (2003) comments that the fact that the scale has become so widely used in clinical practice and research centres is advantageous as it enables research to be
easily compared and results to be standardised. Indeed, the ESS has successfully been translated into a number of different languages such as Spanish, the results of which comply with the findings of Johns (Izquierdo-Vicairo et al 1997)

Nevertheless, the Epworth sleepiness scale has been criticised for a number of reasons. Arguably the most prominent flaw of the ESS is the fact that it relies upon subjective information from a patient. This is detrimental for several reasons – firstly it presumes that the patient is competent enough to assess his own sleepiness and the frequency of situations where he has dozed recently. Physical and mental disabilities such as if the patient has suffered a stroke or has memory impairments may impair the validity of an ESS score. Guilleminault and Brooks (2001) have also criticised the ESS as it asks respondents to give a score for their level of sleepiness in situations which they rarely or never encounter, for example if they do not having a driving license, which may therefore lead the respondent’s overall score to be inaccurate.

Though Johns previously found a high correlation between ESS completed by both the patients and their relatives who filled out a copy on their behalf, other research such as that of Kumru et al (2004) have found the opposite in their research, with results indicating significantly different scores on the ESS between the patient completing it for themselves, and the relatives completing it on their behalf. In some cases there was a difference as large as four points which lead to a change from clinically significant sleepiness to within the normal range and vice versa. This is also the case in Nyugen et al’s (2002) research, who noticed a large difference in the ESS score at the time of referral to the sleep clinic and their first visit to the sleep centre, which in some patients was a 7 point difference. Alarmed by the lack of reproducibility the authors concluded that diagnosis should not be made solely on the ESS score.

Self awareness of dozing or lack thereof can also be an issue in cases such as that of OSA where an individual can often comment in clinic that “I don’t feel I have problem, but my wife says I snore loudly and doze all the time”. This may lead to an underestimated score on the ESS.

Secondly, motivation when completing the scale is always a concern. A person may deliberately underplay their level of sleepiness on the scale if they believe a certain score will mean further investigation into their sleep, and may lead to diagnosis of a sleep disorder which could mean a suspension of their driving license, or loss of their job. Contrastingly, patients may also be motivated to overestimate their score on the MSLT in order receive stimulant medications, as some medications used to treat excessive daytime sleepiness contain amphetamines.
Motivation can also be an inherent problem in a research setting. Though researchers always aim not to communicate the aim of the research to the participant lest it influence their later behaviour, it may be case that participants try to guess what researcher is looking for and adjust their score accordingly.

Though Johns’ (1991) research found the ESS could distinguish between clinical and control populations, many exceptions in clinical practice have been seen, and research such as Gottlieb et al (1999) found that in some of the worst cases of OSA they had seen, the patient had ESS scores of 9 which is within the normal range. Whether this is due to the motivational factors explored above is unclear.

As previously mentioned there are advantages in the widespread use of the ESS, however this can also be detrimental as seen by Avidian and Chervin (2002). When performing an internet search of websites which publish the ESS they found that a quarter of all sites had no advice on how to interpret the final score, and none mentioned the limitations of the ESS or the lack of correlation to other measures of sleepiness (discussed later in this chapter). Avidian and Chervin also criticise the ESS for not including a question on how much of a problem a person’s sleepiness causes in their everyday life, which they consider to be a far more relevant question than frequency of dozing, which in some people may be frequent but not disrupting or problematic.

Johns argues that his research in 1992 showed that the ESS is sensitive to the effect of three months CPAP treatment in cases of OSA. John states that only patients who reported they had used the treatment were included in this study. This methodology seems highly questionable. CPAP machines commonly have a device which records compliance in terms of day used in the year and hours during the night. Johns does not report what level of compliance he deemed acceptable, or why the data on the machine was not used to check compliance. Like other self reports, a patient’s description of CPAP compliance is likely to be hindered by their motivation, or by their ability to accurately and precisely recall their use of their CPAP machine.

Miletin and Hanly (2003) have criticised Johns for not providing a thorough account of how the eight items of the ESS were chosen. They argue that a lack of input from patients in the design of the scale weakens its reliability to be used in a clinical setting. In their article the ESS is criticised for the ambivalence of the instructions. Though there is merit in the instruction which asks the respondent to separate sleepiness from tiredness when answering the questions, items such as number 8 “In a car, while stopped for a few minutes in traffic” are unclear as to whether you are a passenger or the driver. The scale lacks questions related to detrimental effects at work, and Miletin
and Hanly argue that test-retest reliability needs to be examined in a clinical population, and expand on Johns’ research using medical students.

One area of research conducted into the ESS, is whether the measure is affected by individual differences in the subject population. Studies in this area have reported confounding results. One such factor is age of the individual. Though the majority of research (Johns 1991, Johns and Hocking 1997, Izquierdo – Vicario et al 1997, Ruhle et al 2005, Sanford et al 2006) has found no significant differences between age groups on the ESS, this has not been the case in all research into this area. Kim and Young (2005) examined 2913 normal sleepers aged 30-60 years. They found that in both the active and passive situations of the ESS, older participants had significantly higher scores than the younger participants. In contrast Pallesen et al’s study in 2007 found significantly higher scores in the younger participants of a group of 2301 members of the Norwegian general public aged 18-90.

Mixed results are also found in the investigation of gender effect on the ESS. Whereas some research has found a significantly higher ESS score in male participants (Chervin and Aldrich 1999, Gander et al 2005, Pallesen et al 2007), other studies have found significantly higher scores in female participants (Kim and Young 2005, Roky et al 2003) and some have found no significant difference in ESS scores between the sexes (Johns and Hocking 1997, Sanford 2006).

Psychological issues and personality have also been found to be related to the scale. Olson et al (1998) found that the ESS correlated with every element of the symptom checklist 90 (SCL-90) except psychoticism, and Mastin et al (2005) found a significant correlation with the ESS and neuroticism measured by the Neuroticism, Extraversion and Openness personality inventory revised (NEO PI R) indicating the higher scores on the ESS, the higher level of neuroticism in the individual’s personality.

Lastly, the relationship between the ESS and the trait of morningness/eveningness disposition has been examined. Though Taillard et al (1999) found no difference on ESS score between morning, evening or neither types, Roky et al (2003) found significant differences in ESS score between the different chronotypes but this result was only found in the female participants. Female evening types had significantly higher ESS scores than female morning types or female “neither” types.

2.3.2 State Subjective Measures of Sleepiness.
State subjective measures of sleepiness aim to measure the individual’s level of sleepiness at the particular moment the scale is administered, and though they do not provide an insight into the individual’s general level of sleepiness day to day, they are able to track hourly changes in sleepiness.

2.3.2. a) The Stanford Sleepiness Scale (SSS).

The Stanford Sleepiness Scale, devised by Hoddes et al in 1973 at Stanford University, USA, was one of the first items used to measure sleepiness, and it still currently used today in clinical and research fields. It is a Likert scale which asks the person to pick a value on the scale which most represents their current level of sleepiness and answer numerically. The scale is as follows:

<table>
<thead>
<tr>
<th>Degree of Sleepiness</th>
<th>Scale Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeling active, vital, alert, or wide awake</td>
<td>1</td>
</tr>
<tr>
<td>Functioning at high levels, but not at peak; able to concentrate</td>
<td>2</td>
</tr>
<tr>
<td>Awake, but relaxed; responsive but not fully alert</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat foggy, let down</td>
<td>4</td>
</tr>
<tr>
<td>Foggy; losing interest in remaining awake; slowed down</td>
<td>5</td>
</tr>
<tr>
<td>Sleepy, woozy, fighting sleep; prefer to lie down</td>
<td>6</td>
</tr>
<tr>
<td>No longer fighting sleep, sleep onset soon; having dream-like thoughts</td>
<td>7</td>
</tr>
</tbody>
</table>

(https://www.stanford.edu/~dement/sss.html)

2.3.2 b) The Karolinska Sleepiness Scale (KSS).

More recently, another Likert scale, the Karolinska Sleepiness Scale was proposed by Åkerstedt and Gillberg (1990) as another state measure of sleepiness scale. The procedure of the KSS is very similar to that of SSS whereby a person is asked to view the scale and select the number nearest to their level of sleepiness at that moment. Answers are also given in a numerical fashion. The scale is slightly longer than the SSS with nine items to choose from as seen below:

The Karolinska Sleepiness Scale (KSS) Åkerstedt and Gillberg (1990)
1. Extremely Alert
2. Very Alert.
3. Alert.
4. Rather Alert.
5. Neither Alert nor Sleepy.
6. Some signs of Sleepiness.
7. Sleepy, but no effort to keep awake.
8. Sleepy, some effort to keep awake.
9. Very Sleepy, great effort to keep awake, fighting sleep.

2.3.2. c) Benefits and Limitations of State Subjective Measures of Sleepiness.

State subjective measures of sleepiness such as the SSS and KSS are widely used in clinical and research settings because of their inherent strength as measures of sleepiness. Because these scales measure the individual’s level of sleepiness at the time of administering them, there is an opportunity to track moment by moment changes in sleepiness which would not be revealed in trait measures of sleepiness such as the ESS. Research such as Cluydts et al (2002) have indicated that state measures of sleepiness accurately reflect time of day effects as they are sensitive to the circadian dips and troughs that occur in a 24 hour period.

Furthermore, state measures have been found to be sensitive to experimentally induced sleepiness such as sleep deprivation as indicated by Babkoff et al (1991) who found ratings on a Hebrew translation of the SSS increased the longer participants were awake in a 3 day sleep deprivation period.

Validation of state measures of sleepiness has also come from research conducted by the creators of the KSS, Åkerstedt and Gillberg (1990) who found a significant relationship between markers of sleepiness on the EEG such as slow rolling eye movements and alpha waves, with ratings on the KSS. However this relationship was only seen when high KSS ratings were given. Nevertheless, this finding is supported by Kaida et al (2006) who used the alpha attenuation test (AAT). In the AAT, a participant is asked to alternatively close and open their eyes every two minutes for twelve minutes and an EEG is used to record the amount of alpha waves seen when the participants eyes are open or closed. When an individual’s eyes are open a high level of alpha waves indicates sleepiness, whereas when the individual’s eyes are closed, alpha waves indicate alertness. Kaida at al (2006) found a significant relationship between the KSS and the AAT, suggesting that as the scale mirrors objective physiological markers of sleepiness it is a reliable scale to use.

The KSS has also been shown to be sensitive to performance detriments when sleepy. Kaida et al (2006) found a significant relationship between ratings on the KSS and lapses on the PVT. Importantly, state measures of sleepiness have shown to correspond well with sleepiness in everyday activities encountered in life. For
example, the KSS has been found to be sensitive to sleepiness when driving. Ingre et al (2006) asked participants to rate their sleepiness every five minutes in a 2 hour driving simulator task. Participants had either had a normal nights sleep or had completed a night shift prior to completing the driving stimulation, and their performance was scored for accidents and incidents in their driving. Ingre et al’s results showed a significant relationship between the KSS and the number of accidents on the task, with participants who had higher numbers of accidents reported higher levels of sleepiness. Furthermore, the correlation between driving performance and subjective sleepiness became stronger the more serious the accidents were.

However, state subjective sleepiness scales are not without their limitations. Unlike the ESS and other trait measures of sleepiness they are not able to provide a general overview on the individual’s sleepiness in their everyday life, and by association how much of a problem their sleepiness is. Also in contrast to the ESS, they do not ask the participant to try and distinguish between fatigue and sleepiness, which may mean the scores reported may not represent pure sleepiness.

Nor do these scales measure situations which are frequently encountered in everyday life, and some have criticised the KSS and SSS for this. Gillberg (1994) argues that the participant has to assign themselves a level of sleepiness from descriptions of sleepiness or alertness which are abstract concepts. This is important as a participant may find the ESS easier to complete as they can remember that they did doze whilst watching TV a few days ago for example but have difficulty finding an item on the KSS or SSS which accurately represents their feelings. They may have difficulty deciding between two adjoining values, and may not feel able to distinguish whether they are “Very Alert”, “Alert” or “Rather Alert”.

Language is also a limitation in the state measures of sleepiness. Some of the descriptions of sleepiness used in the scale may seem ambiguous to the individual, or may not accurately describe their experience of feeling sleepy. This is particularly the case with the Stanford sleepiness scale which uses descriptions such as “Foggy” or “Woozy”. The scales have also been translated into different languages such as Hebrew and Japanese, but no studies have been completed comparing these translations to the original scales in order to determine whether they have the same impact, are measuring the same aspect of sleepiness or if any meaning has been lost in translation.

Like most measures and tests where an individual provides a subjective report, factors such as motivation, accuracy and understanding are inherent limitations.
As with the ESS, though perhaps to a lesser extent, participants are able to overestimate or underestimate their score willingly if it benefits them by gaining medication or not losing their livelihood. Similarly participants may adjust their rating if they believe they had figured out the aim of the experiment and think the experimenter is expecting them to do so or vice versa.

Research into the subjective state scales has found that many people, particularly in a clinical population are inaccurate in reporting their sleepiness. Moldofsky (1992) found that narcoleptics frequently gave low subjective sleepiness scores which are often in contrast to their sleepiness as indicated by objective measures of sleepiness. This result is supported by Pilcher and Waters (1997) who found the higher the level of sleepiness, the worse the participant was in estimating their sleepiness. Furthermore, Reyner and Horne (1998) found that twenty per cent of their participants who were normal sleepers underestimated their level of sleepiness when completing a driving simulating task.

Mitler (1996) criticises state measures of sleepiness, arguing that they are unable to differentiate between normal and abnormal populations as both populations exhibit the entire range of values over the course of 24 hours.

Research has also indicated that the scores given by these scales do not solely measure a person’s level of sleepiness. Recent research by Åkerstedt et al (2008) has indicated that the KSS is affected by the participants’ prior activity. Participants were asked to rate their current levels of sleepiness after relaxing, after a reaction time, and after free time where they were allowed to do as they pleased. The results revealed a significant difference between the conditions, with the lowest KSS scores given after the participants’ free time. This indicates that the scale does not just measure the individual’s level of sleepiness but also effects of unwanted confounding variables such as previous activity. Similarly, the results of Kaida et al (2006) indicate that simply exposing a person to bright light led to significantly lower ratings on the KSS.

Individual differences have also been shown to affect state subjective scores as well. Mastin et al (2005) found that personality contributed to state subjective scores, with a significant positive correlation between neuroticism and the SSS occurring, indicating higher ratings on the SSS were observed in participants with higher levels of neuroticism. Gender of the participant has also been observed to play a part in KSS scores, with Barrett et al (2004) suggesting that women were more aware of their sleepiness and gave more accurate ratings on the KSS than their male counterparts.
But perhaps the most important criticism of state subjective sleepiness scales as a measure of sleepiness comes from that of Kaida et al (2007). In their study participants who had restricted their sleep to four hours completed two forty minute performance tasks with an EEG recording in situ. Half the participants were asked to rate their sleepiness using the KSS before the test, every 4 minutes during the test, and at the end of the test. The other half were only required to rate their sleepiness before and after the test. Rating were asked by, and collected by the experimenter entering the room. Though the participants’ sleepiness rating increased as the performance test continued, those participants who had been asked to rate their sleepiness every four minutes during the performance test had a significantly lower rating at the end of the test compared to those participants who had simply rated their sleepiness before and after the test. This result was also echoed in the physiological markers of sleepiness in the EEG. Therefore, Kaida et al concluded that the effect of being asked by the experimenter to rate their sleepiness actually increased the alertness of participants. This result indicated that human interaction can be a confounding variable in measuring state subjective sleepiness.

2.4. Relationships Between the Measures of Sleepiness.
Though every measure of sleepiness has different purposes, and each has its strengths and weaknesses they are often used in conjunction with each other in research and clinical purposes to get a well rounded view of an individual’s level of sleepiness. Because of this, it is important the various measures of sleepiness are strongly related to each other statistically to ensure that a consistent picture of sleepiness is formed.

2.4.1 Correlations Between the Measures of Sleepiness.
The wealth of research into the level of concordance between measures of sleepiness has focussed on the relationship between the objective and subjective measures of sleepiness, and this has contrasting results. The MSLT and ESS are frequently used together in clinical and research settings. In clinical contexts the ESS is often the first measure of sleepiness the patient comes into contact with and the resulting score is often used to refer the patient to a sleep service and warrant further investigation. In research, the ESS is often used in the screening process in order to determine the presence or absence of excessive daytime sleepiness, and the MSLT is used in the later stages to quantify sleepiness using sleep latency under a number of experimental conditions.

Johns (1991) who devised the ESS was the first to measure the correlation between the MSLT and ESS, and found a very strong significant negative correlation between the two measures with the higher ESS scores resulting in lower MSLT latencies and vice versa in a clinical population of patients with excessive daytime sleepiness.
Though a significant correlation between the ESS and MSLT has been replicated in a number of other studies (Wichniak et al. 2002, Punjabi et al. 2003, Watson et al. 2004, Kim and Young 2005) many studies have found the correlation to be much lower than that found by Johns’ research (Sangal et al. 1999). A possible explanation for the low correlation between these measures is provided by Schmidt Nowara (1999) who argues that the low correlation found in many studies may be due to a “dilution effect” – the ESS is made up of several situations which are both active and passive in nature, and the MSLT consists of just one passive situation. Though some items, such as the passive elements of the ESS may correlate very highly with mean sleep latency on the MSLT, other elements may not correlate, and this difference within the ESS may lead to the weak or non existent relationship.

Nevertheless, this argument is challenged by the results of Chervin’s (1997) research. When comparing item 5 of the ESS “lying down to rest in the afternoon when circumstances permit” to latencies of the afternoon sleep opportunities of MSLTs, he found a significant negative correlation between the measures, however this correlation was weak, and although item 5 is arguably the most similar to the circumstances of the MSLT, other items of the ESS had higher correlations with the MSLT.

Other studies into the relationship between the ESS and MSLT have found a significant correlation only in specific situations such as only if the person fell asleep in all sleep opportunities without sleep onset REM periods (Chua et al. 1998) or if ESS scores were between 14-21 and MSLT latencies less than 8 minutes (Chervin et al. 1997) and according to Olson et al. (1998) may depend on the individual’s psychological health as depressed patients may overestimate their level of sleepiness, part of which may be due to their mood disorder. Furthermore, results from studies such as Geisler et al. (1998) have found no significant correlation between the ESS and MSLT.

The few studies which have been conducted on the correlation between the MSLT and state subjective measures of sleepiness have failed to find a significant relationship between the MSLT and KSS and MSLT and SSS (Danker Hopfe 2001, Watson et al. 2004, Yang et al. 2004, and Kaida et al. 2006). Manni et al. (1991) also failed to find a significant correlation between latency on the MSLT and scores on a visual analogue scale in healthy alert university students.

Nevertheless, Short et al. (2010) found that significant correlations between the SSS and sleep latency could be achieved when participants had had a restricted night’s sleep prior to test, and if participants were asked to have their eyes closed for one
minute or open but with a fixed gaze for one minute before they gave their sleepiness rating on the SSS.

Another area examining the correspondence between objective and subjective measures has investigated the PVT and the ESS, KSS and SSS. Kim, Dinges and Young’s (2007) research revealed a significant negative correlation between the ESS and the reaction time on the PVT, indicating the lower level of sleepiness measured by the ESS, the higher the reaction time on the PVT. They also found a significant positive relationship between the scale and the number of lapses on the PVT, suggesting the sleepier the individual is the more lapses occur on the PVT. Similarly, Kaida et al (2006) found the KSS also had a significant positive relationship with lapses on the PVT in a clinical patient population. However, in contrast Hoddes et al (1973) found the SSS had a non significant but high correlation with the Wilkinson’s vigilance task, a task similar to the PVT.

Anderson et al (2009) examined habitual sleep times by sleep diary and self reported sleep need in healthy alert individuals. Based on these two sets of data participants were characterised as either having a “sleep deficit” if there was a large difference between their usual sleep taken and how much they perceived they needed, “sleep plus” if they habitually got more sleep then they perceived they needed, or “sleep neutral” if there was no significant difference in the amount of sleep they took on average and the amount of sleep they perceived they needed. There was no significant difference between these three groups for scores on the PVT, ESS or KSS.

Nethertheless, a lack of relationship has not just been found between the objective and subjective measures; the majority of research has also failed to find a significant correlation between the objective measures of the MSLT and PVT (Geisler et al 1998, Wichniak et al 2002, Kim, Dinges and Young 2007) though Dinges et al (1997) reported a significant negative correlation between the MSLT and lapses on the PVT – the more sleepy the individual is according to their latency, the more lapses are seen in their performance on the PVT. Van Dongen et al (2004) found that the ESS scores taken before their participants were subjected to three bouts of 36 hour total sleep deprivation was significantly correlated with the KSS scores given by the participants. This suggests the trait measurement of the ESS and state measurement of the KSS have some relationship in measuring the individual’s level of sleepiness.
2.5. The Current Research.

Few research studies which have focused on investigating the correlation between multiple measures of sleepiness have done so using four separate measures of sleepiness. Previous research which has investigated the relationship between measures of sleepiness have done so primarily within a group of patients who have self referred themselves to centres due to experiencing excessive daytime sleepiness or alternatively have studied healthy sleepers who have been sleep deprived or had their sleep restricted prior to participation. Previous research has examined in detail the correlation between the MSLT and the ESS; however less is known about the relationship between the MSLT and state subjective measures and the PVT or between the PVT and subjective measures of sleepiness. Further investigation into the role of individual differences such as sex, morningness/eveningness disposition and psychological element affect the relationships between the measures of sleepiness is required.

The current research aimed to address these gaps in the research by assessing the relationship between the measures of sleepiness on a sample of young alert and healthy sleepers who had their habitual 7-8 hours of sleep prior to participation. An evaluation into how individual differences in the participant group influence the relationships between the measures of sleepiness was conducted. The MSLT, ESS, KSS and PVT tests were used to assess the participants’ sleepiness and the Horne-Ostberg Morningness/Eveningness Questionnaire, State-Trait Anxiety Inventory and Eysenck Personality Questionnaire were used to measure individual differences in the participant group.

As the research in this literature review has shown investigations into the correlations between various measures of sleepiness and the effect that individual differences within participants have on these measures, have lead to contrasting results. This research will investigate these relationships in further detail in a group of healthy alert individuals, and examine how individual differences in the participant group affect the measures of sleepiness which are so frequently used in research and clinical settings today.

As the results from research into whether there is a relationship between measures of sleepiness is so contrasting, it is hypothesised that that there will be no significant relationship between the measures of sleepiness in the participant sample, but that the individual differences of sex, morningness/eveningness disposition and personality within the sample will be significantly related to the four measures of daytime sleepiness.
3. Methodology.

3.1. Participants.
All participants were volunteers who were studying at the University of Loughborough, or were members of the general public. Participants were recruited by adverts placed around campus, on a University internet forum or through electronic mail. In order to participate in the research, participants had to meet the following criteria:

- Aged between 21 and 40 years of age (to avoid the changes in sleep architecture that occur after this age range)
- Have regular moderate caffeine consumption that does not exceed 250mg caffeine per day.
- Regularly sleep between 7-8 hours a night.
- Be non smokers.
- Have no sleep complaints or excessive daytime sleepiness as determined by an Epworth Sleep Scale (ESS) score of ten or under.
- Avoid regular napping.
- Have a morningness/eveningness score of between 11 and 27 on the Horne-Ostberg Morningness-Eveningness Questionnaire (1976) therefore avoiding extreme “Morningness” or “Eveningness” dispositions in the participant sample.
- Not using any sleep altering medication.

The study gathered results from 50 people with a mean age of 25.18 years, with an age range of 21-38 years of age. This sample consisted of 26 females with a mean age of 25.44 years and range of 21-38 years and 24 males with a mean age of 25 years, and range 21-33 years.

Although participants were not informed of the hypotheses of the research, they were under monetary inducement to participate and received £25 upon completion of their participation.

3.2. Materials.

3.2.1 Questionnaires and Scales
During screening, participants were asked a set of initial screening questions (Appendix B) completed a copy of Loughborough University’s sleep research centre’s screening questionnaire (Appendix C) which included the Epworth sleepiness scale
Karolinska Sleepiness Scale (KSS) screening sheet (Appendix D) and seven day sleep
diary (Appendix E) were also used.

In the testing day, a laminated copy of the KSS was used as well as a copy of the State
Trait Anxiety Inventory (STAI-Y, Spielberger 1970) and Eysenck Personality
Questionnaire (Adult EPQ-R, Eysenck 1974).

3.2.2. Electrode Application Equipment
Standardised “hook-up” for a Multiple Sleep Latency Test (MSLT) montage requires
a china marking pencil, a tape measure, Nuprep exfoliant, cotton buds, IMS, Ten20
conductive paste, Dracard electrode gel, Collodion glue, electrode collars and nine
one meter silver chlorided 10mm electrodes. Acetone and cotton buds were used to
remove electrodes and IMS was used as a skin cleanser. An impedance meter was
used to measure impedances between electrodes.

3.2.3 Electrical Equipment
Somnologica (version 3.3.1) was used to record all Multiple Sleep Latency tests. The
psychomotor vigilance task (PVT) was administered on a MS DOS computer. An
actiwatch was used in screening to monitor the participants’ sleep wake cycle and
sleep length and quality. Further actigraphy was used on the night prior to the
experiment to verify sleep length before participating. The program Statistical
Package for Social Scientists (SPSS) version 16.0.2 was used for statistical analysis of
the data.

3.2.4. Drug testing Equipment.
A six drug multi test (model 5DS3) from Surescreen Diagnostics (Derby) was used
for drug testing.

3.2.5 Paperwork
Recruitment advertisements, consent forms, and participant instructions can be seen in
appendices A, F and G respectively. A scoring sheet for MSLT latencies and KSS
scores was used (Appendix H).

3.3. Procedure.
Details of the design and procedure of the study were put to Loughborough
University’s Research Ethical Clearance committee, who gave Ethical Clearance for
the research to commence.

Recruitment adverts for the study were placed around campus, on the University’s
internet forums and were sent out using electronic mail to all finalists and
postgraduates in the University.
One hundred and ninety five people applied to participate in the study. After contacting the experimenter, participants were invited to the sleep centre for a short interview in which they were initially asked a brief series of questions to ascertain their initial suitability.

If participants gave an age of under 21 or above 40, or did not drink tea or coffee, or were on any medication that affected their sleep they were then eliminated from the screening process at this point.

However if the person’s answers to these questions were satisfactory – that they were the right age, were available weekdays, drank a moderate amount of caffeinated beverages, lived locally and were on no medication affecting their sleep, participants were given an explanation of the study and the screening stages leading to it. After this, the participant’s questions were answered and the participant was left to fill in the centre’s standard screening questionnaire. The questionnaire includes a number of questions relating to the person’s health and sleeping and lifestyle habits. Within this questionnaire they also completed a copy of the Epworth Sleepiness scale (ESS) and Horne and Ostberg’s Morning/Eveningness questionnaire.

After the questionnaire was complete the experimenter examined it to assess the participant’s suitability to proceed to the next screening stage. At this stage, fifty participants were excluded from the screening stage for a number of reasons. Lifestyle factors such as smoking, allergies, and religious practices meant people were unable to participate in the research. Issues relating to the individual’s sleeping patterns, such as sleep of a duration less than 7 hours or more than 8 hours a night, taking sleep opportunities during the day, having an ESS of over 10 or an extreme morningness/eveningness score further prevented people participating. People were excluded from the further screening stages for the reasons above in order to prevent confounding variables on the results of the research. As such, all efforts to remove confounding variables such as the possibility of the person suffering from a sleep disorder, or being adversely affected by the electrode hook-up, were taken.

If the data from the screening questionnaire met the criteria for participation, the individual was given a form which required them to self rate their level of alertness whilst awake by using the KSS every two hours for three days. This revealed the individual’s habitual level of alertness and therefore highlighted the likely level of sleepiness on the testing day. Participants were asked to fill in the sheet for three weekdays, except when the participant has specified that their sleep did not differ between the week and the weekend.
If the KSS form revealed that the participant slept more than the national average of 7-8 hours, or did not have a circadian dip during the day they were excluded from screening.

Nevertheless, if the individual had alertness ratings in line with the normal circadian rhythm with no excessive daytime sleepiness the participant was invited back to the centre for the last screening process – the sleep diary and actiwatch. Participants were instructed to wear the actiwatch and fill in the sleep diary for one week. Both of these devices enabled the experimenter to get a broader picture of the participant’s average sleep length and provided information regarding the participant’s sleep hygiene such as whether they slept with a partner or consumed alcohol before they slept as well as their self-reported sleep latency and sleep efficiency. If the sleep diary and actiwatch revealed that a participant had a total sleep time which fitted within the national average of 7-8 hours and therefore was not too short nor too long a duration, did not include excessively late bedtimes, napping during the day, or very irregular sleep wake cycles, the individual was invited to participate in the study.

Eighty-nine people were excluded from participation after they completed the 3 day KSS form or the sleep diary screening stages as the resources showed they either took too little or too much sleep, or showed an absence of circadian dip and so could not participate, or they simply changed their mind about participating.

After these screening stages were undertaken, fifty-six participants were eligible to participate in the research, however two people chose not to continue to participate prior to the testing day.

Participants visited the Sleep Research centre on the day before testing for the experimenter to remind them of the study’s schedule, to sign a consent form and to pick up an actiwatch and a sleep diary to monitor the total sleep time and sleep efficiency of the night’s sleep prior to testing.

Participants arrived at the Sleep Centre at 9am the next morning. The experimenter reiterated the day’s schedule and checked the sleep diary and actiwatch recording to check that the participant had not had either insufficient, excessive or disrupted sleep that would adversely affect the testing day. Participants were given an information sheet for the day, and the majority of participants were asked to refrain from using their mobile phone until the end of the testing day.

Mobile phones were confiscated whilst participating in this research, as another research study which was running simultaneously at the sleep research centre had
found that there was a significant relationship between talking on a mobile phone before a sleep opportunity and length of sleep onset (Hung et al 2007). Participants were then given a tour of the sleep research centre, and shown their accommodation for the day.

A number of participants were given copies of the EPQ and State/Trait questionnaires to fill in. The rest of the participants were contacted after the study to provide this information. This unfortunate discrepancy is due to a change in experimental procedure partway through recruitment for the study.

Participants were brought into the lab to apply electrodes for the standard Multiple Sleep Latency Test (MSLT) montage which was taken from the International 10-20 electrode system (Jasper 1958). This involved having two electrodes placed in the C3 and C4 positions on scalp. Electrodes were placed behind the individual’s ears (A1 and A2) and on their forehead to act as reference points for the electrodes on the scalp. Further electrodes were placed on their jaw and by each eye to measure muscle tone (EMG) and eye movements (EOG) respectively. After the electrodes had been applied the experimenter checked the impedances for values of less than five ohms on the C3-A1, C4-A2 and Ground positions, and for impedances of less than ten ohms on the EOG and EMG electrodes.

As in the standardised protocol devised by Carskadon and Dement (1978), the MSLTs were conducted at 10.00am, 12.00pm, 14.00pm and 16.00pm. Fifteen minutes before each MSLT the experimenter checked the impedances on the electrodes to ensure a good recording. Five minutes before the MSLT participants were escorted to the bedroom and the electrodes were plugged into the device and the participant lay down on the bed. Participants were asked to report their level of sleepiness using the Karolinska Sleepiness Scale.

After these ratings were given participants were instructed to stay awake and keep their eyes open whilst the experimenter switched the lights off outside the bedroom and started the MSLT on Somnologica. After the impedance test was completed on Somnologica the experimenter re-entered the bedroom and instructed the experimenter to “Lie quietly and relax, close your eyes and keep them closed, and try to go to sleep”. The bedroom lights were then turned out and the bedroom door closed. The experimenter observed the MSLT on Somnologica in an unlit corridor outside the bedroom. The sleep opportunity was scored according to the Rechtschaffen and Kales manual (1973) as the updated scoring guide issued by the American Association of Sleep Medicine (Iber et al 2007) had not yet been published at the time of testing. As per the experimental MSLT protocol, the sleep opportunity was ended after three
epochs of stage one sleep or after one epoch of another stage of sleep or twenty minutes of wakefulness. The sleep latencies from each of the four sleep opportunities were averaged and noted to give a final MSLT score. The light was switched on and participants were unplugged from the Embla and returned to their accommodation.

Participants were given a twenty minute practice on the Psychomotor Vigilance task (hereafter PVT). The parameters of the PVT were set so the rolling clock would appear at intervals of between 2 to 12 seconds and participants were required to rate their sleepiness using the KSS at the start and end of each trial. This practice trial of the PVT was completed between 10.40-11.00am. A full half hour session of the PVT using the same parameters and setup was completed between 16.30-17.00pm.

Participants were provided with refreshments during the day. They were supplied with fresh water from a water cooler in the centre. At 10.30 am they were given a choice of tea or coffee and biscuits. The participants were given tea or coffee which was made to their preference, and were unaware that their drink was decaffeinated. Lunch was served at 13.00pm and consisted of two buttered bread rolls, minestrone soup, water and a choice of an apple or banana. Participants were also given another decaffeinated tea or coffee with optional biscuits at 15.00pm. All food and drink that the participant consumed was recorded in the testing log.

Participants were asked to provide a urine sample within the course of the testing day in order to test for drugs. Disposable tests from Surescreen diagnostics were used to test for cocaine, amphetamines, cannabis, opiates and benzodiazepines in the participants’ urine, in order to avoid the confounding effects of these substances on the measures of sleepiness in the experiment. Should a urine sample be positive for any of these substances, participation in the study was ceased.

Electrodes were removed from the participant after the 16.00pm sleep opportunity, and after the 16.30pm PVT trial, participants were paid £25 in cash and were free to leave the sleep centre.

Four participants who attended the testing day had to be excluded from the study. Two participants had a positive drug test, one participant misunderstood the MSLT instructions and kept their eyes open through the first sleep opportunity, and one participant was unable to sufficiently complete the PVT tasks.

After the data had been collected for each of the remaining fifty participants, each sleep latency was checked by the experimenter, and an independent sleep researcher. In the event that there was a disagreement of sleep latency greater than two minutes
apart, a third sleep researcher with advanced scoring experience checked the sleep opportunity or opportunities and decided which of the two onsets was the most accurate.

The Psychomotor Vigilance task was scored in Microsoft Excel for lapses, defined as reaction times greater than 500 milliseconds, false positives where the participant had pressed the button before the rolling clock had appeared in the rectangle and errors where the response for the individual did not record accurately. The State-Trait Anxiety inventory was scored in accordance with the manual, to produce state and trait values for the individual’s anxiety levels. The Eysenck Personality Questionnaire was scored in the standardised manner, using the templates provided with the manual for the values of P (Psychoticism) E (Extravertism) N (Neuroticism) and L (Lie) scales.

The statistical package Statistical Package for Social Scientists (SPSS) version 16.0.2 was used to analyse the data.
4. Results – Relationships Between Measures Of Sleepiness.

4.1 Correlation Between the Measures of Sleepiness.

In order to examine the relationship between the Epworth sleepiness scale, Karolinska sleepiness scale and Psychomotor vigilance scale and the Multiple sleep latency test, a series of correlations were performed. As the variables of KSS, MSLT and PVT had normal distribution, Pearson’s r correlations were used. Due to the lack of normal distribution in the data resulting from the ESS, Spearman’s Rho correlations were used and an alpha level of .05 was used to determine significance at the two tailed level.

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>KSS</th>
<th>MSLT</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS</td>
<td></td>
<td>rho=.148, p=.304</td>
<td>rho = -.164, p=.127</td>
<td>rho = .187, p=.194</td>
</tr>
<tr>
<td>KSS</td>
<td>rho=.148, p=.304</td>
<td></td>
<td>r = .071, p=.622</td>
<td>r = -.005, p=.972</td>
</tr>
<tr>
<td>MSLT</td>
<td>rho = .164, p=.127</td>
<td>r = .071, p=.622</td>
<td></td>
<td>r = -.238, p=.096</td>
</tr>
<tr>
<td>PVT</td>
<td>rho=.187, p=.194</td>
<td>r = -.005, p=.972</td>
<td>r = -.238, p=.096</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Correlations Between Measures of Sleepiness.

These analyses indicate that none of the measures of sleepiness significantly correlate with each other.

Further analyses were undertaken to investigate whether consistency across measures of sleepiness was significant between the objective and subjective measures of sleepiness.

A Pearson’s r correlation was conducted to investigate the relationship between the two objective measures of sleepiness, the MSLT and PVT. This relationship failed to meet statistical significance. The correlation between the subjective measures of sleepiness, the ESS and KSS also failed to produce a statistically significant correlation.
4.2 Consistency and Time of Day Analyses.

Analysis was undertaken in order to determine whether there was consistency between measures of sleepiness depending on the time of day they were measured. A Pearson’s $r$ correlation examined the relationship between the KSS and MSLT at each of the four sleep opportunities completed in the MSLT. Though all analyses were not significant, it is worth noting that only the 12pm analysis showed the expected negative correlation between the KSS and MSLT, with lower MSLT latencies leading to higher KSS scores and vice versa.

The relationship between item 5 of the ESS, “lying down in the afternoon when circumstances permit” and the afternoon sleep opportunities of the MSLT was investigated with Spearman Rho correlations. The relationship between item 5 of the ESS and the sleep opportunity at 2pm was a weak negative correlation. This was echoed with item 5 of the ESS and the sleep opportunity at 4pm which was also a weak negative correlation. However both correlations failed to reach statistical significance.

Together, these analyses show that correlations between the MSLT and ESS or KSS do not improve as a function of time of day.

4.3 Consistency Amongst Those Who Slept in the MSLT.

An investigation into whether the relationship between the different measures of sleepiness would improve if those participants who did not fall asleep in any of the sleep opportunities were excluded from analysis. When removing the twenty minute latencies from the MSLT, the distribution changed from a normal to a skewed distribution. Therefore Spearman Rho correlations were used for the MSLT in this analysis.

Table 2: Correlations Between Measures of Sleepiness in Latencies <20 minutes.

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>KSS</th>
<th>MSLT</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS</td>
<td></td>
<td></td>
<td>rho=.069 p=.683</td>
<td>rho=-.223 p=.179</td>
</tr>
<tr>
<td>KSS</td>
<td>rho=.069 p=.683</td>
<td></td>
<td>rho=.126 p=.450</td>
<td></td>
</tr>
<tr>
<td>MSLT</td>
<td>rho=-.223 p=.179</td>
<td>rho=.126 p=.450</td>
<td></td>
<td>rho=-.275 p=.094</td>
</tr>
<tr>
<td>PVT</td>
<td>rho=.142 p=.394</td>
<td>r = -.099 p=.553</td>
<td>rho=-.275 p=.094</td>
<td></td>
</tr>
</tbody>
</table>

No correlation in these analyses reached statistical significance.

As when all data was analysed, correlations between the ESS and PVT and ESS and KSS failed to reach significance, as did the correlations between the PVT and KSS.
In summary, excluding participants who did not sleep on any sleep opportunity on the MSLT did not improve the relationships between measures of sleepiness.

4.4 Relationships in Measures of Sleepiness by Latency Groups in the MSLT.
Statistical analysis was undertaken to determine whether dividing the dataset into groups according to their latency on the MSLT would improve relationships between the tests.

Participants were split into three data sets as determined by their average latency on the MSLT test. The first group consisted of nine participants who had latencies of ten minutes and under on the MSLT. The second group consisted of 15 participants who had latencies of between 11-15 minutes on the MSLT. The last group contained the remaining 26 participants who had latencies of 16 minutes or more.

Primarily, Pearson’s r and Spearman Rho correlations were performed between each latency group and scores on the other measures of sleepiness. These can be seen in tables 3, 4 and 5 below.

Table 3: Correlations Between the Measurements of Sleepiness in Latencies of Ten Minutes and Under.

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>KSS</th>
<th>MSLT</th>
<th>PVT</th>
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</thead>
<tbody>
<tr>
<td>ESS</td>
<td>rho=.300</td>
<td>rho=-.026</td>
<td>rho=-.193</td>
<td>rho=.619</td>
</tr>
<tr>
<td></td>
<td>p=.433</td>
<td>p=.948</td>
<td>p=.619</td>
<td>p=.948</td>
</tr>
<tr>
<td>KSS</td>
<td>rho=.300</td>
<td>rho=.180</td>
<td>rho=.110</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.433</td>
<td>p=.643</td>
<td>p=.779</td>
<td>p=.080</td>
</tr>
<tr>
<td>MSLT</td>
<td>rho=.026</td>
<td>rho=.348</td>
<td>rho=.466</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.948</td>
<td>p=.358</td>
<td>p=.080</td>
<td>p=.080</td>
</tr>
<tr>
<td>PVT</td>
<td>rho=-.193</td>
<td>r=.348</td>
<td>rho=.333</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.619</td>
<td>p=.358</td>
<td>p=.226</td>
<td>p=.080</td>
</tr>
</tbody>
</table>

The relationship between measures of sleepiness did not improve when analysis was restricted to participants with latencies of ten minutes and under.

Table 4: Correlations Between Measures of Sleepiness in Latencies of Eleven to Fifteen Minutes.

<table>
<thead>
<tr>
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<th>ESS</th>
<th>KSS</th>
<th>MSLT</th>
<th>PVT</th>
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</thead>
<tbody>
<tr>
<td>ESS</td>
<td>rho=.234</td>
<td>rho=.341</td>
<td>rho=.333</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.402</td>
<td>p=.213</td>
<td>p=.226</td>
<td>p=.080</td>
</tr>
<tr>
<td>KSS</td>
<td>rho=.234</td>
<td>r=.152</td>
<td>rho=.686</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.402</td>
<td>p=.588</td>
<td>p=.080</td>
<td>p=.080</td>
</tr>
<tr>
<td>MSLT</td>
<td>rho=.341</td>
<td>r=.152</td>
<td>rho=.466</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.213</td>
<td>p=.588</td>
<td>p=.080</td>
<td>p=.080</td>
</tr>
<tr>
<td>PVT</td>
<td>rho=.333</td>
<td>r=.056</td>
<td>rho=.466</td>
<td>rho=.466</td>
</tr>
<tr>
<td></td>
<td>p=.226</td>
<td>p=.842</td>
<td>p=.080</td>
<td>p=.080</td>
</tr>
</tbody>
</table>
A non significant trend for a positive correlation between the MSLT and the PVT indicating the higher the latency on the MSLT, the higher the number of lapses on the PVT was observed. However, all correlations failed to reach statistical significance; therefore there was no improvement in the relationship between measures of sleepiness in participants in this latency group.

Table 5: Correlation Between Measures of Sleepiness in Latencies of Sixteen Minutes and above.

<table>
<thead>
<tr>
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<th>ESS</th>
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<th>MSLT</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS</td>
<td></td>
<td>rho=.176</td>
<td>p=.389</td>
<td>rho=.190</td>
</tr>
<tr>
<td>KSS</td>
<td>rho=.176</td>
<td>p=.389</td>
<td></td>
<td>rho=.011</td>
</tr>
<tr>
<td>MSLT</td>
<td>rho=-.011</td>
<td>p=.957</td>
<td>r=.144</td>
<td>p=.482</td>
</tr>
<tr>
<td>PVT</td>
<td>rho=.190</td>
<td>p=.352</td>
<td>r=.154</td>
<td>p=.454</td>
</tr>
</tbody>
</table>

The relationship between the measures of sleepiness did not improve in participants with the longest latencies on the MSLT.

These three analyses therefore indicate that correlations between the measures of sleepiness are not improved by latency on the MSLT.

A one way ANOVA was performed to investigate whether there would be a significant difference in scores on the KSS and PVT by latency. There was no significant difference between the three latency groups in KSS score or in PVT score.

As the data for the ESS was not normally distributed, a Kruskal-Wallis analysis was used to investigate whether there was a significant difference between the three latency groups in ESS score. This analysis revealed that participants who had a latency of ten minutes or less had significantly higher ESS scores than the two other latency groups; \[X^2 (2, n=50)= 7.122, p=.028\]. This result can be seen before in Figure 1:
4.5. Relationships in Measures of Sleepiness by Groups in the ESS, KSS and PVT.

Following the previous analysis, the ESS, KSS and PVT data were each divided by three groups.

The PVT data was split into:
1) 26 participants with 0-1 square rooted lapses.
2) 17 participants with 2-3 square rooted lapses.
3) 7 participants with 4 or more square rooted lapses.

A one way ANOVA was performed for the KSS and PVT variables and a Kruskal Wallis analysis was performed for the ESS scores. The results indicated that there were no significant differences between the three PVT groups on MSLT score, KSS score or ESS score.

The data from the KSS was split into:
1) 19 participants with a KSS score of 0-3.
2) 27 participants with a KSS score of 4-5.
3) 4 participants with a KSS score of 6-9.

A one way ANOVA was performed for the MSLT and PVT variables and a Kruskal Wallis analysis was performed for the ESS scores. The results indicated that there were no significant differences between the three KSS groups on MSLT score, PVT score or ESS score.

The data from the ESS was split into:
1) 21 participants with an ESS score of 0-4.
2) 15 participants with an ESS score of 5-8.
3) 14 participants with an ESS score of 9-12.
A Kruskal-Wallis analysis was performed to investigate whether there was significant difference between the three ESS groups on MSLT, PVT and KSS scores. The results indicated that there were no significant differences between the three ESS groups on MSLT score, PVT score or KSS score.

The investigations undertaken in this chapter have failed to find statistically significant correlations between the measures of sleepiness. Further analyses examined whether the relationships between measures of sleepiness improved in subsets of the data.

No improvement in the relationship between the measures was found in subjective or objective tests, by time of day, or by contrasting those participants who slept in the sleep opportunities with those whose latencies reached twenty minutes. When the data from each measure of sleepiness was split into three participant groups, and the scores of the tests were compared between groups, those with latencies of ten minutes and under were shown to have statistically higher ESS scores than participants with latencies of 11-15 minutes or 16 and above minutes. No other statistically significant difference was observed in any other analysis.
Individual differences may explain some of the variation between the measures of sleepiness, and therefore why the relationships between the measures failed to meet significance on the whole. Analysis focussed on three main individual differences:

5.1. Sex.

5.1.1 - Investigation into Sex Differences in Measures of Sleepiness. (All Data).
To analyse the effect of sex of the participants, data was split into male and female participants to investigate whether scores on the tests were significantly different between the two genders using independent sample T tests.

Three independent t-tests were conducted to compare mean scores on measures of sleepiness for males and females. There was no significant difference in the MSLT, KSS or PVT scores between the two sexes.

Due to the fact that the ESS data was not normally distributed an alternative Mann Whitney U analysis was used. This revealed female participants had significantly higher ESS levels then their male counterparts [U(24,26)=183.5, p=.012.] as seen in Figure 2:

![Average ESS score by Sex.](image-url)

Figure 2: Average ESS score by Sex.
5.1.2 – Investigation into Sex Differences in Measures of Sleepiness (Latencies of 20 minutes Excluded).

The data was then analysed without 20 minute latencies. As with the first analyses there was no significant difference between scores for males and females on the MSLT, KSS or PVT but a significant difference in ESS score between the sexes was still present in the this analysis.

Though the correlations performed in the time of day relationships between the MSLT and KSS were not improved by sex, independent t-tests were conducted to investigate whether there was a significant difference between the genders on the MSLT and KSS over the day of test. There was a significant difference in sleep latency at the 10am sleep opportunity between males (M=19.03 SD=2.05) and females (M=16.34 SD=5.56 t(32.15)=2.30 p=.028), with male participants taking significantly longer to fall asleep then their female counterparts in the first MSLT sleep opportunity. This is reflected in Figure 3 below. However there was no significant difference in MSLT latencies between the sexes at any other time of day. Using a similar analysis, no significant differences were observed between the two sexes in KSS score at any point of the testing day.

![Figure 3: Average MSLT Latency at 10am by Sex.](image)

The above analyses were then repeated, excluding participants with MSLT latencies of 20 minutes. As the MSLT data was not normally distributed in participants who did fall asleep in the sleep opportunities, the independent t test was replaced by a Mann Whitney U analysis. In contrast to the previous analysis using the complete data set, there was no significant difference in MSLT latency at 10am between male and females U(24,26)= -1.580 p=.114. However as with the first analysis, there was no significant difference between male and female participants neither on MSLT scores at other points during test, nor on any KSS scores.
5.2. Morningness/Eveningness Disposition.

5.2.1 – Investigation into Effect of Morningness/Eveningness Disposition on Measures of Sleepiness. (All data Analysed.)
To analyse the effect of morningness/eveningness disposition, the data was split by “Moderately morning” disposition (n=16) and “Neither” disposition (n=32). Only two participants were classed as having a “Moderately Evening” disposition. No reliable analyses could be performed using a sample of only two participants who were classified as “Moderately evening” and therefore this data was excluded from the analysis. Those participants with a “Definitely Morning” and “Definitely Evening” dispositions were excluded in the screening process.

Independent T tests were performed to see if there was a significant difference in scores on the MSLT, KSS and PVT measures of sleepiness between the two morningness/eveningness dispositions. No significant difference was observed between the two groups on their scores for the MSLT, KSS and PVT. Due to the ESS being abnormally distributed, an alternative non parametric version of the independent T test was used. A Mann Whitney U analysis revealed there was no significant difference in ESS scores between the two morningness/eveningness dispositions.

5.2.2 – Investigation into Effect of Morningness/Eveningness Disposition on Measures of Sleepiness Scores (Latencies of 20 Minutes Excluded).
These analyses were repeated with average MSLT latencies of twenty minutes removed. In this analysis the difference in scores of “Moderately morning” types and “Neither” types remained non significant on the ESS, KSS and PVT, but a Mann Whitney U analysis revealed that “Moderately morning” types had significantly shorter latencies than “Neither” types U(11,24)=59 p=.007 as seen in Figure 4 below.
Further analysis investigated whether there was a significant difference between morningness/eveningness types in MSLT and KSS scores by time of day during course of the testing day. When the whole dataset was examined, there was no significant difference between the two groups in MSLT latency or KSS score at any point in the MSLT sleep opportunities.

It was then investigated whether there was a significant difference between chronological type on the KSS and MSLT, when the participants with MSLT latencies of 20 had been removed from the analysis. In this analysis, as the MSLT was not normally distributed the Mann Whitney U test was used. This revealed that “Moderately Morning” types had significantly shorter latencies than “Neither types at 2pm U(11,25)=73 p=.027.(Figure 5 below). A trend for moderately morning types to fall asleep faster at 12pm U(11,25)=85 p=.071 and 4pm U (11,25)=87 p=.079 were observed but this was not significant. All other analyses remained non-significant.
5.3. Psychological Characteristics.

5.3.1 Correlations Between Measures of Sleepiness and Personality Variables
(All data analysed)

Statistical analysis was undertaken to examine whether personality variables such as P (Psychoticism) E (Extraversion) N (Neuroticism) and L(Lie) on the Eysenck personality questionnaire (EPQ), and state and trait anxiety on the State Trait Anxiety Inventory (STAI) correlated with the measures of sleepiness. As the P,E and N values and the ESS were seen to have a skewed distribution; correlations using these values were completed using Spearman Rho correlations. The MSLT, PVT and KSS and the L, ST and TR values were normally distributed so Pearson’s R correlations were used when these factors were involved. The results are shown in Table 6:

Table 6: Correlation Between Measures of Sleepiness and Elements of Personality.

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>MSLT</th>
<th>KSS</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>rho= -.092, p=.563</td>
<td>rho= -.137, p=.387</td>
<td>rho= -.284, p=.068</td>
<td>rho= -.090, p=.571</td>
</tr>
<tr>
<td>E</td>
<td>rho= -.226, p=.150</td>
<td>rho= -.054, p=.732</td>
<td>rho= -.207, p=.189</td>
<td>Rho= -.080, p=.614</td>
</tr>
<tr>
<td>N</td>
<td>rho= .279, p=.074</td>
<td>rho= .284, p=.068</td>
<td>rho= .309, p=.046</td>
<td>rho= -.201, p=.201</td>
</tr>
<tr>
<td>L</td>
<td>rho= .199, p=.206</td>
<td>r= .046, p=.775</td>
<td>r= -.412, p=.007</td>
<td>R= .115, p=.469</td>
</tr>
<tr>
<td>ST</td>
<td>rho= .193, p=.221</td>
<td>r= -.171, p=.280</td>
<td>r= .374, p=.016</td>
<td>r= .146, p=.357</td>
</tr>
<tr>
<td>TR</td>
<td>rho= .276, p=.077</td>
<td>r= .069, p=.666</td>
<td>r= .477, p=.002</td>
<td>r= .067, p=.675</td>
</tr>
</tbody>
</table>

No psychological element was significantly correlated with the ESS.

There were no significant correlations between the psychological elements and the MSLT or the PVT; though a non significant trend of a positive correlation between the MSLT and neuroticism was seen indicating those with higher levels of anxiety took longer to fall asleep on the MSLT. However, as no correlations reached significance this suggests that the MSLT or PVT weren’t affected by elements of personality and anxiety levels in this analysis.

The analysis found that the KSS was the measure of sleepiness which is most related to the psychological elements. The analysis resulted in a significant positive correlation between the KSS and neuroticism (Figure 6, below) indicating that those with higher levels of neuroticism reported higher levels of sleepiness on the KSS.
There were significant positive correlations between KSS scores and both state (Figure 7) and trait (Figure 8) anxiety levels on the STAI indicating the higher the level of anxiety, the higher the level of sleepiness score.
Furthermore, there was a significant negative correlation between KSS scores and scores on the Lie scale of the EPQ (Figure 9) indicating lower levels of sleepiness on the KSS are related to high scores on the “L” element which measures how much an individual changes their answers to be that considered “socially acceptable”.

5.3.2 Correlations Between Measures of Sleepiness and Personality Variables
(20 Minute Latencies Excluded).

The previous analysis was repeated with latencies of 20 on the MSLT removed from the sample. In this sample set, the ESS and MSLT as well as the “L” and “N” factors were seen to have a skewed distribution so Spearman Rho analyses were used for these variables. Pearson’s R correlations were used for the KSS and PVT measures and the “P”, “E”, State and Trait elements.

There was still no significant correlation between the ESS and both state and trait measures of sleepiness:

![Figure 9 – Correlation between KSS score and L score on the EPQ.](image)

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>MSLT</th>
<th>KSS</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Rho=.000</td>
<td>rho=.121</td>
<td>r=-.146</td>
<td>r=-.045</td>
</tr>
<tr>
<td></td>
<td>r=.998</td>
<td>p=.497</td>
<td>p=.411</td>
<td>p=.802</td>
</tr>
<tr>
<td>E</td>
<td>Rho=- .121</td>
<td>rho=.016</td>
<td>r=-.103</td>
<td>r=-.061</td>
</tr>
<tr>
<td></td>
<td>p=.492</td>
<td>p=.927</td>
<td>p=428</td>
<td>p=927</td>
</tr>
<tr>
<td>N</td>
<td>Rho=.218</td>
<td>rho=.431</td>
<td>rho=.316</td>
<td>rho=.272</td>
</tr>
<tr>
<td></td>
<td>p=.217</td>
<td>p=.011</td>
<td>p=.069</td>
<td>p=.119</td>
</tr>
<tr>
<td>L</td>
<td>Rho=.085</td>
<td>rho=.002</td>
<td>rho=.387</td>
<td>rho=.111</td>
</tr>
<tr>
<td></td>
<td>p=.632</td>
<td>p=.992</td>
<td>p=.024</td>
<td>p=.534</td>
</tr>
<tr>
<td>ST</td>
<td>Rho=.321</td>
<td>rho=-</td>
<td>r=.336</td>
<td>r=.089</td>
</tr>
<tr>
<td></td>
<td>p=.064</td>
<td>p=.137</td>
<td>p=.052</td>
<td>p=.616</td>
</tr>
</tbody>
</table>

Table 7: Correlation Between Measures of Sleepiness and Elements of Personality with 20 minute latencies removed.
Interestingly, when data from participants who failed to fall asleep in the MSLT sleep opportunities was removed from analysis, a significant positive correlation between the MSLT and neuroticism scale of the EPQ was observed (Figure 10). This result indicates that the higher levels of neuroticism were associated with increased latencies on the MSLT.

![Figure 10 – Correlation between latency on the MSLT and neuroticism score on the EPQ (20 minute latencies excluded).](image)

No other significant correlations were found between the MSLT and psychological aspects.

When removing those participants with latencies of 20 minutes, a significant positive correlation remained between trait anxiety on the STAI and sleepiness levels on the KSS, and a significant negative correlation between the lie scale and the KSS was once again observed. However the correlations between the KSS and the neuroticism scale, and state anxiety became non significant trends. Once again, no significant correlations were found between the PVT and the psychological factors.

5.3.3. Investigation into Relationship between to Average Scores on Personality Traits and Measures of Sleepiness (All Data).

Next an investigation into whether there was a difference between individuals with a higher than average or lower than average score on the psychological elements differed on their scores on measures of sleepiness was conducted. This was conducted with independent t tests for the L scale and state and trait anxiety and the MSLT, PVT and KSS measures of sleepiness, as these elements were normally distributed. Mann
Whitney U tests were used for P,E and N factors and the ESS which were found to have a skewed distribution when the whole sample was taken into account. The scoring manuals for the STAI and EPQ were consulted in order to find the average score for the age groups and gender for the participants. The data for each psychological element was then split into whether their score was above or below average for each individual’s age and gender.

5.3.3.1 – Psychoticism scale of the EPQ
Statistical analysis revealed that there was no significant difference between participants with a lower than average psychoticism score on the EPQ and those with a higher than average psychoticism score on the scores of any of the measures of sleepiness.

5.3.3.2 – Extraversion scale of the EPQ
Statistical analysis revealed that there was no significant difference between participants with a lower than average extraversion score on the EPQ and those with a higher than average extraversion score on the scores of any of the measures of sleepiness.

5.3.3.3 – Neuroticism scale of the EPQ
A Mann Whitney U test revealed there was no significant difference between participants who had a higher than average neuroticism score on the EPQ and those that had a lower that average neuroticism score on the PVT or on the ESS. However, this Mann Whitney U analysis revealed that those participants with higher than average levels of neuroticism took significantly longer to fall asleep on the MSLT than those with lower than average levels of neuroticism; U(31,11)=82 p=.011, and that those participants with higher than average levels of neuroticism on the EPQ gave significantly higher KSS scores than those with lower than average neuroticism scores; U(31,11)= 65 p=.002.

5.3.3.4 – Lie scale of the EPQ
A Mann Whitney U test revealed there was no significant difference between participants who had a higher than average lie score on the EPQ and those that had a lower that average lie score on the ESS. An independent t test revealed there was no significant difference on MSLT latency or PVT score between participants with lower than average L scores and those with higher than average L scores. However, there was a significant difference on KSS score on participants with a lower than average L score (M=5.10 SD=.899) and participants with a higher than average L score (M=4.18
SD=1.06 t(40)= 2.13 p=.039). This indicated that participants who gave a higher the score on the L scale of the EPQ, gave a lower KSS score.

5.3.3.5 – State Anxiety index of the STAI.
A Mann Whitney U test revealed that there was no significant differences on ESS score between those with lower than average state anxiety scores and those with higher than average scores.
Independent t test showed there was no significant difference on MSLT latencies or PVT scores for those participants with lower than average state anxiety levels and those with higher than average state anxiety levels.

However there was a significant difference in KSS score between those participants with lower than average state anxiety scores (M=4.13 SD=.953) and those participants with a higher than average state anxiety scores (M=5.35 SD=1.22 t(40)= -2.95 p=.005). Those participants with higher state anxiety scores also gave higher KSS scores.

5.3.3.6 – Trait Anxiety index of the STAI.
A Mann Whitney U test revealed that there was no significant difference on ESS score between those with lower than average trait anxiety scores and those with higher than average scores.
An independent t test showed there was no significant difference on MSLT latencies or PVT scores for those participants with lower than average trait anxiety levels and those with higher than average trait anxiety levels.

However there was a significant difference in KSS score between those participants with lower than average trait anxiety scores (M=4.11 SD=1.06) and those participants with a higher than average trait anxiety scores (M=4.97 SD=1.06 t(40)= -2.38 p=.022). Those participants with higher trait anxiety scores also gave higher KSS scores.

5.3.4. Investigation into Relation to Average Scores on Personality Traits and Measures of Sleepiness (20 Minute Latencies Removed).
The analyses into the relationship between the measures of sleepiness and the psychological tests were repeated with those participants who have latencies of 20 minutes removed from the data. In this data set, the ESS, MSLT, N and L variables were not normally distributed and so Mann Whitney U analyses were used on these variables. All other variables were normally distributed and so independent t tests were used.
5.3.4.1 – Psychoticism scale on the EPQ.
A Mann Whitney U test revealed there was no significant difference in ESS score or MSLT latency between those with a lower than average psychoticism score, and those with a higher than average psychoticism score.

An independent t test revealed there was no significant difference in KSS or PVT score for those with lower than average psychoticism scores and those with higher than average psychoticism scores.

5.3.4.2 – Extraversion scale on the EPQ.
A Mann Whitney U test revealed there was no significant difference in ESS score or MSLT latency between those with a lower than average extraversion score and those with a higher than average extraversion score.

An independent t test revealed that there was no significant difference in KSS or PVT lapse scores between participants with lower than average extraversion scores and those with higher than average extraversion scores.

5.3.4.3 – Neuroticism scale on the EPQ.
A Mann Whitney U test revealed that there was no significant difference in number of PVT lapses or ESS scores between those with a lower than average neuroticism score, and those with a higher than average neuroticism score and that there was no significant difference in PVT score between those with a lower than average neuroticism score and those with a higher than average neuroticism score.

However, this analysis did reveal that those with higher than average neuroticism scores had significantly higher KSS scores than those with lower than average neuroticism scores; U(26,8)=38 p=.006 and that those with higher than average neuroticism scores had significantly higher latencies on the MSLT than those with lower than average neuroticism scores; U (26,8)=34 p=.005.

5.3.4.4 – Lie scale on the EPQ.
A Mann Whitney U test revealed there was no significant difference in ESS score, MSLT latency or number of lapses on the PVT between those with a lower than average L score, and those with a higher than average L score. However, there was a significant difference in KSS score between those with a lower than average L score and those with a higher than average L score; U(6,28)=36 p=.029. This indicated that participants who gave a higher the score on the L scale of the EPQ, gave a lower KSS score.
5.3.4.5 – State anxiety index on the STAI.
A Mann Whitney U analysis revealed there was no significant difference on ESS score or MSLT latency between those with a lower than average state anxiety score and those with a higher than average state anxiety score.
An independent measures t test revealed there was a significant difference in KSS score between those participants with lower than average state anxiety (M=4.06 SD=1.00) and those with higher than average state anxiety scores (M=5.25 SD=1.30 t(32)= -2.49 p=.018) but no significant difference in PVT lapse score between those with lower than average state anxiety scores and those with higher than average state anxiety scores. Those participants with higher state anxiety scores also gave higher KSS scores.

5.3.4.6 – Trait anxiety index on the STAI.
A Mann Whitney U analysis revealed there was no significant difference on ESS score or MSLT latency between those with a lower than average trait anxiety score and those with a higher than average trait anxiety.
An independent t test revealed there was a significant difference in KSS scores between those with lower than average levels of trait anxiety (M=3.97 SD=1.03) and those with higher than average levels of trait anxiety (M=4.97 SD=1.12 t(32)= -2.502 p=.018) but there was no significant difference in PVT lapse score between those with lower than average trait anxiety scores and higher than average trait anxiety scores. Those participants with higher trait anxiety scores also gave higher KSS scores.

5.4 - Summary
Female participants were found to have significantly higher scores on the ESS than their male counterparts. However, no other significant differences in sleepiness scores were found between the sexes.
Male participants took significantly longer to fall asleep in the first MSLT sleep opportunity, but this result was not replicated on any other sleep opportunity. This finding was not replicated when those participants with latencies of twenty minutes were removed from analysis.

Those participants with a “moderately morning” disposition had significantly lower latencies on the MSLT than the participants with a “Neither” disposition when analysis was conducted using those participants who fell asleep in the MSLT, and this result was also seen in the sleep opportunity at 2pm. No significant difference was seen at any other time of day and this result was not replicated in the whole dataset which included participants with latencies of 20 minutes.
Investigation into whether the measures of sleepiness were correlated with personality characteristics of the participants was conducted. In the whole data set, only the KSS was significantly positively correlated to scores on the lie scale and neuroticism scale of the EPQ and to state and trait anxiety on the STAI. No other significant correlations were found between the measures of sleepiness and the personality characteristics. When this analysis was repeated without the 20 minute latencies on the MSLT, the above results were replicated except that the KSS was no longer significantly related to the neuroticism scale or state anxiety index. Furthermore, a significant positive correlation was revealed between latency on the MSLT and score on the neuroticism scale of the EPQ.

In the whole group, there was no significant difference between higher than average or lower than average psychoticism scores or extraversion scores on scores in the measures of sleepiness. There was no significant difference between higher than average or lower than average neuroticism scores on scores on the ESS or PVT. However, higher than average neuroticism scores were significantly related to higher latencies on the MSLT and higher scores on the KSS. There was no significant difference between higher than average or lower than average scores on the lie scale on the ESS, PVT of MSLT, but higher than average lie scores were significantly related to lower KSS scores.

There was no significant difference on scores on the ESS, PVT or MSLT between higher than average or lower than average state or trait anxiety scores. However, both higher than average trait anxiety and higher than average state anxiety scores were significantly related to higher scores on the KSS. When 20 minute latencies on the MSLT were removed from analysis, the above results were replicated.
6. Discussion.

6.1 Findings and Implications of the Investigation.

6.1.1 Relationship between the Measures of Sleepiness.
An investigation was performed into whether four well employed measures of sleepiness were significantly related to each other, and whether individual differences in the participant group were related to these measures of sleepiness. Fifty normal sleepers with an average duration of 7-8 hours sleep a night undertook a multiple sleep latency test in a sleep laboratory. During this time they completed an Epworth sleepiness scale, two sessions of the Psychomotor Vigilance Task, and their current level of sleepiness was measured using the Karolinska sleepiness scale before each of the four sleep opportunities of the MSLT and either side of the PVT sessions. Participants also completed the Eysenck Personality Questionnaire, the State Trait Anxiety inventory, and the Horne-Ostberg morningness-eveningness questionnaire.

Much research into the relationship between measures of sleepiness has focussed on clinical populations such as patients who have excessive daytime sleepiness and have been diagnosed with a sleep disorder, or in a non clinical population who have been sleep deprived or whose sleep has been restricted prior to their participation in research. An investigation into the relationship between measures of sleepiness in individuals who have had a full night’s sleep which is consistent with the national average is relatively unbroken ground.

The results of this investigation indicated that none of the measures of sleepiness used in the experiment were significantly correlated in a group of alert young healthy sleepers when the whole data set was examined. These correlations did not improve by time of day or when the data from participants who did not sleep in any of the sleep opportunities was removed.

Indeed, only when the dataset was split by latency on the MSLT a significant relationship between the MSLT and the ESS was revealed, but only in nine participants, all of whom had average latencies of equal to or less than ten minutes on the MSLT.

One may argue that these nine participants had a level of excessive daytime sleepiness which had not been revealed in screening process and of which the
participants were unaware. Yet if this was the case, it would be reasonable to expect this group of individuals to have a significantly different score on the other measures of sleepiness when compared to participants with longer latencies. Nevertheless, no significant difference was found on number of lapses on the PVT or sleepiness score on the KSS between the three latency groups.

The average ESS score for each of the three latency groups was within the “normal” range on the scale as part of the criteria for participation. The highest average ESS score was in participants with latencies of ten minutes with an ESS score of 8/24. However, the lowest average ESS score, seen in the group with latencies of 11-15 minutes was only 5/24 and so the largest difference between the scores was only ever three points. Therefore, it is likely that although the ESS score has been seen to be statistically significantly different in this group of participants to those with higher latencies on the MSLT, the validity of this finding is negligible.

Arguably, the data from this subset of nine participants lends support to Harrison and Horne’s (1996) concept of “High Sleepability without sleepiness” – that within a population of alert individuals who report no issues with sleep there are a group of individuals who are able to fall asleep in situations such as the MSLT, not because they have a physiological need for sleep onset, but rather simply because they are able to fall asleep quickly as an individual trait.

Understandably, a limitation in this investigation is the fact that full nocturnal polysomnography was not carried out prior to investigation in order to objectively exclude sleep disorders in our participant group. This is regrettable of course. However, the majority of the referrals to sleep centres are due to an individual seeking treatment as they suffer from excessive daytime sleepiness which impacts on their day to day life.

In the minority of cases where individuals have a sleep disorder but do not suffer from excessive daytime sleepiness, people very often are aware there is some abnormality in their sleep, either from their own experience – patients with sleep apnoea are often aware of choking in the night, patients with periodic limb movements are often aware they are restless at night – or otherwise they have been made aware of abnormalities in their sleep by their bed partners or others who have witnessed them asleep. With this in mind, it seems unlikely, though not impossible, that an individual with abnormalities in their sleep would remain unaware that this was the case.

In screening individuals for participation in the study, potential participants completed a questionnaire which gave them the opportunity to reveal any daytime
sleepiness, snoring or sleep abnormalities they were aware of. Before participating in the research, individuals were screened with actigraphy which can reveal any excessive fragmentation in an individual’s sleep or any desynchrony their circadian rhythm. Therefore, though it cannot be fundamentally ruled out that one of these nine participants had a sleep disorder that either they were unaware of and/or which was not revealed during screening prior to participation, it seems unlikely.

Previous research by Kaida et al (2006) showed a significant relationship between the scores on the PVT and KSS; however the results of the current study failed to replicate this effect, perhaps because of the design of the study – there was a delay between the participant rating their sleepiness using the KSS and performing a session of the PVT. Fewer research studies had focused on the other correlations between measures of sleepiness such as the PVT and ESS or the KSS and ESS, either in a clinical or “normal” population, and so this research had enabled us to explore this area further.

Had the investigation revealed a significant relationship between several or all measures of sleepiness, it could be inferred that there was an overlap in the particular components of sleepiness that the scales were measuring. However, no significant relationship was found between any measure of sleepiness which would suggest that the MSLT, PVT, ESS and KSS are all measuring different elements of alertness or sleepiness.

Arguably the difference in instruction between the measures of sleepiness leads to the scales measuring different components of alertness to sleepiness. Whilst in the MSLT participants are encouraged to fall asleep, in the PVT the participants are encouraged to react as fast as they can, and so wakefulness is the key. The same could be argued for the difference in instruction between the ESS and the KSS, with the former requiring the participant to answer the questions whilst referring to a general overview of their perceived sleepiness in the previous few weeks, whereas the KSS requires the participant to relay their current levels of sleepiness at the time the scale is administered. Lastly, whilst in the MSLT and PVT, a level of alertness or sleepiness is objectively measured by an event or action such as falling asleep or reacting to a stimulus, the KSS requires introspection to make a subjective judgment about a current level of sleepiness, and the ESS requires an introspective recall of their day to day level of alertness or sleepiness.

The examination of a group of healthy alert individuals who had not been sleep deprived or had their sleep restricted and who had completed four measures of sleepiness provides further information about the alertness dimensions within each of
these measures of sleepiness. Previous research has found inconsistencies in the relationships between the measures of sleepiness in clinical populations and normal sleepers who have been sleep deprived or restricted their prior night’s sleep. One could argue that these inconsistencies in whether there is a significant relationship between measures of sleepiness may be due to variables such as severity of excessive daytime sleepiness experienced by the patient, or an individual’s vulnerability to being sleep deprived or having their sleep restricted.

However, as all of our participants habitually slept between 7-8 hours each night, had similar caffeine intakes and reported no daytime sleepiness or other sleep complaints, it is reasonable to assume that there should have been a significant relationship at least between some if not all of the measures of sleepiness. That there was no significant relationship between any of the measures of sleepiness when the data is examined as a whole indicates that the alertness dimensions in each measure of sleepiness are measuring components other than the individual’s level of sleepiness and may therefore weaken each measure as a whole.

It was therefore investigated as to whether individual differences such as sex, morningness/eveningness disposition and psychological characteristics would be significantly related to the measure of sleepiness. Should any significant relationship be found between a measure of sleepiness and a personality characteristic, it may then explain some of the inconsistencies seen in the relationship between the alertness dimensions of the measures of sleepiness.

6.1.2. – The Effect of Participant Sex on Measures of Sleepiness.

There were no significant differences between the sexes on KSS, PVT and overall MSLT score. However, female participants had significantly higher ESS scores than their counterparts, and this result echoes that seen in previous research such as Kim and Young (2005) and Roky et al (2006).

Although there was no sex difference on the overall MSLT score, when the data was analysed by each sleep opportunity it was revealed that the male participants had significantly higher latencies at the first sleep opportunity at 10am when compared to their female counterparts. However, this result was not replicated at any other time of day or when participants with overall latencies of 20 minutes were removed from the dataset. This echoes the somewhat mixed message about gender and the measures of sleepiness seen in the previous research.

Nevertheless, though statistical analysis showed a significant difference in ESS score between the sexes, the difference was marginal with the female average ESS score being a mere two points higher than the average male score. Furthermore, though a
significant difference in latency on the 10am MSLT sleep opportunity was found between the male and female participants, latencies for both sexes were in “alert” range of the MSLT spectrum, and the average female sleep onset latency was only three minutes earlier than their male counterparts.

The fact that the difference between the two sexes on average ESS score and MSLT latency at 10am is marginal, coupled with the fact that this significant difference in latency was not replicated at any other time of the day, may indicate that the difference, though statistically significant, may be due to chance.

6.1.3- The Effect of Morningness/Eveningness Disposition on the Measures of Sleepiness.

Next the effect of the morningness/eveningness disposition of the participants was analysed. It was investigated whether those participants with a “moderately morning” or “Neither” disposition were significantly different in their scores on the measures of sleepiness, and this was found not to be the case.

However, when those participants with twenty minute latencies on the MSLT were removed from this analysis it was revealed that those with a “Moderately morning” disposition had significantly shorter average latencies on the MSLT than their “Neither” counterparts over the whole of the MSLT, and they also had significantly shorter average latencies in the 2pm MSLT sleep opportunity than those participants with a “Neither” disposition.

It is arguably an unusual result that participants with a “Moderately morning” disposition had shorter sleep latencies than participants with a “Neither” disposition. This is because “Moderately morning” participants were classified as such as they felt they were more alert and efficient in the morning on the Horne Ostberg Morningness-Eveningness questionnaire, and two of the sleep opportunities in the MSLT are conducted in the morning when “Moderately morning” types feel at their best. One may therefore expect that participants with a “Moderately morning” disposition may have much longer latencies in the first two MSLT sleep opportunities which occur in the morning. However, no significant difference was found between the two groups in either the 10am or 12pm MSLT sleep opportunities.

Those with a “Moderately morning” disposition had significantly short latencies at 2pm than those with a “Neither” disposition, and perhaps this may explain why there is an overall difference in MSLT latency. Research has shown there to be a circadian dip in the hours of the early afternoon. Given that participants who were assigned a “Neither” disposition according to the Horne Ostberg questionnaire were assigned this classification due to the fact they reported they felt they didn’t perform better at a
particular time of day, it may be that this group of participants are less sensitive to a circadian dip in the afternoon and therefore do not fall asleep as quickly in the afternoon MSLT sleep opportunities, giving a significant difference in overall latency between the two types of morningness/eveningness disposition.

6.1.4 – The Effect of Personality Characteristics on Measures of Sleepiness.
Lastly, the relationship between measures of sleepiness and psychological characteristics were examined. There were no statistically significant correlations between the psychological characteristics and the MSLT, ESS and the PVT when data from the whole participant group was examined. It was the KSS which was most related with the psychological characteristics, as the analysis revealed a significant positive correlation between the KSS and neuroticism, state and trait anxiety and a significant negative correlation between the KSS and the lie scale on the EPQ. This result supports that of Mastin et al’s (2005) research which found a significant positive correlation between a subjective state measure of sleepiness and neuroticism, and suggests scores on the KSS are influenced somewhat by the levels of neuroticism or anxiety in the participant, or their motivation to appear in a socially acceptable manner.

Upon excluding the twenty minute latencies from analysis, a significant positive correlation between the participants’ score on the neuroticism scale and their average latency on the MSLT was found, which echoed the results of Kronholm et al’s (1995) study. This suggests the latency on the MSLT is not solely due to physiological need for sleep, but is also influenced by how neurotic the individual undergoing the test is. MSLT scores did not significantly correlate with any other psychological characteristic. The correlations between the KSS and neuroticism and state anxiety became non significant, but the correlations between the KSS and the lie scale and trait anxiety remained significant.

Statistical analysis was performed to see if there was a difference in scores on the measures of sleepiness between participants who scored higher than average or lower than average on the personality characteristics.

This analysis was primarily carried out using the whole data set. There was no significant difference found in the scores on all the measures of sleepiness between participants who scored higher than average or lower than average on the psychoticism or extraversion scales of the EPQ. Those with a higher than average scores on the neuroticism scale of the EPQ had higher scores on the KSS and took longer to fall asleep in the MSLT than those
participants with lower than average neuroticism scores. There was no difference seen between the groups on ESS or PVT scores.

The results also indicate that there was no significant difference between those with lower than average and higher than average Lie scale scores on the measures of sleepiness with the exception of the KSS, where those participants with higher than average lie scale scores had significantly lower KSS scores than those participants with lower than average lie scores. Similarly, those participants with lower than average or higher than average scores of state and trait anxiety did not have significantly different scores on the ESS, MSLT or PVT but those with higher than average state and trait anxiety scores reported significantly higher KSS scores in comparison than those who had lower than average anxiety scores.

A second analysis was conducted where the data from the twenty minute latencies was excluded and this replicated the findings of the first investigation.

The results of this research have indicated that the Karolinska Sleepiness scale should be used with caution as the sleepiness scores it produces have been shown to be significantly influenced by an individual’s personality type. The KSS was seen to be influenced by a participant’s motivation to appear in a positive light to others as there was a significant negative correlation between the KSS and the lie scale which measures how a respondent will change their answers on a questionnaire in order to appear to behave in a socially desirable way (Eysenck et al 1974). Interestingly, this was not significantly replicated in the ESS, another subjective measure of sleepiness, indicating the ESS may be less influenced by these confounding variables.

One possible explanation for why the KSS seemed to be more readily affected by the participant’s personality traits than the ESS lies in how easily a participant finds making a judgment on their sleepiness.

The scores on the ESS are based on whether events have occurred or not which are easy for the participant to judge. For example, is it is easy to recall whether you regularly fall asleep in front of the television or not. The ESS uses activities encountered regularly in everyday life are familiar to the participant and it is therefore easier to make a judgement about their sleepiness in relation to these events. However, when a participant uses the KSS to score their sleepiness they do not have the benefit of being able to rely on everyday occurrences to make their judgment, but instead have choose a statement which can be vague or very similar to the statements either side of it. Perhaps because choosing a statement from the KSS is more ambiguous than recalling if you fall asleep in front of the television, other
confounding variables such as an individual’s underlying personality traits have a larger influence in the decision process.

Lastly, it was seen that those participant’s levels of neuroticism can lead to significantly longer latencies on the MSLT. This finding lends support to one of the main criticisms of the MSLT; that it is an alien situation to the average person, and that the application of electrodes and the procedures necessary for carrying out the test may affect the individual’s ability to relax enough to fall asleep and therefore produce inaccurate results. With this result in mind, it would be prudent, both in areas of research and clinical practice that a “warm up day” should be employed so that the individual has the opportunity to get used to the equipment and schedule of the MSLT and this may eliminate the effects of the test being an alien situation and produce sound results on the following day of the MSLT tests.

6.2 Limitations of the Investigation.

Nevertheless, this research is not without its limitations. The sample used in the research presents several limitations to the investigation. As the majority of participants came from the University’s population of students, there is only a limited age range in the sample; therefore it is not possible to deduce the correlation between the measures of sleepiness and the effect of individual variations on age groups that did not participate in the investigation.

It might be argued that because participants were students who were recruited into the study on a voluntary basis that would limit the sample as certain individuals may be more likely to volunteer for experiments or indeed become students in the first place and therefore may not represent the results you would get in a more general population. However, the psychometric scales that were used in the investigation show that the participants tested showed personality traits throughout the whole of the spectrum of the factors on the EPQ and STAI, and so would reflect the general population.

In terms of the investigation into morningness-eveningness disposition, there were only two participants with “moderately evening” disposition, and therefore this data was excluded from investigations into the influence of morningness-eveningness disposition as it was not possible accurately analyse the difference between those participants with “moderately evening” preferences with the other groups of “moderately morning” and “neither” dispositions. Because of this, the analyses into morningness-eveningness dispositions are somewhat limited, and cannot be extrapolated to those with a “moderately evening” tendency.
Although the majority of participants completed the psychological questionnaires on the testing day, a few exceptions occurred whereby the individual completed these tests at a later date as part of the wider research project or the questionnaires were posted to the participant. Though this should have no detrimental effect on the EPQ or trait measures of anxiety on the STAI as they measure the individual’s general disposition, this may bring some of the data from the state anxiety scores of the STAI into question. This is because the individual may not have completed the data in the experimental environment and therefore their resulting state anxiety score may not be the same as if they had completed the scale in the experimental environment, especially as the MSLT is a situation that is normally alien to an everyday environment.

6.3 Directions of Future Research.
Though this research study has contributed some new information into the area of concordance between the measures of sleepiness in alert individuals, as always there is potential for further research to be undertaken in the area.

The influence of morningness-eveningness disposition on the correlation between the measures of sleepiness needs to be further explored by including a large sample of individuals with a “Moderately Evening” disposition as well as those with a “Neither” and “Moderately Morning” disposition.

This research has failed to find a relationship between four measures of sleepiness in alert individuals who have taken their habitual 7-8 hours sleep, and previous research into the relationship between the measures of sleepiness has had mixed results in clinical populations and in sleep deprived or sleep restricted healthy individuals. Nevertheless, it would be very interesting to see whether the measures of sleepiness are better related in specific patient groups. Perhaps significant relationships between the measures of sleepiness can be observed more in patients with severe obstructive sleep apnoea or narcolepsy for which the majority of patients report severe excessive daytime sleepiness, better than they do in patients with REM behaviour disorder where excessive daytime sleepiness is not always present (Mahowald and Schenck 2005).

This investigation was limited into looking at the correlation between measures of sleepiness in a relatively young age group, and it would be beneficial to advance our knowledge of this area by replicating this experiment in multiple age groups in order to investigate whether the measures of sleepiness relate better in a particular age group.
A further exploration of the positive correlation between a higher than average neuroticism score on the EPQ and latency on the MSLT could be pursued by adding the intervention of a “warm up day” to the protocol. A group of participants would have two simultaneous days of MSLT testing, with an EPQ and STAI administered on each day. The first of the two days could act as a practice for the true experiment on the second day and as participants have already experienced the unusual situation of the application of electrodes and the MSLT on the first day, it may eliminate these confounding variables on the second day. A control group would undergo a standard MSLT procedure and undertake the EPQ, but would not have the warm up day on the day prior to participation in the experiment. Latencies and scores on the psychological questionnaires would be statistically compared to see if there is a significant effect of the warm up day.

Lastly, this experiment could be replicated with alternative measures of sleepiness and/or alternative psychological questionnaires. The Karolinska Sleepiness Scale could be replaced with the equivalent Stanford Sleepiness scale in order to examine if the latter scale correlates better with the other measures of sleepiness or is less prone to be influenced by confounding variables than the KSS. The maintenance of wakefulness scale could replace the MSLT in order to examine its relationship to the other measures of sleepiness.

An investigation into a broader number of individual differences should be conducted in order to gain further knowledge as to the cause of the inconsistencies in the alertness dimensions of measures of sleepiness.
7. Conclusion.

Four commonly used measures of sleepiness were shown to have no significant relationship with each other in a group of healthy alert individuals who had attained their habitual length of sleep prior to participation.

That the measures of sleepiness do not correlate with each other indicates that each measure of sleepiness may be measuring different elements of an individual’s level of alertness or sleepiness, as well as measuring individual differences within the person. This serves to reiterate that no single measure of sleepiness can be used to solely measure an individual’s level of alertness or sleepiness.

The lack of significant relationship between the measures of sleepiness indicates there is a level of inconsistency within the alertness dimensions of each measure of sleepiness, and that these alertness dimensions are influenced by individual differences in the individual. This could weaken the scales and lead to the poor relationship between the measures of sleepiness.

Investigation into whether individual differences in the participant group explained the lack of relationship in the alertness dimensions of sleepiness has had mixed results.

Sex of the participant was only found to produce a significant difference in the ESS and as discussed previously, this result may be negligible. The morningness/eveningness disposition of the participants was only seen to have an effect on the MSLT, with no other significant differences in scores on the ESS, PVT or KSS between those with a “moderately morning” or “neither disposition” and furthermore the difference in MSLT latency between the two dispositions was not seen consistently throughout the testing day.

The effect of the personality traits of the participants on the measures of sleepiness was also inconsistent. There was no significant relationship between any personality characteristic and scores on the ESS or PVT. Latency on the MSLT was only
significantly related to neuroticism score in participants, with no other significant relationship between the MSLT and personality characteristics being seen.

The KSS was the measure of sleepiness most likely to be related to the personality of the participant with significant relationships between the KSS and neuroticism, lie scale and state and trait levels of anxiety seen.

Individual differences within the participant group have been seen to be significantly related to some measures of sleepiness and may therefore explain in part why the measures of sleepiness do not significantly relate to each other in alert individuals. However, as none of the individual differences in the participant group was significantly related to all of the measures of sleepiness, they cannot be solely responsible for the lack of relationship between measures or all of the inconsistency in the levels of alertness measured by the scales.

It is more probable that poor correlation in the alertness dimensions of the measures of sleepiness is due to a combination of each measure of sleepiness measuring a different component of the alertness-sleepiness spectrum and that each measure of sleepiness has a different strength of relationship to the individual differences in a participant group.

This investigation has partly addressed the gap in the research, and finding a lack of significant correlation between the measures has not only expanded knowledge into relationships between alertness dimensions of measures of sleepiness but also provided new information on the relationships between measures of sleepiness which have not been previously examined in alert individuals.

More research into the cause of the inconsistency in the measurement of alertness within the measures of sleepiness is required, and examination of further individual differences may provide further insight into this discrepancy in measures of alertness and sleepiness.
8. References


BaHamman, A. (2004). Effect of fasting during Ramadan on sleep architecture, daytime sleepiness and sleep pattern. Sleep and Biological Rhythms; (2) 135–143.


National Sleep Foundation Gallup Survey on Sleepiness in America (1997) Press conference held on June 3 1997 at the New York Academy of Sciences, New York, USA.


Chapter 9 - Appendices.

- Appendix A: Recruitment Advertisement.
- Appendix B: Initial Screening Questions.
- Appendix C: Screening Questionnaire.
- Appendix D: KSS screening sheet.
- Appendix E: Sleep Diary.
- Appendix F: Consent form.
- Appendix G: Participant Information Sheet.
- Appendix H: MSLT scoring sheet.
Appendix A: Recruitment Advertisement.

££££££          PPAAIIDD
VOLUNTEERS
WANTED
££££

For Sleep Project

We are looking for:

- Males and Females aged 21 - 40yrs
- Good, Healthy Sleepers that don’t Nap
- Regularly Sleep less than 8h a night
- Can come into the centre one day a week for 5 consecutive weeks – meals included….
- (Plenty of time to do your own thing e.g. work, read etc. whilst you’re here)
For more information, please contact:

Charlotte Platten
Sleep Research Laboratory
Department of Human Sciences
Tel: (01509) 223044
Appendix B: Initial Screening Questions.

1. How old are you?
2. What do you do?
3. Do you have a part time job?
4. What weekdays are you free to participate in the study?
5. Do you feel they sleep well?
6. What time do you usually go to bed at night?
7. What time do you usually wake up in the morning?
8. Do you feel sleepy in the afternoon - if yes, how often?
9. Do you drink coffee / tea?
10. Do you nap during the day - if yes, how often?
11. Are you on any tablets or medication?
12. Where do you live?
PERSONAL INFORMATION

Name: .................................................................
Address: ...............................................................  
........................................................................  
........................................................................  
Phone Number: .........................................................
National Ins: ............................................................
Age/D.O.B. ...............................................................  
Sex: ........................................................................  
Weight: .....................................................................  
Height: .......................................................................  
Occupation: ..............................................................  
BMI: ..........................................................................  
R / L Handed: ............................................................

GENERAL QUESTIONS

1. Do you smoke?
   
   Yes ................................................................. 1
   Sometimes ......................................................... 2
   No ....................................................................... 3
   Don’t Know .......................................................... 0

1a. If yes, How many cigarettes per day?
   
   1-5 ................................................................. 1
   5 or more ........................................................... 2
   Don’t Know .......................................................... 0

2. How many cups of tea/coffee do you usually drink in a day?
   
   None ...................................................................... 1
   1-2 ....................................................................... 2
   3-4 ....................................................................... 3
   5-6 ....................................................................... 4
   Over 6 ..................................................................... 5
   Don’t Know ............................................................ 0

3. Are you available to come into the Sleep Centre any day of the working week?
   
   No .......................................................................... 1
   Yes ......................................................................... 2

3a. If no, what week days are you available?
   
   Monday .................................................................... 1
   Tuesday .................................................................... 2
   Wednesday ............................................................. 3
   Thursday ............................................................... 4
   Friday ...................................................................... 5
HEALTH QUESTIONS

4. In general would you say your health is:

<table>
<thead>
<tr>
<th>Option</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1</td>
</tr>
<tr>
<td>Very Good</td>
<td>2</td>
</tr>
<tr>
<td>Good</td>
<td>3</td>
</tr>
<tr>
<td>Fair</td>
<td>4</td>
</tr>
<tr>
<td>Poor</td>
<td>5</td>
</tr>
</tbody>
</table>

5. Have you ever experienced any of the following medical conditions and if so, when?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>No = 1</td>
</tr>
<tr>
<td>Hay fever</td>
<td>Yes in the past = 2</td>
</tr>
<tr>
<td>Yes, sometimes = 3</td>
<td></td>
</tr>
<tr>
<td>Yes, at present = 4</td>
<td></td>
</tr>
<tr>
<td>Thyroid Problems</td>
<td>(c)</td>
</tr>
<tr>
<td>Allergies</td>
<td>(d)</td>
</tr>
<tr>
<td>Sleepwalking</td>
<td>(g)</td>
</tr>
<tr>
<td>Loud snoring</td>
<td>(h)</td>
</tr>
<tr>
<td>Nightmares</td>
<td>(l)</td>
</tr>
<tr>
<td>Bruxism</td>
<td>(j)</td>
</tr>
<tr>
<td>Difficulty reading/writing</td>
<td>(k)</td>
</tr>
<tr>
<td>Arthritis/Rheumatism</td>
<td>(l)</td>
</tr>
<tr>
<td>Sleepwalking</td>
<td>(m)</td>
</tr>
<tr>
<td>Heart problems</td>
<td>(n)</td>
</tr>
<tr>
<td>Stomach problems</td>
<td>(o)</td>
</tr>
<tr>
<td>Waking up with a jolt</td>
<td>(p)</td>
</tr>
<tr>
<td>Waking up excessively early</td>
<td>(q)</td>
</tr>
<tr>
<td>Difficulty falling asleep</td>
<td>(r)</td>
</tr>
<tr>
<td>Stress/anxiety at home/work</td>
<td>(s)</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>(t)</td>
</tr>
<tr>
<td>Migraine</td>
<td>(u)</td>
</tr>
<tr>
<td>Colour blindness</td>
<td>(v)</td>
</tr>
<tr>
<td>Hearing Problems</td>
<td>(w)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>(x)</td>
</tr>
<tr>
<td>Chronic Fatigue Syndrome</td>
<td>(y)</td>
</tr>
<tr>
<td>Restless Leg Syndrome</td>
<td>(z)</td>
</tr>
</tbody>
</table>

6. Do you regularly take pills or medicines from the chemist or by prescription?

<table>
<thead>
<tr>
<th>Option</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>0</td>
</tr>
</tbody>
</table>

If so can you tell me what they are?

SLEEP QUESTIONS

7. How well do you feel that you sleep generally?

<table>
<thead>
<tr>
<th>Option</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very well</td>
<td>1</td>
</tr>
<tr>
<td>Well</td>
<td>2</td>
</tr>
<tr>
<td>Not very well</td>
<td>3</td>
</tr>
<tr>
<td>Poorly</td>
<td>4</td>
</tr>
</tbody>
</table>

8. What time do you normally go to bed? ..............................................

9. What time do you normally get up? ...................................................

10. How long does it normally take you to fall asleep?

<table>
<thead>
<tr>
<th>Option</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 minutes</td>
<td>1</td>
</tr>
<tr>
<td>5-10 Minutes</td>
<td>2</td>
</tr>
<tr>
<td>10-20 Minutes</td>
<td>3</td>
</tr>
<tr>
<td>20-30 Minutes</td>
<td>4</td>
</tr>
<tr>
<td>Over 30 Minutes</td>
<td>5</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
</tbody>
</table>
11. How much sleep do you feel you need each night?

<table>
<thead>
<tr>
<th>Hours</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5</td>
<td>1</td>
</tr>
<tr>
<td>5-6 hours</td>
<td>2</td>
</tr>
<tr>
<td>6-7 hours</td>
<td>3</td>
</tr>
<tr>
<td>7-8 hours</td>
<td>4</td>
</tr>
<tr>
<td>8-9 hours</td>
<td>5</td>
</tr>
<tr>
<td>Greater than 9</td>
<td>0</td>
</tr>
</tbody>
</table>

12. Do you ever miss a night's sleep or have much more sleep than usual?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>Yes, sometimes</td>
<td>2</td>
</tr>
<tr>
<td>Yes, regularly</td>
<td>3</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>

12a) If yes, can you tell me what is the reason for this?


13. How much does your quality of sleep vary from one night to the next?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very much</td>
<td>1</td>
</tr>
<tr>
<td>Moderately</td>
<td>2</td>
</tr>
<tr>
<td>Slightly</td>
<td>3</td>
</tr>
<tr>
<td>Not at All</td>
<td>4</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>

14. How many times do you wake, on average, a night?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>1</td>
</tr>
<tr>
<td>Once</td>
<td>3</td>
</tr>
<tr>
<td>Twice</td>
<td>4</td>
</tr>
<tr>
<td>More than twice</td>
<td>5</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>

14a) If you wake up: How long does it take you to get back to sleep again?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 minutes</td>
<td>1</td>
</tr>
<tr>
<td>10 – 30 Minutes</td>
<td>2</td>
</tr>
<tr>
<td>30 – 60 Minutes</td>
<td>3</td>
</tr>
<tr>
<td>Over 60 Minutes</td>
<td>4</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>

15. Do you ever feel sleepy during the day?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes every day</td>
<td>1</td>
</tr>
<tr>
<td>Yes, several times a week</td>
<td>2</td>
</tr>
<tr>
<td>Yes, several times a month</td>
<td>3</td>
</tr>
<tr>
<td>Yes, once a month</td>
<td>4</td>
</tr>
<tr>
<td>Never</td>
<td>5</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>

15a) If yes, at about what time does this sleepiness usually start?


16. Do you ever nap during the day?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
</tbody>
</table>
16b) If yes, why?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boredom</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate sleep / sleepiness</td>
<td>2</td>
</tr>
<tr>
<td>Routine</td>
<td>3</td>
</tr>
<tr>
<td>Hang over / Late night</td>
<td>4</td>
</tr>
<tr>
<td>No reason</td>
<td>0</td>
</tr>
</tbody>
</table>

17. Do you ever experience ‘poor sleep’?

- Yes: 1
- Sometimes: 2
- No: 3
- Don’t know: 0

18. If you had a poor nights sleep, does it affect:

- How you feel: 1
- How you perform: 2
- Both of these: 3
- Neither of these: 4
- Don’t know: 0

19. If you had a poor night’s sleep, when do you feel the consequences?

- The next day: 1
- The day after: 2
- Both of these days: 3
- Neither of these days: 4

20. Please Complete the Following:

How likely are you to fall asleep in the following situations? Please indicate, using the following scale, which is most appropriate given the situation.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of Dozing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and Reading</td>
<td>.....................</td>
</tr>
<tr>
<td>Watching TV</td>
<td>.....................</td>
</tr>
<tr>
<td>Sitting inactive in a public place (e.g. theatre/meeting)</td>
<td>.....................</td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td>.....................</td>
</tr>
<tr>
<td>Lying down in the afternoon when circumstances permit</td>
<td>.....................</td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td>.....................</td>
</tr>
<tr>
<td>Sitting quietly after lunch without alcohol</td>
<td>.....................</td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in the traffic</td>
<td>.....................</td>
</tr>
</tbody>
</table>

21. Considering your own “feeling best” rhythm, at what time would you get up if you were entirely free to plan your day?

5am – 6.30am
22. Considering your own “feeling best” rhythm, at what time would you go to bed if you were entirely free to plan your day?

<table>
<thead>
<tr>
<th>Time</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>8pm – 9pm</td>
<td>5</td>
</tr>
<tr>
<td>9pm – 10.15pm</td>
<td>4</td>
</tr>
<tr>
<td>10.15pm – 12.30am</td>
<td>3</td>
</tr>
<tr>
<td>12.30am – 1.45am</td>
<td>2</td>
</tr>
<tr>
<td>1.45am – 3am</td>
<td>1</td>
</tr>
</tbody>
</table>

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

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

24. Assuming adequate environmental conditions, how easy do you find getting up in the mornings?

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

25. How alert do you feel during the first half hour after having woken in the morning?

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

26. How is your appetite during the first half hour after having woken in the morning?

- Very poor: 1
- Fairly poor: 2
- Fairly good: 3
- Very good: 4

27. During the first half hour after having woken in the morning, how tired do you feel?

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

28. When you have no commitments the next day, at what time do you go to bed compared to your usual bedtime?

<table>
<thead>
<tr>
<th>Time</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seldom or never later</td>
<td>4</td>
</tr>
<tr>
<td>Less than one hour later</td>
<td>3</td>
</tr>
<tr>
<td>1 – 2 hours later</td>
<td>2</td>
</tr>
<tr>
<td>More than 2 hours later</td>
<td>1</td>
</tr>
</tbody>
</table>

29. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is between 7 – 8am. Bearing in mind nothing else but your own “feeling best” rhythm, how do you think you would perform?

- Would be on good form: 4
- Would be on reasonable form: 3
- Would find it difficult: 2
30. At what time in the evening do you feel tired and in need of sleep?
- 8pm – 9pm
- 9pm – 10.15pm
- 10.15pm – 12.45am
- 12.45pm – 2am
- 2am – 3am

31. You wish to be at your peak performance for a test, which you know is going to be mentally exhausting and last for two hours. If you are entirely free to plan your day, when would you do this task?
- 8am – 10am
- 11am – 1pm
- 3pm – 5pm
- 7pm – 9pm

32. If you went to bed at 11pm, at what level of tiredness would you be?
- Not at all tired
- A little tired
- Fairly tired
- Very tired

33. 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 events are you most likely to experience?
- Wake up at the usual time and not go back to sleep
- Wake up at the usual time and doze
- Wake up at the usual time and go back to sleep
- Wake up later than usual

34. One night you have to remain awake between 4 – 6am in order to carry out a night watch. You have no commitments the next day. Would you...
- Not go to bed until 6am
- Nap before 4am and sleep after 6am
- Sleep before 4am and nap after 6am
- Sleep before 4am and remain awake after 6am

35. You have to do two hours of hard physical work. Which hours would you prefer to do it between?
- 8am – 10am
- 11am – 1pm
- 3pm – 5pm
- 7pm – 9pm

36. 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 – 11pm. How well do you think that you would perform?
- Would be on good form
- Would be on reasonable form
- Would find it difficult
- Would find it very difficult

37. Suppose that you can choose your own work hours, but had to work five hours in the day. Which FIVE CONSECUTIVE HOURS would you select?
38. At what time of the day do you feel at your best?
- midnight – 5am | 1
- 5am – 9am | 5
- 9am – 11am | 4
- 11am – 5pm | 3
- 5pm – 10pm | 2
- 10pm – midnight | 1

39. Do you consider yourself to be a “morning” or “evening” type of person?
- Morning | 6
- More morning than evening | 4
- More evening than morning | 2
- Evening | 0

LIFESTYLE QUESTIONS

40. How many hours of exercise do you do per week?
- 0 – 1 | 1
- 1 – 2 | 2
- 2 – 3 | 3
- 4 or more | 4

41. On average, how many hours do you spend at work per week?
- Less than 30 | 1
- 30 – 35 | 2
- 35 – 40 | 3
- 40 or more | 4

42. Do you work mainly indoors or outdoors? Tick the appropriate answer
- Indoors
- Outdoors

43. Whilst at work, how many hours, on average, do you spend sitting down each day?
- Less than 2 | 1
- 2 – 4 | 2
- 4 – 6 | 3
- More than 6 | 4

44. Have you ever worked unsocial hours, e.g. night shift work?
- Yes
- No

44a. If yes, please indicate roughly what hours you worked and the dates when you did this
..................................................................................................................................................
THANK YOU, THAT IS THE END OF THE QUESTIONNAIRE

http://sleep.lboro.ac.uk
Tel: 01509 223044
E-Mail: c.r.platten@lboro.ac.uk
Appendix D: KSS Screening Sheet.

This scale shows how sleepy you feel at a given time during the day. Please rate your feeling of sleepiness every two hours that you are awake for 3 days using the scale below. Please write in what time you went to sleep and what time you awoke.

**Confidential**

The Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990)

1. Extremely Alert
2. Very Alert
3. Alert
4. Rather Alert
5. Neither Alert nor sleepy
6. Some signs of Sleepiness
7. Sleepy, but no effort to keep awake
8. Sleepy, some effort to keep awake
9. Very Sleepy, great effort to keep awake, fighting sleep

<table>
<thead>
<tr>
<th>TIME</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
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<td>06:00</td>
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<td>07:00</td>
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<td>08:00</td>
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<td>05:00</td>
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</tbody>
</table>

Any queries please contact: Charlotte Platten
Sleep Research Centre,
Department of Human Sciences,
Loughborough University.
c.r.platten@lboro.ac.uk
Appendix E: 7 Day Sleep Diary.

This shortened sleep diary will enable us to gain a picture of how you slept over the week. Please fill each day as appropriate.

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last night I went to bed at…</td>
<td></td>
<td></td>
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<tr>
<td>This morning I woke up at…</td>
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<tr>
<td>This morning I got out of bed at…..</td>
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<tr>
<td>Last night, I slept for a total of …. hours</td>
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<tr>
<td>Last night, I fell asleep in…. minutes</td>
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<tr>
<td>Last night, I woke up…. Times</td>
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<tr>
<td>Last night my sleep was disturbed by….</td>
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<tr>
<td>When I woke I felt refreshed/somewhat refreshed/fatigued…</td>
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<tr>
<td>I slept better/worse/somewhat the same as usual</td>
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<tr>
<td>I did/did not sleep with my partner</td>
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<tr>
<td>I had difficulty staying awake during the day</td>
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<tr>
<td>I felt extremely sleepy between the hours of….. and ….</td>
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<tr>
<td>Last night, before going to bed, I consumed alcohol (extent?)</td>
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</tr>
</tbody>
</table>

Please note below any times when you remove the actiwatch and why:

________________________________________
________________________________________
________________________________________

Any queries please contact:
Charlotte Platten
Sleep Research Centre,
Department of Human Sciences,
Loughborough University.

c.r.platten@lboro.ac.uk
01509 223044
Consent of Subject to be included in Research Trial:

I, ..........................................................

Consent to taking part in an experiment within the Sleep Research Centre, for daytime testing. An explanation of the nature and purpose of the procedure has been given to me by Charlotte Platten and Kate Jordan.

I understand that I may feel sleepy during some parts of the experiment and consent to abide by the instructions given to me by the experimenter during the testing period for reasons relating to safety.

I understand that I may withdraw from the experiment at any time and that I am under no obligation to give reasons for such withdrawal. Upon withdrawal, I understand that I may request any data already collected to be discarded from the study.

I understand that any information about me that I have given will be treated as confidential by the experimenter.

Signed: ..................................................
Date: ..................................................

Signature of Experimenter: ..................................
Appendix G: Participant Instructions

Sleep Research Centre

Participant Instructions

Thank you for volunteering to participate in this study. You will be required to attend the Loughborough Sleep Research Centre to undergo various tests throughout the day to measure how sleepy you are. Prior to the day of testing and during testing, it is very important that you follow the protocol of the study in terms of sleep length, caffeine / alcohol consumption etc. If at any time you do not adhere to any protocol, for whatever reason, please ensure you indicate this to us.

Please refrain from drinking alcohol/caffeine at 22.00h on the night prior to testing. You are allowed breakfast on the morning of the trial and are asked to avoid strongly caffeinated drinks (tea is fine). You will be provided with refreshments throughout the day of testing and are requested to eat and drink as normal.

On the day of testing you should arrive at the centre at 09.00h. Throughout the morning and afternoon you will be asked to undergo short nap opportunities. These will occur at 10.00h, 12.00h, 14.00h and 16.00h. In addition, you will practice a simple reaction time test in the morning, which you will then carry out in the afternoon, at 16.30h. The test lasts for 30 minutes, after which, you are free to leave the centre.

Your day for testing is: ..........................................................

All of the data collected in this study will be encoded so you remain anonymous and only those involved in this research will have access to the data. If for any reason you do not wish to continue your participation, you are free to leave the experiment at any time without having to explain your reason.

You will be paid £25 for your participation.

If you have any questions or are unsure about anything associated with this study please do not hesitate to contact me.

http://sleep.lboro.ac.uk
Tel: 01509 223044
E-Mail: c.r.platten@lboro.ac.uk
## MULTIPLE SLEEP LATENCY TEST - SCREENING

Loughborough Sleep Research Centre

**Confidential**

Any queries please contact:
Charlotte Platten
Sleep Research Centre,
Department of Human Sciences,
Loughborough University.

c.r.platten@lboro.ac.uk
01509 223044

### SUBJECT NUMBER:

<table>
<thead>
<tr>
<th>KSS</th>
<th>Sleep in 5min</th>
<th>MSLT</th>
<th>Test Start Time</th>
<th>Sleep Onset Time</th>
<th>Sleep Latency (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>10:00</td>
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<td>After</td>
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**Average:**