

Adverse Affect, Physical Activity, and Biological Sex Predict Sleep in Young Adults

Kirsten Clacey and Candice Edmunds

ACSENT Laboratory

Department of Psychology

University of Cape Town

Supervisor: Pedro Wolf

Word Count:

Abstract: 174 words

Main body: 9721 words

Abstract

Few studies assess the constructs of sleep, affect, and physical activity simultaneously in a naturalistic environment. Using objective and subjective measures, the current study examined how these variables predict sleep in 66 undergraduate students. From the literature we predicted that high positive affect, low adverse affect, and high physical activity would be positively related to healthy sleep. However, our analysis, which tested these specific hypotheses, revealed that our results only supported the hypothesis that low adverse affect is related to healthy sleep. The control variable race and the predictor variable adverse affect were statistically significant and the model's R^2 was .42. An extra exploratory data analysis introduced biological sex as a variable into the equation, rather than being controlled for as in the previous model. The R^2 increased to .53 with the introduction of biological sex to the model. In this second model, a significant interaction among biological sex, the adverse affect factor, and the physical activity factor was identified. This interaction suggests that these variables have different implications for sleep, depending on sex.

Keywords: sleep, positive affect, negative affect, fatigue, sadness, physical activity, biological sex, actigraph

TABLE OF CONTENTS

Introduction.....	6
Operationalizing and Measuring Sleep.....	6
Sleep and Physical Activity.....	8
Introducing Affect to the Relationship.....	9
Connecting the Third Side of the Triangle.....	10
Rationale and Specific Aims.....	12
Design and Methods.....	14
Design and Setting.....	14
Participants.....	15
Measures.....	15
Procedure.....	18
Ethical Considerations.....	19
Statistical Analysis.....	20
Results.....	22
Sample Characteristics.....	22
Descriptive Statistics.....	22
Unit Weighted Factor Scoring.....	24
General Linear Models.....	26
Discussion.....	28
Confirmatory Phase.....	29
Exploratory Phase.....	29
Limitations and Directions for Future Research.....	30
References.....	33
Appendix A.....	38
Appendix B.....	40
Appendix C.....	43
Appendix D.....	45
Author Note.....	47

LIST OF ABBREVIATIONS

AA	Average Awakening Length
AAF	Adverse Affect Factor
AF	(Physical) Activity Factor
CES-D	Center for Epidemiologic Studies Depression Scale
NEO-FFI	NEO-Five Factor Inventory
NW	Number of Wakeups
PA	Positive Affect
PANAS	Positive and Negative Affect Schedule
PANAS-X	Positive and Negative Affect Schedule - Expanded Form
PSG	Polysomnograph
PSQI	Pittsburgh Sleep Quality Index
PSQIG	PSQI Global Score
SD	Sleep Duration
SF	Sleep Factor
SF-36	Short Form (36) Health Survey
SQ	Sleep Quality
WASO	Wake After Sleep Onset

Physical Activity, Adverse Affect, and Biological Sex Predict Sleep in Young Adults

Introduction

Whether it is through personal or vicarious experience, encounters with research or via the pervasiveness of the media, the link between sleep and both physical and psychological wellbeing is well established. For example, a host of problems ranging from psychological diagnoses such as depression, to physiological ailments such as diabetes, are significantly correlated with diminished or interrupted sleep (Bower, Bylsma, Morris, & Rottenberg, 2010; Darukhanavala et al., 2011). As sleep is of such importance, it is worthwhile considering variables that might affect it. This research explored how physical activity, affect, and biological sex are related to sleep.

Operationalizing and Measuring Sleep

Owing to the immense value of healthy sleep, many researchers have attempted to quantify and assess the phenomenon. Some studies focus solely on objective measures, such as sleep duration, whereas others use more subjective measures of sleep quality. Ranging from physiological measures, such as polysomnography, to psychological self-reports, such as the frequently used Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1988) a variety of sleep measures are currently in use.

Apart from the methodological diversity available in sleep research, sleep as a construct is operationalised in a variety of ways: sleep quantity and quality are the two dominant factors considered in sleep research. Health and general emotional and psychological wellbeing correlate more significantly to sleep quality than to sleep quantity (Pilcher, Ginter, & Sadowsky, 1997). Furthermore, sleep quality has a very low correlation with sleep quantity, .08 (Pilcher et al., 1997). Thus whereas sleep quality and sleep quantity appear to be related, because they overlap little with one another they are often considered to be two distinct factors both relevant to sleep assessment.

Objective and subjective measures of sleep. Owing to the fact that sleep is associated with distinct physiological changes, various objective measures have been developed to capture such changes. The polysomnograph (PSG) is frequently heralded as a gold standard in sleep research (Turner, 2004). A PSG monitors a host of bodily functions, such as brain activity and

eye movement, during sleep. As different physiological states and brain waves are associated with different sleep stages, a PSG provides comprehensive information for use in sleep assessment (Krystal & Edinger, 2008).

Owing to the complexity of the PSG, such tests are usually conducted in a laboratory or hospital setting. Besides the cost of such procedures, the foreignness of the environment in which people are required to sleep is of concern in relation to ecological validity. Bruyneel et al. (2011) measured sleep using a PSG in two different environments: people's homes and a hospital. The greatest difference between the two settings pertained to sleep efficiency: the number of minutes of sleep divided by the number of minutes in bed. Home settings resulted in significantly higher sleep efficiency values in comparison to hospitals. Thus although a PSG is probably the most physiologically comprehensive method of sleep assessment, it has limitations in relation to cost and ecological validity.

Brought onto the market in 2004 and thus relatively new to the field of sleep research is the actigraph. Measuring energy expenditure, ambient light, and various aspects of movement, the actigraph has a host of applications in sleep research. The unnatural environment of sleep laboratories is avoided with the use of the actigraph, which can be worn discretely on a daily basis. Many researchers use the actigraph to estimate sleep efficiency, total sleep time, and number of wake-ups at night referred to as wake after sleep onset (Garnier & Benefice, 2006; Loprinzi, Loprinzi, & Cardinal, 2012).

Actigraphy has been used across many different populations and been found to be a valid and reliable measure of sleep (Van De Water, Holmes, & Hurley, 2011). However, Krystal and Edinger (2008) caution that people often engage in what is referred to as still wakefulness, which on an actigraph may misleadingly appear to be sleep. Furthermore, motor restlessness during sleep, particularly associated with adolescent development, frequently results in deflated total sleep time actigraphic scores (Short, Gradisar, Lack, Wright, & Carskadon, 2012). Thus some concern exists surrounding the validity of using an actigraph as a measure of total sleep time.

As with objective measures of sleep, a variety of subjective measures are currently in use. Concern exists surrounding the reliability of self-reports because sleep is an unconscious pattern of behaviour. However, many subjective measures of sleep have been found to have high concordance rates with objective measures such as the PSG (Rogers, Caruso, & Aldrich, 1993).

The PSQI is perhaps the most frequently used self-report measure of sleep, owing to its high validity and reliability estimates (Buysse et al., 1988). The Medical Outcomes Sleep Study (Hays, Martin, Sesti, & Spritzer, 2005) is another subjective questionnaire that too has psychometrically valuable reliability and validity estimates. Factors such as sleep duration and number of night-time wake-ups are frequently assessed with sleep diaries. Sleep diaries have significantly high correlations with objective measures of sleep such as the PSG and actigraphy (Asaka & Takada, 2011; Rogers et al., 1993).

Despite the frequently high reliability and validity estimates derived from subjective measures, their reliance on subjective perception can be problematic and is a topic of debate. Krystal and Edinger (2008) found it difficult to develop a completely reliable subjective measure of sleep because sleep is influenced by a variety of factors that affect not only the behaviour itself but also the way sleep is perceived. Additionally, whereas some studies show high concordance rates between objective and subjective measures of sleep, others suggest that people often significantly underestimate their sleep duration compared to what a PSG reflects (Jackowska, Dockray, Hendrickx, & Steptoe, 2011). Thus many studies use a combination of objective and subjective measures to gain a more holistic perspective on sleep (Short et al., 2012).

Sleep and Physical Activity

It has long been assumed that a ‘good day’s work’ rewards a person with sound sleep and vice-versa. Whether they are medical studies of the mechanisms behind sleep and physical activity, or behavioural studies correlating the two activities, a multitude of research exists in confirmation of this relationship (Garnier & Benefice, 2006; Santosa, Tufika, & De Melloa, 2007). Foti, Eaton, Lowry, and McKnight-Ely (2011), focusing on adolescents without specific sleep pathologies, found a significant relationship between sufficient sleep and physical activity provided that the level of exercise was greater than 60 minutes per day. Robillard, Rogers, Lambert, Prince, and Carrie (2011) confirmed these results in a relatively nonpathological adult population, suggesting that physical activity is strongly related to more consolidated and deeper sleep.

Whereas Foti et al. (2011) and Robillard et al. (2011) focused on populations with relatively healthy sleep behaviours, Youngstedt et al. (2003) suggested that it is difficult to find a

significant positive relationship between sleep and physical activity in populations without sleep complaints. Youngstedt et al. (2003) argue that unless people have sleep problems that allow room for improvement, sleep is affected by a host of factors, of which physical activity is insignificant. Thus although literature exists in confirmation of the relationship between sleep and physical activity, the generalizability of such results to populations without disordered sleep behaviours is problematic.

Furthermore, when drawing conclusions as to the relationship between sleep and physical activity, most studies implement exercise programs to assess the effect on sleep (Garnier & Benefice, 2006; Santosa et al., 2007). Expectancy effects may improve sleep and inflate the relationship found between the two variables. Furthermore, such studies define physical activity in terms of bouts of exercise rather than general daily levels of physical activity. There is a need for research that explores a more holistic idea of physical activity because many people engage in physically active lifestyles outside of specific exercise routines.

Introducing Affect to the Relationship

Considering sleep and physical activity in isolation portrays a somewhat limited picture of how sleep and physical activity interact. For example, of the 233 patients who visited a major sleep disorders centre in California, 67% reported symptoms of depression in the last five years (Mosko et al., 2006). A study focusing on mediator variables involved in the relationship between physical activity and sleep found that although increased activity results in a significant improvement in sleep, affect is a significant mediator of the relationship: participants with greater depressive symptoms whose sleep improved showed a marked reduction of depressive symptoms (Buman, Hekler, Bliwise, & King, 2011). In his review of literature on the way sleep, cognition, and emotion interact, Walker (2009) supports the notion that sleep and affect are related and that sufficient sleep is connected to lower negative affect and greater positive affect.

Positive and negative affect may appear simply to be binaries of one another. However, it is worthwhile mentioning that they are to a great degree independent of one another and warrant independent consideration (Diener & Emmons, 1984; Watson, Clark, & Tellegen, 1988). Both affect factors can be measured either as traits (i.e., enduring differences in general affective levels) or as states (i.e., transient variations in affect) (Watson, 1988). Positive affect refers to the extent to which one feels enthusiastic, energetic, and attentive (Watson et al., 1988). Low

positive affect pertains to misery and desolation. Conversely, high negative affect refers to aversive mood states distinctly different from low positive affect, such as anger, fear, and nervousness. Therefore, individuals high in negative affect display higher levels of distress, anxiety, and dissatisfaction, and are inclined to focus on the unpleasant aspects of themselves, the world, and the future (Judge & Larsen, 2001). In contrast, low negative affect is a state of calmness and serenity (Watson et al., 1988).

There is a bidirectional relationship between negative affect and sleep: negative affect often leads to poor sleep quality and quantity, which in turn exacerbates negative affect, further worsening sleep problems (Talbot et al., 2012). Positive affect is not only significantly correlated to healthy sleep, but can also buffer individuals from negative psychosocial factors, such as stress. Negative psychosocial factors often hinder sleep, further emphasizing the value of positive affect in relation to healthy sleep (Steptoe, O'Donnell, Marmot, & Wardle, 2007). Hence, both positive and negative affects have significant connections with sleep.

In addition, fatigue is viewed as an affective reaction to poor sleep. Although fatigue, which represents feelings of tiredness and sluggishness, is not defined as one of the basic negative emotions, it is positively correlated with the broad dimension of negative affect and negatively correlated with positive affect (Scott & Judge, 2006). Furthermore, fatigue has been associated with sadness and depression (Bixler et al., 2005). Thus some research suggests that negative affect, fatigue, and sadness are all adverse affective states related to poor sleep (Bixler et al., 2005; Scott & Judge, 2006).

Connecting the Third Side of the Triangle

Perhaps connecting the third side of the triangle is to consider affect and exercise. Aerobic exercise has consistently been found to produce beneficial changes in mood (Berger & Motl, 2000; Giacobbi, Hausenblas, & Frye, 2005). Provided that exercise is not too strenuous, the positive relationship between positive affect and exercise is well established (Sigfusdottir, Asgeirsdottir, Sigurdsson, & Gudjonsson, 2011; Yeung, 1996). The relationship between physical activity and affect appears to be bidirectional in nature: decreased positive affect leads to a decrease in optional physical activity, with physical activity simultaneously resulting in a decrease in negative affect (Jerstad, Boutelle, Ness, & Stice, 2010). As a result, individuals

suffering from depression often remain caught in self-perpetuating cycles of low positive affect and low physical activity.

However, the connection between affect and exercise may be more complicated than it appears. In samples not given prescribed exercise routines and left to their own routines or lack thereof, exercise predominantly increases positive affect, rather than decreasing negative affect alone (Pasco et al., 2011; Reed & Ones, 2006). One may be tempted to assume that exercise decreases negative affect, whereas it often increases positive affect, which buffers against negative affect. However, to further complicate the picture, some researchers have found that exercise is associated with a direct reduction in negative affect with positive affect controlled for (Yeung, 1996). Therefore, considering that both positive and negative affects are independently related to exercise, the relationship between affect and exercise is well established.

The majority of studies that draw conclusions about affect and exercise focus on limited sessions of exercise. Such findings are no doubt valuable. However, there are less concrete findings as to the relationship between general daily activity levels and affect. Sexton, Sogaard, and Olstad (2001) move away from a focus on exercise alone by assessing general activity levels as determined by the degree of physicality of one's job in conjunction with recreational exercise. Rather than all physical activity being beneficial in relation to affect, only recreational activity is significant (Sexton et al., 2001). To explore the possibility that not all types of physical activity influence affect, further research looking at general daily physical activity is required.

Looking at Biological Sex Differences

Much research exists that confirms the influence of biological sex on the variables of physical activity, affect, and sleep. In relation to physical activity, it has been well established that males are generally more active than females. In a study investigating the daily physical activity levels of students using accelerometry, males spent more time engaging in moderate to vigorous physical activity on a daily basis compared to females (Trost et al., 2002). McArthur and Raedeke (2009) confirmed that in both student and adult populations, physical activity is higher in males.

Furthermore, clear differences have been observed in males' and females' experiences of affect. In particular, the intensity of emotional experiences and the capacity to detect and express emotion has been found to be greater in women (Terracciano, McCrae, Hagemann, & Costa,

2003). Moreover, a large body of empirical evidence indicates sex differences in the prevalence of affective disorders such as depression and anxiety. On average, women have been found to experience higher negative affect and lower positive affect. Thus depression and anxiety are more prevalent among females (Voderholzer, Al-Shajlawi, Weske, Feige, & Riemann, 2003).

In contrast to the clear relationships between biological sex and physical activity, and biological sex and affect, findings related to sex differences in sleep are inconclusive. Although it has been established that there are sex differences in sleep architecture using PSG measures, other analyses revealed that there is no evidence that sleep is inherently different in males and females (Voderholzer et al., 2003). Studies using PSG have found that sex hormones influence sleep, particularly at different stages of the menstrual cycle in females (Armitage & Manber, 1999). Furthermore, some research shows that females sleep longer than males, although they report lower sleep quality. However, other evidence reveals that females exhibit higher sleep quantity and quality than males when actigraphy technology is used (Jean-Louis, Mendlowicz, Von Gizycki, Zizi, & Nunes, 1999).

Interestingly, in relation to sex differences and sleep, evidence points towards the interaction of affect. For example, insomnia, which often co-occurs with affective disorders such as anxiety and depression, is more prevalent in females. It has been found that without the interaction of affect, biological sex seems to have very little impact on objective and subjective measures of sleep (Voderholzer et al., 2003).

In conclusion, research supports the notion that sleep, physical activity, and affect are strongly related. Healthy sleep is most strongly related to high positive affect, low negative affect, and relatively high levels of physical activity. However, as Sexton et al. (2001) point out, different types of physical activity have different relationships with affect. Nevertheless, one might reasonably surmise that there is little doubt that sleep, affect, and physical activity are highly related. Furthermore, whether it is through indirect interactions with the aforementioned variables or through direct relationships, biological sex is evidently associated with positive affect, negative affect, physical activity, and sleep.

Rationale and Specific Aims

Sleep is of vital importance to both physical and psychological well-being. Thus research that attempts to explore factors that optimise or hinder sleep is of great value. The current study

aimed to consider sleep, affect, and physical activity simultaneously, and to consider which of these variables had the strongest relationship to sleep. Furthermore, the aim was to consider interaction effects, control for potential third variables, and use composite measures in the aid of shedding light on how the respective variables are related.

Whereas some studies focusing on mediator variables mention affect in relation to sleep and exercise, no published studies intentionally assess affect, physical activity, and sleep simultaneously (Buman et al., 2011). By considering the respective variables simultaneously, one can observe how they interact with one another, which is necessary because the relationship between the variables may not be as simple as it appears. Additionally, there is sparse literature exploring how sleep, affect, and physical activity are related when other variables of potential influence are held constant. For example, living in a university residence as opposed to living at home might affect both an undergraduate's sleep and physical activity levels. If third variables are controlled for, the relationship between sleep, physical activity, and affect might begin to change.

When studies focus on sleep, affect, or physical activity individually, it is common to see multiple measures employed (Garnier & Benefice, 2006; Santosa et al., 2007). However, few studies use multiple measures in the simultaneous assessment of these variables. For example, many studies assess physical activity using data from daily diaries regarding how long one spent exercising and the respective intensity thereof. However, physical activity has an objective component and thus can be defined in a variety of other ways. As variables relevant to the current research are broad, the use of multiple measures in their assessment is valuable in gaining a more holistic understanding of how they relate to one another. The emphasis on gaining a holistic perspective is common in sleep research, yet seldom appears to be the focus of prior physical activity research. Thus this study used multiple measures of physical activity, moving away from a sole reliance on subjective perception.

The majority of studies considering sleep and physical activity focus primarily on positive and negative affect because positive and negative affect account for roughly one half to three quarters of the variance in affect scores (Watson & Clark, 1994). However, there are also specific emotional states that can be identified which are highly related to these constructs. In particular, negative affect is highly related to sadness and fatigue (Bixler et al., 2005; Scott & Judge, 2006). Furthermore, fatigue, sadness, and negative affect share a relatively similar

relationship to sleep and physical activity (Scott & Judge, 2006). Thus this study considered the emotional states of negative affect, fatigue, and sadness together, combining them to form a composite factor referred to as adverse affect.

In conclusion, the aim of this research was to explore how sleep, positive affect, adverse affect, and general physical activity interact in the daily routines of young adults. Using a combination of objective and subjective measures, the study aimed to gain a comprehensive understanding of how sleep, physical activity, and affect are related and potentially interact. To confirm current theoretical understandings of sleep, three directional hypotheses were assessed simultaneously: high positive affect is related to good sleep, low adverse affect is related to good sleep, and high physical activity is related to good sleep.

Additional more exploratory hypotheses were tested in relation to biological sex and potential interactions with the variables. While much research exists in confirmation of the fact that biological sex is highly related to the aforementioned variables, such studies do not assess the variables simultaneously. Simultaneous assessment of the variables is of value in determining how they interact and whether or not the variables have different influences on sleep depending on the sex of the individual. Thus an additional non-directional hypothesis existed: sex interacts with some or all of the variables when predicting sleep.

Design and Methods

Design and Setting

This study was cross-sectional and relational. The goal was to examine sleep, positive affect, adverse affect, and physical activity in a naturalistic environment. Therefore, an observational design was preferable to one that might interfere with how the variables naturally interact. The majority of data capturing occurred as participants went about their everyday lives. Questionnaires pertinent to the study were available online and diaries were completed on a daily basis, enabling participants to fill them out wherever was convenient. Furthermore, data capturing with the use of actigraphs monitored participants' behaviours in their own environments.

The data collected for this study were part of a larger study observing movement patterns in undergraduates at the University of Cape Town (UCT). Thus some additional demands that are not relevant to the current study were placed on participants.

Participants

The total number of participants included in the study was 66. Using G*Power 3.1 (<http://www.psych.uni-duesseldorf.de/aap/projects/gpower/>) and inputting four predictors, a power level of 0.95, and aiming for an effect size of 0.333 (considered to be a moderate effect size), the required sample size was calculated to be 61. As we expected some of the data to be incomplete, we recruited as many participants as possible in the given time frame. Owing to some missing data, the final sample included 66 participants.

Postgraduate students were excluded from the sample because their activity, sleep, and affect may have been distinctly different owing to factors beyond those under investigation. For example, postgraduate students' coursework might be more demanding than that of undergraduates, limiting their activity levels. By focusing on a relatively homogenous sample that controlled for some potential third variables, the goal was to improve methodological strength. Apart from year of study, there were no further exclusion criteria. No specific restrictions were placed on race, sex, or age. These demographic variables formed part of an online questionnaire and were either controlled for or interpreted in the general linear models.

Sampling procedure. Convenience sampling, a non-random sampling technique, was used to recruit participants. Participants were recruited from the UCT Vula website for the Student Research and Participation Programme (SRPP). The announcement on Vula informed participants of what would be required of them and the benefits of participation (Appendix A). All of the participants were enrolled in Psychology courses that required them to participate in research as a course prerequisite and thus volunteered to join the study. Students received all necessary SRPP points for the year and an email containing some of their data in the form of graphs and tables.

Measures

The current research used a variety of measures that converged on the various factors to gain a comprehensive perspective on the relationship among the variables. A combination of

subjective and objective measures was employed. The goal was to maximise the amount of true variance captured in each variable.

PSQI. The PSQI contains 19 self-rated questions that assess sleep over the past month. From the PSQI seven component scores are derived: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. The seven components yield a reliability coefficient of .83, suggesting that each has value in sleep research and measures a specific aspect of the same overall construct, sleep (Buysse et al., 1988). The seven components are summed to provide a global score ranging from 0 to 21 with higher scores indicating poorer sleep quality: scores above 5 suggest clinically problematic sleep.

Carpenter and Andrykowski (1998) found that the PSQI has a test-retest reliability estimate of .8. Similarly, Backhaus, Junghanns, Broocks, Riemann, and Hohagen (2002) gave the PSQI to the same participants at three different time intervals and found an average test-retest reliability of .87. The test correlates moderately to highly with similar construct measures, indicating high construct validity, and correlates poorly to unrelated measures, demonstrating high discriminant validity (Carpenter & Andrykowski, 1998).

The PSQI is slightly less effective in a non-western population such as Nigeria (Aloba, Adewuya, Ola, & Mapayi, 2007). Nevertheless, in such a population, the PSQI maintained the ability to discriminate significantly between participants with clinical diagnoses of insomnia, as determined by the DSM-IV, and normal sleepers. As the current sample was South African, it was important that we employed a measure that maintained its psychometric properties across diverse samples.

Positive and Negative Affect Schedule: Expanded version (PANAS-X). The PANAS-X (Watson & Clark, 1994) is a 60-item mood scale and requires participants to respond on a 5-point rating scale indicating the degree to which they have experienced the respective emotion in a specified time period. The PANAS-X was created to assess emotional experience. While the PANAS-X measures 11 specific affects, it contains two original higher order scales that assess positive and negative affects. These two general dimensions account for most of the variance in self-rated affect: when combined they account for approximately half to three-quarters of the common variance in affect (Watson & Tellegen, 1985).

Trait scores from the PANAS-X are stable over time, with test-retest coefficients ranging from .51 to .71 (Watson & Clark, 1994). Discriminant and convergent validity have been found to be high for all the various affective states except 'surprise'. The PANAS-X is strongly related to other measures of affect and emotionality. For example, in relation to the Profile of Mood States that is a commonly used affect scale, convergent correlations ranged from .85 to .91 (Watson & Clark, 1994). Thus apart from the specific affective state of surprise, the PANAS-X is a valid measure of individual differences in affect over long periods of time.

In particular, in relation to both positive and negative affects, the PANAS-X has reliability estimates above .8 in non-clinical populations (Watson & Clark, 1994). The PANAS-X's sensitivity to affective differences in non-clinical populations was important for the current study, as the majority of participants were unlikely to have extreme scores. Thus whereas many measures of affect are used predominantly as diagnostic tools to separate problematic affect from 'normal' affect, the PANAS-X is sensitive enough to capture subtle differences between individuals without mood disorders (Watson & Clark, 1994). Additionally, the PANAS-X is derived from an original measure, the PANAS, which is a stable and valid measure across diverse demographic groups, being of value for use in South African populations that are known for diversity (Crawford & Henry, 2004).

Sleep diary. Sleep diaries have high correlations with data from PSGs and actigraphs (Abraham, 2009; Asaka & Takada, 2011; Rogers et al., 1993). The sleep diary that was employed in this research included questions about sleep quantity and quality (Appendix B). The sleep diary formed part of a general daily diary, containing questions pertinent to the larger study. The diary was printed on the front and back of one A4 page.

Actigraph. The GT3X + (512MB) Activity Monitor records a host of measurements, such as number of steps taken, light exposure, and calorie expenditure. One of the benefits of this device is its compact size, allowing it to be worn discretely: it weighs 19g and is 4.6cm x 3.3cm x 1.9cm. The actigraphs were worn on an elastic belt around the hips and positioned on the right side.

Tryon (2005) assessed the validity and reliability of two different makes of actigraphs in relation to measuring daily physical activity. Both yielded validity coefficients of .99. Additionally, the actigraph appears to be a stable measure of activity as reliability coefficients are generally about .98, regardless of the make (Tryon, 2005). Actigraphic data increases in

reliability the longer the device is worn (Wood, Kuntsi, Asherson, & Saudino, 2008). Thus wearing the devices for four complete days and two half days was in aid of increasing reliability.

Whereas actigraphs are frequently employed in sleep research, their use in this domain is more complicated than in relation to physical activity. As Krystal and Edinger (2008) caution, people often engage in what is referred to as still wakefulness, which on an actigraph misleadingly appears to be sleep. A focus on adolescents reveals some discrepancies between subjective sleep data and actigraphs (Short et al., 2012). Actigraphically scored night-time wake-ups are higher than self-report data, whereas actigraphic measures of total sleep time are lower than self-reports suggest. Adolescent sleep is often marked by significantly greater motor activity, which on an actigraph appears to be wakefulness (Short et al., 2012). Although the sample for the current research was hoped to have matured beyond this unstable period of motor activity during sleep, care was taken when interpreting actigraphic measures of sleep, with sleep diaries providing valuable comparisons.

The actigraph provides sleep duration and sleep efficiency data that are not significantly different from PSG measures of sleep (Kushida et al., 2001). Additionally, the number of wake-ups in the night is not significantly different when measured by an actigraph as opposed to a PSG (Kushida et al., 2001). Thus an actigraph was a reliable and valid alternative to the PSG for the current research. Additionally, as this research attempted to gain a broad, general approximation of sleep and also aimed to measure physical activity variables, the actigraph was more appropriate than a PSG. Furthermore, the diverse and precise information that a PSG provides was not necessary for the purposes of this research.

Procedure

Initial questionnaire. From a hyperlink on Vula, participants who decided to participate were directed to the first battery of online questionnaires. This battery contained questions pertinent to demographics (Appendix C) and the larger study (Mini-K and NEO-FFI). The questionnaire took roughly half an hour to complete. Having finished the online questionnaire, participants signed up for the group that best suited their timetables.

Receiving the devices. Participants met the researchers at the ACSENT laboratory where the informed consent procedure was explained, giving participants the opportunity to withdraw. The group of participants waited outside as each person had their height and weight

measurements taken and recorded in the actigraph software. They were given the actigraph on a waist belt and received an explanation of how the device worked. It was emphasized that the device should be worn at all times, except in water. The diaries were given to participants along with detailed instructions. This first session lasted about half an hour.

Wearing the devices. Participants collected the equipment either on a Wednesday or a Friday, allowing two full weekdays and two full weekend days of data collection. When participants collected the devices they were asked to wear the belt for the rest of the day, although only the data collected from the four full days was used in the analysis. The devices were worn on a belt under their clothes so as not to interfere with their daily routines. Along with wearing the devices, participants filled out the sleep section of the diary every morning and a section pertinent to the larger study at night.

Returning the devices. Having worn the devices for four complete days and two half days, participants returned the devices to the laboratory. This session was as brief as possible and gave participants a chance to remove some or all of their data. Debriefing was suspended until the last questionnaire had been completed.

Final questionnaire and debriefing. The final online questionnaire included the retrospective questionnaires relating to sleep and affect: the PSQI and the PANAS-X. Included in this questionnaire were measures pertinent to the larger study: the Short Form (36) Health Survey (SF-36) and the Centre for Epidemiologic Studies Depression Scale (CES-D). The questionnaire was slightly longer than the first and took roughly 45 minutes to complete. Upon completion participants were sent a debriefing form describing the study in detail. A few weeks later participants received graphical representations of their data.

Ethical Considerations

Ethical approval was granted by the Psychology Department of UCT. Owing to the nature of the study, the information collected was especially personal, requiring careful handling. Therefore, it was of great importance that participants were well informed.

Consent and incentives. Participants read through comprehensive consent forms at the beginning of both online questionnaires (Appendix D). They were informed that their participation was voluntary and that they could withdraw from the study at any time without any repercussions. Additionally, when participants returned the devices they were given the

opportunity to remove some or all of their data. The study placed a high demand on participants' time and required commitment over a period of six days. Therefore, participants received all of their SRPP points for the year.

Confidentiality. Confidentiality was emphasised to ensure that participants did not feel that their privacy was violated and in the hope that they would not drastically alter their normal behaviour. An issue of particular importance was that participants were made aware that in no way could researchers monitor their activity in real-time.

Deception. Participants were vaguely aware of the purpose of the study, referred to as 'The Human Movement Study' on recruitment announcements. Thus they were aware that movement and activity were of importance. The online questionnaires may have sensitised participants to the fact that affect and sleep were of importance in the study. However, as sleep and affect are relatively stable this was a minor concern.

Debriefing. Debriefing partially occurred on the day the participants returned the devices. However, the main aims of the study were withheld until completion of the second online questionnaire. Once the participant filled out the final online questionnaire, the participant was informed of the full purpose of the study via email.

Statistical Analysis

The current study was observational in nature and attempted to discover how three variables, namely positive affect, adverse affect, and physical activity are related to sleep. We tested a series of general linear models to determine which variables predicted statistically significant proportions of variance in sleep. Since it was conceivable that the predictor variables may interact with each other in ways that might lead to more precise theory, we included plausible interaction terms when predicting sleep.

The following demographic variables were controlled for in the models: age, biological sex, test/exam written one week prior or in the week to come, race, and place of residence. While little research suggests that race has direct implications for sleep, affect, or physical activity, race in South Africa is often a proxy for other factors such as socio-economic status. Thus controlling for race was a means of controlling for 'hidden' demographic factors.

Unit-weighted factor scoring. As the variables of interest were tapped using a variety of measures, the measures had to be combined to create factor scores for each variable. Unit

weighted factor scoring is a method of data aggregation. It is done by calculating the z-scores for each variable and finding the average of those z-scores (Gorsuch, 1983). This method was used since we did not have a large enough sample size to run a proper factor analysis. We excluded an indicator variable when it did not correlate higher than .6 with the factor, as .6 is a statistical convention (Gorsuch, 1983).

The sleep variables included in the sleep factor were selected by taking one variable from each measure that had the highest item total correlation. Thus the sleep factor was derived by considering the following variables:

- PSQI - global score
- Sleep diary - sleep quality and average number of awakenings
- Actigraph - sleep duration, sleep efficiency, number of wake-ups, and average length of wakeups.

The physical activity factor took into consideration the average number of calories per day and the average number of steps per day. As measured by the PANAS-X, negative affect, fatigue, and sadness were considered for the adverse affect factor. Positive affect consisted of one variable and thus was not a factor.

Confirmatory general linear model. After factors were created by selecting the most appropriate variables, a linear model was created using combinations of demographic variables and predictor variables to predict the sleep factor. We started with an inclusive model that included all the predictors and interactions we wanted to test. We then estimated a series of restricted models. In every one of these nested models we partitioned the variance hierarchically and systematically eliminated statistically non-significant three-way interaction terms first, then statistically non-significant two-way interaction terms, and finally eliminated statistically non-significant main effects. The goal of this statistical approach was to arrive at a model that is parsimonious and explains the maximum amount of variance.

Exploratory general linear model. The above procedure was repeated but instead of considering biological sex as a pure control variable, we treated it as theoretically interesting and interacted biological sex with adverse affect, positive affect, and physical activity. Hierarchically partitioning variance in this manner allowed us to test various hypotheses against each other. This was done because from the literature, we suspected that biological sex might have different implications for the variables. Thus sex was included in the second model in addition to the

factors to determine if this variable significantly affected the way the variables were related to sleep.

Results

Sample Characteristics

The average age of participants in years was 20.45. There were 52 females and 14 males. Of the sample, 15 classified themselves as black, 30 as white, 11 as coloured, 4 as Asian, 4 as Indian and 2 as other or 'prefer not to say.' 50 participants were South African. The remaining 16 participants were from Mauritius, Norway, Zimbabwe, Qatar, Malawi, Botswana, and Kenya. 54 of the participants were studying a degree in Humanities and the remaining 12 were from the Health Sciences Faculty. The participants ranged from being in first year to fourth year, with no postgraduate students.

Seven participants removed the actigraphs and forgot to put them back on for a period of at least one day. Thus for seven participants some data was missing. However, in the final sample of 66, none of the data was completely unusable because of missing data or problems with the devices.

Descriptive Statistics

Table 1.

Means and standard deviations

Variable	Mean	Standard Deviation
SQ	3.75	.69
WASO	1.45	1.04
AA	3.59	3.72
NW	6.14	3.44
SE	95.92	2.81
SD	444.81	62.23
PSQIG	5.61	2.69
Calories	707	411.12
Steps	14089.64	5390.13
PA	31.21	6.91
NA	21.33	8.42
Fatigue	11.17	3.86
Sadness	9.91	4.5

Note. Sleep Diary: SQ = Sleep Quality, WASO = Wake After Sleep Onset; Actigraph: AA = Average Awakening Length, NW = Number of Wakeups, SE = Sleep Efficiency, SD = Sleep Duration; PSQIG = Global PSQI Score; PA = Positive Affect, NA = Negative Affect.

Table 2, Table 3, and Table 4 display the inter-correlations of the sleep variables, activity variables, and affect variables respectively. The PSQI global scores ranged from 0 to 13, with an overall group mean of 5.61. Out of the 66 participants, 27 scored above five on the PSQI. This was interesting as scores above five indicate clinically meaningfully disturbed or poor sleep. However, while the mean of the sample was above five, the majority of the sample scored under five, suggesting that the mean might have been inflated by excessively problematic sleepers.

Table 2.

Inter-correlations among sleep variables

	SQ	WASOAA	NW	SE	SD	C1	C2	C3	C4	C5	C6	C7	PSQIG	
SQ	1	-.42**	.08	.25*	-.24	.14	-.53**	-.29*	-.19	-.01	-.18	.09	-.23	-.39**
WASO		1	.13	-.08	-.06	-.15	.17	.15	.11	.13	.09	-.03	.14	.21
AA			1	.16	-.36**	-.01	-.04	-.10	.01	-.01	-.04	-.11	-.06	-.06
NW				1	-.53**	.29*	-.13	-.08	-.15	-.04	.01	-.10	-.29*	-.22
SE					1	.14	.20	.16	-.02	-.24	-.08	.05	.10	.08
SD						1	-.18	-.09	-.58**	-.27*	-.15	-.07	-.17	-.44**
C1							1	.28*	.38**	.01	.36**	-.07	.23	.62**
C2								1	.19	-.04	.28*	.11	.06	.55**
C3									1	.38**	.18	.05	.13	.69**
C4										1	.05	.04	.07	.40**
C5											1	.17	.33**	.56**
C6												1	.24	.32**
C7													1	.53**
PSQIG														1

Note. Sleep diary: SQ = Sleep Quality, WASO = Wake After Sleep Onset; Actigraph: AA = Average Awakening Length, NW = Number of Wakeups, SE = Sleep Efficiency, SD = Sleep Duration; PSQI: C1 = Subjective Sleep Quality, C2 = Sleep Latency, C3 = Sleep Duration, C4 = Habitual Sleep Efficiency, C5 = Sleep Disturbances, C6 = Use of Sleeping Medication, C7 = Daytime Dysfunction, PSQIG = Global PSQI Score.

*. Correlation is significant at the .05 level (2-tailed).

** . Correlation is significant at the .01 level (2-tailed).

Table 3.

Inter-correlations between activity variables

	Calories	Steps
Calories	1	.765**
Steps		1

Note. **. Correlation is significant at the .01 level (2-tailed)

Table 4.
Inter-correlations among affect variables

	Positive Affect	Negative Affect	Fatigue	Sadness
Positive Affect	1	-.180	-.221	-.253
Negative Affect		1	.591**	.694**
Fatigue			1	.342*
Sadness				1

Note. *. Correlation is significant at the .05 level (2-tailed).

** . Correlation is significant at the .01 level (2-tailed).

In relation to the skew of the data, actigraphically determined sleep duration, sleep diary sleep quality, the global PSQI score and number of steps taken were all normally distributed. The number of wake-ups determined by the actigraph was positively skewed. A potential reason for this skew may be due to a floor effect because scores below 0 were not obtainable. The data for the average length of awakenings was also strongly positively skewed. While outliers had a role to play, when they were accounted for, the data remained slightly skewed, potentially attributable to the sample size. For sleep efficiency, there was a strong negative skew, possibly owing to the fact that sleep efficiency scores are usually above 90%, illustrative of another floor effect. Thus while the data is skewed, its conformity to theoretical understandings of sleep suggests that the skew was not cause for concern. The data for wake after sleep onset scores from the diaries were positively skewed. Once again, this was expected because the sample did not consist of participants with major sleep disorders. The data for calories expended is slightly positively skewed.

Unit Weighted Factor Scoring

Sleep factor. The final sleep factor was comprised of the PSQI global score, actigraphically determined sleep duration, and sleep diary sleep quality, ensuring all measures were represented in the final factor. The PSQI global score and sleep quality were highly correlated (Table 2). Sleep duration and the PSQI were also highly correlated (Table 2). While sleep efficiency correlated highly with number of awakenings and average length of awakenings, these measures did not correlate highly with the global PSQI and thus high correlations observed were likely due to shared method variance.

Table 5 shows item total correlations for the sleep factor. The global PSQI had the highest item total correlation with the sleep factor. However, sleep quality and sleep duration were also above the threshold of .6 and were thus retained in the final sleep factor.

Table 5.

Item total correlations for sleep factors

	Item total r
PSQI Global	.82
SD	.71
SQ	.69

Note. SD = Sleep Duration, SQ = Sleep Quality.

Physical activity factor. The physical activity factor was comprised of daily calorie expenditure and number of steps. These variables are correlated at a significance level of .01 (Table 3). The item total correlations reveal that both variables are above the threshold of .6 and were thus retained (Table 6).

Table 6.

Item total correlations for physical activity factor

	Item total r
Calories	.84
Steps	.77

Adverse affect factor. Negative affect, sadness, and fatigue are all highly inter-correlated at a significance level of at least .05 (Table 4). However, as expected positive affect was not highly correlated with any of these affect variables (Table 4). Thus positive affect was excluded and used as its own variable. Therefore, sadness, fatigue, and negative affect comprised the final adverse affect factor. The item total correlations for the adverse affect factor were all above the threshold of .6 (Table 7).

Table 7.

Item total correlations for adverse affect factor

	Item total r
Fatigue	.77
Sadness	.81
Negative Affect	.91

General Linear Models

Confirmatory general linear model. The first model predicted the sleep factor using the demographic variable of race and the adverse affect factor. The model explained 42% of the variance in the sleep factor. Taking into account the degrees of freedom of the model, the amount of variance explained was 35%. The resulting model was statistically significant, $F(7,58) = 6.03$, $p < .001$. The final model's equation is illustrated in Table 8. It appears that the categories 'other' and 'prefer not to say' are driving the significance found in the race variable (Table 8). These two groups had small sample sizes, both below two, which may be potentially responsible for the significance found. Nevertheless, both race and adverse affect factor are significant predictors of sleep (Table 9).

Table 8.

General linear model predicting sleep factor

Coefficients	Estimate	Std. Error	t	p
Intercept	.32	.30	1.08	.283
Race Black	-.52	.34	-1.55	.128
Race Coloured	-.63	.35	-1.81	.076
Race Indian	-.10	.43	-.23	.816
Race Other	-2.40	.67	-3.59	.001***
Race Prefer Not Say	-1.2	.67	-1.77	.081
Race White	-.09	.32	-.28	.782
AAF	-.33	.09	-3.49	.001***

Note. AAF = Adverse Affect Factor.

***. Significant at the .001 level (2-tailed).

Table 9.

ANOVA table predicting sleep factor

Coefficients	df	F ratio	p
Race	6	5.01	.001***
AAF	1	12.2	.001***

Note. AAF = Adverse Affect Factor.

***. Significant at the .001 level (2-tailed).

Exploratory general linear model. Using sex as a variable rather than a control, the second model predicted the sleep factor using race, and an interaction between sex, the adverse affect factor, and the physical activity factor. The model explained more of the variance in sleep than the previous model: 53.01%. Taking into account the degrees of freedom of the model, the amount of variance explained was 37.67%. The resulting model was statistically significant, $F(16,49) = 3.46$, $p < .001$. The resulting equation can be deduced from Table 10.

Table 10.

ANOVA table predicting sleep factor

Coefficients	<i>df</i>	<i>F</i> ratio	<i>p</i>
Intercept	1	.03	.87
Race	6	4.25	.002**
Sex	1	3.78	.06
AAF	1	.53	.47
AF	1	.23	.64
Sex : AF	1	1.14	.29
Sex : AAF	1	1.21	.28
AAF : AF	1	2.29	.14
Sex : AAF : AF	1	5.22	.03*

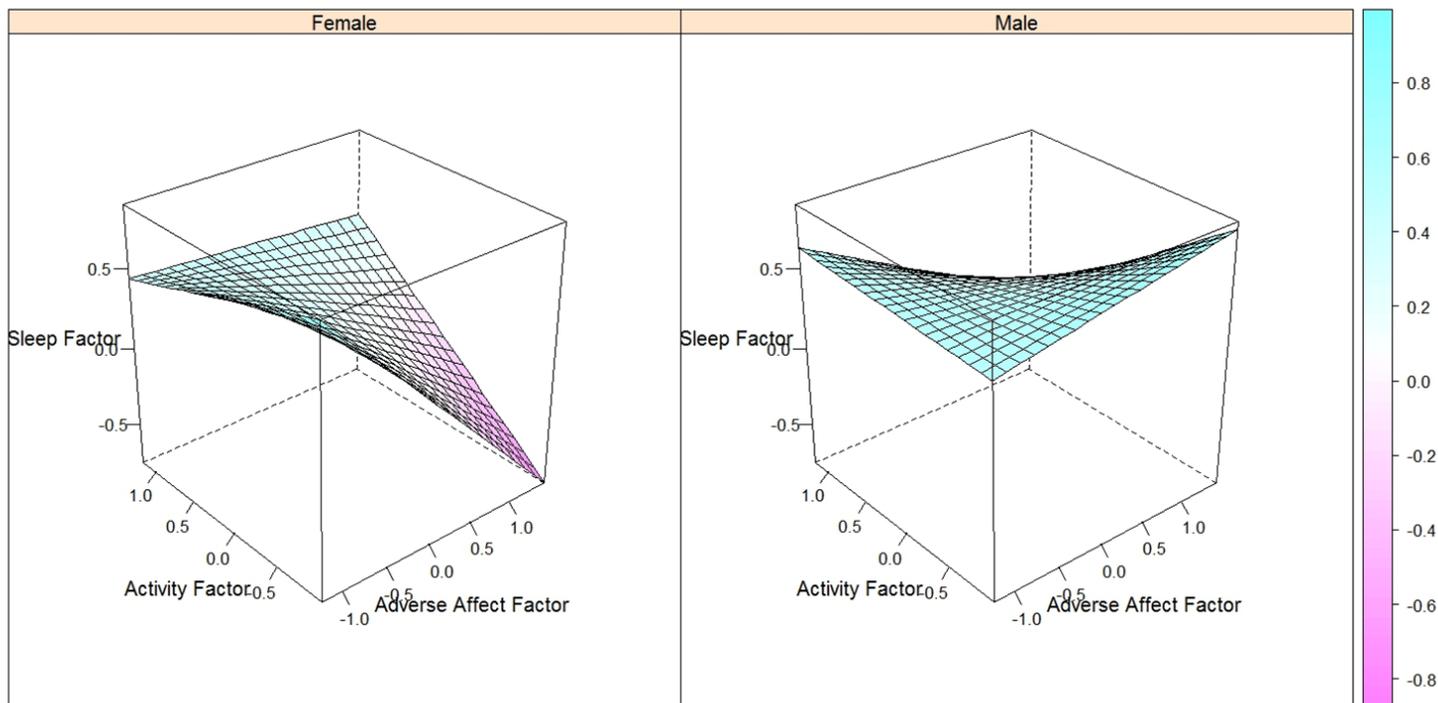
Note. AAF = Adverse Affect Factor, AF = Physical Activity Factor.

*. Significant at the .05 level (2-tailed).

**. Significant at the .01 level (2-tailed).

Positive affect was excluded because it did not have a significant main effect or interaction effect. Surprisingly neither of the factors, namely adverse affect and physical activity had main effects on sleep. Biological sex showed a trend towards significantly predicting sleep (Table 10). Nonetheless, such main effects were retained in the final model to follow statistical convention and show that the interaction is statistically significant beyond the main effects of the respective variables. The interaction among sex, adverse affect factor, and physical activity factor is illustrated in Figure 1.

Figure 1: The interaction among sleep, negative affect and physical activity



In some ways this interaction goes against current theoretical understandings of the relationships amongst the variables. As expected, females who have low adverse affect sleep well (Figure 1). Furthermore, females with high physical activity levels slept well regardless of their affect scores. However, females who had high adverse affect and low physical activity slept worse than males with such scores (Figure 1). The interaction reveals that when a female has particularly low physical activity and high adverse affect, her sleep is negatively affected.

In relation to males, at low levels of physical activity sleep was good (Figure 1). Similarly, males with low adverse affect and high physical activity slept well. However, at high levels of adverse affect and high levels of physical activity males exhibited poor sleep. This is different to what was observed in females: while females who had high adverse affect slept poorly, such poor sleep was only observed in instances of low physical activity. Thus the interaction among sex, physical activity, and adverse affect revealed that high adverse affect is related to poor sleep in males only if they have high physical activity, whereas for females, poor sleep was observed only at low levels of physical activity.

Discussion

In light of the immense importance of sleep, studies that explore factors affecting sleep can be of great value. The current research focused on the following factors: positive affect, adverse affect, and physical activity. An additional variable found to be of significance was biological sex. While literature exists in relation to sleep and the aforementioned variables, little research explores the constructs simultaneously. Thus prior research has not explored interactions.

The current study moved away from a sole reliance on self-reports by using multiple measures. The majority of studies explore physical activity in relation to bouts of exercise and fail to capture a holistic sense of a person's physical activity. Thus with the use of both objective and subjective measures, the current study examined how positive affect, adverse affect, and physical activity were related to sleep in undergraduate students. Furthermore, as biological sex appeared to influence the variables, we aimed to explore these relationships simultaneously, allowing interactions to be identified.

General linear models were constructed with the sleep factor as the outcome variable. Demographic variables were included in the models to control for their potential effect on the variables. Surprisingly very few demographic variables affected sleep significantly: the only significant demographic predictor of sleep was race. This is potentially due to the complex position of race in South Africa and its possible connection to a variety of other factors. However, two groups with small sample sizes, 'other' and 'prefer not to say,' might have been responsible for the significance of the race category. Biological sex was included as a demographic control variable in the first model and as a variable on its own in the second model. Ultimately two final significant models were created explaining 42% and 53% of the variance in sleep respectively.

Confirmatory Phase

There were multiple working hypotheses in relation to the confirmatory phase of the analysis. The following hypotheses were tested against one another: high positive affect is related to good sleep, low adverse affect is related to good sleep, and high physical activity is related to good sleep. The strongest predictor of sleep in this model was the adverse affect factor, comprised of sadness, fatigue, and negative affect. The other two hypotheses were not supported.

Thus the data in some ways conformed to current theoretical understandings of sleep: adverse affect is inversely related to sleep. Surprisingly positive affect was excluded from the final model because it was found to be a weak predictor of the sleep factor, possibly because positive affect was the only predictor not to be comprised of multiple variables. Physical activity was also found to have no significant main effect with sleep, possibly owing to the holistic definition of physical activity that intentionally moved away from the prior focus on limited bouts of exercise.

Exploratory Phase

In the exploratory phase of the analysis, non-directional hypotheses were explored: sex interacts with some or all of the variables when predicting sleep. In the general linear model in this phase, the interaction among sex, adverse affect factor, and physical activity factor is potentially important to theory. Few prior studies considered the variables in combination and as a result, potentially important interactions have not been found.

In some ways the interaction conformed to current research, although only at certain levels of the variables. As research suggests, the adverse affect factor was found to be associated with poor sleep in both sexes (Scott & Judge, 2006; Talbot et al., 2012). However, in this study, with regards to females, poor sleep was observed only if high levels of the adverse affect factor co-occurred with low levels of the physical activity factor. In contrast, with regards to males, those with high adverse affect factor slept poorly only if high adverse affect factor scores co-occurred with high levels of physical activity. Therefore, in this instance the general theory that high physical activity and low adverse affect result in better sleep may not be complete. The relationship between such variables might not be rectilinear as theory predicts.

Limitations and Directions for Future Research

One of the limitations of this study was our unfamiliarity with the actigraphs. As a result, setting the sensitivity levels and coding much of the sleep data from the software allows room for improvement in future studies. Variables such as sleep efficiency and number of awakenings were excluded from the sleep factor as they had very low inter-correlations and item-total correlations. However, this may have been as a result of the way in which the sensitivity of the actigraphs was set rather than problems with the actual variables themselves.

As prior literature has asserted, adolescents tend to be restless at night (Short et al., 2012). We had hoped that young adults would not conform to this erratic pattern of movement during sleep. However, perhaps the inaccuracy of the actigraph in relation to measuring night-time wake-ups was in part due to the possibility that the sample had not matured beyond this phase. Thus as the actigraph relies solely on movement, measures pertinent to night-time movement may have incorrectly represented restlessness as wakefulness. As a result, relatively little of the actigraphically derived sleep data was usable. Thus we may have potentially robbed the sleep factor of useful variables. Future research might be conducted focusing specifically on the accuracy of actigraphs and perhaps determine which aspects of sleep the actigraph is most suited to assessing in a young adult population.

In relation to the physical activity factor, there was speculation that the actigraph was biased against certain movement types. Participants who reported having been avid cyclists had low or average caloric scores, suggesting that the actigraph is more favoured towards running or more obvious movements. Additionally, whereas the other factors all in some way incorporated

self-report data, the physical activity factor relied solely on actigraphic data, potentially limiting the shared variance it had with other measures on a purely methodological level. This could be addressed in further studies by including a self-report measure in the daily diary of physical activity.

While the actigraph was potentially biased towards certain movement types, the insignificance of the main effect for physical activity may be as a result of other reasons. As mentioned in the literature review, the majority of literature focuses on bouts of exercise or implemented exercise routines rather than general daily physical activity (Garnier & Benefice, 2006; Santosa et al., 2007). Sexton et al. (2001) make a point of distinguishing between general daily physical activity and recreational physical activity, arguing that only the latter significantly increases positive affect. If such was the case for affect, it seems reasonable to surmise that in conjunction with our findings, physical activity ought to be further explored in relation to daily physical activity and sleep. Thus the finding that the physical activity factor did not have a significant main effect with the sleep factor might mean that prior conceptions of the relationship between sleep and physical activity have not captured the latter concept holistically, being an avenue for further research.

The fact that the sample included a greater number of females than males means that rather than interpreting the findings as absolute, the interaction should be seen as a valuable avenue for future research. Although it was expected that few males would participate, we were unable to control for this in the design of the study owing to our sample being recruited from Psychology classes that typically include a greater number of females than males. Thus while significant sex differences were observed and outliers in each group were assessed to ensure that groups, particularly the male group, were not unduly affected by outliers, a larger number of males would have been preferable. Further research, apart from attempting to have a larger sample in general to detect greater effect sizes, could focus on including a greater number of males so that more meaningful comparisons might be drawn.

Positive affect did not perform as well as the other factors in the general linear models, possibly because it was comprised of only one individual score derived from the PANAS-X. Thus in future studies, additional measures of positive affect could be employed. Alternatively, as was done for adverse affect factor, literature could be consulted to identify other emotional

states that are highly related to positive affect to create a more composite measure of the construct.

Race was found to be a strong predictor of sleep in all the models. Thus further studies could explore the deeper implications of race by examining related demographic variables in further depth. For example, in South Africa race is often related to circumstances linked to socioeconomic status, which may affect sleep differently.

Additionally, in future research it may be valuable to explore further the interaction found among adverse affect, physical activity, and sex from a theoretical paradigm. For example, it is possible that the interaction observed in this study is related to evolutionary underpinnings regarding the ways in which males and females manage adverse affect. Based on the findings of the interaction one might explore the possibility of sex differences in evolutionary coping mechanisms.

In conclusion, these results indicate that sadness, fatigue, and negative affect combined as a factor are the greatest predictors of sleep. The only relevant demographic or contextual variable in relation to predicting sleep was race. The positive affect factor was not a significant predictor of sleep. Furthermore, the physical activity factor on its own was not a significant predictor of the sleep factor.

The current research ultimately suggests that biological sex may be valuable when exploring how sleep is related to affect and physical activity because sex is intimately intertwined with these variables and appears to affect each differently. Thus the findings of the current study are valuable as they suggest that current theoretical understandings of how positive affect, adverse affect, and physical activity are related to sleep may not be as sound as expected. As sleep is important for physical and psychological wellbeing it is worthwhile exploring further whether such findings are related to methodological issues such as a restricted sample size, or are genuine differences in how these variables relate to one another.

References

- Abraham, T. L. (2009). *Comparison of accelerometers and a self-report record*. (Unpublished doctoral dissertation). Arizona State University, Arizona.
- Aloba, O., Adewuya, A., Ola, B., & Mapayi, B. (2007). Validity of the Pittsburgh Sleep Quality Index (PSQI) among Nigerian university students. *Sleep Medicine, 8*, 266-270.
- Armitage, R., & Manber, R. (1999). Sex, steroids, and sleep: A review. *Sleep, 22*, 540-555.
- Asaka, Y., & Takada, S. (2011). Comparing sleep measures of infants derived from parental reports in sleep diaries and acceleration sensors. *Acta Paediatrica, 100*, 1158-1163.
- Backhaus, J., Junghanns, K., Broocks, A., Riemann, D., & Hohagen, F., (2002). Test-retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. *Journal of Psychosomatic Research, 53*, 737-740.
- Berger, B. G., & Motl, R. W. (2000). Exercise and mood: A selective review and synthesis of research employing the profile of mood states. *Journal of Applied Sport Psychology, 12*, 69-92.
- Bixler, E. O., Vgontzas, A. N., Lin, H. M., Calhoun, S. L., Vela-Bueno, A., & Kales, A. (2005). Excessive daytime sleepiness in a general population sample: The role of sleep apnea, age, obesity, diabetes, and depression. *Journal of Clinical Endocrinology & Metabolism, 90*, 4510-4515.
- Bower, B., Bylisma, L. M., Morris, B. H., & Rottenberg, J. (2010). Poor reported sleep quality predicts low positive affect in daily life among healthy and mood-disordered persons. *Journal of Sleep Research, 19*, 323-332.
- Bruyneel, M., Sanida, C., Art, G., Libert, W., Cuvelier, L., Paesmans, M., ... Ninane, V. (2011). Sleep efficiency during sleep studies: results of a prospective study comparing home-based and in-hospital polysomnography. *Journal of Sleep Research, 20*, 201-206.
- Buman, M. P., Hekler, E. B., Bliwise, D. L., & King, A. C. (2011). Moderators and mediators of exercise-induced objective sleep improvements in midlife and older adults with sleep complaints. *Health Psychology, 30*, 579-587.
- Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1988). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*, 193-213.

- Carpenter, J. S., & Andrykowski, M. A. (1998). Psychometric evaluation of the Pittsburgh Sleep Quality Index. *Journal of Psychosomatic Research, 45*, 5-13.
- Crawford, J. R., & Henry, J. D. (2004). The positive and negative affect schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*, 245-265.
- Darukhanavala, A., Booth, J. N., Bromley, L., Whitmore, H., Imperial, J., & Penev, P. D. (2011). Changes in insulin secretion and action in adults with familial risk for Type 2 diabetes who curtail their sleep. *Diabetes Care, 34*, 2259-2264.
- Diener, E., & Emmons, R. A. (1984). The independence of positive and negative affect. *Journal of Personality and Social Psychology, 47*, 1105-1117.
- Foti, K. E., Eaton, D. K., Lowry, R., & McKnight-Ely, L. R. (2011). Sufficient sleep, physical activity, and sedentary behaviors. *American Journal of Preventive Medicine, 41*, 596-602.
- Garnier, D., & Benefice, A. (2006). Reliable method to estimate characteristics of sleep and physical inactivity in free-living conditions using accelerometry. *Annals of Epidemiology, 16*, 364-369.
- Giacobbi, P. R., Hausenblas, H. A., & Frye, N. (2005). A naturalistic assessment of the relationship between personality, daily life events, leisure-time exercise, and mood. *Psychology of Sport & Exercise, 6*, 67-81.
- Gorsuch, R. L. (1983). *Factor Analysis (2nd ed.)*. London: Lawrence Erlbaum Associates.
- Hays, R. D., Martin, S. A., Sesti, M., & Spritzer, K. L. (2005). Psychometric properties of the medical outcomes study sleep measure. *Sleep Medicine, 6*, 41-44.
- Jackowska, M., Dockray, S., Hendrickx, H., & Steptoe, A. (2011). Psychosocial factors and sleep efficiency: Discrepancies between subjective and objective evaluations of sleep. *Psychosomatic Medicine, 73*, 810-816.
- Jean-Louis, G., Mendlowicz, M. V., Von Gizycki, H., Zizi, F., & Nunes, J. (1999). Assessment of physical activity and sleep by actigraphy: Examination of gender differences. *Journal of Women's Health and Gender-Based Medicine, 8*, 1113-1117.
- Jerstad, S. J., Boutelle, K. N., Ness, K. K., & Stice, E. (2010). Prospective reciprocal relations between physical activity and depression in adolescent females. *Journal of Consulting and Clinical Psychology, 78*, 268-272.

- Judge, T. A., & Larsen, R. J. (2001). Dispositional affect and job satisfaction: A review and theoretical extension. *Organizational Behavior and Human Decision Processes*, 86, 67-98.
- Kushida, C. A., Chang, A., Gadkary, C., Guilleminault, C., Carrillo, O., & Dement, W. C. (2001). Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. *Sleep Medicine*, 2, 389-396.
- Krystal, A. D., & Edinger, J. D. (2008). Measuring sleep quality. *Sleep Medicine*, 9, 10-17.
- Loprinzi, P. D., Loprinzi, K. L., & Cardinal, B. J. (2012). The relationship between physical activity and sleep among pregnant women. *Mental Health and Physical Activity*, 1, 1-6.
- McArthur, L. H., & Raedeke, T. D. (2009). Race and sex differences in college student physical activity correlates. *American Journal of Health Behavior*, 33, 80-90.
- Mosko, S., Zetin, M., Glen, S., Garber, D., DeAntonio, M., Sassin, J., ... Warren, W. (2006). Self-reported depressive symptomatology, mood ratings, and treatment outcome in sleep disorders patients. *Journal of Clinical Psychology*, 45, 51-60.
- Pasco, J., Jacka, F., Williams, L., Brennan, S., Leslie, E., & Berk, M. (2011). Don't worry, be active: Positive affect and habitual physical activity. *Australian and New Zealand Journal of Psychiatry*, 45, 1047-1052.
- Pilcher, J., Ginter, D., & Sadowsky, B. (1997). Sleep quality versus sleep quantity: Relationships between sleep and measures of health, well-being and sleepiness in college students. *Journal of Psychosomatic Research*, 42, 583-596.
- Reed, J., & Ones, D. (2006). The effect of acute aerobic exercise on positive activated affect: A meta-analysis. *Psychology of Sport and Exercise*, 7, 477-514.
- Robillard, R., Rogers, N. L., Lambert, T., Prince, F., & Carrie, J. (2011). Associations between physical activity and sleep in young and older adults. *Sleep Medicine*, 12, 24.
- Rogers, A. E., Caruso, C. C., & Aldrich, M. S. (1993). Reliability of sleep diaries for assessment of sleep/wake patterns. *Nursing Research*, 42, 368-372.
- Santosa, R. V., Tufika, S., & De Melloa, M. T. (2007). Exercise, sleep and cytokines: Is there a relation? *Sleep Medicine Reviews*, 11, 231-239.
- Scott, B. A., & Judge, T. A. (2006). Insomnia, emotions, and job satisfaction: A multilevel study. *Journal of Management*, 32, 622-645.

- Sexton, H. H., Sogaard, A. J., & Olstad, R. R. (2001). How are mood and exercise related? Results from the Finnmark study. *Social Psychiatry & Psychiatric Epidemiology*, *36*, 348-353.
- Short, M. A., Gradisar, M., Lack, L. C., Wright, H., & Carskadon, M. A. (2012). The discrepancy between actigraphic and sleep diary measures of sleep in adolescents. *Sleep Medicine*, *13*, 378-384.
- Sigfusdottir, I., Asgeirsdottir, B., Sigurdsson, J., & Gudjonsson, G. H. (2011). Physical activity buffers the effects of family conflict on depressed mood: A study on adolescent girls and boys. *Journal of Adolescence*, *34*, 895-902.
- Stephens, A., O'Donnell, K., Marmot, M., & Wardle, J. (2007). Positive affect, psychological well-being, and good sleep. *Journal of Psychosomatic Research*, *64*, 409-415.
- Talbot, L. S., Stone, S., Gruber, J., Hairston, I. S., Eidelman, P., & Harvey, A. G. (2012). A test of the bidirectional association between sleep and mood in bipolar disorder and insomnia. *Journal of Abnormal Psychology*, *121*, 39-50.
- Terracciano, A., McCrae, R. R., Hagemann, D., & Costa, P. T. (2003). Individual difference variables, affective differentiation, and the structures of affect. *Journal of Personality*, *71*, 669-704.
- Turner, M. (2004). *Actigraphy and polysomnography: A comparison in depressed and healthy children and adolescents*. (Unpublished doctoral dissertation). University of Texas, Texas.
- Trost, S.G., Pate, R.R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., & Sirard, J. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise*, *34*, 350-355.
- Tryon, W. W. (2005). The reliability and validity of two ambulatory monitoring actigraphs. *Behavior Research Methods*, *37*, 492-497.
- Van De Water, A. M., Holmes, A., & Hurley, D. A. (2011). Objective measurements of sleep for non-laboratory settings as alternatives to polysomnography - a systematic review. *Journal of Sleep Research*, *20*, 183-200.
- Voderholzer, U., Al-Shajlawi, A., Weske, G., Feige, B., & Riemann, D. (2003). Are there gender differences in objective and subjective sleep measures? A study of insomniacs and healthy controls. *Depression and Anxiety*, *17*, 162-172.

- Walker, M. W. (2009). The role of sleep in cognition and emotion. *Cognitive Neuroscience*, *1156*, 169-197.
- Watson, D. (1988). Intraindividual and interindividual analyses of positive and negative affect: Their relation to health complaints, perceived stress, and daily activities. *Personality and Social Psychology*, *54*, 1020-1030.
- Watson, D., & Clark, L. A. (1994). *The PANAS-X: Manual for the positive and negative affect schedule-expanded form*. New York: Springer Publishing.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063-1070.
- Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, *98*, 219-235.
- Wood, A. C., Kuntsi, J., Asherson, P., & Saudino, K. J. (2008). Actigraph data are reliable, with functional reliability increasing with aggregation. *Behavior Research Methods*, *40*, 873-878.
- Yeung, R. (1996). The acute effects of exercise on mood state. *Journal of Psychosomatic Research*, *40*, 123-141.
- Youngstedt, S. D., Perlis, M. L., O'Brien, P. M., Palmer, C. R., Smith, M. T., Orff, H. J., & Kripke, D. F. (2003). No association of sleep with total daily physical activity in normal sleepers. *Physiology & Behavior*, *78*, 395 - 401.

Appendix A

Recruitment Announcement on Vula

Earn all your SRPP points for the year by participating in the Human Movement Study!

Would you like to know how many calories you spend per day, how many steps you take and the number of places you go? This is an opportunity to participate in psychological research using cutting edge technology. All you need to do is fill out a few online questionnaires in the comfort of your own home and wear two small devices for 4 days.

In return, you will **receive all your SRPP points for the year** in one go. You will also receive data about your calories spent, steps taken, light exposure, movement patterns and sleep activity for the week.

In order to take part in this exciting study,

1. Click on the link below and fill in the online questionnaire.
2. Then send an email to candice.edmunds@gmail.com stating the group number you would like to join. (Please make sure you can make it to both the allocated time slots for the group that you choose). Once you sign up, you **MUST** attend both of these short meetings.
3. Then, meet us in the ACSENT Lab (Room 4.17) in the Psychology Department at the time allocated to your group for “Meeting Time 1” so that we can give you the devices, explain the procedure to you and answer any questions you might have.
4. Then, bring the devices back to the ACSENT Lab (Room 4.17) at the allocated time slot under “Meeting Time 2” of your group.
5. Lastly, fill in the second set of online questionnaires (you will be given the link at a later stage).
6. Then your SRPP points for the year will be added.

All the data collected from your participation in this study is completely confidential and your devices will be allocated a random number so your participation is also anonymous.

In order to receive all your SRPP points for the year, you must complete the study from beginning to end. No SRPP points will be awarded unless you complete all the required tasks.

Click on this link to fill in the online questionnaire:

<http://www.zoomerang.com/Survey/WEB22FH6XVYSDP>

Group Number	Meeting Time 1	Meeting Time 2
1	Wednesday 2nd May - 1pm	Monday 7th May - 2pm
2	Friday 4th May - 1pm	Wednesday 9th May - 1pm
3	Wednesday 9th May - 1pm	Monday 14th May - 2pm
4	Friday 11th May - 1pm	Wednesday 16th May - 1pm
5	Wednesday 16th May - 1pm	Monday 21st May - 2pm

*Note that the Monday meetings are scheduled for 2pm

This study does not require you to sign up on the SRPP site. Just send an email to candice.edmunds@gmail.com to book your time-slot.

If you have further questions or are unsure whether you would like participate, contact the researchers at the following email addresses: candice.edmunds@gmail.com or kmclacey@gmail.com

Appendix B

Daily Diary

Daily Journal (Group 5) Student number _____

Instructions: Fill in the sleep section in the morning and the activity section in the evening. Please answer the questions about sleep and your quality of sleep (1-terrible --- 5- very good) each morning. Every evening, for the activity section, next to each number please write the place you went (i.e.: Jameson Hall) and how you rate it in terms of the degree of exercise/physical activity at the place with a number from 1 to 5 (1-not active --- 5- very active). Do the same for the social row (1-not social --- 5-very social).

Day 1 activity (17/05)

Place #	1	2	3	4	5	6	7	8	9	10
Exercise										
Social										
Place #	11	12	13	14	15	16	17	18	19	20
Exercise										
Social										

At any stage today, did you forget to wear the devices/did the GPS battery die? Yes No
 If so, between what times did this occur? _____ to _____

Day 1 sleep section - fill out in the morning for last night's sleep (18/05)

Time you fell asleep _____ Time you woke up _____ Number of wakeups _____ Quality of sleep _____

Day 2 activity (18/05)

Place #	1	2	3	4	5	6	7	8	9	10
Exercise										
Social										
Place #	11	12	13	14	15	16	17	18	19	20
Exercise										
Social										

At any stage today, did you forget to wear the devices/did the GPS battery die? Yes No
 If so, between what times did this occur? _____ to _____

Day 2 sleep section - fill out in the morning (19/05)

Time you fell asleep _____ Time you woke up _____ Number of wakeups _____ Quality of sleep _____

Day 3 activity (19/05)

Place #	1	2	3	4	5	6	7	8	9	10
Exercise										
Social										

Place #	11	12	13	14	15	16	17	18	19	20
Exercise										
Social										

At any stage today, did you forget to wear the devices/did the GPS battery die? Yes No
 If so, between what times did this occur? _____ to _____

Day 3 sleep section - fill out in the morning (20/05)

Time you fell asleep _____ Time you woke up _____ Number of wakeups _____ Quality of sleep _____

Day 4 activity (20/05)

Place #	1	2	3	4	5	6	7	8	9	10
Exercise										
Social										

Place #	11	12	13	14	15	16	17	18	19	20
Exercise										
Social										

At any stage today, did you forget to wear the devices/did the GPS battery die? Yes No
 If so, between what times did this occur? _____ to _____

Day 4 sleep section - fill out in the morning (21/05)

Time you fell asleep _____ Time you woke up _____ Number of wakeups _____ Quality of sleep _____

Appendix C

Demographic Questionnaire

Questionnaire 1 (Demographics)

Please fill in the following information about yourself.

***1. Name and surname**

***2. Student number**

***3. Email address**

***4. Cellphone number**

***5. List the course codes for all the Psychology courses you will be taking this year in order to receive SRPP points for all these courses if you complete this study from beginning to end.**

***6. Faculty**

Humanities

Science

Commerce

EBE

Law

Health Science

Other, please specify

***7. Year of study**

First year

Second year

Third year

Other, please specify

***8. Gender**

- Male
- Female

9. Age**10. Race/ethnicity**

- Black
- White
- Coloured
- Indian
- Asian
- Prefer not to say
- Other, please specify

***11. Background**

- Urban
- Suburban
- Rural
- Other, please specify

***12. Relationship status**

- Single
- In a relationship
- It's complicated
- Prefer not to say
- Other, please specify

***13. Country where you have lived most of your life**

Appendix D

Consent Form for Online Questionnaires

Informed Consent Form: Human Movement Study

Invitation and Purpose

You are being invited to voluntarily participate in the above-titled research study. This study is investigating activity, movement patterns and sleep.

Procedure

If you agree to participate, your participation will involve filling out online questionnaires about your demographic information, personality, mood, health and sleep patterns. You will fill out the surveys online at the beginning and end of the study (on any computer). During the study, you will be required to meet with the researchers in the ACSENT Lab during your chosen time-slot for “Meeting Time 1.” Here they will explain the procedure to you, giving you instructions on how to wear the devices. You will then be required to wear the equipment around your waist/hips for 4 days and fill in a few brief questions. Then, you will return the equipment to the ACSENT Lab at “Meeting Time 2” and fill in the last set of online questionnaires.

Alternatives

You may withdraw from the study at any time. However, if you decide to do so, you will not receive any SRPP points and your name will be removed from the lucky draw. You will also still have to return the equipment on the scheduled day for your second meeting.

Risks

There are no known risks from your participation. There is no cost to you except for your time and commitment to the study.

Confidentiality and Anonymity

The researchers will not be able to follow your movement patterns during the duration of the study. Data can only be accessed once you return the equipment, so you do not have to worry about invasion of privacy. Once you return the equipment, your data will be assigned a random

number and your name erased. Therefore, the study is completely confidential and anonymous. We have asked for your name, student number and contact details so that we can assign you your SRPP points and send you one reminder SMS on each of the 4 days during the study (to remind you to fill in some short questions). Your name and contact details will not be shared with anyone other than the researchers and will not be used in any reports that result from this project. You will also have the opportunity to delete any sections of your data upon returning your equipment if necessary.

Benefits

You will be compensated for your participation by receiving all the SRPP points that you require for the year. You will also receive a graph of your movement patterns for the four days via email. You will be able to see how many calories you spent, how many steps you took and various other interesting facts you may not be aware of pertaining to your movement.

Questions

If you have any questions or concerns about the study, please feel free to email the principal researchers. However, any questions you have will be answered when you come in to the ACSSENT Lab for your first meeting. By clicking on the "SUBMIT" button below and proceeding in these surveys, you are giving your consent to participate in this study and giving permission for the researchers to use your anonymous data for research purposes.

Contact Details

Psychology Research Ethics Committee: lauren.wild@uct.ac.za; 021 650 4607

Pedro Wolf: pedrosaw@gmail.com; 076 027 4658

Kirsten Clacey: kmclacey@gmail.com; 082 068 0604

Candice Edmunds: candice.edmunds@gmail.com; 083 225 3735

Thank you for your participation,

Kirsten Clacey & Candice Edmunds

Author Note

Acknowledgements

We would like to thank Dr Pedro Wolf, supervisor of this project, for his enthusiastic and passionate attitude towards our project. His thorough knowledge and eagerness to learn were a great source of guidance. He was always willing to make time for us and we are grateful for his commitment to this study.

We would also like to thank Dr Kevin Thomas for his insightful guidance related to all aspects of this project. His insistence on excellence and attention to detail motivated us to do our best at all times.

PLAGIARISM DECLARATION

1. We know that plagiarism is wrong. Plagiarism is to use another's work and to pretend that it is one's own.
2. We have used the American Psychological Association (APA) convention for citation and referencing. Each contribution to and quotation in this report from the work(s) of other people has been attributed, and has been cited and referenced.
3. This report is our own work.
4. We have not allowed, and will not allow, anyone to copy our work with the intention of passing it off as his or her own work.
5. We acknowledge that copying someone else's assignment, or part of it, is wrong, and declare that this is our own work

Signatures:

Date: 29 October 2012

Student numbers: CLCKIR001; EDMCAN001