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Sleep, anxiety and the effects on cognition

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**This thesis is submitted in partial fulfilment of the requirements for
the degree of Doctorate in Clinical Psychology**

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List of abbreviations

ACT = Acceptance and Commitment Therapy

ASC = Autism Spectrum Condition

ASD = Autism Spectrum Disorder

ANOVA = Analysis of Variance

BOS = Bristol Online Survey

BPS = British Psychological Society

CNS = Central Nervous System

DSM = Diagnostic and Statistical Manual of Mental Disorders

DV = Dependent Variable

GAD = General Anxiety Disorder

GAD-7 = Generalized Anxiety Disorder 7 questionnaire

IV = Independent Variable

PSG = Polysomnography

PSQI = Pittsburgh Sleep Quality Index questionnaire

ROCF = The Rey-Osterrieth Complex Figure Test and Recognition Trial

RST = The Reading Span Test

SD = Standard Deviations

SPSS = IBM Statistical Package for the Social Sciences

SQAC = Standard Quality Assessment Criteria

TD = typically developing

TOPF = The Test Of Premorbid Functioning

WAIS = Wechsler Adult Intelligence Scale-Fourth UK Edition

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Declaration

This thesis has not been submitted for any other degree or to any other institution. Emergent findings from the empirical paper were submitted as a presentation talk at University of Warwick Postgraduate Research Day. The thesis was carried out under the academic and clinical supervision of Dr Lesley Pearson (Senior Lecturer, Coventry University), Dr Magdalena Marczak (Lecturer, Coventry University) and Dr Anna Joyce (Research Associate, Coventry University), all of whom were involved in the initial formulation of ideas and the development of the research design. Apart from the collaborations stated, all the material presented in this thesis is my own work. The literature review is written in preparation for submission to Journal of Sleep Health, and the empirical paper is written in preparation for submission to Journal of Sleep Medicine.

Summary

Poor sleep and high levels of anxiety have a detrimental effect on cognitive functioning. However, very little is known about what cognitive functions are affected by poor sleep or high levels of anxiety and if some are more affected than others. This thesis informs the understanding of poor sleep and anxiety with a focus on generalised anxiety disorder and how they affect specific cognitive functioning namely Attention and Working Memory.

Chapter one is a systematic literature review of the qualitative research exploring how sleep deprivation impacts on the cognitive functioning of people with Autistic Spectrum Conditions (ASC) and the principal challenges associated with trying to study the impact of sleep deprivation in people with ASC. Following both database and manual searches, fifteen studies were included and reviewed. The review highlights the suggestions that poor sleep has a detrimental effect on the cognitive functioning of people with ASC. Also, the use of objective and subjective measures of sleep was discussed to help in the early detection of these problems and considerations of carers and families was reviewed. Future research/clinical implications are discussed.

Chapter two is a quantitative research study that investigated the combined effects of GAD and poor sleep on Attention and Working Memory. Sleep quality and quantity were assessed using subjective and objective measures of sleep. Attention and Working Memory was measured using various neuropsychological measures. Groups were compared for differences in cognitive scores using a non-parametric test. Relationships between GAD-7 scores, sleep quality/quantity and cognition scores were investigated using correlation analyses. Implications for future research and clinical implications are discussed.

Chapter three is a reflective account, exploring the role of reflexivity in personal and professional development during the research process.

**CHAPTER 1: Sleep and the effects on cognition in people with
Autism Spectrum Condition: A systematic literature review**

**Written in preparation for submission to Journal of Sleep Health. Overall chapter word count
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1.0 Abstract

AIM: Studies have shown that poor and disturbed sleep can lead to an increase in the severity of core Autism Spectrum Conditions (ASC) symptoms such as communication difficulties, social, repetitive behaviours and a decrease in cognitive functioning. However, very little is known about the impact on cognitive functioning. This systematic review aims to review the cognitive functions that are impacted upon by sleep deprivation in people with ASC and review the principal challenges associated with trying to study the impact of sleep deprivation in people with ASC. This understanding may lead to developing clinical interventions for managing poor sleep in a person with ASC and/or their parents.

METHOD: Searches used Psychinfo, Medline, Scopus, Science direct, SAGE, Cochrane Library and Web of Science and Google Scholar. Fifteen original studies that met the inclusion criteria and Quality assessment criteria were identified. Kappa scores for each study were no lower than 0.51, resulting in a strong inter-rater reliability score (Kappa = 0.73).

FINDINGS: Specific cognitive functions that are negatively affected by poor sleep in people with ASC include: memory consolidation, declarative memory, selective attention, spatial memory, poorer immediate recall, overall memory recall, impaired intelligence and verbal skills. The reasons that poor sleep is often not reported in those with ASC because those with ASC often have a wide range of presentations and may have an unaddressed problem in the child, family, or environment and parents/carers might be unaware of the poor sleep. Several sleep interventions are identified such as behavioural training, pharmacological treatment, cognitive training, psycho-educational programmes and sensory interventions to improve sleep to help alleviate poor sleep in people with ASC. Reduced cognitive functioning in people with ASC has a significant impact on the daily functioning of people with ASC, as well as impacting on the families and carers.

CONCLUSION: Poor sleep has a detrimental effect on the cognitive functioning of people with ASC. Using objective and subjective measures of sleep would help in the early detection of these problems which may contribute towards, and help

develop, new interventions that will help those with ASC as well as their carers and families.

KEYWORDS: ASC, ASD, SLEEP, OBJECTIVE SLEEP MEASURES, COGNITIVE FUNCTIONING

1.1 Introduction

Poor sleep is common amongst people with an Autism Spectrum Condition (ASC) and affects between 40-80% of children (Cohen, Conduit, Lockley, Rajaratnam, & Cornish, 2014) and 80% of adolescents and young adults (Oyane & Bjorvatn, 2005) experiencing problems. Studies have also shown that poor and disturbed sleep can lead to an increase in the severity of core ASC symptoms such as communication difficulties and social and repetitive behaviours (Park et al., 2012; Tudor, Hoffman, & Sweeney, 2012). In the UK the cost of looking after children with ASC is estimated to be £2.7 billion, and adults with ASC is estimated at £25 billion a year (Knapp, Romeo, & Beecham, 2009).

Functional magnetic resonance imaging (fMRI) studies comparing sleep-deprived and 'well-rested brains' provide significant evidence that sleep is essential for optimal cognitive function and learning (Chee & Chuah, 2008). In a randomised study looking at the effects of sleep deprivation in medical students. Those who worked a traditional schedule were found to make 36% more medical errors than the medical students who worked under an intervention schedule which included more sleep (Landrigan et al., 2004). Poor sleep also has a severe impact on an individuals' ability to learn new skills (Chee & Chuah, 2008). The impairments that are resulting from poor sleep comprise are diminished cognitive and behavioural functioning, partly from reduced attention and arousal. The shortfall of restorative sleep includes missing sleep-dependent cognitive processes such as memory consolidation and insight formation which are the essential elements of knowledge acquisition (Ellenbogen, 2005).

Children and adolescents with ASC are particularly susceptible to poor sleep, with approximately two-thirds suffering from poor sleep at some point in childhood (Stores & Wiggs, 2001). However, it is unclear why this link exists (Cohen et al., 2014). Rates of parent-reported sleep problems in children with ASC range from 50% to 80%, compared with 9% to 50% among typically developing (TD) children (Park et al., 2012). Among the sleep problems most commonly found in children, sleep onset and maintenance problems, in addition to sleep duration are consistently those of highest concern as expressed by parents of children with an

ASC (Richdale & Schreck, 2009). Park et al. (2012) found that children with ASC were more likely to have bedtime resistance, insomnia and daytime sleepiness compared to their unaffected siblings. Therefore, the literature suggests that sleep has a significant impact on children with ASC. Thus, the severity of sleep problems in children with ASC is a matter of concern. Due to increased stress experienced in parenting a child with ASC and the possible adverse effects of poor sleep on daytime behaviour and general functioning of the child (Hill et al., 2014; Limoges, Bolduc, Berthiaume, Mottron, & Godbout, 2013; Park et al., 2012).

1.1.1 Definitions

The DSM 5 (APA, 2013, P. 299F84) defines Autism Spectrum Disorder (ASD) as “characterised by persistent deficits in social communication and interaction, as well as restricted, repetitive patterns of behaviour, activities or interests”. It is now generally accepted that Autistic Spectrum Condition (ASC) is a more accurate term to use when referring to people with autism, hence this review will use the term ‘ASC’ to describe the range of the autism spectrum, including Asperger syndrome. Of note, some of the studies reviewed make reference to ‘ASD’ or ‘Autism’ for this was the term defined by the author of the paper reviewed. Cognitive functioning is an intellectual process which involves being aware, perceiving and comprehending ideas. It encompasses all facets of thinking, reasoning, perception and memory (Gazzaniga, Ivry, & Mangun, 2009). Poor sleep is difficult to define and is defined differently by many researchers. For example, Ohayon (2002) defines poor sleep as early morning awakening, and nonrestorative sleep, difficulty initiating sleep and difficulty maintaining sleep and other definitions include associated daytime impairment and sleep dissatisfaction (Edinger et al., 2004). Therefore, this review will be using the term 'poor sleep' as an umbrella term for all known sleep problems found in people with ASC.

1.1.2 Rationale for review

A recent review of the literature examined the relationship between sleep disturbances and its impact on the problematic behaviour of people with ASC (Cohen et al., 2014). Cohen et al. concluded that sleep interventions might help with problematic behaviour but discussed the gap in the literature for understanding the impact of sleep disturbances. Sleep disturbances in neurotypical individuals have also been shown to have a negative impact on cognitive functioning (Chee & Chuah, 2008) but little is known about the impact of sleep disturbances on the cognitive functioning in people with ASC. This could be due to communication difficulties being a core symptom of ASC, and as such, they struggle to report their sleep disturbances (Cohen et al., 2014; Limoges et al., 2013). Hollway, Aman, and Butter (2013) also found that children with more severe symptoms of ASC are at a higher risk of sleep disturbances and sleep disturbances can lead to an increase in the severity of ASC symptoms (Park et al., 2012; Tudor et al., 2012). Sleep difficulties in children with ASC appear to continue throughout their lifetime (Cohen et al., 2014). Therefore, there is a need to review how sleep affects cognitive functioning in people of all ages with an ASC.

1.1.3 Review aims and objectives

This systematic review aims to identify and critically evaluate available research that looks at how sleep affects cognitive functioning in people with ASC. This understanding may lead to developing clinical interventions for managing poor sleep in a person with ASC and/or their parents.

It is intended that the proposed review will look at the empirical evidence to address the following questions:

- 1) How does sleep deprivation impact on the cognitive functioning of people with Autistic Spectrum Conditions?
- 2) What are the principal challenges associated with trying to study the impact of sleep deprivation in people with Autistic Spectrum Conditions?

1.2 Method

1.2.1 Literature Search

A systematic search of the literature for qualitative and quantitative studies from 1994 that have investigated sleep problems and their effect on cognitive functioning in people with ASC was carried out between October 2017 and November 2017. The studies included in this search were from 1994 onwards, this was to include participants that had a diagnosed with ASC from the DSM IV & DSM V criteria. Despite changes in diagnosis of ASC in the DSM V not all people with a previous diagnosis of Autism based on the criteria of the DSM IV are re-diagnosed under the new criteria in the DSM V (Young & Rodi, 2014). Due to the difference in diagnostic criteria of ASC across the world only countries that use the DSM were included (Elsabbagh et al., 2012). Asperger's syndrome was a separate diagnosis to ASC prior to DSM V. Therefore; some studies may be including Asperger's syndrome under the ASC umbrella and others may not.

The most relevant databases covered literature within psychology and nursing and included: Psychinfo, Medline, Scopus, Science direct, SAGE, Cochrane Library, Web of Science and Google Scholar. The reference lists of extracted articles were examined for additional relevant articles. Searches were also carried out using non-electronic sources such as the library book catalogues. Finally, attempts were made to search for unpublished work via a combination of sources including Coventry University Locate, Google search and The University of Warwick Online Library search.

1.2.2 Search terms

Table 1 presents an overview of the key search terms used relevant to the subject area of interest. These terms include the main concepts, synonyms and the location of the keywords within the database search.

Table 1 - Overview of key search terms

Main Concepts	Synonyms	Location
Sleep	Sleep	Title Abstract Keywords
Autism Spectrum Disorder (ASD)	Autis* ASD Autism Spectrum Disorder	Title Abstract Keywords
Cognitive Functioning	Cognitive functioning Cognition	Title Abstract Keywords

1.2.3 Search strategy

The search strategy involved: Sleep AND Autis* OR ASD OR Autism Spectrum Disorder AND Cognitive functioning OR Cognition.

1.2.4 Inclusion and exclusion criteria

Table 2 illustrates the inclusion and exclusion criteria utilised in this systematic review. Article titles and abstracts were initially screened and retained if they were written in the English language, were peer reviewed qualitative and quantitative empirical studies and they were fully accessible. Following the primary screening, full-text articles were attained and evaluated for eligibility for review according to the following inclusion criteria.

Table 2 - Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Gender	Males and Females	None
Age	All ages	None
Study Type	Peer-reviewed qualitative and quantitative empirical studies	Reviews, commentaries

Language	English	Non-English
Accessibility	Full-text access	Title or Abstract only
Date	1994 – Present	< 1994
Geography	UK, USA, Canada, Australia, New Zealand and Europe	Other countries not listed for Inclusion

1.2.5 Classification of studies

Figure 1 illustrates the study selection process which was recorded on a ‘Preferred Reporting Items for Systematic Reviews and Meta-analyses’ flow diagram (Moher, Liberati, Tetzlaff, & Altman, 2009).

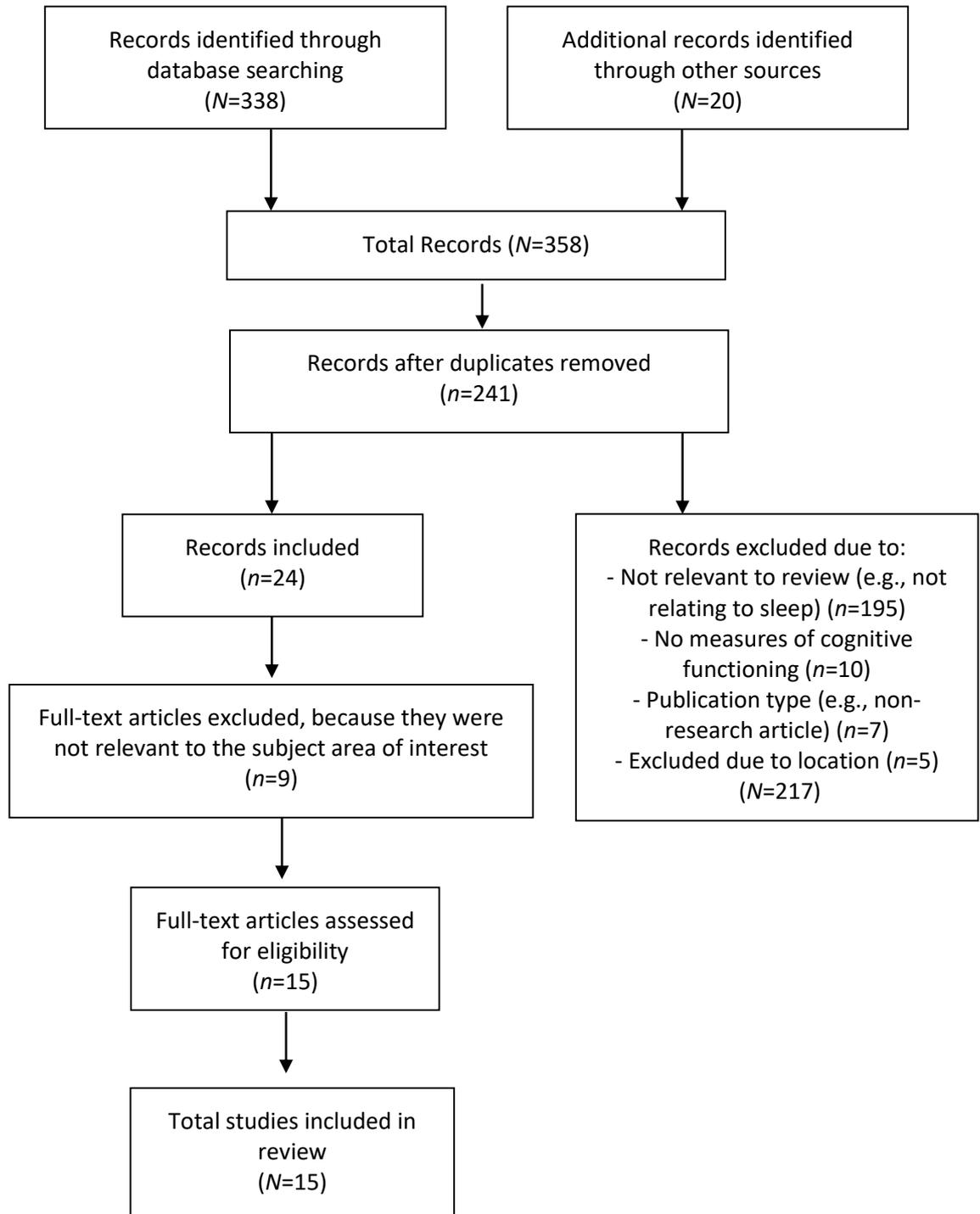


Figure 1: PRISMA flow diagram- the study selection process

In total 338 articles were initially identified, of which 117 were duplicates. Following a subsequent manual review of the title and abstracts, a further 217 articles were removed due to being not relevant and not addressing the specific

subject matter of the review. The full text of the remaining 24 articles was reviewed, and 9 further articles were excluded as they did not satisfy the review's inclusion criteria. No further articles were found from other sources such as hard copy and grey literature searches. Therefore, following a search of the literature, a total of 15 studies met the inclusion criteria and so were included in this systematic review.

Standard Quality Assessment Criteria (SQAC) was used to evaluate the quality of the studies the 15 studies from the study selection process (Kmet, Lee, & Cook, 2011). The SQAC was used as it has been shown to be effective in assessing the quality of research in other systematic literature reviews of sleep (Henry et al., 2016; Koffel, Koffel, & Gehrman, 2015; Miller et al., 2014). SQAC provides a quantitative, reproducible and systematic means of assessing the quality of quantitative and qualitative study designs. There is a checklist for quantitative studies (Appendix A) and a separate checklist for qualitative studies. However, no qualitative studies were found, and therefore only the quantitative checklist was utilised.

The quantitative checklist contains 14 questions, which are assessed as the item being completely met (Yes) scoring 2 points, partially met (Partial) scoring 1 point, not met (No) and not applicable (n/a) both scoring 0 points (Kmet et al., 2011). Each study under review was scored using the checklist, and a percentage score added. Kmet et al. (2011) suggest a cutoff score of 50% and above and any study that does not meet that cut off will be excluded with the reason(s) to be recorded. As all 15 studies scored above 50% using the Standard Quality Assessment Criteria, no study was removed from the review. To improve the reliability of the Standard Quality Assessment Criteria, 50% of the studies were assessed by another researcher against the same quality assessment criterion and an inter-rater reliability analysis using the Kappa statistic was performed. The second rater was independent of this review. Kappa scores for each study were no lower than 0.51, resulting in a strong inter-rater reliability score (Kappa = 0.73).

1.3 Results

1.3.1 Characteristics of Studies

A summary of the key characteristics of the 15 studies included in this review can be found in Table 3. Geographically, 13 studies used sample populations outside the UK; 7 from the USA, 1, from Canada, 2 in Australia and 3 from Italy.

The methodology reviewed was, 5 randomised control trial, 4 studies were a cross-sectional design, 3 correlational design, 1 exploratory design, 1 experimental design and 1 case-control design. No qualitative studies were found.

The age of participants varied among the studies; 11 looked at participants below the ages of 19 years old; 2 studies looked at participants from 16 years and older; 2 studies were not specific about participant ages. The sample sizes ranged from 14 to 1859 participants.

Table 3 - Characteristics of reviewed studies

Author/Date/ Location/ Quality Assessment Rating	Study Aim	Research Design/Sampl ing Method	Sample population	Method of data collection/ data analysis	Key Findings
<p>Bruni,O., Ferri,R., Vittori,E., Novelli,L., Vignati, M., et al.</p> <p>2007</p> <p>Italy</p> <p>QR=78.6% (Kappa=0.68)</p>	<p>To analyse sleep in children with Asperger syndrome (AS) and Autism</p>	<p>Cross-sectional study</p> <p>Opportunity Sampling</p>	<p>8 “Asperger children” (7 males, 1 female; Ages (years) $M=12.7$, $SD=2.6$ years, $range=7-15$)</p> <p>10 “Autistic children” (9 males, 1 female; Ages (years) $M=11.9$, $SD=2.5$ years, $range=7-15$)</p> <p>12 Control matched for age (5 females and 7 males, Ages (years) $M=12.6$, $SD=3.7$ years, $range=7-15$)</p>	<p>Sleep Questionnaire, PDSS**, ADOS**, CBCL**, WISC-III**, PSG**</p> <p>Mann-Whitney test, Cohen’s & Spearman correlation</p>	<p>Children with AS show peculiar sleep patterns compared to control. Short sleep duration (<9 h) was almost twofold (59% vs 32%), and the risk for sleep onset problems more than fivefold (53% vs 10%) more common in the AS group than in the control group.</p> <p>Asperger Vs Controls $U=0.023$ $p<0.05$, $d=1.35$ Asperger Vs Autism $U=0.041$ $p<0.05$, $d=1.24$ This showed that stages of sleep are significantly different between Autism, Asperger and controls.</p> <p>The following significant relationships between PSG & Behavioural/Cognitive measures were found: -REM latency & Full-scale IQ, $r_s=0.89$, $p<0.05$ -REM latency & Performance IQ, $r_s=0.86$, $p<0.05$ -REM % & CBCL Internalising, $r_s=0.81$, $p<0.05$ - SE% & CBCL Externalising, $r_s=0.95$, $p<0.05$</p>

<p>Delahaye, J., Kovacs, E., Sikora, D., Hall, T., Orlich, F., et al.</p> <p>2014</p> <p>USA</p> <p>QR=71.4%</p>	<p>To investigate the relationship between Health-related quality of life (HRQoL) and overall sleep problems within the context of critical clinical characteristics in children with ASD</p>	<p>Cross-sectional study</p> <p>Opportunity Sampling</p>	<p>86 parents of children (72 males, 14 females;</p> <p>Ages (years) <i>Mean</i>=7.18, <i>range</i>=4-12)</p> <p>4 "Asperger children"</p> <p>57 "Autistic children"</p> <p>21 PDD-NOS*</p> <p>4 participants dropped out</p>	<p>PedsQL*, CSHQ*, CBCL*, PDDBI*, SB5* & MSEL*</p> <p>T-tests, Pearson correlation coefficients, Pearson correlation analysis, linear regression models</p>	<p>Correlations were found between the sleep duration scale and the PedsQL total $r=-0.36, p<.001$ and psychosocial summary $r=-0.36, p<.001$ scores.</p> <p>Sleep duration/anxiety has been significantly predicted by:</p> <ul style="list-style-type: none"> - PedsQL physical summary score ($\beta=-0.73, p<0.01$) - PedsQL total score ($\beta=-1.61, p<0.05$) - CHSQ total ($\beta=-2.16, p<0.01$) - CHSQ psychosocial ($\beta=-2.11, p<0.01$)
<p>Hollway, J., Aman, M., Butter, E.</p> <p>2013</p> <p>USA</p> <p>QR=78.6% (<i>Kappa</i>=0.68)</p>	<p>To investigate if:</p> <ul style="list-style-type: none"> - an inverse association existed between disturbed sleep, intellectual functioning, adaptive behaviour, age, and parent education - a positive association existed between sleep disturbance, autism symptom severity, and internalising and externalising behaviour - medical issues such as epilepsy, GI problems, 	<p>Cross-sectional study</p> <p>Opportunity Sampling</p>	<p>1,583 children (1327 males, 256 females;</p> <p>Ages (years) <i>M</i>=6.34, <i>SD</i>=3.5, <i>range</i>=2-17).</p> <p>1032 "Autistic children"</p> <p>152 "Asperger's Disorder"</p> <p>399 PDD-NOS*</p>	<p>CSHQ*, VABS*, MSEL*, SB5*, CBCL*, ADOS* & SSP*</p> <p>T-tests, ANOVA*, Hierarchical Regression Models</p>	<p>Anxiety, autism symptom severity, sensory sensitivities, and GI problems were associated with sleep disturbance, $F(5,1430)=33.101, p<.001$.</p> <p>IQ positively predicted sleep disturbance, and children with Asperger's Disorder were more vulnerable than others $R^2=0.193; F(12, 1376)=27.345, p<0.001$</p>

	and medication use, were positively associated with sleep disturbance				
Limoges, É., Bolduc, C., Berthiaume, C., Mottron, L., Godbout, R. 2013 Canada QR=71.5%	To investigate if markers of poor sleep, documented in ASD, correlate with non-verbal cognitive performance	Randomised Control Trial Opportunity Sampling	17 ASD pts (9 with high-functioning autism and 8 with Asperger's syndrome (16 males, 1 females; Ages (years) $M=21.7$, $SD=3.5$, range=16–27) 14 Controls(13 males, 1 female; Ages (years) $M=21.8$, $SD=4.1$, range=16–27)	Sleep questionnaire, WAIS-III**, BDI-II**, STAI**, AYSRS**, FCRTT**, CblTa**, FLS-BEM144**, PRPT** & TLT** Spearman's correlation	Significant correlations were found for controls between: Selective attention <ul style="list-style-type: none"> • TR total and sleep $rs=-0.82$, $p<0.01$ • Errors and sleep $rs=-0.59$, $p<0.05$ Declarative episodic memory and sleep <ul style="list-style-type: none"> • Recall 1 and %SWS, $rs=0.60$, $p<0.05$ • Recall 2 and %SWS, $rs=0.65$, $p<0.05$ • Recall 3 and %WASO, $rs=-0.55$, $p<0.05$; and %SWS, $rs=0.61$, $p<0.05$ • delayed recall and %WASO, $rs=-0.53$, $p<0.05$ Sensory-motor and cognitive procedural memory and sleep <ul style="list-style-type: none"> • learning phase and %SWS 3rd, $rs=-0.75$, $p<0.01$ Significant correlations were found for ASD between: <ul style="list-style-type: none"> - Declarative episodic memory Recall 1 and: <ul style="list-style-type: none"> • Sleep latency, $rs=-0.62$, $p<0.01$ • % stage 1, $rs=-0.47$, $p<0.05$ • % WASO, $rs=-0.54$, $p<0.05$ - learning phase and: <ul style="list-style-type: none"> • %SWS 3rd, $rs=-0.53$, $p<0.05$ • C3SS, $rs=-0.66$, $p<0.01$ - Selective attention <ul style="list-style-type: none"> • RT total and SL, $rs=0.71$, $p<0.01$

					<ul style="list-style-type: none"> • Errors and SL, $rs=0.55$, $p<0.05$; and %S1, $rs=0.59$, $p<0.05$ - Memory • Initial time and %S1, $rs=-0.61$, $p<0.05$ • Execution time and SL, $rs=0.62$, $p<0.05$ • % correct and SL, $rs=-0.55$, $p<0.05$
Maski, K., Holbrook, H., Manoach, D., Hanson, E., Kapur, K., et al 2015 USA QR=67.9% (<i>Kappa</i> =0.71)	To examine the role of sleep in the consolidation of declarative memory in children with ASD	Case-control study Opportunity Sampling	22 ASD pts (19 males, 3 female; Ages (years) $M=11.3$, $SD=2.1$, <i>range</i> =9-16) 20 TD* pts (18 males, 2 females; Ages (years) $M=12.3$, $SD=2.1$)	Actigraph, PSG**, VSMT**, CBCL**, SRS**, DAS-II**, NVIQ**, D-KEFS**, CSHQ** & IFMS** Unpaired t-tests, Wilcoxon rank sum test, Fisher exact test, mixed-effects regression, Pearson correlation tests	Memory performance deteriorated significantly more across the Wake condition than in the Sleep [Wake: 16-25.8, Sleep:0.7-8.7, $F(1,40)=7.95$, $p<0.01$] and the ASD group demonstrated poorer overall memory recall than participants with TD [ASD: 16.7-26.9, TD:2.2-8.6, $F(1,40)=6.2$, $p<0.02$]
Miano, S., Bruni, O., Elia, M., Trovato, A., Smerieri, A., et al 2007 Italy	To evaluate sleep in children with ASD with sleep questionnaires and polysomnography (PSG)	Randomised Control Trial Opportunity Sampling	31 ASD children (28 males, 3 females; Ages (years) $M=9.53$, $SD=3.82$, <i>range</i> =7-19 years) 18 age-matched controls children (9 males, 9 females; Ages	PSG**, WISCR**, WAIS-III** & Sleep questionnaire Pearson's chi-squared, Mann-Whitney	Compared to typical development in children the ASD children were significantly different on: - Sleep duration < 8 hrs, $X^2=5.55$, $p<0.02$ - Latency to sleep, $X^2=16.42$, $p<0.00001$ - Difficulty getting to sleep, $X^2=9.87$, $p<0.002$ - Drinks stimulant beverages in the evening, $X^2=63.12$, $p<0.00001$ - Fluids or drugs to facilitate sleep, $X^2=81.58$, $p<0.00001$ - Hypnic jerks, $X^2=48.78$, $p<0.00001$ - Poor sleep quality, $X^2=117.46$, $p<0.00001$

QR=64.3%			(years) $M= 10.2$ years, $SD=2.93$, $range=7-19$ years)		<ul style="list-style-type: none"> - More than two awakenings per night, $\chi^2=3.91$, $p<0.05$ - Waking up to drink or eat in the night, $\chi^2=5.94$, $p<0.015$ - Difficulty to fall asleep after awakenings, $\chi^2=25.31$, $p<0.00001$ - Bedwetting, $\chi^2=41.72$, $p<0.00001$ - Daytime somnolence, $\chi^2=4.69$, $p<0.03$ - Falling asleep at school, $\chi^2=5.80$, $p<0.02$ <p>Subtle alterations of NREM sleep was detected between groups (significance at $p<0.05$):</p> <p>TIB: $u=0.044$ SPT: $u=0.014$ TST: $u=0.007$ RL: $u=0.02$</p>
Patzold, L., Richdale, A., Tonge, B. 1998 Australia QR=64.3% (Kappa=0.87)	To investigate sleep problems in children with autism and explore the association between sleep problems and daytime behaviour.	Correlational design Opportunity Sampling	31 ASD children (Autism 25 males, 6 females Asperger 6 males, 1 female; Ages (months) $M=93.5$, $SD=31.5$, $range=44-152$) 36 PDD children (29 males and 7 females; Ages (months) $Mean=101.2$, $SD=31.0$, $range=63-171$)	Sleep diary/questionnaire , DBC** & CBCL** Pearson and point-biserial correlation	The type of past ($r=0.42$, $p<0.01$) and present ($r=0.42$, $p<0.01$) sleep problems reported by parents of children included night waking difficulties ($r=0.49$, $p<0.01$), co-sleeping with parents, ($r=0.40$, $p<0.01$), and poorer sleep quality ($r=0.45$, $p<0.01$)

Quist, H., Chaplin, E., Hendey, O. 2015 UK QR=50%	To determine the effectiveness of a psychoeducation sleep-hygiene group intervention for adults diagnosed with autism spectrum condition (ASC), without a concurrent learning disability	Experimental Design Opportunity Sampling	14 ASC* pts (14 males, 0 females; Ages (years) $M=28.16$, $range=20-55$)	PIRS 20** t-test	Significant improvements were seen on the $t^{***}=2.51$, $p<0.05$ and on follow-up measures of self-reported sleep distress $t^{***}=3.06$, $p<0.05$
Taylor, M., Schreck, K., Mulick, J. 2012 USA QR=57.1%	To investigate the relationships between sleep behaviour in children with ASD and subsequent day-time cognitive and adaptive performance	Randomised control trial Opportunity Sampling	219 Autism & 116 PDD-NOS* 335 PDD* children (296 males, 3 females; Ages (years) $M=5.15$, $SD=3.27$, $range=1-18$)	WPPSI**, Leiter-R**, DP-II**, MSEL**, SB5**, SIB-R**, VABS* & BEDS** Pearson correlation, Stepwise multiple linear regression	-Parental report of more hours slept per night singularly predicted better daily living skills ($R^2=0.09$; $p<0.01$) and the combination of more total hours slept per night and hours napped during the day predicted better Adaptive Behaviour Composite ($R^2=0.18$; $p<0.01$); motor skills scores ($R^2=0.16$; $p<0.01$), and socialization scores ($R^2=0.17$, $p=0.01$) -More hours slept per night in combination with fewer episodes of night waking with screaming and more sensitivity to sleeping environment disturbances significantly predicted children's higher communication scores ($R^2=0.14$, $p<0.01$)
Elia, M., Ferri, R., Musumeci, S., Del Gracco, S., Bottitta, M., et al	Evaluate the possible correlation between neurophysiological and psychological data in children with AD*	Randomised control trial ***	17 male children with AD* (Ages (years) $M=10.36$, $SD=3.79$, $range=5$ years and 7	Anamnesis, clinical examination, karyotyping, neurometabolic screenings, brain	A negative*** correlation between scores of passing items of PEP-R perception and SL ($p<0.02$), Ssh ($p<0.015$), FRL ($p<0.03$), and %WASO ($p<0.015$) was found together with a positive*** correlation between the same items and TIB value ($p<0.04$).

<p>2000</p> <p>Italy</p> <p>QR=67.9%</p>			<p>months-16 years and 8 months)</p> <p>5 Control male subjects (Ages (years) $M=9.22$, $SD=2.02$, $range=7.17-11.58$)</p> <p>7 male subjects with fragile X syndrome and mental retardation (Ages (years) $M=9.92$, $SD=1.67$, $range=8.25-12$ years)</p>	<p>CT**, MRI**, PEP-R**, CARS** & PSG**</p> <p>Correlations</p>	<p>PEP-R eye-hand coordination passing items were correlated negatively*** with Ssh ($p<0.015$), FRL ($p<0.02$), and %WASO ($p<0.02$), and positively*** with SPT ($p<0.03$).</p> <p>The score of the CARS visual response was correlated negatively*** with SPT ($p<0.003$) and positively*** with %WASO ($p<0.03$); CARS non-verbal communication was negatively*** correlated with TST ($p<0.01$).</p> <p>People and activity level CARS items were correlated negatively*** with REMd ($p<0.01$ and $p<0.02$, respectively).</p>
<p>Goldman, S., Richdale, A., Clemons, T., Malow, B.</p> <p>2012</p> <p>USA</p> <p>QR=67.9% ($Kappa=0.51$)</p>	<p>To identify areas defined by the parental report to be problematic in children with ASD</p>	<p>Cross-sectional study</p> <p>Opportunity sampling</p>	<p>1859 ASD children (1571 males, 288 females; Ages (Months) $M=80.1$, $SD=42.3$, $range=36-216$)</p> <p>67.2% Autism children 9.8% Asperger children 23% PDD-NOS*</p>	<p>ADOS**, CSHQ** & PCQ**</p>	<p>Areas reported to be problematic include:</p> <ul style="list-style-type: none"> - Bedtime resistance - Sleep onset delay - Sleep duration - Sleep anxiety - Night waking's - Parasomnias - Sleep-disordered breathing - Daytime sleepiness

<p>Krakowiak, P., Goodlin-Jones, B., Hertz-Picciotto, I., Croen, L., Hansen, R.</p> <p>2008</p> <p>USA</p> <p>QR=78.6%</p>	<p>To compare parent-reported sleep characteristics in young children with ASD between 2 and 5 years of age to typically developing children of the same age as well as children with other developmental delays</p>	<p>Randomised control trial</p> <p>Opportunity sampling</p>	<p>163 TD* children (134 males, 29 females; Ages (years) $M=3.3$)</p> <p>303 ASD* children (267 males, 36 females; Ages (years) $M=3.7$)</p> <p>63 DD* children (46 males, females 17; Ages (years) $M=3.6$)</p>	<p>ADI-R**, ADOS**, MSEL**, VABS**, SCQ**, CSHQ** & EEQ**, Sleep questionnaire/history</p> <p>Multivariate Linear Regression Analysis</p>	<p>- Children with ASD had higher sleep onset factor scores compared with TD children ($\beta=0.177$, $SE=0.091$, $p=0.05$)</p> <p>- Night waking factor scores were significantly elevated in the ASD group compared to TD children ($\beta=0.294$, $SE=0.090$, $p=0.001$)</p> <p>- Parent report of average sleep duration in a 24-hour period that children with ASD tended to sleep about half an hour less than TD children ($\beta=-0.473$, $SE=0.156$, $p=0.003$)</p>
<p>Polimeni, M., Richdale, A., Francis, A.</p> <p>2005</p> <p>Australia</p> <p>QR=67.9% ($Kappa=1.00$)</p>	<p>- to compare sleep patterns in Asperger, autism, and TD* children</p> <p>- to explore treatments used for sleep problems and examine treatment outcomes in these groups</p>	<p>Correlational design</p> <p>Opportunity Sampling</p>	<p>66 TD* children (39 males and 27 females; Ages (years) $M=6.0$, $SD=3.1$, $range=2-11$)</p> <p>53 Autism children (41 males and 12 females; Ages (years) $M=6.5$, $SD=2.7$, $range=2-16$)</p> <p>52 Asperger children (42 males and 8 females; Ages (years) $M=9.3$, $SD=3.1$, $range=4-17$)</p>	<p>Sleep questionnaire & BEDS**</p> <p>ANOVA & Tukey-Kramer post hoc tests</p>	<p>- TD group reported significantly fewer sleep problems than the other two groups [$\chi^2(N=171)=9.618$, $p=0.018$]</p> <p>- There was a significant difference between the three groups on the disoriented waking factor of the BEDS [$F(2,77)=4.145$, $p=0.020$]. Post hoc tests revealed the Asperger group had significantly higher scores on this factor than the TD group [$M=8.07$ ($SD=4.40$) vs $M=4.47$ ($SD=3.69$), $p<0.05$]</p> <p>- There was a significant difference between the groups on the BEDS total score [$F(2, 81)=6.305$, $p=0.003$]. Post hoc tests indicated the Asperger group had significantly higher BEDS total scores than both the TD and the autism groups [$M=116.85$ ($SD=51.75$) vs $M=73.48$ ($SD=30.11$) vs $M=79.53$ ($SD=38.78$), $p<0.01$]</p>

					<p>- Four categories were reported to be used for sleep problems: Behavioural intervention, medication, herbal treatment, and a mixed group of other treatments</p> <p>- Behavioural interventions were reported to be significantly more successful in the autism group than in the Asperger group [$F(2,32)=3.978, p=0.029$]. Medication was rated as more successful by parents in the autism group and the Asperger group than by parents in the TD group [$F(2, 39)=5.045, p=0.011$]</p>
<p>Schreck, K., Mulick, J., Smith, A.</p> <p>2004</p> <p>USA</p> <p>QR=60.7% ($Kappa=0.559$)</p>	<p>To provide a preliminary examination of the hypothesis that specific sleep problems may be related to the expression of cardinal behavioural features of autism.</p>	<p>Correlational design</p> <p>Opportunity Sampling</p>	<p>55 children with Autism (Ages (years) $M=8:2, SD=2:1, range=5-12$) - ***Gender missing</p>	<p>Sleep questionnaire, GARS* & BEDS*</p> <p>Pearson correlations, Stepwise multiple linear regression</p>	<p>- Communication problems were significantly related to increased sensitivity to stimuli in the sleeping environment and by periods of screaming during the night ($R^2=0.18, p<0.01$)</p> <p>- Fewer number of hours slept per night also predicted difficulties with social interactions ($R^2=0.12, p<0.01$) and overall diagnostic characteristics of autism ($R^2=0.11, p<:02$)</p>
<p>Wiggs, L., Stores, G.</p> <p>2004</p> <p>UK</p> <p>QR=78.6%</p>	<p>To investigate sleep disturbance in children with ASD</p>	<p>Exploratory Design</p> <p>Opportunity sampling</p>	<p>69 ASD children (55 males, 14 females; Ages $M=9$ years 4 months, $SD=2$ years 7 months, $range=5-16$)</p>	<p>Sleep history</p> <p>Sleep diary</p> <p>Actigraph</p> <p>Child/Parental functioning questionnaire, SPSQ**</p>	<p>- Behavioural sleep problems were more common in the younger age group than in the older children ($\chi^2(1)=6.48, p=0.01$)</p>

				Mann–Whitney U tests, T-test, Chi-squared test	
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* Analysis of Variance (ANOVA), Pervasive Developmental Disorder (PDD), Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS), Typical Development (TD), Autism Spectrum Condition (ASC), Autistic Disorder (AD), Autism Spectrum Disorder (ASD), Developmental Delays (DD)

** Achenbach Child Behaviour Checklist (CBCL), Achenbach Youth Self-Report Scale (AYSRS), Autism Diagnostic Interview-Revised (ADI-R), Autism Diagnostic Observation Schedule (ADOS), Beck Depression Inventory, 2nd edition (BDI-II), Behavioural evaluation of disorders of sleep (BEDS), Brain Computed tomography (CT), Child Behaviour Checklist (CBCL), Childhood Autism Rating Scale (CARS), Children’s Sleep Habits Questionnaire (CSHQ), Corsi block-tapping (CbITa), Developmental Profile II (DP-II), Differential Abilities Scale II (DAS-II), Environmental Exposure Questionnaire (EEQ), Figure-learning subtest of the BEM 144 battery (FLS-BEM144), Four choices reaction time test (FCRTT), Gilliam Autism Rating Scale (GARS), Interest/Fatigue/Mood Scales (IFMS), Leiter International Performance Scale-Revised (Leiter-R), Magnetic resonance imaging (MRI), Mullen Scales of Early Learning (MSEL), Nonverbal IQ scores (NVIQ), Parental Concerns Questionnaire (PCQ), Paediatric Daytime Sleepiness Scale (PDSS), Paediatric Quality of Life Inventory 4.0 (PedsQL), Pervasive Developmental Disorder Behaviour Inventory (PDDBI), Photoelectric Rotary Pursuit Task (PRPT), Pittsburgh Insomnia Rating Scale 20 (PIRS 20), Polysomnographic (PSG), Psychoeducational Prolerevised test (PEP-R), Scales of independent behavior-revised (SIB-R), Short Sensory Profile (SSP), Simonds and Parraga Sleep Questionnaire (SPSQ), Sleep diary/questionnaire, Developmental Behaviour Checklist (DBC), Social Communication Questionnaire (SCQ), Social Responsiveness Scale (SRS), Stanford-Binet Intelligence Scale (SB5), Stanford-Binet Intelligence Scales, Fifth Edition (SB5), State-Trait Anxiety Inventory (STAI), Tower and Trail Making subtests of the Delis-Kaplan Executive Function System (D-KEFS), Tower of London task (TLT), Vineland adaptive behaviour scales (VABS), Visual spatial memory task (VSMT), Wechsler Adult Intelligence Scale – Third Edition Revised (WAIS-III), Wechsler Intelligence Scale for Children—Third Edition Revised (WISC-III), Wechsler Intelligence Scale for Children—Fourth Edition Revised (WISC-IV), Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Wechsler Intelligence Scale for Children Revised (WISCR).

*** Missing data.

1.3.2 Findings of studies

1.3.2.1 What cognitive functions are impacted upon by sleep deprivation in people with ASC?

Four of fifteen studies explicitly mentioned the cognitive functions affected by a disruption of sleep in individuals with ASC (Bruni et al., 2007; Limoges et al., 2013; Maski et al., 2015; Taylor, Schreck, & Mulick, 2012).

Bruni et al. (2007) discussed that a high level of slow oscillatory activity during sleep is associated with an improved performance in prefrontal cortical tasks. The term 'oscillatory activity' denotes the recurring and rhythmic electrical activity produced spontaneously as a reaction to stimuli supplied by neurons in the central nervous system (CNS) (Başar, 2013). Therefore, Bruni et al. (2007) suggests that if a person has a high amount of fast oscillatory activity during sleep then it is going to negatively affect performance in prefrontal cortical tasks.

The prefrontal cortex has been associated in decision making, personality expression, predictions and consequences of current activities and future outcomes, regulating social behaviour (Yang & Raine, 2009). Functions carried out by the prefrontal cortex are often called executive functions. Executive functioning is also responsible for attention and working memory (Kane & Engle, 2002).

Bruni et al. (2007) suggested that people with Asperger's syndrome are exceptionally talented or skilled in one or more specific areas and this can be explained by superior memory abilities. The long-term consolidation of new memories is a function of high level of slow oscillatory activity during sleep. This means that the more restorative sleep (deep sleep) enables more potentiation which then provides better cognitive performance. The Bruni et al., 2007 study scored high on the SQAC score (22/28=78.6%) indicating that this study was of good quality and provided detailed methodology. The Bruni et al. study also provides answers to why restorative sleep improves cognitive performance.

Maski et al.'s (2015) study involved twenty-two children with ASC and twenty control participants between the ages of nine and sixteen and looked at the role of sleep in declarative memory. Parents of children with ASC reported more sleep problems than parents of typically developed (TD) children. Declarative memory was then tested using a two-dimensional visual spatial memory task which involved being trained to criterion and then given a cued recall test after a period of 'wake' or a night 'sleep'.

Maski et al. (2015) found that participants with ASC had poorer overall memory consolidation than typically developed (TD) participants. Specifically, people with ASC had impairments in spatial memory and poorer immediate recall and overall memory recall than TD participants. Also, it was found better-quality sleep in the ASC group correlated with memory consolidation, showing a direct link with poor sleep and a detrimental effect on cognitive functioning in people with ASC. This is important as it demonstrates the detrimental effect that poor sleep has on memory consolidation when just looking at the correlations of poor sleep on memory in children with ASC.

Maski et al.'s (2015) study found that children with ASC had poorer memory consolidation than children with TD, both groups demonstrated more consolidation following sleep than following the same period of wakefulness. These outcomes demonstrate that well rested sleep aids hippocampally mediated memory consolidation in children regardless of their neurodevelopment. Therefore, Maski et al. (2015) suggest that if sleep quality is increased in children with ASC, it could offer another way to help improve memory retention and cognitive functioning. The Maski et al. (2015) study scored well on the SQAC, ($19/28 = 67.9\%$). However, the sample size was small ($n=22$) when considering the age range (9 – 16 years old) and although age matched with the control group ($n=20$) results should be treated with caution.

Limoges et al.'s (2013) study explored the relationship between sleep and cognitive daytime performance in young adults with ASC and Typical Development (TD). The study found that young adults with ASC had clear signs of poor sleep compared to the TD group. The study also found that young adults with ASC performed as accurately as the TD group in the memory and attention tasks, even with the presence of poor sleep. However, people with ASC were slower than the TD group in most of the tasks undertaken that required memory or attention. Interestingly, despite being slower, the ASC group made fewer mistakes than the TD group in tasks that involved selective attention and sensory-motor memory.

Limoges et al. (2013) explained that these results could be the result of alternative strategies that people with ASC utilise to overcome the difficulties they would have using the strategies of TD people. These strategies have been shown in brain imaging studies, where people with ASC will use different pathways in attention and memory tasks due to a defect of neural and synaptic development that has produced over-connected neural systems (Belmonte and Yurgelun-Todd, 2003, Luna et al., 2002, Muller et al., 2003, cited in Limoges et al., 2013, p. 1332).

Limoges et al. (2013) concluded that investigating the variances between the young adults with ASC and the young adults with TD in tasks that involve memory and attention is problematic. This is due to the association between poor sleep and cognitive functioning between those with ASC and those with TD as they have been shown to take different neural pathways and altered connectivity substrates in certain tasks. Therefore, it brings up methodological problems when comparing the cognitive functioning between people with ASC and TD.

Despite the differences in the neural pathways and altered connectivity substrates in certain tasks between the ASC group and the TD group, there was a significant correlation between signs of poor sleep and declarative memory and selective attention in both groups. The Limoges et al. (2013) study scored well on the SQAC ($20/28=71.45\%$), and would have scored higher if there was a bigger sample size ($n=17$) of people with ASC and the estimate of variance was clearer in the main results.

Taylor et al.'s (2012) study also investigated sleep and cognitive functioning in 335 children with ASC or pervasive developmental disorder-not otherwise specified (PDD-NOS). The aim of the study was to describe the relationships between sleep and subsequent daytime cognitive and adaptive functioning. The study found that those whom slept fewer hours per night demonstrated impaired intelligence, perceptual and verbal skills, compared to children who slept longer. This is important as the Taylor et al. study identified that poor sleep has a detrimental effect on the ability to learn, understand and communicate in children with ASC.

Children with ASC who slept for fewer hours and suffered from (parent-reported) night-time breathing problems exhibited less aptitude to complete nonverbal tasks (e.g., puzzles, mazes, block building) and therefore Taylor et al. (2012) highlight a possible relationship between apnea and perceptual tasks for children with ASC. This suggests that treatment for apnea could improve cognitive functioning. Indeed, a study by Malow, McGrew, Harvey, Henderson and Stone (2006) demonstrated improvements in sleep, social communication, attention and improved daytime behaviour in a five-year-old female with ASC after an adenotonsillectomy for her obstructive sleep apnea.

Therefore, children with ASC whom, on average, slept more per night without waking, demonstrated a better ability to learn, understand and communicate with others during the day. The Taylor et al.'s. (2012) study scored $16/28= 57.1\%$ because the outcome measure(s) were not well defined due to the numerous materials utilised. This could have led to problems with controlling for confounding variables due to the number of tests and results from the various materials used, which may have led to a misclassification bias.

All the literature reviewed used quantitative methods to investigate the effects of poor sleep on cognitive functioning in people with ASC. There was a lack of qualitative research suggesting that this question lacked exploratory depth which may have provided additional data. However, the literature all had good quality scores (Bruni et al., 2007, $22/28=78.6\%$; Limoges et al., 2013, $20/28=71.45\%$; Maski et al., 2015, $19/28= 67.9\%$; Taylor, Schreck, & Mulick, 2012, $16/28= 57.1\%$).

In summary, from the literature reviewed, the cognitive functions that are specifically affected by a disruption of sleep in people with ASC are memory consolidation, declarative memory, selective attention, spatial memory, poorer immediate recall, overall memory recall, impaired intelligence and verbal skills. Also highlighted was the problem with comparing people with ASC to people with Typical Development as they use different neural pathways when performing certain cognitive tasks which may cause methodological validity problems when comparing cognitive scores amongst these groups.

1.3.3 What are the principal challenges associated with trying to study the impact of sleep deprivation in people with ASC?

To answer the question regarding the principal challenges associated with trying to study the impact of sleep deprivation in people with ASC four main themes have been highlighted 'problems with psychometric measures', 'under-reporting poor sleep in people with ASC', 'the role of carers and family members' and 'risks and ethical implications of looking at poor sleep in people with ASC' and will be presented in the following section:

1.3.3.1 Theme 1: Problems with psychometric measures

Five studies (Delahaye et al., 2014; Goldman, Richdale, Clemons, & Malow, 2012; Hollway et al., 2013; Krakowiak, Goodlin-Jones, Hertz-Picciotto, Croen, & Hansen, 2008; Maski et al., 2015) used the Children's Sleep Habits Questionnaire (CSHQ). The CSHQ consists of 45 items that relate to clinical sleep complaints exhibited over the past month. The CSHQ measures bedtime resistance, sleep onset delay, sleep duration, night awakenings, sleep anxiety, and other aspects of poor sleep such as daytime sleepiness, parasomnias, and sleep-disordered breathing. Krakowiak, Goodlin-Jones, Hertz-Picciotto, Croen, and Hansen (2008) used questions based on the CSHQ as part of the ongoing population-based case-control Childhood Autism Risks from Genetics and the Environment study. The

CSHQ is a valid measure that covers a wide range of sleep problems with excellent psychometric properties (Hollway et al., 2013).

Three studies (Polimeni et al., 2005; Schreck, Mulick, & Smith, 2004; Taylor et al., 2012) used the parent reported Behavioural Evaluation of Disorders of Sleep (BEDS) questionnaire. The BEDS is a 28-item parent-report questionnaire, developed for use with children (5–12 years). It measures aspects of sleep quality. Three questions address general characteristics of children's sleep, and one question asks whether the parent identifies their child as having poor sleep. This could be an interesting question to see how the parents interpret their child's sleep. Parents' answers on the BEDS relate to their child's sleep behaviour over the last six months. The BEDS has adequate internal consistency and identifies children with poor sleep and those without (Taylor et al., 2012).

Four of the reviewed studies (Bruni et al., 2007; Maski et al., 2015; Miano et al., 2007; Wiggs & Stores, 2004) used subjective measures of sleep in addition to polysomnography (laboratory sleep recordings)¹. These subjective measures of sleep included a sleep questionnaire developed by the authors (Miano et al., 2007), Simonds and Parraga Sleep Questionnaire (Miano et al., 2007), Pediatric Daytime Sleepiness Scale (PDSS; (Bruni et al., 2007) and an actigraph (Maski et al., 2015).

Patzold et al. (1998) used a sleep diary in which various questions about the participant's sleep were included, while Quist et al. (2015) used a sleep diary together with the Pittsburgh Insomnia Rating Scale 20 (PIRS 20). The final two studies (Elia et al., 2000; Limoges et al., 2013) out of the fifteen studies did not use any psychometric measures, using just polysomnography. However, Elia et al. (2000) did not report the strength of correlations in their study, and therefore, the results must be regarded with caution. All the studies reviewed in this section had very good quality scores (Hollway et al., 2013, 22/28=78.6%; Krakowiak, Goodlin-

¹ Polysomnography records of the biophysiological fluctuations that happen throughout sleep (Levendowski et al., 2009). The PSG records many body functions including brain (EEG), muscle activity or skeletal muscle activation (EMG), eye movements (EOG) and heart rhythm (ECG) during sleep and has good reliability (Levendowski et al., 2009)

Jones, Hertz-Picciotto, Croen, & Hansen, 2008, 22/28=78.6%; Delahaye et al., 2014, 20/28=71.4%; Goldman, Richdale, Clemons, & Malow, 2012, 19/28=67.9%; Maski et al., 2015, 19/28= 67.9%).

1.3.3.2 Theme 2: Under-reporting poor sleep in people with ASC

Only three studies (Delahaye et al., 2014; Miano et al., 2007; Wiggs & Stores, 2004) discussed why sleep disturbances are not often reported in people with ASC. This seems to be due to different ASC presentations, comorbid presentations and parental reporting. Delahaye et al. (2014) suggest that it is difficult to collect data on poor sleep variability with a range of ASC presentations. These difficulties stem from the variability in presentation, differences in participants' age range and using different ASC diagnostic criterion, with having poor sleep possibly indicating an unaddressed problem in the child, family, or environment (Delahaye et al., 2014).

Miano et al. (2007) removed participants with ASC whose parents reported habitual snoring, respiratory sleep disturbances, abnormal sleep patterns, craniofacial abnormalities, obesity or respiratory sleep disorders from their study to improve standardisation of participants. However, this has highlighted that some people with comorbid sleep disorders are often under-reported in ASC sleep studies and therefore, may not be an accurate reflection of the overall population of people with ASC.

Wiggs and Stores (2004) state that the parents of children with ASC may be biased in their recording of poor sleep. This is suggested by the discrepancies between actigraphy data and paternal reports. An actigraph is a small device that monitors the movement of sleep and is interpreted to indicate the quality and quantity of sleep (Morgenthaler et al., 2007). Wiggs and Stores (2004) discussed the importance of making a distinction between general sleep problems and underlying sleep disorders that may increase patterns of poor sleep. This distinction would help indicate more appropriate clinical interventions.

These studies have indicated that sleep disturbances often under-reported in people with ASC. This may be because those with ASC often have a wide range of presentations and may have an unaddressed problem in the child, family, or environment (Delahaye et al., 2014). Those with comorbid presentations are also being removed from sleep studies to make the sample more homogeneous (Delahaye et al., 2014; Miano et al., 2007). Wiggs and Stores (2004) indicated that parents might be unaware of the poor sleep their child may be experiencing and the use of objective measures of sleep may resolve this. All the afore-mentioned studies focussed on children, and there is a gap in the literature for understanding why poor sleep is under-reported in adults with ASC. They also had very good quality scores (Delahaye et al., 2014, 20/28=71.4%; Miano et al., 2007, 18/28=64.3%; Wiggs & Stores, 2004, 22/28=78.6%).

1.3.3.3 Theme 3: Role of carers and family members

Four (Krakowiak et al., 2008; Polimeni, Richdale, & Francis, 2005; Quist, Chaplin, & Hendey, 2015; Wiggs & Stores, 2004) of the reviewed studies investigate how are carers/ family members were affected by the disrupted sleep of people with ASC.

Polimeni et al. (2005) suggest that behaviour analysis followed by behavioural interventions are more effective for young children with ASC. They discussed that parents of children with ASC may be more experienced at using behavioural techniques generally with their child's problematic behaviours and may be more experienced in delivering behavioural interventions than other techniques. Polimeni et al. (2005) conclude that behavioural interventions may have better outcomes for poor sleep in children with ASC than other approaches such as Cognitive Behavioural Therapy. Quist et al. (2015) found that their psychoeducation sleep-hygiene group for adults with a diagnosis of ASC helped improve poor sleep. However, this was a small study, and the paper was not specific as to how the participants were educated. This study also scored low on the quality assessment scale (50%).

Wiggs and Stores (2004) suggest that the existing discrepancies between actigraphy data and parental reports may be due to the parent's sleep also being disturbed. Wiggs and Stores (2004) suggest that while mental states of mothers of children with ASC and mothers of children with typical development did not significantly differ, it is possible that their disturbed sleep may be having an impact on their wellbeing. This could support the idea that sleep interventions focussed on altering a child's behaviour or cognitions regarding sleeplessness might also be of benefit to the carers/family members with disrupted sleep.

Wiggs and Stores (2004) discussed how children with ASC experience poor sleep because of sensory difficulties including hearing noises, wrapping themselves in a duvet or refusing to have covers touch their bodies. Wiggs and Stores suggest that parents may not be aware of these problems and therefore the lack of awareness means that the parents do not consider interventions such as using soft bedding, minimising noise etc. Therefore, a cognitive and behavioural assessment may benefit those people with ASC who find themselves awake during the night, to understand the pattern and how to break the maintaining factors. Wiggs and Stores (2004) conclude that further investigation of this phenomenon may result in developing novel sleep interventions. However, no novel interventions were suggested. The Wiggs and Stores' (2004) study scored high on the quality assessment (78.6%) and included the discussion on the limitations of using parent subjective sleep measures.

Krakowiak et al. (2008) found that parents of children with typical development rarely reported their child's sleep problems as affecting family functioning. However, a high proportion of parents of children with ASC (one in five families) did report problems with family functioning because of their child's poor sleep.

This aim also highlighted a lack of data concerning the impact that poor sleep on cognitive functioning has on families, carers and the person with ASC. This may be a result of a lack of qualitative research focussing on the families and carers of those with ASC.

In conclusion, carers/ family members are affected by the disrupted sleep of people with ASC and sleep interventions aimed at children could also help educate carers/ family members on how to manage their poor sleep. However, both studies are focussed on children and highlight the lack of research into the impact of poor sleep on adults with ASC and their families and carers. Despite this limitation, both studies scored high on the quality assessment (Krakowiak et al., 2008, 22/28=78.6%; Polimeni, Richdale, & Francis, 2005, 19/28=67.9%; Patzold, Richdale, & Tonge, 1998, 18/28=64.3%; Quist, Chaplin, & Hendey, 2015, 14/28=50%; Wiggs & Stores, 2004, 22/28=78.6%).

1.3.3.4 Theme 4: Risks and ethical implications of looking at poor sleep in people with ASC

Four (Delahaye et al., 2014; Krakowiak et al., 2008; Limoges et al., 2013; Wiggs & Stores, 2004) of the fifteen studies explicitly mentioned the risk and ethical implications of studying poor sleep in people with ASC.

Delahaye et al. (2014) found that children with ASC who have more significant sleep problems are more likely to experience more reduced health-related quality of life using the Health-related quality of life (HRQoL) questionnaire. However, HRQoL, with its multi-faceted approach to attaining subjective experiences of health, emphasises an individual's perception of their wellbeing rather than objective indicators of health. Thus, findings from this study should be treated with caution. Also, it is worth noting that the study by Delahaye et al. (2014) did not know the IQ for 40% of the participants in their study. It is essential to record the IQ of all the participants because of the varying presentations of ASC which is reflected in their IQ score (Cohen et al., 2014).

Krakowiak et al. (2008) discussed the limitations of relying on subjective parent reporting of their child's poor sleep. Krakowiak et al. (2008) suggest that while parent reports are correlated with objective actigraphy of sleep routines in children with ASC, this is the case only if they are made aware of the disturbed sleep by their child. Limoges et al. (2013) also highlighted that poor sleep in 'non-

complaining' persons with ASC is under-reported, as the parents are not being made aware. This suggests that individual consideration or a form of objective monitoring should be given to children with ASC who have limited communication abilities.

Wiggs and Stores (2004) found that children with ASC often have high levels of anxiety, challenging daytime behaviour, use of inappropriate or fixed routines and rituals, and impaired communication and social skills. All these factors could result in difficulties with the implementation of specific behavioural interventions for poor sleep and more challenging to implement than in children without such problems. Therefore, there is an increased risk of using behavioural interventions with children with ASC compared to children from the general population. However, there was little discussion about the potential risk in people with ASC who have disrupted sleep.

Wiggs and Stores (2004) discuss the importance of using an objective sleep measure to be able to understand the nature of the sleep disturbances in people with ASC and further develop the knowledge around the mechanisms underlying successful sleep interventions. In conclusion, if researchers are relying on subjective sleep measures, the results could be misinterpreted and provide misleading evidence of poor sleep in people with ASC.

These studies had very good quality assessment scores (Delahaye et al., 2014, 20/28=71.4%; Krakowiak et al., 2008, 22/28=78.6%; Limoges et al., 2013, 20/28=71.45%; Wiggs & Stores, 2004, 22/28=78.6%).

1.4 Discussion

1.4.1 Significance of the Main Findings

This review aimed to identify what cognitive functions are impacted upon by sleep deprivation in people with ASC and the principal challenges associated with trying to study the impact of sleep deprivation in people with ASC and critically review the quality of the research. These findings indicate a relationship between sleep

disturbances and a negative impact on the lives of people with ASC as well as their families/carers. These findings highlight the adverse effects of poor sleep on daytime behaviour and general functioning in people with ASC (Hill et al., 2014; Limoges et al., 2013; Park et al., 2012) as well as the impact on their cognitive functioning (Bruni et al., 2007; Limoges et al., 2013; Maski et al., 2015; Taylor et al., 2012).

Poor sleep in people with ASC has been shown to have a detrimental effect on different cognitive functioning such as memory consolidation, declarative memory, selective attention, spatial memory, poorer immediate recall, overall memory recall, impaired intelligence and verbal skills (Bruni et al., 2007; Limoges et al., 2013; Maski et al., 2015; Taylor et al., 2012). Importantly, when sleep improves it has a positive effect on cognitive functioning (Limoges et al., 2013; Taylor et al., 2012).

Now there is a clearer understanding of the cognitive functioning affected by poor sleep in people with ASC this may help develop measures and interventions that may help with these areas. Also highlighted was the different neural pathways that people with ASC have when comparing cognitive functioning in people with Typical Development (TD), Therefore this review has highlighted a possible methodological problem when comparing the cognitive functioning between those with ASC and those with TD.

The literature review also highlighted the problems of identifying sleep disturbances in people with ASC. As there is such variation in ASC presentations including a wide range of communication difficulties, this variation may result in sleep disturbances being under-reported by people with ASC (Delahaye et al., 2014; Wiggs & Stores, 2004). Comorbid presentations alongside the ASC diagnosis also complicate this under-reporting. Many people with ASC are often excluded from studies investigating sleep disturbances which may result in an under-representation of this client group in the broader literature. Therefore, these complex presentations should be considered and represented when measures that may identify sleep disturbances in children with ASC are developed.

This review highlighted the number of measures that researchers use to investigate sleep problems. These include numerous different psychometric measures that are used to identify sleep disturbance in children with ASC, subjective questionnaires, sleep diaries, actigraphy and PSG recordings. Moore, Evans, Hanvey, and Johnson (2017) discussed the importance of using an objective measure as well as parental reports to screen for poor sleep in children with ASC for the parental recording alone may not be accurate. Schreck and Mulick (2000) found that the perception of their child's sleep in parents of children with ASC is different to other groups as these parents significantly reported more sleep problems in their child more than other groups. Moore et al. (2017) discuss the costs that are associated with using multiple measures, however indicating that with advances in technology, actigraphy and PSG recordings may become less expensive and more user-friendly and may help with accurately diagnosing sleep disorders in ASC population.

Therefore, more research needs to be focussed on appropriate measures of sleep in people with ASC that take into consideration the impact on cognitive dysfunction rather than just focus the measure on behaviours. Further research also needs to be focussed on why poor sleep is often under-reported in people with ASC. This could be because the area is under-researched and therefore clinicians, parents and carers are not aware of the impact of poor sleep on cognitive functioning. Exploration in this area could also help provide more rich data regarding how parents and carers currently deal with poor sleep in those with ASC. Likewise, information is also lacking in how parents and carers positively help with dealing with poor sleep. In addition, this information could also be received from people with high functioning.

1.4.2 Summary of methodological constraints and research limitations

This review supports the finding that the effects of poor sleep, in people with ASC, on cognitive functioning are complex and require further investigation. The review highlighted a lack of data regarding the impact that impaired cognitive

functioning, due poor sleep, has on families, carers and the person with ASC. A qualitative approach could involve interviewing families, carers and the person with ASC and exploring the impact that impaired cognitive functioning, due to poor sleep, has on their daily functioning and wellbeing. This qualitative approach may also highlight successful parental approaches to poor sleep in children with ASC.

Several studies did not report the IQ or severity of symptoms of the participants in their studies entirely (Delahaye et al., 2014; Wiggs & Stores, 2004). This is important as several studies have IQ and symptom severity in children with pervasive developmental disorders as main predisposing factors for the development of insomnia (Cohen et al., 2014; Hollway et al., 2013). This information would have been helpful as poor sleep has been shown to negatively affect cognitive functioning in the general population (Dahl, 1996; Killgore, 2010) and possible links between IQ and poor sleep may have been discovered if this information was provided.

Another limitation of this review was the use of the key terms. There are lot of different terms for poor sleep, ASC and cognitive functioning. This might have caused the search of the literature to be too narrow. A possible way to overcome this limitation in the future is to be more specific in searching for literature – for example, look at physical problems causing poor sleep e.g., apnea. Also, key terms for cognitive functioning could be more specific e.g., attention, working memory and finally key terms for sleep could include; insomnia, night terrors etc.

1.4.3 Clinical implications and future research recommendations

This review has highlighted that, for accurate reporting of poor sleep in children with ASC, both objective and subjective measures of sleep are the gold standard as they can counter misinterpretation and provide additional insight into the nature of the poor sleep (Krakowiak et al., 2008; Wiggs & Stores, 2004). This review has also highlighted that there is a gap in the literature regarding the

impact that poor sleep in children with ASC has on their family/carers' wellbeing. Therefore, additional measures regarding family/carers wellbeing and stress would help to identify any risk factors that lead to a proliferation of parenting stress (Benson, 2006). The use of a wide range of different neuropsychological tests would provide a more in-depth view of the impact of poor sleep on cognitive functioning rather than just focussing on the behavioural dysfunction. This multidimensional approach to sleep dysfunction in people with ASC will help identify risk factors and provide more accurate data. This, in turn, might help identify the most appropriate sleep intervention for the person with ASC.

This literature review has found a gap in the literature for the most appropriate clinical interventions for this client group. Future research might compare sleep interventions to identify which intervention is the most effective for this group.

1.4.4 Conclusion

This literature review has highlighted that cognitive functions in people with ASC are negatively affected by poor sleep. Reduced cognitive functioning in people with ASC has a major impact on their daily functioning, as well as impacting upon the families and carers. The findings from this literature review have discovered that there are a limited number of standardised measures for identifying poor sleep in this population. Additionally, there are methodological problems relying on subjective parental reports. A methodological limitation of this review was the lack of parental accounts regarding successful methods of being able to manage the poor sleep. Finally, there is a lack of evidence-based clinical interventions to help improve poor sleep in people with ASC which may be due to the lack of standardised measures.

1.5 References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed. ed.). Arlington, Va.: American Psychiatric Publishing.
- Başar, E. (2013). Brain oscillations in neuropsychiatric disease. *Dialogues in clinical neuroscience*, *15*(3), 291.
- Benson, P. R. (2006). The impact of child symptom severity on depressed mood among parents of children with ASD: The mediating role of stress proliferation. *Journal of Autism and Developmental Disorders*, *36*(5), 685-695.
- Bruni, O., Ferri, R., Vittori, E., Novelli, L., Vignati, M., Porfirio, M. C., . . . Curatolo, P. (2007). Sleep architecture and NREM alterations in children and adolescents with Asperger syndrome. *Sleep*, *30*(11), 1577-1585.
- Chee, M. W., & Chuah, L. Y. (2008). Functional neuroimaging insights into how sleep and sleep deprivation affect memory and cognition. *Current Opinion in Neurology*, *21*(4), 417-423. doi:10.1097/WCO.0b013e3283052cf7 [doi]
- Cohen, S., Conduit, R., Lockley, S. W., Rajaratnam, S. M., & Cornish, K. M. (2014). The relationship between sleep and behaviour in autism spectrum disorder (ASD): A review. *Journal of Neurodevelopmental Disorders*, *6*(1), 44.
- Dahl, R. E. (1996). (1996). The impact of inadequate sleep on children's daytime cognitive function. Paper presented at the *Seminars in Pediatric Neurology*, *3*(1) 44-50.

- Delahaye, J., Kovacs, E., Sikora, D., Hall, T. A., Orlich, F., Clemons, T. E., . . .
- Kuhlthau, K. (2014). The relationship between health-related quality of life and sleep problems in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 8(3), 292-303. doi:10.1016/j.rasd.2013.12.015
- Edinger, J. D., Bonnet, M. H., Bootzin, R. R., Doghramji, K., Dorsey, C. M., Espie, C. A., . . . Stepanski, E. J. (2004). Derivation of research diagnostic criteria for insomnia: Report of an American academy of sleep medicine workgroup. *Sleep*, 27(8), 1567-1596.
- Elia, M., Ferri, R., Musumeci, S. A., Del Gracco, S., Bottitta, M., Scuderi, C., . . .
- Grubar, J. (2000). Sleep in subjects with autistic disorder: A neurophysiological and psychological study. *Brain and Development*, 22(2), 88-92.
- Ellenbogen, J. M. (2005). Cognitive benefits of sleep and their loss due to sleep deprivation. *Neurology*, 64(7), E25-7. doi:64/7/E25 [pii]
- Elsabbagh, M., Divan, G., Koh, Y., Kim, Y. S., Kauchali, S., Marcín, C., . . . Wang, C. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research*, 5(3), 160-179.
- Gazzaniga, M., Ivry, R., & Mangun, G. (2009). *Cognitive neuroscience: The biology of the mind* (3rd ed.). London: Norton.
- Goldman, S. E., Richdale, A. L., Clemons, T., & Malow, B. A. (2012). Parental sleep concerns in autism spectrum disorders: Variations from childhood to

adolescence. *Journal of Autism and Developmental Disorders*, 42(4), 531-538.

Henry, A. L., Kyle, S. D., Bhandari, S., Chisholm, A., Griffiths, C. E., & Bundy, C. (2016). Measurement, classification and evaluation of sleep disturbance in psoriasis: A systematic review. *PloS One*, 11(6), e0157843.

Hill, A. P., Zuckerman, K. E., Hagen, A. D., Kriz, D. J., Duvall, S. W., van Santen, J., . . . Fombonne, E. (2014). Aggressive behaviour problems in children with autism spectrum disorders: Prevalence and correlates in a large clinical sample. *Research in Autism Spectrum Disorders*, 8(9), 1121-1133.
doi:<https://doi.org/10.1016/j.rasd.2014.05.006>

Hollway, J. A., Aman, M. G., & Butter, E. (2013). Correlates and risk markers for sleep disturbance in participants of the autism treatment network. *Journal of Autism and Developmental Disorders*, 43(12), 2830.

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic bulletin & review*, 9(4), 637-671.

Killgore, W. D. (2010). Effects of sleep deprivation on cognition. *Progress in brain research* (pp. 105-129) Elsevier.

- Kmet, L., Lee, R., & Cook, L. (2011). Standard quality assessment criteria for evaluating primary research papers from a variety of fields. 2004. *Edmonton: Alberta Heritage Foundation for Medical Research,*
- Knapp, M., Romeo, R., & Beecham, J. (2009). Economic cost of autism in the UK. *Autism, 13*(3), 317-336. doi:10.1177/1362361309104246
- Koffel, E. A., Koffel, J. B., & Gehrman, P. R. (2015). A meta-analysis of group cognitive behavioural therapy for insomnia. *Sleep Medicine Reviews, 19*, 6-16. doi:10.1016/j.smrv.2014.05.001 [doi]
- Krakowiak, P., Goodlin-Jones, B., Hertz-Picciotto, I., Croen, L., & Hansen, R. (2008). Sleep problems in children with autism spectrum disorders, developmental delays, and typical development: A population-based study. *Journal of Sleep Research, 17*(2), 197-206.
- Landrigan, C. P., Rothschild, J. M., Cronin, J. W., Kaushal, R., Burdick, E., Katz, J. T., . . . Bates, D. W. (2004). Effect of reducing interns' work hours on serious medical errors in intensive care units. *New England Journal of Medicine, 351*(18), 1838-1848.
- Levendowski, D. J., Zack, N., Rao, S., Wong, K., Gendreau, M., Kranzler, J., . . . Westbrook, P. R. (2009). Assessment of the test-retest reliability of laboratory polysomnography. *Sleep and Breathing, 13*(2), 163-167.
- Limoges, É, Bolduc, C., Berthiaume, C., Mottron, L., & Godbout, R. (2013). Relationship between poor sleep and daytime cognitive performance in

young adults with autism. *Research in Developmental Disabilities*, 34(4), 1322-1335.

Maski, K., Holbrook, H., Manoach, D., Hanson, E., Kapur, K., & Stickgold, R. (2015). Sleep-dependent memory consolidation in children with autism spectrum disorder. *Sleep*, 38(12), 1955-1963. doi:10.5665/sleep.5248

Malow, B. A., McGrew, S. G., Harvey, M., Henderson, L. M., & Stone, W. L. (2006). Impact of treating sleep apnea in a child with autism spectrum disorder. *Pediatric neurology*, 34(4), 325-328.

Miano, S., Bruni, O., Elia, M., Trovato, A., Smerieri, A., Verrillo, E., . . . Ferri, R. (2007). Sleep in children with autistic spectrum disorder: A questionnaire and polysomnographic study. *Sleep Medicine*, 9(1), 64-70.

Miller, C. B., Espie, C. A., Epstein, D. R., Friedman, L., Morin, C. M., Pigeon, W. R., . . . Kyle, S. D. (2014). The evidence base of sleep restriction therapy for treating insomnia disorder. *Sleep Medicine Reviews*, 18(5), 415-424. doi:10.1016/j.smr.2014.01.006 [doi]

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ*, 339 doi:10.1136/bmj.b2535

Moore, M., Evans, V., Harvey, G., & Johnson, C. (2017). Assessment of sleep in children with autism spectrum disorder. *Children*, 4(8), 72.

- Morgenthaler, T., Alessi, C., Friedman, L., Owens, J., Kapur, V., Boehlecke, B., . . . Lee-Chiong, T. (2007). Practice parameters for the use of actigraphy in the assessment of sleep and sleep disorders: An update for 2007. *Sleep, 30*(4), 519-529.
- Ohayon, M. M. (2002). Epidemiology of insomnia: What we know and what we still need to learn. *Sleep Medicine Reviews, 6*(2), 97-111.
- Oyane, N. M. F., & Bjorvatn, B. (2005). Sleep disturbances in adolescents and young adults with autism and Asperger syndrome. *Autism: The International Journal of Research and Practice, 9*(1), 83.
- Park, S., Cho, S., Cho, I. H., Kim, B., Kim, J., Shin, M., . . . Yoo, H. J. (2012). Sleep problems and their correlates and comorbid psychopathology of children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6*(3), 1068-1072. doi:10.1016/j.rasd.2012.02.004
- Patzold, L., Richdale, A., & Tonge, B. (1998). An investigation into sleep characteristics of children with autism and Asperger's disorder. *Journal of Paediatrics and Child Health, 34*(6), 528-533.
- Polimeni, M., Richdale, A., & Francis, A. (2005). A survey of sleep problems in autism, Asperger's disorder and typically developing children. *Journal of Intellectual Disability Research, 49*(4), 260-268.
- Quist, H., Chaplin, E., & Hendey, O. (2015). Sleep intervention for adults with autism spectrum condition. *Mental Health Practice, 18*(10), 14-18.

- Richdale, A. L., & Schreck, K. A. (2009). Sleep problems in autism spectrum disorders: Prevalence, nature, & possible biopsychosocial aetiologies. *Sleep Medicine Reviews, 13*(6), 403-411.
- Schreck, K. A., & Mulick, J. A. (2000). Parental report of sleep problems in children with autism. *Journal of Autism and Developmental Disorders, 30*(2), 127-135.
- Schreck, K. A., Mulick, J. A., & Smith, A. F. (2004). Sleep problems as possible predictors of intensified symptoms of autism. *Research in Developmental Disabilities, 25*(1), 57-66.
- Stores, G., & Wiggs, L. (2001). *Sleep disturbance in children and adolescents with disorders of development: Its significance and management* Cambridge University Press.
- Taylor, M. A., Schreck, K. A., & Mulick, J. A. (2012). Sleep disruption as a correlate to cognitive and adaptive behaviour problems in autism spectrum disorders. *Research in Developmental Disabilities, 33*(5), 1408-1417.
- Tudor, M. E., Hoffman, C. D., & Sweeney, D. P. (2012). Children with autism sleep problems and symptom severity. *Focus on Autism and Other Developmental Disabilities, 27*(4), 254-262.
- Wiggs, L., & Stores, G. (2004). Sleep patterns and sleep disorders in children with autistic spectrum disorders: Insights using parent report and actigraphy. *Developmental Medicine and Child Neurology, 46*(6), 372-380.

Yang, Y., & Raine, A. (2009). Prefrontal structural and functional brain imaging findings in antisocial, violent, and psychopathic individuals: a meta-analysis. *Psychiatry Research: Neuroimaging*, *174*(2), 81-88.

Young, R. L., & Rodi, M. L. (2014). Redefining autism spectrum disorder using DSM-5: The implications of the proposed DSM-5 criteria for autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *44*(4), 758-765.

CHAPTER 2: Sleep, General Anxiety Disorder (GAD) and the effects on cognition

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2.0 Abstract

BACKGROUND: Poor sleep and General Anxiety Disorder (GAD) independently have a considerable impact on cognitive functioning. This study aims to investigate the combined effects of GAD and poor sleep on cognitive functioning.

METHODS: Current study employed quantitative design with purposive sampling of university students ($N=40$, age mean of 22.88, 33 females and 7 males). Four groups were investigated: 'Sleep & GAD', 'Sleep', 'GAD' and 'Normal' (Control). Sleep quality and quantity were assessed using the Pittsburgh Sleep Quality Index (PSQI) and an actigraphy unit. GAD was evaluated using GAD-7 item questionnaire (GAD7). The cognitive functions of Attention and Working Memory were measured using the Stroop Test and Reading Span Task (RST) scales respectively. Differences between groups was measured using the non-parametric Kruskal-Wallis H test. Relationships between GAD-7 scores, sleep quality/quantity and cognition scores were investigated using correlation analyses.

RESULTS: Hypothesis 1 that objective poor sleep quality and/or duration will have a negative effect on cognition has been confirmed. Hypothesis 2 that GAD and poor sleep quality/duration combined will have a stronger negative effect on cognition than GAD or poor sleep quality/duration alone has been confirmed.

CONCLUSIONS: Objective poor sleep quality and quantity had an adverse effect on Attention and Working memory. Poor sleep rather than GAD was found to have the most detrimental impact on Attention and Working Memory.

KEYWORDS: SLEEP, GAD, ANXIETY, OBJECTIVE SLEEP MEASURES, COGNITIVE FUNCTIONING.

2.1 Introduction

General Anxiety Disorder (GAD) and Insomnia have a considerable impact on the lives of people living with either condition. Seventy-five percent of people with GAD also have insomnia (Bélanger, Morin, Langlois, & Ladouceur, 2004) but it is unknown whether one disorder is a precursor to the other. This study will explore the importance of good sleep quality/duration and the subsequent difficulties that arise when either or both are disrupted. Sleep perception and the misperception people have when self-reporting sleep quality/duration will also be discussed. This misperception has been shown to make people more hypervigilant about their lack of sleep and result in an increase in anxiety (Wicklow & Espie, 2000). Sleep anxiety will be explored with attention to GAD as the dominant anxiety disorder that co-exists with sleep difficulties (Bélanger et al., 2004). Finally, the consequences of GAD and poor sleep quality/duration on a person's cognitive functioning and the impact this has on their quality of life will be highlighted.

2.1.1 Sleep quality and duration

Insomnia is a sleep disorder and is characterised by a person reporting difficulty in getting to sleep, or broken and disrupted sleep despite adequate opportunity for a full night's sleep (Ohayon, 2009; Roth, 2007). Causal factors for insomnia include psychoactive drugs, the use and withdrawal of opioids and/or alcohol (Chaudhary et al., 2015; Zisapel & Laudon, 2003), physical health problems (Fortier-Brochu, Beaulieu-Bonneau, Ivers, & Morin, 2010; Sivertsen, Krokstad, Øverland, & Mykletun, 2009), depression (Berger, van Calker, & Riemann, 2003) and anxiety (Peterson, Rumble, & Benca, 2008). It has also been found that insomnia exacerbates psychological problems such as anxiety and depression (Taylor, Lichstein, Durrence, Reidel, & Bush, 2005), with evidence to suggest that insomnia may also precede such difficulties (Mendelson, 2008; Statharou & Taka, 2012). National Institute for Health and Care Excellence (NICE) guidelines suggest that those experiencing long-term insomnia are referred to an Improving Access to Psychological Therapies IAPT service for a cognitive or behavioural

intervention (NICE, 2015). However, some IAPT services only accept referrals for people who are experiencing depression and anxiety (NHS, 2018).

2.1.2 Sleep state misperception

People with sleep difficulties often misperceive the quality and duration of their sleep (Bianchi, Williams, Mckinney, & Ellenbogen, 2013). This misperception has been noted when comparing subjective reports to many different objective measures (Harvey & Tang, 2012) including actigraphy (movement monitoring) (Tang & Harvey, 2006; Wicklow & Espie, 2000). Wicklow and Espie (2000) found that people often ruminate about their lack of sleep when they are trying to get to sleep. This rumination about their lack of sleep leads to a vicious cycle of worry during the day about the lack of perceived sleep.

Sleep state misperception is particularly common in people with insomnia (Fernandez-Mendoza et al., 2011). Harvey and Tang (2012) discuss how selective attention and monitoring are key characteristics of people experiencing sleep difficulties. People with sleep difficulties may be paying more attention to bodily sensations (e.g., physically tired, lack of concentration) and internal and external monitoring (e.g., looking at the clock). In another study, Tang and Harvey (2006) asked 48 participants who experienced insomnia to wear an actigraph unit and keep a sleep diary for two nights. Half of the participants were then shown the discrepancy between the objective and subjective measures of their sleep and the other participants were verbally told this information. The participants then recorded their sleep over another two nights to monitor the effects of being shown the results or just being verbally informed about the discrepancies. Both groups reported a reduction in sleep impairment, symptoms of insomnia and sleep-related anxiety but the group that was shown their disparities rather than verbally being told, had a more significant reduction in symptoms. This study indicates that if interventions are directed at a person's sleep state misperception, and they are shown this discrepancy rather than verbally told them, it could help reduce sleep-related anxiety.

2.1.3 General Anxiety Disorder (GAD)

GAD is one of the most common anxiety disorders and affects 2% of the adult population in Europe (Lieb, Becker, & Altamura, 2005) and is characterised by excessive worry about several topics around past, present and future events. People experience a wide range of physical symptoms including restlessness, headaches, nausea, difficulty concentrating and muscle aches (American Psychiatric Association, 2013). Risk factors for the development of GAD include family genetics (Hettema, Neale, & Kendler, 2001), life stressors (Donner et al., 2008) and substance abuse (Hasin et al., 2015). Saletu and colleagues (1997) suggest that hypervigilance and hyperarousal of the Central Nervous System (CNS) caused by GAD result in a decrease in total sleep time and sleep efficiency.

2.1.4 Impact of GAD and poor sleep quality/duration on the quality of life

People with insomnia often report difficulty in handling minor stresses, fatigue and experience reduced interest in pleasurable activities and relationships (Fortier-Brochu et al., 2012). There have been reports of cognitive impairments which result in problems with decision making, difficulty in concentration and an increased frequency of mistakes during employment (Linton & Bryngelsson, 2000; Ohayon, 2009). However, very few studies have shown cognitive impairments when using objective measures of performance and instead rely more on subjective accounts of cognitive functioning (Fortier-Brochu et al., 2012). Current literature provides some information on the combined effects of anxiety and sleep on cognitive functioning when using subjective measures of sleep but lacks in-depth investigation on the combined effects when using objective measures of sleep.

2.1.5 The impact of GAD and poor sleep quality/duration on cognition

People who experience insomnia or GAD report impairment in their cognitive functioning (Fortier-Brochu et al., 2012; Paterniti, Dufouil, Bisserbe, & Alperovitch,

1999). Cognitive functioning is a process by which one becomes aware of, perceives, or comprehends ideas through cerebral activities (Gazzaniga, Ivry, & Mangun, 2009). It is involved in all aspects of thinking, perception, remembering and reasoning.

Fortier-Brochu and colleagues (2012) conducted a meta-analysis of 24 studies and found that there was a significant impairment for people with insomnia in tasks that assessed working memory, episodic memory and problem-solving. However, there was no considerable deficit in tasks that assessed other cognitive functions such as procedural learning, features of executive functioning (cognitive flexibility and verbal fluency), verbal functions and features of attention (selective attention, complex reaction time, the speed of information processing, sustained attention/vigilance and alertness).

Studies have found a link between anxiety and impaired cognitive functioning (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Paterniti et al., 1999). However, other studies have found the opposite, that high levels of anxiety do not affect cognitive functioning (Eysenck, Derakshan, Santos, & Calvo, 2007; Kizilbash, Vanderploeg, & Curtiss, 2002). Yang and colleagues (2015) focused on people who had a diagnosis of GAD using the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and showed that they had impaired cognitive functioning with a significant impairment in their attention and working memory. However, the DSM-5 criteria for GAD include difficulty with sleep and cognitive difficulties, e.g. impaired concentration. Therefore, there is conflicting evidence regarding the impact of GAD and poor sleep on cognitive functioning especially in the areas of Attention and Working Memory.

There are different research designs that have been used to investigate these associations. For example, Paterniti et al.'s (1999) research looked at similar associations between anxiety and depression on cognitive functioning and they used multiple linear regression as a research design. Yang et al.'s (2015) study investigating the cognitive function in subjects with GAD and used analysis of variance (ANOVA) to look at the differences between levels of anxiety on cognitive

functioning and Pearson's correlation was utilized to examine the relationship between symptom measures and cognitive functioning.

2.1.6 Present study

Since 75% of people with GAD experience insomnia, people who report both anxiety and sleep difficulties may experience an increased impairment of their cognitive function beyond that experienced by people with GAD or insomnia in isolation. People with insomnia and GAD often report a reduction in work productivity and increased use of mental health services (Wade, 2010; Wittchen, 2002). Therefore, having a clear understanding of the associations between sleep problems, GAD and cognitive functioning might help prioritise clinical interventions which, in turn, might help reduce the economic burden by increasing work productivity and reducing the use of mental health services. It is also important to look at the differences between the use of subjective and objective measures when exploring cognitive performance. This may lead to more clinical interventions being focused on treating sleep dysfunction based on objective measures rather than relying solely on subjective accounts. The current study may highlight or provide ideas for interventions for sleep-related difficulties such as targeting attention and working memory.

Evidence appears to suggest GAD and poor sleep impacts on attention and working memory (Fortier-Brochu et al., 2012; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Paterniti et al., 1999). However, due to conflicting evidence (Eysenck, Derakshan, Santos, & Calvo, 2007; Kizilbash, Vanderploeg, & Curtiss, 2002) it seems these interactions are more complex and therefore this study will look at the relative effect of each one and then look at the interaction of both on cognitive functioning. As Attention and Working Memory seem to be mentioned frequently as being affected by GAD and poor sleep (Fortier-Brochu et al., 2012; Linton & Bryngelsson, 2000; Ohayon, 2009), these cognitive functions will be used to explore these effects.

Therefore, this study aims to investigate the combined effects of GAD and poor sleep on cognitive functioning by collecting measures from participants with GAD and sleep difficulties. This will be done by using subjective and objective sleep measures, anxiety measures and testing functioning in different cognitive domains: Attention and Working Memory.

2.1.7 Aims of the study

The aim of this study is to address two research questions:

- 1) Does poor sleep quality/duration have a negative impact on cognitive functioning (Attention and Working Memory)?
- 2) Does the interaction between anxiety and poor sleep quality influence cognitive functioning (Attention and Working Memory).

2.1.8 Hypotheses

Two general hypotheses have been stated:

H1 – Poor sleep quality/duration will have a negative impact on cognitive functioning (Attention and Working Memory).

H2 – The interaction between anxiety and poor sleep quality will have a significant influence on cognitive functioning (Attention and Working Memory).

2.2 Methods

2.2.1 Research Design

Broadly, any research study is designed to investigate either relationships or differences between variables. The former approach employs techniques such as correlation and multiple regression, while that latter uses statistical tests such as analysis of variance. The decision as to which design is the most appropriate is initially governed by theoretical considerations (what hypotheses need to be

tested), but the final solution is determined by more practical considerations such as: ‘effect size’ and statistical power, which can influence the confidence the researcher can have in their findings. This study, based on sound theoretical principles, used a differential group (quasi-experimental design) and employed non-parametric tests to investigate the hypotheses. However, given the small sample size, it could be argued that adopting a correlational approach towards the analysis of the findings might have been helpful. The relative strengths and limitations associated with these issues will be considered in both the methods and discussion sections of this thesis.

2.2.2 Sample

This study used a non-probability sampling. The quota for each subgroup was set at 10. A power analysis using the Gpower computer program (Faul & Erdfelder, 1998) indicated that a total sample of 40 people would be needed to detect large effect ($f^2=0.35$) and a significance of 0.05 with three predictor variables (‘Level of anxiety’, ‘Sleep quality’ and ‘Sleep duration’).

Table 4 - Inclusion & Exclusion Criteria for participants

Criteria	Inclusion	Exclusion
Gender	Males and Females	None
Age	18 – 59	<18 and >60
Language	English speaking (First language)	Non-English speaking or English as the second language
Geography	Willing to travel to Coventry University for neuropsychological tasks & collect/return Actiwatch	Not willing to travel to Coventry University for neuropsychological tasks & collect/return Actiwatch

Ages for inclusion was between 18 and 59 years old. This was because cognitive functioning has been found to decline by 0.04 to 0.05 standard deviations (SD) units per year after age 60 compared to 0.02 to 0.03 SD units per year for adults under the age of 60 (Salthouse, 2009).

2.2.3 Materials/ Measures

2.2.3.3 Outcome Measures: Measures of Cognitive Function

Participants completed a series of cognitive function tests relating to Attention and Working Memory, and then the findings across groups were compared using non-parametric statistics.

Several neuropsychological tasks were administered using the psychology experiment building language (PEBL) software to measure cognitive functioning (S. T. Mueller & Piper, 2014).

Cognitive Function: Attention

The Stroop task is a test of attention and processing speed that requires the participant to read a series of coloured words aloud. In the first part of the test, the word and the colour are congruent. In the second part of the test, the word and colour are incongruent. The speed of the test is recorded as well as the number of incorrect responses. An example of the Stroop task is provided in Appendix F. The Stroop task detects impairments in 'Attention' (Error responses). Therefore, the more error responses participants give on the Stroop task is indicative of increased impairment in their 'Attention'. The Stroop task has both high levels of internal consistency (Cronbach's Alpha ranges from .83 to .91: Marshall, Gurd, & Kischka, 2012) and test-retest reliability ($r=.83$ to $.91$: Spreen, 1998).

Cognitive Function: Working memory

The Reading Span Test (RST) requires participants to read sequences of unconnected sentences and to recall a random letter at the end of each sentence (Daneman & Carpenter, 1980). The RST task detects impairments in Working Memory (Response time). The longer the participant's response time on the RST indicates increased impairment in their 'Working Memory'. An example of the RST is provided in Appendix G. The RST has both high levels of internal consistency ($\alpha=.92$: Van, Bosch, Haverkort, & Hugdahl, 2008) and test-retest reliability ($r=.82$ to $.91$: Schretlen, Bobholz, & Brandt, 1996).

2.2.3.1 Predictor subjective measures of Anxiety and Sleep

The Generalized Anxiety Disorder 7 (GAD7) is a 7-item questionnaire with a score range of 0 to 21. An example of a question is; "*Over the last 2 weeks, how often have you been felt nervous, anxious, or on edge?*". The GAD7 questionnaire is provided in Appendix C. A clinical cut-off score of 10 has been found as indicating the presence of GAD (Spitzer et al., 2006). The GAD7 has both high levels of internal consistency ($\alpha=.89$ to $.92$) and test-retest reliability ($r=.83$: Lowe et al., 2008; Spitzer et al., 2006). The scores of the GAD7 produced high internal consistency ($\alpha=.89$) for this study.

The Pittsburgh Sleep Quality Index (PSQI) is a 19-item questionnaire with a score range of 0 to 21 (Buysse et al., 1989). An example of a question is; "*How many hours of actual sleep do you get at night?*". The PSQI questionnaire is provided in Appendix D. A score greater than 5 indicates poor sleep quality. The PSQI has both high levels of internal consistency ($\alpha=.80$) and test-retest reliability ($r=.69$ to $.77$: Carpenter & Andrykowski, 1998). The scores of the PSQI produced an acceptable internal consistency ($\alpha=.61$) for this study.

2.2.3.2 Predictor objective measures of sleep

An actiwatch device was used as an objective measure of sleep. The actiwatch is a small movement detector (accelerometer), worn like a wristwatch, that distinguishes sleep from wake (Hyde et al., 2007). It does this by using algorithms to measure the reduction in the movement associated with sleep. Due to the different models of actiwatch and the sensitivity of the measurement required there is limited information on the levels of validity and reliability of using the actiwatch or its software. However, a systematic review by Water, Holmes, and Hurley (2011) has shown the actiwatch to be a useful tool in the measurement of sleep disturbances. Moreover, actigraphy has been shown to be more than 90% concordant with polysomnography² (PSG) measures (Sadeh, Sharkey, & Carskadon, 1994). The actiwatch was worn by the participants for 24 hours per day for a minimum of five days to obtain reliable actigraph measures of sleep (Acebo et al., 1999). Participants also filled out a sleep diary to note sleep times on the nights of the study which was then inputted into the Actiwatch software by the lead researcher to enable more accurate analysis of sleep data. The software then provides the raw score for the quality of sleep and the quantity of sleep. The raw scores for the quantity of sleep indicate assumed sleep duration compared to the actual sleep duration (as recorded by the Actiwatch) and the score range is between 0 and 100 with the higher score indicating the better sleep quality. The raw scores for the quality of sleep are based on the movement during sleep. The lower the amount of movement recorded the more rested a person should be. The scores range from 0 and 100 and the closer to 0 the less movement is recorded and hence the more restful sleep a person should have had. The difference between quality and quantity therefore is quality indicates the amount of sleep a person has had compared with the quantity indicating how restful the sleep has been. An example of all the raw data produced by the Actiwatch is provided in Appendix U.

² Polysomnography records of the biophysiological fluctuations that happen throughout sleep (Levendowski et al., 2009). The PSG records many body functions including brain (EEG), muscle activity or skeletal muscle activation (EMG), eye movements (EOG) and heart rhythm (ECG) during sleep and has good reliability (Levendowski et al., 2009)

Based on the PSQI results participants were allocated to the four groups ('GAD', 'GAD & Poor sleep', 'Poor sleep' and 'Normal' (control)). Scores were categorised into these four groups to create research that was clinically relevant, and therefore, clinical cut off points for the GAD-7 and PSQI was used to create the four groups. The Generalized Anxiety Disorder 7 (GAD7) is a 7-item questionnaire with a score range of 0 to 21. A clinical cut-off score of 10 has been found as indicating the presence of GAD (Spitzer et al., 2006). The Pittsburgh Sleep Quality Index (PSQI) is a 19-item questionnaire with a score range of 0 to 21 (Buysse et al., 1989). A score greater than 5 indicates poor sleep quality. Therefore, the four groups were constructed as follows;

- ◆ 'Normal' group = PSQI score of 5 or less and GAD-7 score of 9 or less
- ◆ 'GAD' group = PSQI score of 5 or less and GAD-7 score of 10 or more
- ◆ 'Poor sleep' group = PSQI score of 6 or more and GAD-7 score of 9 or less
- ◆ 'GAD & Poor sleep' group = PSQI score 6 or more and GAD-7 score of 10 or more

These four groups reflect the referral criteria of some Improving Access to Psychological Therapies (IAPT) services (Clark, 2011; Joice, Freeman, Toplis & Bienkowski, 2011; Clark et al., 2009; Mollon, 2009). However, some IAPT services only accept referrals for people who are experiencing depression and/or anxiety (NHS, 2018) and therefore, a score greater than 5 was used for the inclusion to the poor sleep group as this score indicates the presence of poor sleep (Buysse et al., 1989).

Actigraphy was used as an objective measure of sleep, and the Pittsburgh Sleep Quality Index (PSQI) questionnaire (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) as the subjective measure of sleep. GAD was assessed using the subjective Generalized Anxiety Disorder 7 (GAD-7) measure (Spitzer, Kroenke, Williams, & Löwe, 2006). Attention and Working memory were the cognitive functions assessed in this study. Groups ('GAD', 'GAD & Poor sleep', 'Poor sleep' and

'Normal') were compared for differences in cognitive scores using a non-parametric equivalent of Analysis Of Variance (ANOVA). Thus, independent variables (IVs) included Sleep Duration/Quality recorded by the Actiwatch and GAD-7 scores, while dependent variables (DVs) consisted of cognitive scores on (1) Attention (2) Working Memory tests.

2.2.4 Procedure

Participants were recruited from the Coventry University student population. The study was advertised via posters (Appendix T) on Coventry University campus and through Sona. Sona is a system provided by Coventry University that allows researchers to allocate credits to potential participants.

Participants were asked to complete three phases of the project. These involved:

Phase 1 - Participants were asked to complete the GAD7 and PSQI questionnaire via Bristol Online Survey (BOS). Participants were then allocated to each subgroup based upon their scores from the GAD7 and PSQI. Once the minimum quotas were full for each subgroup ($n=10$), the recruitment for that subgroup ceased, and the BOS was closed to stop any unnecessary data collection. For example, once the first 10 participants, who fulfilled the criteria for the 'Sleep' group, had been recruited, the recruitment for the 'Sleep' group then stopped. Any additional participants who fulfilled the criteria for the Sleep group were not included in the dataset.

Phase 2 - Participants who completed Phase 1 attended a meeting at Coventry University where they were given a sleep diary and an actiwatch to wear for 24 hours per day for five days to collect a summary of their sleep.

Phase 3 - Participants returned to Coventry University to hand in their actiwatch, upon which the data was downloaded for analysis. During this time the participants completed the neuropsychological tasks.

2.2.5 Ethical Considerations

Participants who scored over the clinical cut off for GAD may not have been aware that their score indicated possible symptoms of GAD. Likewise, participants who scored over the clinical cut off for sleep dysfunction may not have been aware that their score indicated signs of sleep dysfunction. To help those identified with possible GAD and sleep dysfunction, *all* participants were provided with contact numbers for suitable services in their area.

Participants may have been concerned about who sees their data and how the data was used. For example, they may have been concerned that a record of GAD and poor sleep quality/duration may appear in their medical history because of their participation in the study. Therefore, participants were informed that their data would remain confidential with the research team and their names would be anonymised in line with the British Psychology Society guidelines (BPS, 2009). They were also informed that they could withdraw from the study at any time during the study and for up to two weeks following Phase 3. Participants were fully informed of the purpose of the study; there was no deception. Each participant was required to give fully informed consent (Appendix Q).

Ethical approval was sought from Coventry University Research Ethics Committee to conduct the study (Appendix O). The study also adhered to the BPS Code of Ethics and Conduct (British Psychological Society, 2009) and the Code of Human Research Ethics (British Psychological Society, 2010).

2.3 Results

2.3.1 Sample

The characteristics of participants is provided in Table 5.

Table 5 – Characteristics of participants

Participant Groups	Normal (n=10)	Sleep (n=10)	GAD (n=10)	Sleep & GAD (n=10)	Total (N=40)
Age Mean/ Standard Deviation	M=24.40 SD=3.89	M=25.80 SD=4.05	M=20.90 SD=4.72	M=20.40 SD=2.88	M=22.88 SD=4.44
Gender	Female=8 Male=2	Female=6 Male=4	Female=9 Male=1	Female=10 Male=0	Female=33 Male=7

2.3.2 Analysis

The following results section is separated into the two Hypotheses. Hypothesis 1 will be using Pearson correlations between the participants' actigraph data (Objective measure) on sleep quality (Sleep Fragmentation Score) and sleep duration (Actual sleep percentage). Better sleep quality is indicated by a *lower fragmentation score (0 to 100)* . Better sleep duration is indicated by a *higher actual sleep score (0 to 100)*. The results from Hypothesis 2 will then be presented. Hypothesis 2 was analysed using non-parametric tests when the assumptions for the parametric test were not met. The order of presentations for both hypotheses will be attention, working memory.

Table 6 shows a summary of the significant tests from tasks.

Table 6 - A summary of significant tests from tasks.

H1 – Correlation	Objective Sleep Quality $p < .05$	Objective Sleep Duration $p < .05$	H2 - Kruskal Wallis $p < .05$
Stroop Error Responses (Attention)	☑	☑	☑
RST Response Time (Working Memory)	☑	☑	☑

2.3.3 Hypothesis 1: Objective poor sleep quality and/or duration will have a negative effect on cognition.

Hypothesis 1.1: Objective poor sleep quality and/or duration will have a negative effect on attention as evidenced by fewer correct responses on the Stroop task.

Attention

A lower fragmentation score indicates better objective sleep quality. *A higher actual sleep percentage* indicates better objective sleep duration. More incorrect responses on the Stroop indicates poor attention.

There was a weak positive significant correlation between objective sleep quality and Attention (Incorrect responses on Stroop test; $r=.31, p<.05$; Appendix I). This indicates that the lower quality of sleep (high fragmentation score) the worse a participant's Attention (fewer incorrect responses on the Stroop test). Although Person's correlation is associative, it does not indicate the causal pathway of that association. However, on the basis of previous research it can be surmised that poor sleep may be one of the reasons behind poor Attention and not the other way around (it is conceivable, but unlikely).

For further investigation into the results the participants were split into two groups based on their GAD7 score, High GAD (11 to 21) and Low GAD (0 to 10). The Low GAD group showed no significant difference between Low GAD scores and Attention ($r=.22, p>.05$). The High GAD group showed no significant difference between High GAD scores and Attention ($r=.04, p>.05$). This indicates that GAD is not significantly linked to Attention.

There was a weak negative significant correlation between objective sleep duration and Attention (Incorrect responses on Stroop test; $r=-.32, p<.05$; Appendix I). This indicates that the higher the quantity of sleep (higher actual sleep percentage) the better the participant's Attention (fewer incorrect responses on the Stroop test).

There was no significant difference between gender and the number of incorrect Stroop responses ($r=-.16, p>.05$).

Thus, these results support the hypothesis that objective poor sleep quality and duration will have a negative effect on Attention. Gender differences and the presence of GAD does not have a significant effect on Attention. These results indicate that both the quality and the quantity of sleep impact on a person's attention. Therefore, if a person's quality of sleep was poor but the quantity of their sleep was good (and vice-versa) their Attention would still be affected. This demonstrates that both quality and quantity of sleep is important for Attention regardless of gender.

Hypothesis 1.2: Objective poor sleep quality and/or duration will have a negative effect on working memory evidenced by a slower response time of RST.

Working Memory

A lower fragmentation score indicates better objective sleep quality. A higher actual sleep percentage indicates better objective sleep duration. Slower response time on the RST indicates poorer working memory.

There was a weak significant positive correlation between objective poor sleep quality and working memory (slower response time of RST; $r=.30$, $p<.05$; Appendix I). This indicates that the higher the quality of sleep (lower fragmentation score) the better participants working memory (faster response time of the RST).

There was a weak significant negative correlation between objective poor sleep duration and working memory (slower response time of RST; $r=-.31$, $p<.05$; Appendix I). These results indicate that the higher the quantity of sleep (higher actual sleep percentage) the better the participant's working memory (faster response time of the RST).

Therefore, these results support the hypothesis that objective poor sleep quality and duration had a negative effect on working memory evidenced by a slower response time on the RST. Please see Appendix K for correlations between

objective sleep duration/ objective sleep quality and the measures of cognitive functions.

For further investigation into the results the participants were split into two groups based on their GAD7 Score, mainly a High GAD group (with a GAD score between 11 to 21) and a Low GAD group (with a score between 0 to 10). The Low GAD group showed no significant difference between Low GAD scores and Working Memory ($r=.27, p>.05$). The High GAD group showed no significant difference between High GAD scores and Working Memory ($r=.05, p>.05$). This indicates that level of GAD is not significantly linked to Working Memory. There was also no significant difference between gender and the number of incorrect responses ($r=-.16, p>.05$).

These results indicate that both the quality and the quantity of sleep impact on a person's working memory. As with the Attention task, if either quality or quantity of sleep is affected it will significantly affect Working Memory. This demonstrates the importance of the quality and the quantity of sleep in maintaining effective Working Memory. It also highlights that gender and GAD do not have a significant influence on Working Memory.

2.3.4 Hypothesis 2: The interaction between anxiety and poor sleep quality will have significant influence on cognitive functioning (Attention and Working Memory) .

An analysis of how the groups ('Normal', 'Sleep', 'GAD' and 'Sleep & GAD') performed compared to each other. A visual report will be given of each significant outcome. The data was interval, the Shapiro-Wilk test shows data was normally distributed for each group of the independent variable ($p>.05$). However, the Levene's test shows data did not have homogeneity of variance for each group for the ROCF delayed score ($p<.05$). Therefore, the non-parametric Kruskal Wallis H test was used for Attention (Stroop error responses) and for Working Memory (RST response time). All data for parametric assumptions are provided in Appendix

M. There were no outliers in the data, as assessed by inspection of a boxplot (Appendix L).

Hypothesis 2.1: The interaction between anxiety and poor sleep quality will have a significant influence on cognitive functioning (Attention) .

Attention

In order to test this hypothesis, scores on the DV of Attention (as measured by incorrect responses on the Stroop test) were compared across the study's four groups. The Kruskal-Wallis H test was used to determine whether there were significant differences between these four groups, with an alpha level set at $p < .05$. It revealed a significant difference between the groups, $H(3)=17.46$, $p=.01$.

Bonferroni-adjusted post-hoc comparisons using Mann-Whitney U tests indicated that, with an alpha level set at $p < .05$ (two-tailed):

- there was a significant difference in median scores between the 'Normal' group ($Mdn=7$) and 'Sleep' group ($Mdn=18.5$), $U=4.5$, $N^1=10$, $N^2=10$, $p=.01$;
- there was a significant difference in median scores between the 'Sleep' group ($Mdn=18.5$) and the 'GAD' group ($Mdn=6$), $U=0.00$, $N^1=10$, $N^2=10$, $p=.01$;
- there was a significant difference in median scores between the 'GAD' group ($Mdn=6$) and the 'Sleep & GAD' group ($Mdn=11.5$), $U=24.5$, $N^1=10$, $N^2=10$, $p=.05$.

These results are illustrated in Figure 2 below.

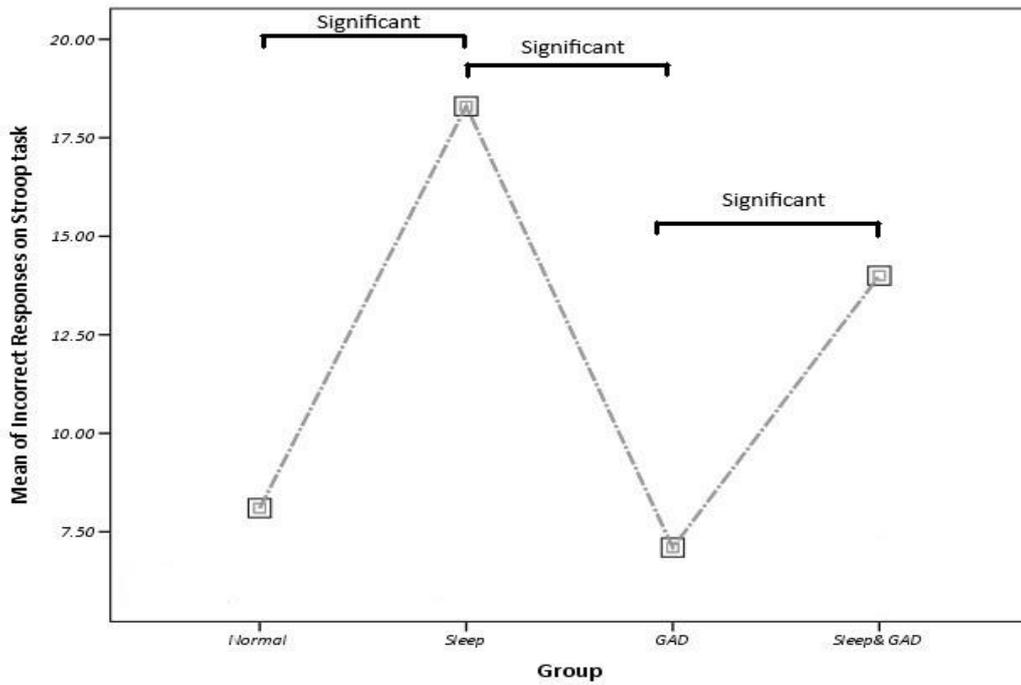


Figure 2 - Mean plots of Stroop incorrect responses

These results suggest that those whom just have poor sleep have the most affected Attention.

The Sleep group (who experienced poor sleep) significantly differs from both the Normal group and the GAD group but is not significantly different from the Sleep and GAD (the interaction) group ($p > .05$). This suggests that experiencing problems with sleep quality is likely to have a detrimental impact on the ability to maintain Attention/focus on tasks. The difference relative to those with normal sleep patterns is unsurprising. However, poor quality sleep impacts on Attention more severely than for those who suffer from clinical anxiety and those who suffer from both sleep and anxiety related difficulties. High anxiety significantly differentiates this group from those with sleep problems and those with both anxiety and sleep difficulties; no significant difference was found with the control group. Anxiety per se does not seem to have any impact on participants' attention. In conclusion, there is no support for the hypothesis that the interaction between anxiety and poor sleep quality will have a significant influence on Attention.

Hypothesis 2.2: The interaction between anxiety and poor sleep quality will have a significant influence on cognitive functioning (Working Memory).

Working Memory

In order to test this hypothesis, scores on the DV of Working Memory (as measured by response time on the RST) were compared across the study's four groups. The Kruskal-Wallis H test was used to determine whether there were significant differences between these four groups, with an alpha level set at $p < .05$, it revealed a significant difference between the groups, $H(3)=10.43$, $p=.02$. The results are illustrated in Figure 3.

The significant results will be presented in order of the hypothesis: the 'Sleep & GAD' compared to other groups, then the 'Sleep' group and then the 'GAD'. The results are illustrated in Figure 3.

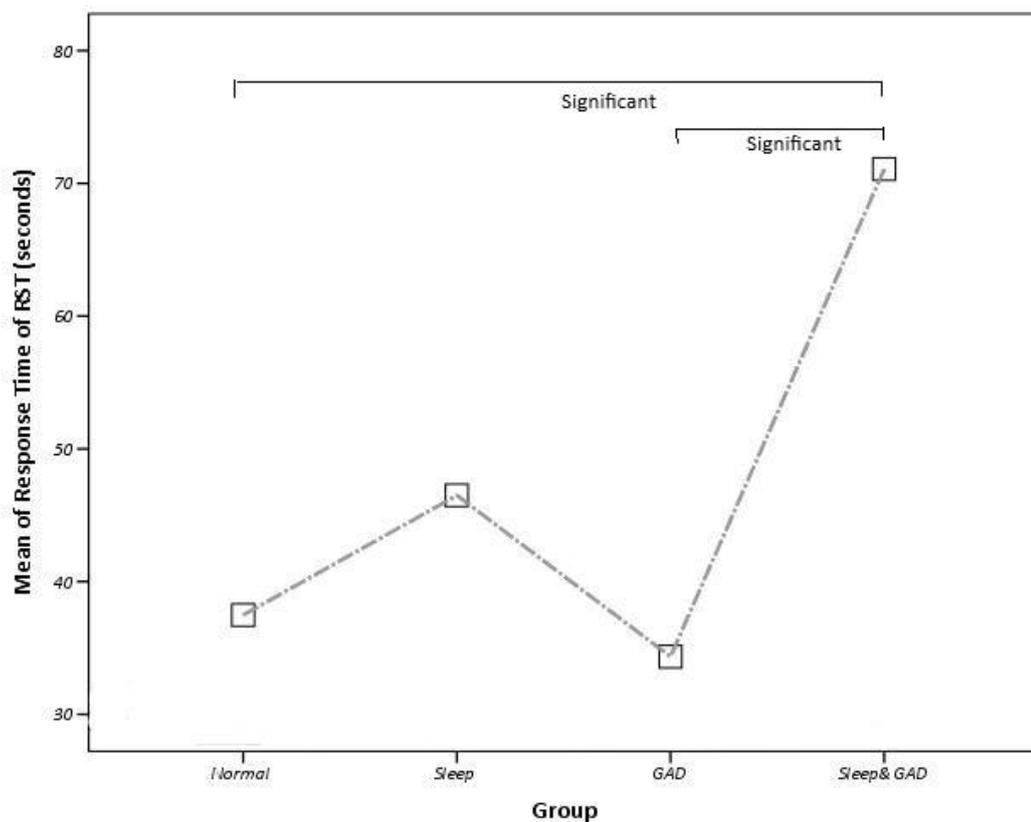


Figure 3 - Mean of the response time of RST amongst groups

Bonferroni-adjusted post-hoc comparisons using Mann-Whitney U tests indicated that, with an alpha level set at $p < .05$, (two-tailed):

- the difference in median scores between the 'Normal' group ($Mdn=37482.59$) and the 'Sleep&GAD' group ($Mdn=71078.1660$) was significant: $U=17.00$, $N^1=10$, $N^2=10$, $p=.01$.
- the difference in median scores between the 'GAD' group ($Mdn=34343.93$) and the 'Sleep&GAD' group ($Mdn=71078.1660$) was significant: $U=13.00$, $N^1=10$, $N^2=10$, $p=.01$.

The Sleep group did not significantly differ from either the Normal group or the GAD group in terms of Working Memory. However, the interaction of poor sleep and being anxious impacts negatively on Working Memory. Thus, being either anxious or suffering from sleep difficulties seems to have no real impact on Working Memory. It also appears from these results that there is a benefit from the presence of anxiety, at least in terms of Working Memory. This will be considered in the discussion.

2.4 Discussion

Sleep, Anxiety and Attention

The results indicated a significant difference between the four groups with the 'Sleep' group making the most errors and the GAD group making the least errors in the Stroop Task. There was a significant difference between the 'Sleep' group and 'GAD' group but not 'Sleep & GAD' group scores which indicate that it is poor sleep rather than GAD that is having the most detrimental effect on attention.

These results are consistent with Kizilbash, Vanderploeg and Curtiss (2002) who indicated that high levels of anxiety did not have a significant adverse impact on cognitive functions. Although some studies have shown that anxiety does not

negatively affect cognitive functions (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Paterniti et al., 1999) they did not specifically focus on GAD nor did they explain why the GAD groups from this study would perform better than the control group. However, Lazarus and Folkman's (1984) cognitive appraisal model may help explain this outcome. The cognitive appraisal model suggests that stress is a positive or negative motivator. Thus, GAD may be a positive motivator to those who have good quality sleep. The cognitive appraisal model suggests that a stressor (the cognitive task) is a threat or a challenge. When a task is seen as a threat, it may be interpreted as too difficult and bring up feelings of inadequacy and predictions of failure because the resources (attention and working memory) are not available to deal with it. Alternatively, when a task is seen as a challenge, it may develop a positive stress response because it is an opportunity to perform well because the participant believes they have the resources to deal with it.

Yang and colleagues (2015) suggest that GAD negatively affects attention, but they used participants with a DSM V diagnosis of GAD and did not control for those with poor sleep. In fact, for a diagnosis of GAD, the DSM V states that GAD needs to impact daily functioning and cause frequent sleep disturbances. Therefore, there may be a difference in the cognitive functioning of people with a diagnosis of GAD compared to those who have GAD identified with questionnaires.

In conclusion, the results from this study may be indicating that in the absence of poor sleep, individuals with GAD may perceive cognitive tasks as a positive challenge and thus improve their performance. When individuals with GAD suffer from poor sleep, the combination may lead to the task being seen as a threat and therefore performance in cognitive tasks may be negatively affected (Lazarus & Folkman, 1984). It may be useful for future research to see if different types of anxiety disorders (e.g., Phobias, Panic) have the similar response to GAD when facing stress-inducing situations.

Sleep, Anxiety and Working Memory

The results indicated a significant difference between the four groups with the 'Sleep & GAD' group being the slowest in the Reading Span Test, followed by the 'Sleep' group, 'Normal' group and 'GAD' group. It seemed that the individuals with GAD who also suffer from poor sleep have the worst Working Memory. This could help to explain why some studies have not found that anxiety affects certain cognitive functioning including working memory (Eysenck, Derakshan, Santos, & Calvo, 2007; Kizilbash, Vanderploeg, & Curtiss, 2002). Both Eysenck et al.'s (2007) and Kizilbash et al.'s (2002) studies do not mention sleep and therefore it is plausible that the participants in these studies did not have sleep difficulties. If that was the case, then their working memory would not be as negatively affected as if they have had GAD and suffered from poor sleep.

Interestingly, the results show that 'Sleep & GAD' group scores are significantly different from the other groups apart from the 'Sleep' group. This is demonstrating that the scores in the 'Sleep & GAD' group are closer to those in the 'Sleep' group. This is consistent with research that looks at the effects of poor sleep on Working memory (Chee et al., 2006; Chee & Choo, 2004; Frenda & Fenn, 2016). Chee and colleagues (2006) used Functional Magnetic Resonance Imaging (fMRI) and actigraphy and found that poor sleep negatively affected tasks that were related to working memory because sleep deprivation affects a vast network of neural activity including the front and parietal cortex. In conclusion, these results are consistent with Fortier-Brochu and colleagues's (2012) who showed that poor sleep negatively affects Working Memory, and provided more evidence that attention and memory are affected by poor sleep, especially in tasks that last more than a few minutes (Doran, Van Dongen, & Dinges, 2001).

Overall discussion about sleep, anxiety and cognitive functioning

This study has shown that whilst the interaction of GAD and poor sleep does not affect attention it does impact on working memory. This is of interest as it is showing that poor sleep and GAD affects different parts of cognition. This could

be further investigated as it can help assessments be more specific for poor sleep and GAD and therefore help with more problem-focussed clinical interventions.

2.4.3 Limitations

An important limitation to consider in this study is its methodological design, mainly the use of categorical groups. These reflected the clinical presentation of people who attempt to access help for their GAD and/or poor sleep symptoms in primary care services. It can be argued that dichotomising continuous and discrete variables, which is common in psychological research, enables investigation if there are differences between groups who may be at the extremes of the continuous and discrete variables (Dancey and Reidy, 2011). However, dichotomising continuous and discrete variables reduces the sensitivity of the statistical analysis performed (Dancey and Reidy, 2011).

It is thus possible that employing regression analysis instead of the used non-parametric equivalent of ANOVA would allow for the main effects to explain more variance in the investigated cognitive functioning domains and which is not possible to ascertain from the chosen methodological approach.

Another methodological limitation was the chosen sample; mainly psychology students. It has been argued that the use of student participants can affect the internal and external validity of a study because a student population may be more familiar with the topic being studied (Druckman & Kam, 2011; Sears, 1986). For example, psychology students may be more used to participating or conducting neuropsychological studies and may perform better than other disciplines. Therefore, if this study were to be replicated, then a broader sample from the general population would increase the validity.

Another methodological limitation was the use of a limited number of cognitive tests. To gain a fuller understanding of the different cognitive domains affected by sleep, a battery of cognitive tests could be utilised to achieve this goal. A widely used battery of tests is the Wechsler Adult Intelligence Scale-Fourth UK Edition

(WAIS). The WAIS measures many different cognitive functions (Appendix N) and includes normative data for ages 16-90 years (Benson, Hulac, & Kranzler, 2010). However, it is worth noting that the WAIS takes between 60 to 90 minutes to administer and requires training to accurately administer and interpret the scores (Lichtenberger & Kaufman, 2009).

2.4.4 Future research

Future research could focus on the effectiveness of sleep interventions. This could be achieved in many ways. For example, an updated comparison could be made of the effectiveness of current sleep interventions like Morin, Culbert and Schwartz meta-analysis (1994). This new comparison could include new techniques such as mindfulness (Felver, Celis-de Hoyos, Tezanos, & Singh, 2016) and Acceptance and Commitment Therapy (ACT) (Hulbert-Williams, Storey, & Wilson, 2015) or even the development of new sleep strategies. These new sleep strategies could be developed through exploring how the poor sleep developed and how it is maintained and what successful strategies people use to overcome poor sleep.

Further research could also focus on why the presence of GAD leads to better performance in specific cognitive tasks. This could be investigated by ensuring those with GAD do not have subjective and objective reported poor sleep and comparing to those with other types of anxiety. This may indicate that the presence of GAD is functional in certain situations and needs to be further investigated.

2.4.5 Clinical Implications

The clinical implications of this study imply that poor sleep impacts on daily cognitive functioning. However, treatment for sleep disorders is hugely varied due to a lack of clinical insomnia services and a shortage of trained insomnia treatment providers (Pigeon, Crabtree, & Scherer, 2007). It will often not be treated in

primary care services unless the poor sleep is associated with depression and/or anxiety and seen as an underlying symptom (Stepanski & Rybarczyk, 2006). Therefore, this study provides further evidence that poor sleep should be treated as a primary disorder and have dedicated clear evidence-based approach to achieve successful outcomes.

This study has also highlighted that sleep is impacting on specific cognitive functions more than GAD. Therefore, if a person presents with both Sleep and GAD, it may be more beneficial to the person to receive treatment for the poor sleep first and then if necessary continue with appropriate GAD interventions (Taylor & Roane, 2010). There has also been some evidence that sleep and GAD treatments can be administered conjointly (Clementi & Alfano, 2014). However, further research could compare the treatment outcomes if both sleep and GAD are present to see which is the most effective.

This study has shown the usefulness of actigraphy measures for accurate reporting of sleep problems. In this study, the objective and subjective sleep measures were significantly correlated. However, other studies have shown that sleep misinterpretation is a problem when trying to accurately measure poor sleep (Bianchi et al., 2013; Harvey & Tang, 2012). Therefore, for accurate reporting of sleep difficulties and measuring treatment efficacy, actigraphy could provide this additional measurement. Also, the actigraph itself could be used as part of an intervention, if that intervention is directed at a person's sleep state misperception and helps to reduce sleep-related anxiety (Tang & Harvey, 2006).

2.5 Conclusion

The results from this study should be interpreted with caution due to the small sample size and methodological limitations. It was found that that objective poor sleep quality and duration have an adverse effect on Attention and Working Memory. The results also indicated a significant difference between the four groups in the Stroop task and RST. These results indicated that poor sleep rather

than GAD is having the most detrimental effect on Attention and Working Memory. The results suggest clinical implications and the further research mentioned will help address the limitations and provide more support for these findings.

2.6 References

- Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., & Carskadon, M. A. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? *Sleep, 22*(1), 95.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed. ed.). Arlington, Va.: American Psychiatric Publishing.
- Bélanger, L., Morin, C. M., Langlois, F., & Ladouceur, R. (2004). Insomnia and generalised anxiety disorder: Effects of cognitive behaviour therapy for gad on insomnia symptoms. *Journal of Anxiety Disorders, 18*(4), 561-571. doi:10.1016/S0887-6185(03)00031-8
- Benson, N., Hulac, D. M., & Kranzler, J. H. (2010). Independent examination of the Wechsler adult intelligence Scale-Fourth Edition (WAIS-IV): What does the WAIS-IV measure? *Psychological Assessment, 22*(1), 121.
- Berger, M., van Calker, D., & Riemann, D. (2003). Sleep and manipulations of the sleep-wake rhythm in depression. *Acta Psychiatrica Scandinavica.Supplementum, (418)*, 83.
- Bianchi, M. T., Williams, K. L., Mckinney, S., & Ellenbogen, J. M. (2013). The subjective-objective mismatch in sleep perception among those with insomnia and sleep apnea. *Journal of Sleep Research, 22*(5), 557.
- British Psychological Society. (2009). *Code of ethics and conduct*. Leicester: British Psychological Society.
- British Psychological Society. (2010). *Code of human research ethics*. Leicester: British Psychological Society.
- Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14*(5), 365.

- Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193-213.
- Carpenter, J. S., & Andrykowski, M. A. (1998). Psychometric evaluation of the Pittsburgh sleep quality index. *Journal of Psychosomatic Research, 45*(1), 5-13.
doi:10.1016/S0022-3999(97)00298-5
- Chaudhary, N. S., Kampman, K. M., Kranzler, H. R., Grandner, M. A., Debbarma, S., & Chakravorty, S. (2015). Insomnia in alcohol-dependent subjects is associated with greater psychosocial problem severity. *Addictive Behaviors, 50*, 165.
- Chee, M. W., Chuah, L. Y., Venkatraman, V., Chan, W. Y., Philip, P., & Dinges, D. F. (2006). Functional imaging of working memory following normal sleep and after 24 and 35 h of sleep deprivation: Correlations of frontoparietal activation with performance. *NeuroImage, 31*(1), 419-428.
- Chee, M. W., & Choo, W. C. (2004). Functional imaging of working memory after 24 hr of total sleep deprivation. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience, 24*(19), 4560-4567. doi:10.1523/JNEUROSCI.0007-04.2004 [doi]
- Clark, D. M., Layard, R., Smithies, R., Richards, D. A., Suckling, R., & Wright, B. (2009). Improving access to psychological therapy: Initial evaluation of two UK demonstration sites. *Behaviour research and therapy, 47*(11), 910-920.
- Clark, D. M. (2011). Implementing NICE guidelines for the psychological treatment of depression and anxiety disorders: the IAPT experience. *International Review of Psychiatry, 23*(4), 318-327.
- Clementi, M. A., & Alfano, C. A. (2014). Targeted behavioural therapy for childhood generalised anxiety disorder: A time-series analysis of changes in anxiety and sleep. *Journal of Anxiety Disorders, 28*(2), 215-222.
- Cornell, D. G., Roberts, M., & Oram, G. (1997). The ray- osterrieth complex figure test as a neuropsychological measure in criminal offenders. *Archives of Clinical Neuropsychology, 12*(1), 47-56. doi:10.1016/S0887-6177(96)00024-8

- Dancey, C. P., & Reidy, J. (2004). *Statistics without maths for psychology: Using SPSS for Windows*. New York: Prentice Hall.
- Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*(4), 450-466.
- Derakshan, N., Ansari, T. L., Hansard, M., Shoker, L., & Eysenck, M. W. (2009). Anxiety, inhibition, efficiency, and effectiveness: An investigation using the antisaccade task. *Experimental Psychology*, *56*(1), 48.
- Donner, J., Pirkola, S., Silander, K., Kananen, L., Terwilliger, J. D., Lönnqvist, J., . . . Hovatta, I. (2008). An association analysis of murine anxiety genes in humans implicates novel candidate genes for anxiety disorders. *Biological Psychiatry*, *64*(8), 672-680. doi:10.1016/j.biopsych.2008.06.002
- Doran, S., Van Dongen, H., & Dinges, D. F. (2001). Sustained attention performance during sleep deprivation: Evidence of state instability. *Archives Italiennes De Biologie*, *139*(3), 253-267.
- Druckman, J. N., & Kam, C. D. (2011). Students as experimental participants. *Cambridge Handbook of Experimental Political Science*, *1*, 41-57.
- Espie, C. A. (2002). Insomnia: Conceptual issues in the development, persistence, and treatment of sleep disorder in adults. *Annual Review of Psychology*, 215.
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*(2), 336.
- Felver, J. C., Celis-de Hoyos, C. E., Tezanos, K., & Singh, N. N. (2016). A systematic review of mindfulness-based interventions for youth in school settings. *Mindfulness*, *7*(1), 34-45.
- Fernandez-Mendoza, J., Calhoun, S. L., Bixler, E. O., Karataraki, M., Liao, D., Vela-Bueno, A., . . . Vgontzas, A. N. (2011). Sleep misperception and chronic insomnia in the general population: Role of objective sleep duration and psychological profiles. *Psychosomatic Medicine*, *73*(1), 88-97. doi:10.1097/PSY.0b013e3181fe365a [doi]

- Fortier-Brochu, É, Beaulieu-Bonneau, S., Ivers, H., & Morin, C. M. (2010). Relations between sleep, fatigue, and health-related quality of life in individuals with insomnia. *Journal of Psychosomatic Research*, *69*(5), 475-483.
doi:10.1016/j.jpsychores.2010.05.005
- Fortier-Brochu, É, Beaulieu-Bonneau, S., Ivers, H., & Morin, C. M. (2012). Insomnia and daytime cognitive performance: A meta-analysis. *Sleep Medicine Reviews*,
doi:10.1016/j.smr.2011.03.008
- Frenda, S. J., & Fenn, K. M. (2016). *Sleepless, think worse: The effect of sleep deprivation on working memory* doi:<https://doi.org/10.1016/j.jarmac.2016.10.001>
- Gazzaniga, M., Ivry, R., & Mangun, G. (2009). *Cognitive neuroscience: The biology of the mind* (3rd ed.). London: Norton.
- Harvey, A. G., & Tang, N. K. Y. (2012). (Mis) Perception of sleep in insomnia: A puzzle and a resolution. *Psychological Bulletin*, *138*(1), 77-101. doi:10.1037/a0025730
- Hasin, D. S., Shmulewitz, D., Stohl, M., Greenstein, E., Aivadyan, C., Morita, K., . . . Grant, B. F. (2015). Procedural validity of the AUDADIS-5 depression, anxiety and post-traumatic stress disorder modules: Substance abusers and others in the general population. *Drug and Alcohol Dependence*, *152*, 246-256.
doi:10.1016/j.drugalcdep.2015.03.027
- Hettema, J., Neale, M., & Kendler, K. (2001). A review and meta-analysis of the genetic epidemiology of anxiety disorders. *The American Journal of Psychiatry*, *158*(10), 1568-78.
- Hulbert-Williams, N. J., Storey, L., & Wilson, K. G. (2015). Psychological interventions for patients with cancer: Psychological flexibility and the potential utility of acceptance and commitment therapy. *European Journal of Cancer Care*, *24*(1), 15-27.
- Hyde, M., O'DRISCOLL, D. M., Binette, S., Galang, C., Tan, S. K., Verginis, N., . . . Horne, R. S. (2007). Validation of actigraphy for determining sleep and wake in children with sleep-disordered breathing. *Journal of Sleep Research*, *16*(2), 213-216.

- Joice, A., Freeman, L., Toplis, L., & Bienkowski, G. (2011). A review and discussion of psychological therapies and interventions delivered within stepped care service models. *Information systems*, 1.
- Kizilbash, A. H., Vanderploeg, R. D., & Curtiss, G. (2002). The effects of depression and anxiety on memory performance. *Archives of Clinical Neuropsychology*, 17(1), 57-67. doi:10.1016/S0887-6177(00)00101-3
- Lazarus, R., S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York: New York: Springer.
- Levendowski, D. J., Zack, N., Rao, S., Wong, K., Gendreau, M., Kranzler, J., . . . Westbrook, P. R. (2009). Assessment of the test-retest reliability of laboratory polysomnography. *Sleep and Breathing*, 13(2), 163-167.
- Lichtenberger, E. O., & Kaufman, A. S. (2009). *Essentials of WAIS-IV assessment* John Wiley & Sons.
- Lieb, R., Becker, E., & Altamura, C. (2005). The epidemiology of generalised anxiety disorder in Europe. *European Neuropsychopharmacology*, 15(4), 445-452. doi:10.1016/j.euroneuro.2005.04.010
- Linton, S. J., & Bryngelsson, I. -. (2000). Insomnia and its relationship to work and health in a working-age population. *Journal of Occupational Rehabilitation*, 10(2), 169-183. doi:10.1023/A:1009408204694
- Lowe, B., Decker, O., Muller, S., Brahler, E., Schellberg, D., Herzog, W., & Herzberg, P. (2008). Validation and standardisation of the generalised anxiety disorder screener (GAD- 7) in the general population. *Medical Care*, 46(3), 266.
- Marshall, J., Gurd, J., & Kischka, U. (2012). *The handbook of clinical neuropsychology* (2nd ed.). Oxford: OUP.
- Mendelson, W. B. (2008). New research on insomnia: Sleep disorders may precede or exacerbate psychiatric conditions. *Psychiatric Times*, 25(7), 58-60.
- Mercer, J. D., Bootzin, R. R., & Lack, L. C. (2002). Insomniacs' perception of wake instead of sleep. *Sleep*, 25(5), 564-572.

- Mollon, P. (2009). The NICE guidelines are misleading, unscientific, and potentially impede good psychological care and help. *Psychodynamic Practice*, 15(1), 9-24.
- Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology*, 49(10), 1417-1425.
- Morin, C. M., Culbert, J. P., & Schwartz, S. M. (1994). Nonpharmacological interventions for insomnia: A meta-analysis of treatment efficacy. *The American Journal of Psychiatry*, 151(8), 1172-1180. doi:10.1176/ajp.151.8.1172 [doi]
- Mueller, E. M., Nguyen, J., Ray, W. J., & Borkovec, T. D. (2010). Future-oriented decision-making in generalised anxiety disorder is evident across different versions of the Iowa gambling task. *Journal of Behavior Therapy and Experimental Psychiatry*, 41(2), 165-171.
- Mueller, S. T., & Piper, B. J. (2014). The psychology experiment building language (PEBL) and PEBL test battery. *Journal of Neuroscience Methods*, 222, 250-259.
- NICE. (2015). Scenario: Managing long-term insomnia (> 4 weeks). National Institute for Health and Care Excellence (NICE). Retrieved from <https://cks.nice.org.uk/insomnia#!scenariorecommendation:2>
- NHS. (2018). Changing minds IAPT. Retrieved from <https://www.nhft.nhs.uk/iapt>
- Ohayon, M. M. (2009). Difficulty in resuming or inability to resume sleep and the links to daytime impairment: Definition, prevalence and comorbidity. *Journal of Psychiatric Research*, 43(10), 934-940. doi:10.1016/j.jpsychires.2009.01.011
- Paterniti, S., Dufouil, C., Bisslerbe, J. -, & Alperovitch, A. (1999). Anxiety, depression, psychotropic drug use and cognitive impairment. *Psychological Medicine*, 29(02), 421-428.
- Peterson, M., Rumble, M., & Benca, R. (2008). Insomnia and psychiatric disorders. *Psychiatric Annals*, 38(9), 597-605.
- Pigeon, W. R., Crabtree, V. M., & Scherer, M. R. (2007). The future of behavioural sleep medicine. *Journal of Clinical Sleep Medicine*, 3(01), 73-79.

- Rapport, L., Charter, R., Dutra, R., Farchione, T., & Kingsley, J. (1997). Psychometric properties of the rey- osterrieth complex figure: Lezak- osterrieth versus Denman scoring systems. *The Clinical Neuropsychologist*, *11*(1), 46-53.
doi:10.1080/13854049708407028
- Roth, T. (2007). Insomnia: Definition, prevalence, etiology, and consequences. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *3*(5), S7.
- Sadeh, A., Sharkey, K. M., & Carskadon, M. A. (1994). Activity-based sleep-wake identification: An empirical test of methodological issues. *Sleep*, *17*(3), 201.
- Saletu, B., Saletu-Zyhlarz, G., Anderer, P., Brandstätter, N., Frey, R., Gruber, G., . . . Lintzmayer, L. (1997). Nonorganic insomnia in generalised anxiety disorder. *Neuropsychobiology*, *36*(3), 130-152.
- Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of Aging*, *30*(4), 507-514. doi:10.1016/j.neurobiolaging.2008.09.023
- Schretlen, D., Bobholz, J. H., & Brandt, J. (1996). Development and psychometric properties of the brief test of attention. *The Clinical Neuropsychologist*, *10*(1), 80-89. doi:10.1080/13854049608406666
- Sears, D. O. (1986). College sophomores in the laboratory: Influences of a narrow data base on social psychology's view of human nature. *Journal of Personality and Social Psychology*, *51*(3), 515.
- Sivertsen, B., Krokstad, S., Øverland, S., & Mykletun, A. (2009). The epidemiology of insomnia: Associations with physical and mental health.: The HUNT-2 study. *Journal of Psychosomatic Research*, *67*(2), 109-116. doi:10.1016/j.jpsychores.2009.05.001
- Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalised anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092-1097.
- Spren, O. (1998). In Strauss E. (Ed.), *A compendium of neuropsychological tests: Administration, norms, and commentary* (2nd ed.). Oxford: Oxford University Press.

- Statharou, A., & Taka, C. (2012). Insomnia and depression in primary psychiatric care. *Health Science Journal*, 6(3), 378-384.
- Stepanski, E. J., & Rybarczyk, B. (2006). Emerging research on the treatment and etiology of secondary or comorbid insomnia. *Sleep Medicine Reviews*, 10(1), 7-18. doi:S1087-0792(05)00093-6 [pii]
- Stores, G. (2007). Clinical diagnosis and misdiagnosis of sleep disorders. *Journal of Neurology, Neurosurgery, and Psychiatry*, 78(12), 1293-1297. doi:78/12/1293 [pii]
- Tang, N. K. Y., & Harvey, A. G. (2006). Altering misperception of sleep in insomnia: Behavioral experiment versus verbal feedback. *Journal of Consulting and Clinical Psychology*, 74(4), 767-776. doi:10.1037/0022-006X.74.4.767
- Taylor, D. J., & Roane, B. M. (2010). Treatment of insomnia in adults and children: A practice-friendly review of research. *Journal of Clinical Psychology*, 66(11), 1137-1147.
- Taylor, D. J., Lichstein, K. L., Durrence, H. H., Reidel, B. W., & Bush, A. J. (2005). Epidemiology of insomnia, depression, and anxiety. *Sleep*, 28(11), 1457.
- Van, D. N., Bosch, P., Haverkort, M., & Hugdahl, K. (2008). A standard computerised version of the reading span test in different languages. *European Journal of Psychological Assessment*, 24(1), 35-42. doi:10.1027/1015-5759.24.1.35
- VanVoorhis, C. W., & Morgan, B. L. (2007). Understanding power and rules of thumb for determining sample sizes. *Tutorials in Quantitative Methods for Psychology*, 3(2), 43-50.
- Wade, A. (2010). The societal costs of insomnia. *Neuropsychiatric Disease and Treatment*, 2011, 1-18.
- Water, V. D., 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(1), 183-200. doi:10.1111/j.1365-2869.2009.00814.x
- Wechsler, D. (2011). *Test of premorbid functioning - UK version (TOPF UK) - administration, scoring and techniques manual*. Oxford: Pearson Education Limited.

- Wicklow, A., & Espie, C. A. (2000). Intrusive thoughts and their relationship to actigraphic measurement of sleep: Towards a cognitive model of insomnia. *Behaviour Research and Therapy*, 38(7), 679-693. doi:10.1016/S0005-7967(99)00136-9
- Wittchen, H. (2002). Generalized anxiety disorder: Prevalence, burden, and cost to society. *Depression and Anxiety*, 16(4), 162.
- Yang, Y., Zhang, X., Zhu, Y., Dai, Y., Liu, T., & Wang, Y. (2015). Cognitive impairment in generalised anxiety disorder revealed by event-related potential N270. *Neuropsychiatric Disease and Treatment*, 2015, 1405-1411.
- Zisapel, N., & Laudon, M. (2003). Subjective assessment of the effects of CNS-active drugs on sleep by the Leeds sleep evaluation questionnaire: A review. *Human Psychopharmacology*, 18(1), 1.

CHAPTER 3: Challenges investigating cognitive functioning in people with General Anxiety Disorder (GAD) and Sleep difficulties: A reflective account

Overall chapter word count (excluding quotations, references and tables): 3542

3.1 Introduction

This chapter will be a reflection on my experiences as a trainee clinical psychologist with a focus on my skills of developing my reflexivity of being a scientist-practitioner during the thesis process. It will be a reflection on the difficulties of being a scientist-practitioner, trainee and the conflicting demands that these roles bring. It will also explore my hopes and fears for my research, and it will examine the impact that the process of research had on my professional and personal development.

The British Psychological Society (BPS, 2017) suggests that psychologists should have a good understanding of the self in the context of others to help with the biases that may occur when assisting clients to make decisions about their life. This is because decision making is frequently subject to vying biases. Therefore, trainee clinical psychologists might like to be aware there is a risk that they may be influenced by these biases rather than experience, professional knowledge and skills. Reflection has been defined as “a metacognitive process that occurs before, during and after situations with the purpose of developing a greater understanding of both the self and the situation so that future encounters with the situation are informed from previous encounters” (Sandars, 2009, p. 685). This understanding of the experience is not enough for learning to transpire. Kolb (2015) described that an understanding of the experience should be understood and assimilated into the current knowledge base to expand and further that knowledge. Therefore, reflection is an important and necessary process of learning.

Kolb’s (2015) model of ‘experiential learning cycle’ helps structure the process of reflective practice. It has four main phases. The first phase includes the actual experience. The second phase involves the reflection on the experience. The third phase consists of the person making generalisations of the event and conceptualising their learning from the event. This is a critical phase for the learner to identify any learning needs or identify any biases that may have occurred and may occur in a similar experience in the future. The fourth phase involves active

experimentation which helps with planning and trying out what the person has learned. This can be a repeated process because every cycle of the phases includes increased learning and understanding and may lead to useful and effective reflective practice. It has been found that reflective practice helps improve academic performance in clinicians (Baernstein & Fryer-Edwards, 2003), it helps facilitate a more profound approach to learning and identify a wide range of professional issues that can assist with both professional effectiveness and personal development.

The scientist-practitioner model proposes that training of clinical psychologists should have time equally split between clinical competencies and research skills (Navab, Koegel, Dowdy, & Vernon, 2016). These clinical competencies and research skills adhere to the scientific method in integrating the latest empirical findings and in assessments, formulations and interventions (Shapiro, 2002). As the scientific method is a central tenet of being a scientist-practitioner, trainee clinical psychologists are encouraged to query and analyse hypotheses that are appropriate to the latest evidence-based care (Koerner & Castonguay, 2015).

Therefore, I will be using Kolb's 'experiential learning cycle' framework to challenge my assumptions, explore different/new ideas and then examine new approaches towards doing or thinking about things while linking practice and theory.

3.2 Background and Epistemological Position

I have been interested in how sleep affects wellbeing since reading research on an evolutionary theory of sleep (Coolidge & Wynn, 2006). The theory suggests that as our species evolved to a more ground-dwelling species (*Homo habilis* to *Homo erectus*), our sleep patterns changed accordingly. It is suggested that as ground-dwelling species we became more susceptible to predators. Therefore, through natural selection, a modification began to occur in the quality and quantity of our sleep to improve waking survival abilities. This paper made me reflect on how our

anxiety response is linked to a survival ability. Lima and Rattenborg (2007) suggest that sleep is a form of neural maintenance, but for optimum maintenance, there needs to be a complete shutdown of consciousness which would leave us vulnerable to predators. Therefore, to be able to detect potential predators, it would require some neural activity. Stage 4 sleep is known as the restorative sleep stage, and it is this stage where the most restorative sleep occurs (Bonnet, 1986). However, it is also the stage where our neural activity is at its lowest and takes longer to awake from, therefore being the most vulnerable to external threats. It has also been shown that anxiety severely disturbs this stage of sleep (Rosa, Bonnet, & Kramer, 1983). This gave me the idea that when a person is experiencing fear, from an evolutionary point of view, it will make sense that the body would not allow the brain to spend long in stage 4 sleep, as it would be more vulnerable to these (mis)interpreted threats. This led me to read around different theories of sleep and anxiety to formulate my idea.

Sleep problems are prevalent amongst those with anxiety and depression disorders (Roth et al., 2006) and sleep disturbances can have detrimental effects on well-being (Stein, Belik, Jacobi, & Sareen, 2008). During my employment in different services, I have noticed that clients complain about having sleep disturbances which are often untreated. National Institute for Health and Care Excellence (NICE) guidelines suggest that those experiencing long-term insomnia are referred to an Improving Access to Psychological Therapies IAPT service for a cognitive or behavioural intervention (NICE, 2015). However, some IAPT services only accept referrals for people who are experiencing depression and anxiety (NHS, 2018). Therefore, despite NICE guidelines, people with sleep difficulties are not being supported and must rely on self-help materials. This is despite face to face Cognitive Behavioural Therapy (CBT) treatment being shown to be more effective in treating insomnia than other forms of interventions (Lancee, van Straten, Morina, Kaldò, & Kamphuis, 2016). This started to make me think about whether it is poor sleep or high anxiety that has the most impact on daily functioning. If my research could answer that question, it would help provide evidence that a new approach to treating sleep disturbances is required.

To develop my study, I needed to reflect on my epistemological position. I was trying to measure the difference between isolated variables and look at their casual relationships. Therefore, my position is an objectivist epistemologist. It is important to reflect and consider how the methods and analysis may affect the results of a study (Yilmaz, 2013). While epistemological reflexivity is traditionally thought of as a qualitative process (Dowling, 2006), it can be a helpful process to identify any biases in the methods and analysis that might influence the results (Kleinsasser, 2000). Throughout my research, I have kept a reflective journal and kept copies of all the research meetings. I was able to use research meetings to reflect on the aims of the study, methodology and how I was going to analyse the data once it was completed. The use of supervision enabled me to explore any biases in collecting data. For example, I decided to use both objective and subjective measures of sleep to get a more accurate recording of the quality and quantity of sleep in the participants.

In conclusion, being reflective has allowed me to explore the initial steps of the research design, development of my research idea and why it was important to me. Keeping a reflective journal and having regular meetings with my supervision team, allowed me to gain a deeper understanding of the methodological and ethical biases in my research and to adjust this research design accordingly which in turn enabled a stronger theoretical framework.

3.3 The conflicting demands of being a scientist-practitioner and a trainee

One of the most significant challenges I faced during the research process was managing my time as a researcher and a trainee on placement. This was due to the conflicting demands on my time and the frequently changing priorities throughout the course. These contradictory demands included challenging placements, academic deadlines and personal wellbeing, and resulted in a frequent change in priorities. This, in turn, made me feel anxious about balancing the needs of being a scientist-practitioner and a trainee. These changing priorities

occurred during the data collection when I was meeting different participants who were struggling with anxiety and sleep difficulties. It has been shown that GAD symptoms and impairment severity may fluctuate significantly between participants regardless of their self-reported score on the GAD7 questionnaire (Beard & Björgvinsson, 2014; Szkodny, Newman, & Goldfried, 2014). GAD is frequently associated with high comorbidity that can result in a more prominent impairment in a person's daily functioning (Bruce et al., 2005). These participants also scored highly on the Pittsburgh Sleep Quality Index (PSQI). People who score highly on the PSQI show impairment in daytime performance, cognitive functioning, and it can also exacerbate other mental health conditions that can result in a lower quality of life (Mollaveva et al., 2016). Therefore, it is likely that these participants with high scores of both GAD7 and PSQI were struggling with their daily functioning and their general wellbeing.

I felt anxious as I was pulled between being a clinician with an obligation to help those who were struggling with their daily functioning and their general wellbeing and a researcher who was seeing their emotional difficulties as data required for the study. Yanos and Ziedonis (2006) discussed this pull between clinician and researcher as very common amongst scientist-practitioners (therapist-researcher). Scientist-practitioners are exposed to clinical settings or service systems that can encourage innovative and vital research that might be missed by non-clinical researchers. However, being a scientist-practitioner can also cause conflict between a "clinical mandate to act in the patient's best interest (beneficence) and the scientific mandate to pursue truth with all appropriate rigour (scientific autonomy)" (Yanos & Ziedonis, 2006, p. 250). Due to ethical considerations, participants were given their anxiety and sleep scores and an interpretation of what their scores could indicate. When participants were told about their level of anxiety and sleep, they were also provided with signposting information. However, while this was good for the participants to be made aware of potential adverse results from their scores, it may have caused distress to have been told this. Upon reflection, this is what may have created a lot of anxiety in myself, as in a clinical setting I would have administered the questionnaire during

an assessment and it would have guided what intervention I would then deliver. Then after completion of treatment, an outcome measure would be administered to see how successful the response was in reducing the anxiety and sleep disturbances. However, after their participation in this study, I provided them with their scores and signposting information. As there was no follow-on contact to see if the signposting information was useful, it was against my mandate as a clinician with an obligation to help those who were struggling with their daily functioning and their general wellbeing.

Yanos and Ziedonis (2006) suggested several considerations to address the issue of balancing the duality of being a researcher and a clinician. They suggested participants need to be aware of the goal of the clinical research. Therapeutic misconception is when participants believe that the study is therapeutic, and they will receive some form of treatment (Lidz et al., 2015). Therapeutic misconception occurs more frequently when the participants know the researcher as a therapist, and they are recruited from a treatment centre, e.g. a sleep clinic. This was not applicable to my study as I was using university students as my participants, but this is an important point to consider if I was employed and conducting research at the same service.

Another suggestion is for scientist-practitioners (clinician-researchers) to fully inform potential participants that the research is not therapeutic (Roberts, 2002) and to provide a written document reflecting this. This was addressed in my research by giving every participant the 'participant information sheet' (Appendix P) which declared the intention of the study and what the participant would receive in return. The study also went through the ethical review process at the university (Appendix O). This is important for future research that participants from a clinical setting are fully informed about the advantages and disadvantages of taking part in the study.

To help with the duality of being a scientific-practitioner (clinician-researcher) Rosenstein and DeRenzo (2012) suggest a 'coherent moral identity' is needed to develop a good ethical judgement. Developing good ethical judgement can be

cultivated through the scientist-practitioner being aware of themselves as researchers and as a clinician with a moral responsibility to the participant, society and themselves (Yanos & Ziedonis, 2006). Being a reflective scientist-practitioner can help identify conflicts with either role and help address situations where bias may occur towards a specific client group (e.g. those with GAD) which may compromise the scientific rigour of the research.

Keeping a reflective journal has been helpful throughout my training as a clinical psychologist and has proven an essential tool for keeping my reflexivity as a scientist-practitioner. It has been beneficial during the research process to identify any potential biases between being a scientist, practitioner and a trainee. Yanos and Ziedonis (2006) made suggestions to keep the balance between being a clinician and a researcher and provide a good ethical framework to maintain the integrity of being a scientist-practitioner which I will attempt to adhere to in the future. Rosenstein and DeRenzo (2012) discuss the importance of developing a 'coherent moral identity' which can help keep the balance between dual nature of being a scientist-practitioner and how reflecting on self can help with this. Therefore, being a reflective clinical psychologist will help with my anxiety arising from the pull between being a clinician and a researcher.

3.4 Hopes and fears of the research

My biggest hope for my thesis is that it can be used to further explore the impact of sleep on cognitive functioning in both those with typical development and those with a diagnosis of Autism Spectrum Condition (ASC). My research has highlighted the importance of using objective and subjective measures in evaluating a person's sleep quality. The empirical study has also shown that poor sleep appears to be having more of a negative impact on well-being than GAD and further research might look to expand on these findings.

I feel proud of my research. I thoroughly enjoyed the research process from developing the aims of the study to analysing the results. I enjoyed the systematic

approach to the literature review, and I enjoyed the empirical research as it enabled me to develop my idea and investigate an area that interested me. My greatest fear is that this research will not be recognised or extended on and that the impact of sleep on wellbeing continues to be underestimated. I do have some worries about my research not being published and therefore not having any impact in the research community.

It is common amongst researchers to experience anxiety about their research not being published (Kamler, 2008). Low publication output is a natural characteristic of doctoral courses in the UK and elsewhere (A. Lee & Kamler, 2008). This could be because of publication-related anxiety, and thesis hand in anxiety occurs at the same time. The resilience of the doctoral student to criticism is quite low during this period due to the tremendous effort and struggle in writing a doctoral thesis. It has also been shown that being in a small research team leads to more consensus, lower coordination costs, fewer emotional conflicts and a higher quality of enjoyment in the research (Y. Lee, Walsh, & Wang, 2015). Having regular research meetings has also been shown to reduce stress levels and increase resilience (Halse, 2011). This is because problems can be addressed quicker and progress can be discussed and recorded.

Analysing the situation carefully, I can see how I experienced anxiety at the thought of not being published. I feel the publication-related anxiety was being heightened because of the typical stress that doctoral students experience when writing their thesis. Acceptance and Commitment Therapy (ACT) suggests that the anxiety that I experienced about getting my research published indicates that I care about the subject matter being impactful (Ruiz, 2010). I also felt that the small research team helped to manage this anxiety and made me feel competent about my research. The meetings were mostly harmonious and productive and enabled me to have clear objectives to achieve. This helped reduce stress and gave me more resilience to face other challenges during the thesis write up.

In conclusion, I have learned that hopes and fears I have for my research are typical for a doctoral student writing up their thesis. I was fortunate to have a good supervisory team that helped keep me on track and provided helpful advice and suggestions for my thesis. I am proud of the research I have undertaken and hoped that it will have an impact in the research community. More importantly, I hope that it will have a positive clinical effect for those who experience sleep difficulties and it will help highlight an area that needs further investigation. In the future, if I supervise a doctoral-level thesis, I will remember the importance of providing the student with regular supervision that will help reduce their stress levels and offer them encouragement and clear and realistic objectives to achieve. This will hopefully help the supervisee feel more confident and help build their resilience to face the typical challenges of writing a doctoral thesis, much like my supervisors provided for me.

3.5 The impact of the research process on professional and personal development

The research process has had a significant impact on both my professional and personal development. Professionally, I was initially unsure about the role of a scientist-practitioner. My clinical experience before the clinical psychology doctorate course was predominantly directly working with clients with very little research. I did work as an assistant research psychologist in a service, but my role was research-based, and I did not have any direct client work. At the start of the training, it was daunting to learn more about the scientist-practitioner role. Being a scientist-practitioner meant that I would be bringing both my experiences as a researcher and as a clinician together.

The research process was an excellent opportunity to be able to explore the latest research in GAD and sleep disorders. For example, I was really struck how useful the literature review was. Being able to review all the research in the area was helpful to identify gaps in the knowledge and possible future directions and clinical implications. Looking at the methodological limitations of each study in the review

could also influence the research design of any future studies thus improving the quality of the study design. The results of the literature review can also provide practitioners, policy makers and services with the available evidence in a particular research area (e.g., evidence-based interventions) and can help with justifying the need for services to change or defend current policies (Booth, Sutton, & Papaioannou, 2016). In the future, using literature reviews will be an excellent resource in my career to help develop new tools, instruments or scales to conduct my studies to help positively influence services with evidence-based research.

The research process has also had a positive impact on my personal development. It has helped me gain confidence and personal insight about the role of a clinical psychologist involved in professional practice. Preparing for dissemination and presenting my research have enabled other professionals to take a genuine interest in my study as they believe it will impact upon their own clinical work. This has increased my confidence in the work and has helped me identify more with being a future scientist-practitioner.

Reason and Marshall (1987) suggest that researchers often select areas of research which stimulates unresolved patterns of distress. Theories of human development indicate that humans strive towards the full realisation of self (Ivtzan, Gardner, Bernard, Sekhon, & Hart, 2013). Therefore, it could be possible that as a researcher I was trying to resolve anxiety and old distress by unconsciously choosing my research topics in a bid for personal development (Reason & Marshall, 1987). Keeping a reflective diary throughout the research process has helped identify if anxiety was due to these unresolved patterns of distress. Reason and Marshall (1987) state that if researchers have the skills and supervision to handle and transcend these unresolved patterns of distress, they can be used to develop personally and be more creative with future research. I feel using reflection and supervision regularly throughout the research process has helped me understand more about any potential unresolved patterns of distress that might have directly influenced the research but also cause further distress if not identified and resolved.

3.6 Conclusion

In conclusion, being reflective and using supervision during the research process has helped me develop professionally and personally. Professionally, using reflective journals to identify problematic areas in services that an evidence-based research process can help create new tools, instruments or scales to influence services positively. Personally, being reflective during the research process to look deeply at the reasons why the research topic was important to me and highlighted areas of personal development which helped with improving motivation and alleviating any possible distress.

3.7 References

- Baernstein, A., & Fryer-Edwards, K. (2003). Promoting reflection on professionalism: A comparison trial of educational interventions for medical students. *Academic Medicine, 78*(7), 742-747.
- Beard, C., & Björgvinsson, T. (2014). *Beyond generalised anxiety disorder: Psychometric properties of the GAD-7 in a heterogeneous psychiatric sample*
doi:<https://doi.org/10.1016/j.janxdis.2014.06.002>
- Bonnet, M. (1986). Performance and sleepiness following moderate sleep disruption and slow wave sleep deprivation. *Physiology & Behavior, 37*(6), 915-918.
- Booth, A., Sutton, A., & Papaioannou, D. (2016). *Systematic approaches to a successful literature review* Sage.
- BPS. (2017). *Practice guidelines third edition - British psychological society* (Third ed.). Leicester: BPS.
- Bruce, S. E., Yonkers, K. A., Otto, M. W., Eisen, J. L., Weisberg, R. B., Pagano, M., . . . Keller, M. B. (2005). Influence of psychiatric comorbidity on recovery and recurrence in generalised anxiety disorder, social phobia, and panic disorder: A 12-year prospective study. *American Journal of Psychiatry, 162*(6), 1179-1187.
- Coolidge, F., & Wynn, T. (2006). The effects of the tree-to-ground sleep transition in the evolution of cognition in early homo. *Before Farming, 2006*(4), 1-18.
- Dowling, M. (2006). Approaches to reflexivity in qualitative research. *Nurse Researcher (through 2013), 13*(3), 7.
- Halse, C. (2011). 'Becoming a supervisor': The impact of doctoral supervision on supervisors' learning. *Studies in Higher Education, 36*(5), 557-570.
doi:10.1080/03075079.2011.594593
- Ivtzan, I., Gardner, H. E., Bernard, I., Sekhon, M., & Hart, R. (2013). Wellbeing through self-fulfilment: Examining developmental aspects of self-actualisation. *The Humanistic Psychologist, 41*(2), 119.

- Kamler, B. (2008). Rethinking doctoral publication practices: Writing from and beyond the thesis. *Studies in Higher Education, 33*(3), 283-294.
- Kleinsasser, A. M. (2000). Researchers, reflexivity, and good data: Writing to unlearn. *Theory into Practice, 39*(3), 155-162. doi:10.1207/s15430421tip3903_6
- Koerner, K., & Castonguay, L. G. (2015). Practice-oriented research: What it takes to do collaborative research in private practice. *Psychotherapy Research, 25*(1), 67-83.
- Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (Second edition.. ed.)
- Lancee, J., van Straten, A., Morina, N., Kaldo, V., & Kamphuis, J. H. (2016). Guided online or face-to-face cognitive behavioural treatment for insomnia: A randomised wait-list controlled trial. *Sleep, 39*(1), 183-191.
- Lee, A., & Kamler, B. (2008). Bringing pedagogy to doctoral publishing. *Teaching in Higher Education, 13*(5), 511-523.
- Lee, Y., Walsh, J. P., & Wang, J. (2015). Creativity in scientific teams: Unpacking novelty and impact. *Research Policy, 44*(3), 684-697.
- Lidz, C. W., Albert, K., Appelbaum, P., Dunn, L. B., Overton, E., & Pivovarova, E. (2015). Why is therapeutic misconception so prevalent? *Cambridge Quarterly of Healthcare Ethics, 24*(2), 231-241.
- Lima, S. L., & Rattenborg, N. C. (2007). *A behavioural shutdown can make sleeping safer: A strategic perspective on the function of sleep*
doi:<https://doi.org/10.1016/j.anbehav.2006.12.007>
- Mollayeva, T., Thurairajah, P., Burton, K., Mollayeva, S., Shapiro, C. M., & Colantonio, A. (2016). The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep Medicine Reviews, 25*, 52-73.
- Navab, A., Koegel, R., Dowdy, E., & Vernon, T. (2016). Ethical considerations in the application of the scientist-practitioner model for psychologists conducting intervention research. *Journal of Contemporary Psychotherapy, 46*(2), 79-87.

- NHS. (2018). Changing minds IAPT. Retrieved from <https://www.nhft.nhs.uk/iapt>
- NICE. (2015). *Scenario: Managing long-term insomnia (> 4 weeks)*. ().National Institute for Health and Care Excellence (NICE). Retrieved from <https://cks.nice.org.uk/insomnia#!scenariorecommendation:2>
- Reason, P., & Marshall, J. (1987). Research as personal process. *Appreciating Adult Learning*. London: Kogan Page, 112-126.
- Roberts, L. W. (2002). Ethics and mental illness research. *Psychiatric Clinics of North America*, 25(3), A525-A545.
- Rosa, R. R., Bonnet, M. H., & Kramer, M. (1983). The relationship of sleep and anxiety in anxious subjects. *Biological Psychology*, 16(1-2), 119-126.
- Rosenstein, D. L., & DeRenzo, E. G. (2012). Professional integrity in clinical research. *The ethical challenges of human research: Selected essays* () Oxford University Press.
- Roth, T., Jaeger, S., Jin, R., Kalsekar, A., Stang, P. E., & Kessler, R. C. (2006). Sleep problems, comorbid mental disorders, and role functioning in the national comorbidity survey replication. *Biological Psychiatry*, 60(12), 1364-1371.
- Ruiz, F. J. (2010). A review of acceptance and commitment therapy (ACT) empirical evidence: Correlational, experimental psychopathology, component and outcome studies. *International Journal of Psychology and Psychological Therapy*, 10(1)
- Sandars, J. (2009). The use of reflection in medical education: AMEE guide no. 44. *Medical Teacher*, 31(8), 685-695. doi:10.1080/01421590903050374
- Shapiro, D.,S. (2002). Renewing the scientist-practitioner model. *Psychologist*, 15(5), 232-235.
- Stein, M. B., Belik, S. L., Jacobi, F., & Sareen, J. (2008). Impairment associated with sleep problems in the community: Relationship to physical and mental health comorbidity. *Psychosomatic Medicine*, 70(8), 913-919. doi:10.1097/PSY.0b013e3181871405 [doi]

- Szkodny, L. E., Newman, M. G., & Goldfried, M. R. (2014). *Clinical experiences in conducting empirically supported treatments for generalised anxiety disorder*
doi:<https://doi.org/10.1016/j.beth.2013.09.009>
- Yanos, P. T., & Ziedonis, D. M. (2006). The patient-oriented clinician-researcher:
Advantages and challenges of being a double agent. *Psychiatric Services, 57*(2),
249-253.
- Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions:
Epistemological, theoretical, and methodological differences. *European Journal of
Education, 48*(2), 311-325.

Appendices

Appendix A: Standard Quality Assessment Criteria (SQAC) checklist criteria

Table 7 - Standard Quality Assessment Criteria (SQAC) checklist criteria

		Yes (2)	Partial (1)	No (0)	N/A
Criteria					
1	Question / objective sufficiently described?				
2	Study design evident and appropriate?				
3	Method of subject/comparison group selection or source of information/input variables described and appropriate?				
4	Subject (and comparison group, if applicable) characteristics sufficiently described?				
5	If interventional and random allocation was possible, was it described?				
6	If interventional and blinding of investigators was possible, was it reported?				
7	If interventional and blinding of subjects was possible, was it reported?				
8	Outcome and (if applicable) exposure measure(s) well defined and robust to measurement/misclassification bias? means of assessment reported?				
9	Sample size appropriate?				
10	Analytic methods described/justified and appropriate?				
11	Some estimate of variance is reported for the main results?				
12	Controlled for confounding?				
13	Results reported in sufficient detail?				
14	Conclusions supported by the results?				

Appendix B: SQAC scores for individual studies reviewed

Table 8 - SQAC scores for individual studies reviewed

Author	Date	Inter-rater reliability (Kappa statistic)	Standard Quality Assessment Criteria	Q 1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Bruni, O., Ferri, R., Vittori, E., Novelli, L., Vignati, M., et al	2007	0.682 p>0.001	22/28= 78.6%	2	2	2	2	n/a	n/a	n/a	2	2	2	2	2	2	2
Delahaye, J., Kovacs, E., Sikora, D., Hall, T., Orlich, F., et al	2014		20/28= 71.4%	2	2	2	2	n/a	n/a	n/a	2	2	2	2	0	2	2
Hollway, J., Aman, M., Butter, E.	2013	0.682 p>0.001	22/28= 78.6%	2	2	2	2	n/a	n/a	n/a	2	2	2	2	2	2	2
Limoges, É., Bolduc, C., Berthiaume, C., Mottron, L., Godbout, R.	2013		20/28= 71.45	2	2	2	2	n/a	n/a	n/a	2	1	2	1	2	2	2
Maski, K., Holbrook, H., Manoach, D., Hanson, E., Kapur, K., et al	2015	0.714 p>0.001	19/28= 67.9%	2	2	2	2	n/a	n/a	n/a	1	0	2	2	2	2	2
Miano, S., Bruni, O., Elia, M., Trovato, A., Smerieri, A., et al	2007		18/28= 64.3%	2	2	2	2	0	0	0	2	1	2	1	0	2	2
Patzold, L., Richdale, A., Tonge, B.	1998	0.868 p>0.000	18/28= 64.3%	2	2	2	2	0	0	0	2	1	2	1	0	2	2
Quist, H., Chaplin, E., Hendey, O.	2015		14/28 = 50%	2	2	0	2	0	0	0	2	0	2	0	0	2	2
Taylor, M., Schreck, K., Mulick, J.	2012	0.75 p>0.000	16/28= 57.1%	2	2	2	2	0	0	0	0	2	2	0	0	2	2
Elia, M., Ferri, R., Musumeci, S., Del Gracco, S., Bottitta, M., et al	2000		19/28= 67.9%	2	1	2	2	n/a	n/a	n/a	2	2	2	1	1	2	2
Goldman, S., Richdale, A., Clemons, T., Malow, B.	2012	0.509 p>0.009	19/28= 67.9%	2	2	2	2	n/a	n/a	n/a	2	1	2	1	1	2	2
Krakowiak, P., Goodlin-Jones, B., Hertz-Picciotto, I., Croen, L., Hansen, R.	2008		22/28= 78.6%	2	2	2	2	2	n/a	n/a	2	2	2	0	2	2	2
Polimeni, M., Richdale, A., Francis, A.	2005	1.000 p>0.000	19/28= 67.9%	2	1	2	1	1	n/a	n/a	2	2	2	1	1	2	2
Schreck, K., Mulick, J., Smith, A.		0.559 p> 0.003	17/28= 60.7%	1	2	1	2	n/a	n/a	n/a	2	2	1	1	1	2	2
Wiggs, L., Stores, G.			22/28= 78.6%	2	2	2	2	n/a	n/a	n/a	2	2	2	2	2	2	2

Appendix C: Generalised Anxiety Disorder 7-item (GAD7) questionnaire

Generalized Anxiety Disorder 7-item (GAD-7) scale

Over the last 2 weeks, how often have you been bothered by the following problems?	Not at all sure	Several days	Over half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it's hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3
<i>Add the score for each column</i>	+	+	+	
Total Score (add your column scores) =				

Source: Spitzer RL, Kroenke K, Williams JBW, Lowe B. A brief measure for assessing generalized anxiety disorder. *Arch Intern Med.* 2006;166:1092-1097.

Appendix D: Pittsburgh Sleep Quality Index (PSQI)

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

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

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

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

3. During the past month, when have you usually gotten up in the morning?
USUAL GETTING UP TIME _____

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

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

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

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...cannot get to sleep within 30 minutes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(b) ...wake up in the middle of the night or early morning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(c) ...have to get up to use the bathroom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(d) ...cannot breathe comfortably	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(e) ...cough or snore loudly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(f) ...feel too cold	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(g) ...feel too hot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(h) ...had bad dreams	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(i) ...have pain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(j) Other reason(s), please describe _____ _____				
How often during the past month have you had trouble sleeping because of this?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

PSQI Page 1

	Very good	Fairly good	Fairly bad	very bad
6. During the past month, how would you rate your sleep quality overall?	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	No bed partner or roommate	Partner/roommate in other room	Partner in same room, but not same bed	Partner in same bed
10. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

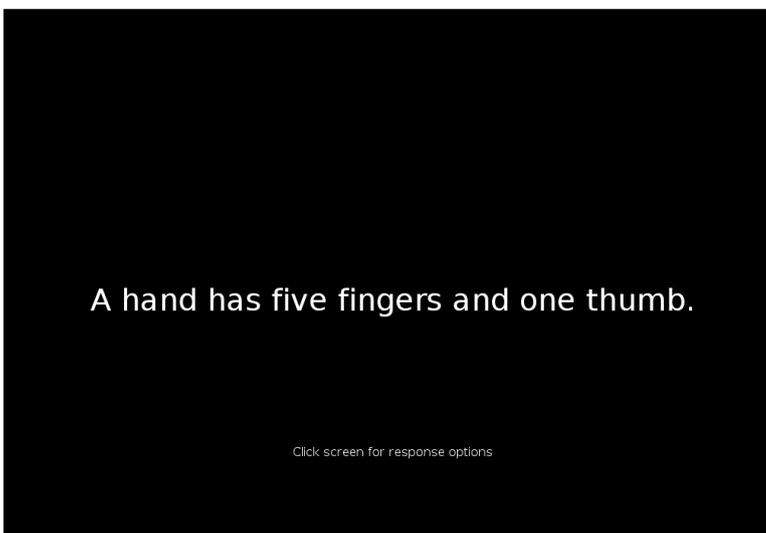
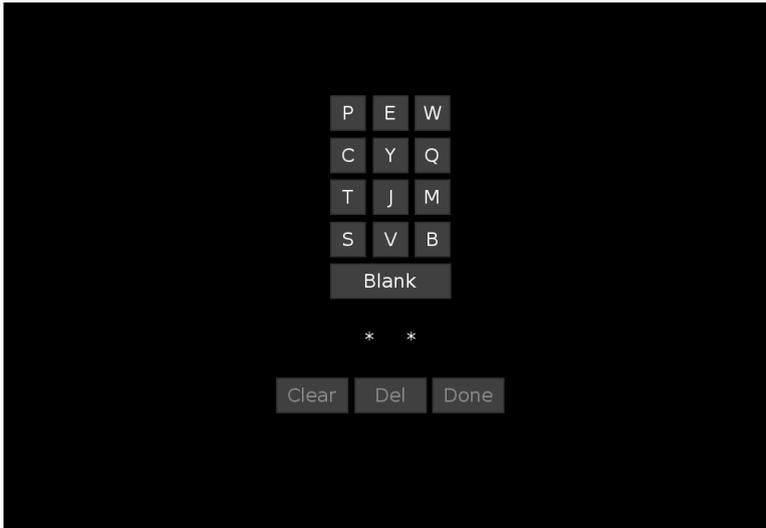
If you have a roommate or bed partner, ask him/her how often in the past month you have had...

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

Appendix F: Example of Stroop Task



Appendix G: Example of Reading Span Test (RST)



Appendix H: Descriptive statistics for sample data

Table 9 - Descriptive statistics

	Normal (n=10)	Sleep (n=10)	GAD (n=10)	Sleep & GAD (n=10)	Total (N=40)
M/ SD of age	M=24.40 SD=3.89	M=25.80 SD=4.05	M=20.90 SD=4.72	M=20.40 SD=2.88	M=22.88 SD=4.44
Gender (%)	Female=80 Male=20	Female=60 Male=40	Female=90 Male=10	Female=100 Male=0	Female=82.5 Male=17.5
TOPF	M=61.80 SD=5.79	M=53.00 SD=11.22	M=55.50 SD=4.60	M=45.30 SD=12.85	M=53.90 SD=10.75
Acti sleep %	M=88.01 SD=3.87	M=82.45 SD=7.99	M=82.66 SD=10.36	M=81.22 SD=7.67	M=83.59 SD=7.97
Acti sleep frag	M=14.40 SD=8.37	M=27.62 SD=10.53	M=26.64 SD=11.19	M=35.41 SD=9.93	M=26.02 SD=12.30
ROCF	M=26.20 SD=5.55	M=22.40 SD=4.06	M=27.60 SD=3.81	M=23.55 SD=7.72	M=24.94 SD=5.69
Stroop Time	M=126093.40 SD=14778.90	M=146957.10 SD=24669.30	M=132014.40 SD=27947.40	M=155018.80 SD=36065.68	M=140020.93 SD=28415.55
Stroop Error	M=8.10 SD=4.43	M=18.30 SD=3.40	M=7.10 SD=3.84	M=14.00 SD=8.06	M=11.88 SD=6.84
RST Time	M=37482.59 SD=7103.37	M=46498.22 SD=24645.19	M=34343.94 SD=9765.97	M=71078.17 SD=41923.09	M=47350.73 SD=28147.79
RST Correct	M=100.40 SD=12.10	M=78.30 SD=16.87	M=103.80 SD=17.88	M=76.10 SD=27.54	M=89.65 SD=22.57

Appendix I: Scatter graph illustrating significant correlations from Hypothesis 1

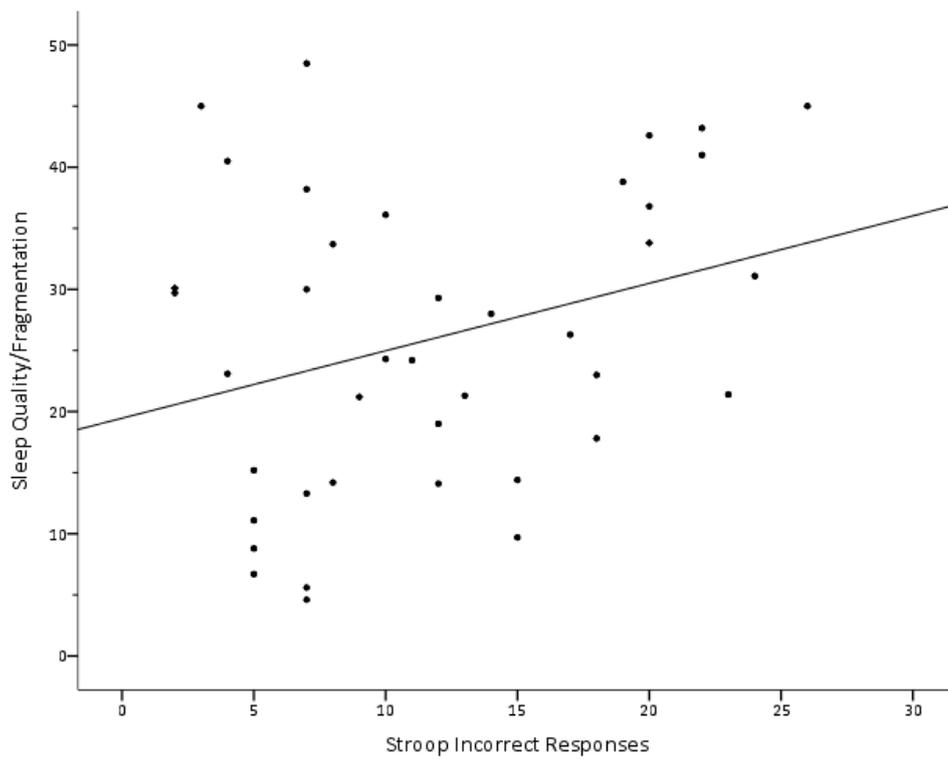


Figure 3 - Scatter graph illustrating the sig. correlation between Obj. Sleep Quality and Incorrect responses on Stroop test

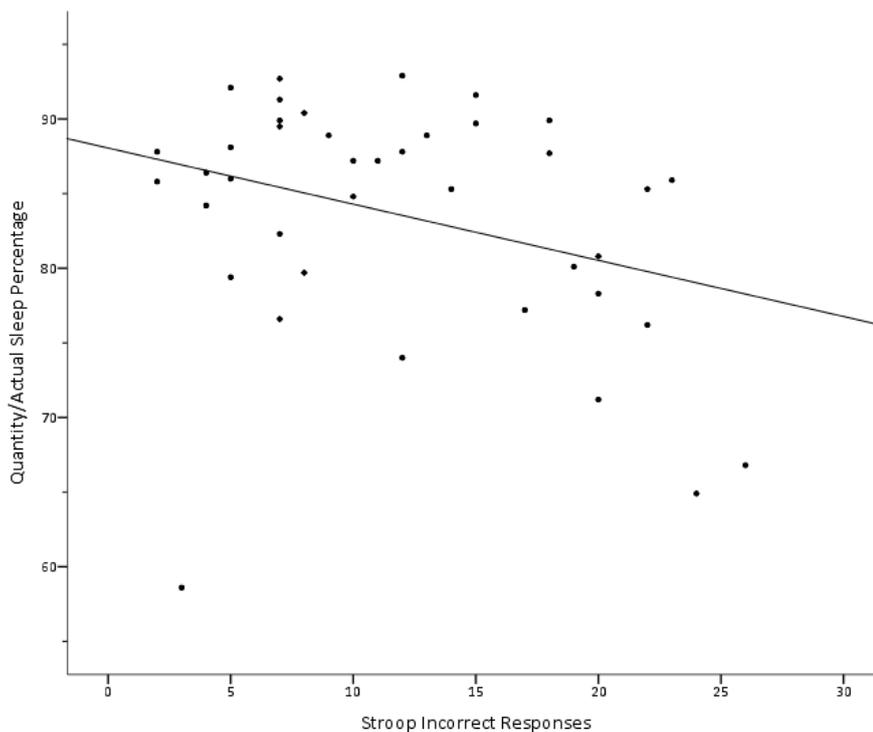


Figure 4 - Scatter graph illustrating the sig. correlation between Obj. Sleep Quantity and Incorrect responses on Stroop test

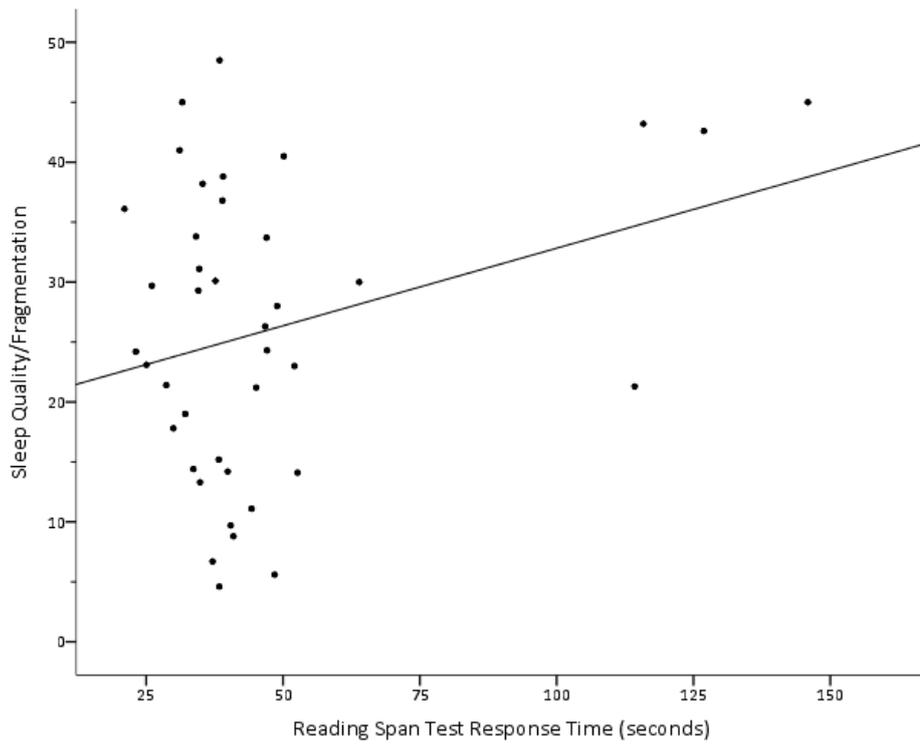


Figure 5 - Scatter graph illustrating the sig. correlation between Obj. Sleep Quality and response time on RST

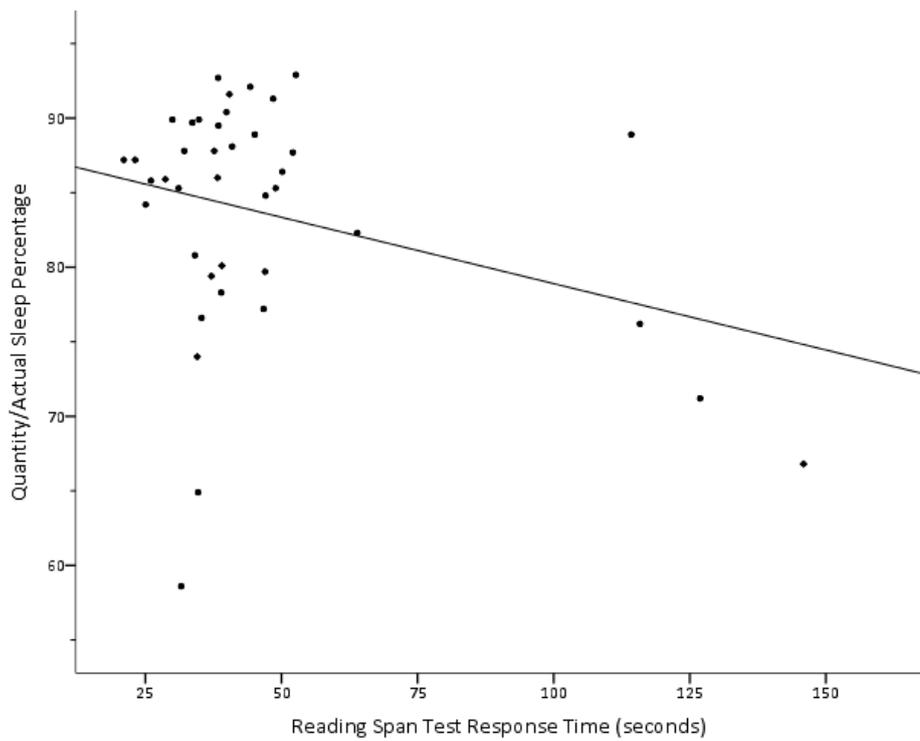


Figure 6 - Scatter graph illustrating the sig. correlation between Obj. Sleep Quantity and response time on RST

Appendix J: Correlation of Hypothesis 1

Table 10 - Correlation of Hypothesis 1 (*Significance at 0.05 level two-tailed)

	ROCF (lower scores)	Stroop Error Responses	Stroop Response Time	Reading Span Correct Responses	Reading Span Response Time
Obj. sleep duration	$r=-.17,$ $p=.155$	$r=-.32^*,$ $p=.021$	$r=-.17,$ $p=.153$	$r=.12,$ $p=.233$	$r=-.31^*,$ $p=.024$
Obj. sleep quality	$r=.06,$ $p=.352$	$r=.31^*,$ $p=.027$	$r=.14,$ $p=.197$	$r=-.10,$ $p=.277$	$r=.30^*,$ $p=.032$

Appendix K: Correlations between Objective and Subjective Sleep measures

Table 11 - Correlations between Objective and Subjective Sleep measures

	PSQI	Objective Sleep Percentage (Actiwatch)	Objective Sleep Fragmentation (Actiwatch)
PSQI	1	-.315*	.379**
Objective Sleep Percentage (Actiwatch)	-.315*	1	-.621**
Objective Sleep Fragmentation (Actiwatch)	.379**	-.621**	1

N=40, * Correlation is significant at the .05 level,

** Correlation is significant at the .01 level

Appendix L: Box plots showing group means for different sample statistics and neuropsychological tests

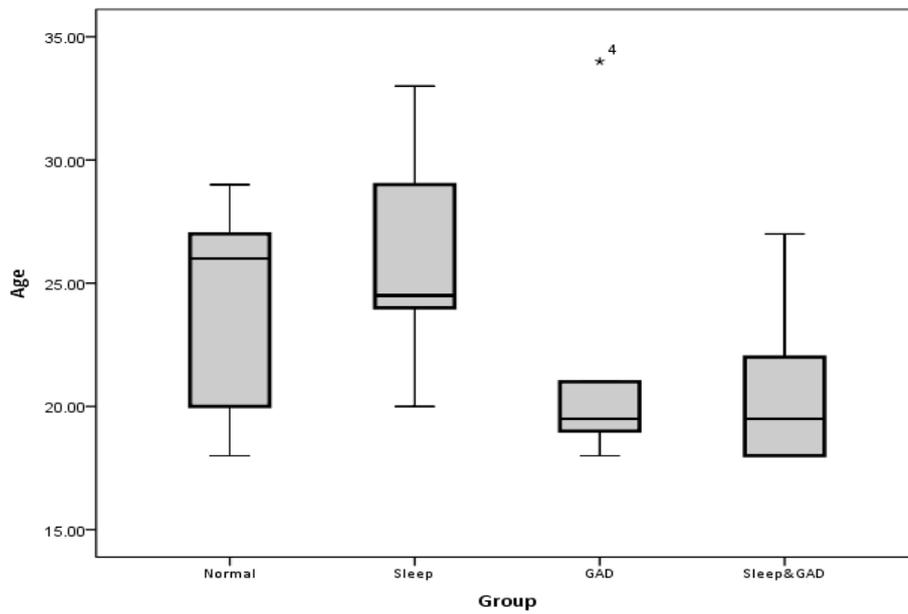


Figure 7 - Box plots showing the mean age of each group

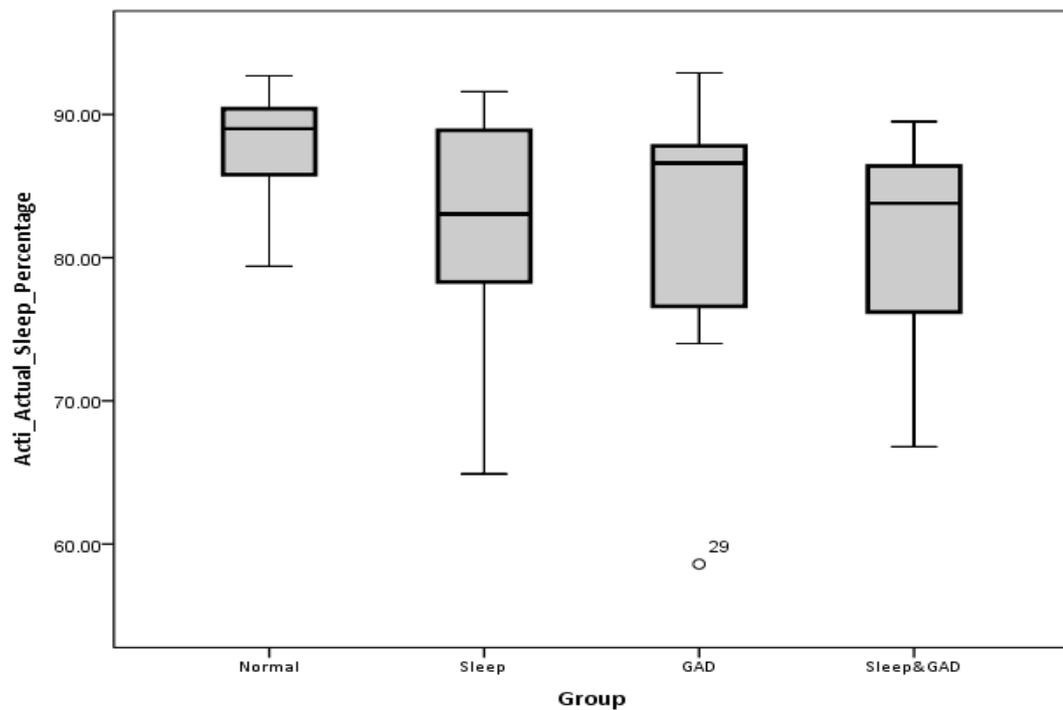


Figure 8 - Box plots showing sleep quantity of each group

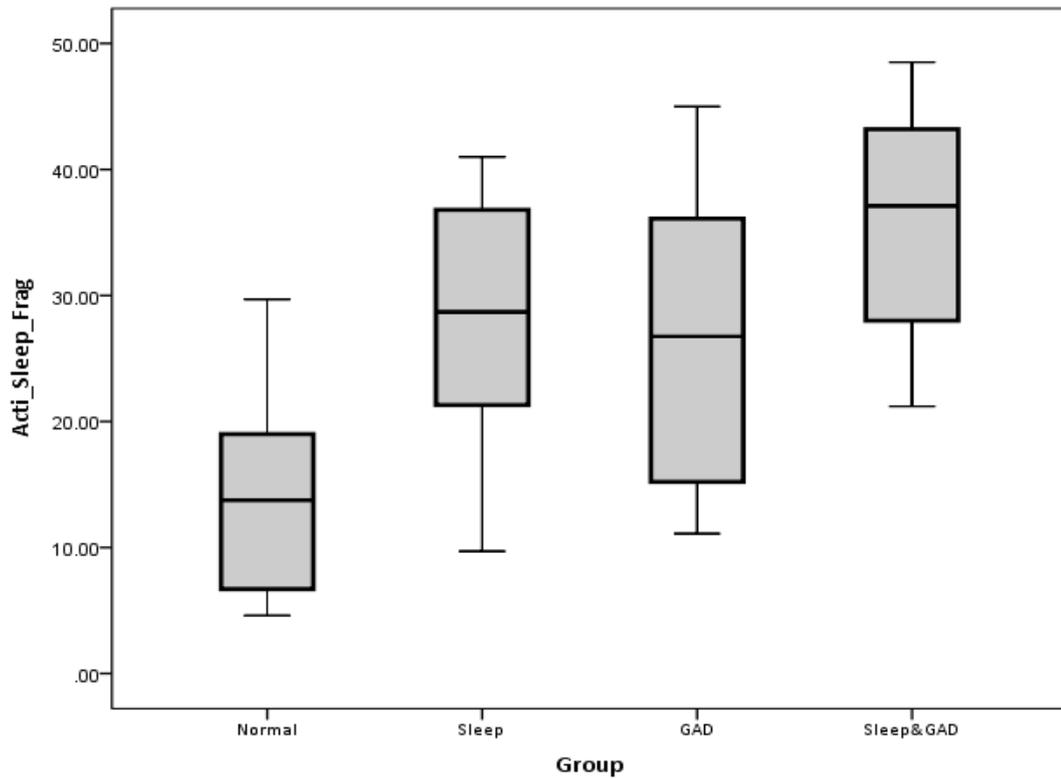


Figure 9 - Box plots showing sleep quality of each group

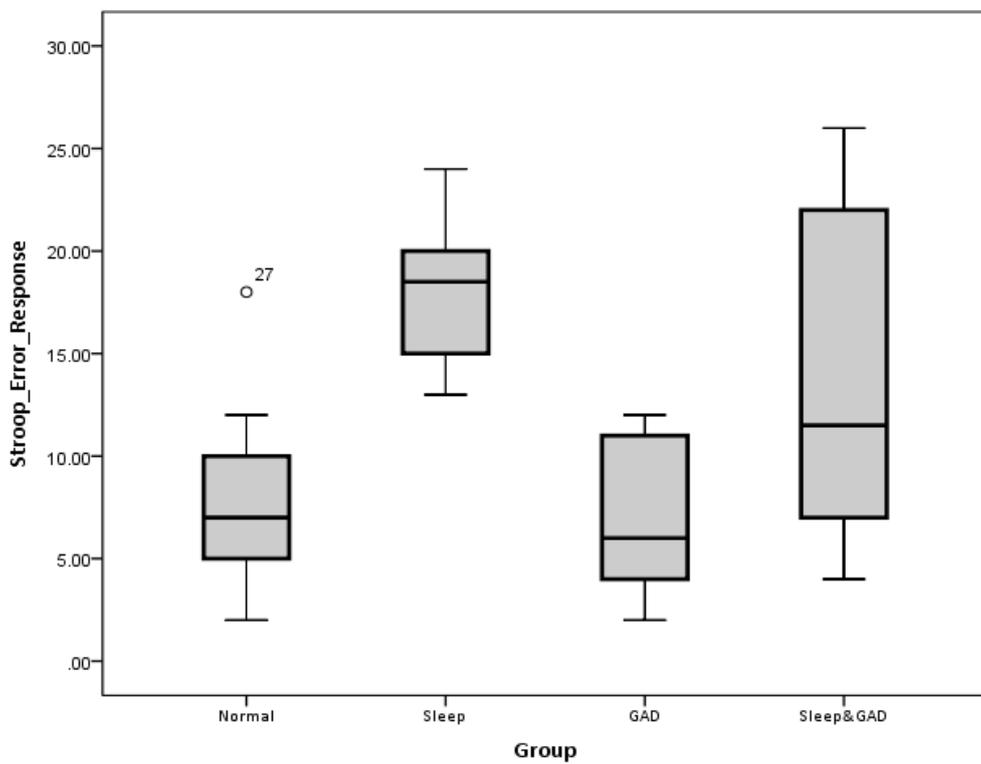


Figure 10 - Box plots showing Stroop incorrect responses of each group

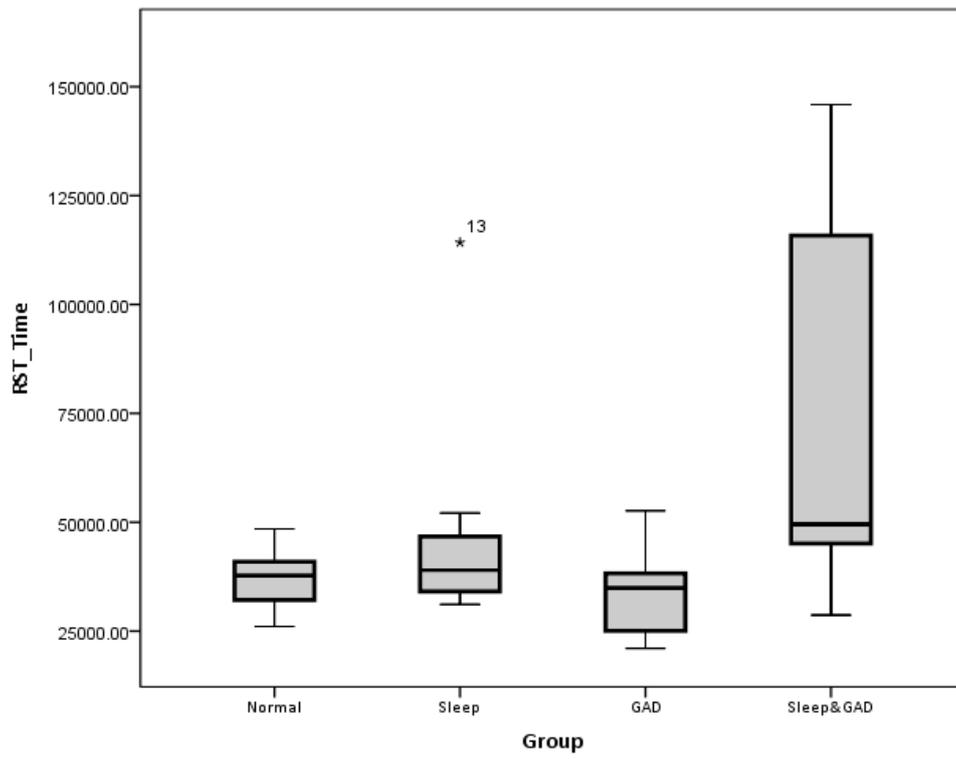


Figure 11 - Box plots showing RST response time of each group

Appendix M: Test of Normality & Levene's Test of Homogeneity of Variance

Table 12 - Tests of Normality (Shapiro-Wilk)

Group		Statistic	Sig.
Stroop Incorrect Response	Normal	0.91	0.27
	Sleep	0.98	0.96
	GAD	0.89	0.18
	Sleep&GAD	0.89	0.16
RST Response Time	Normal	0.98	0.94
	Sleep	0.60	0.01*
	GAD	0.96	0.79
	Sleep&GAD	0.82	0.02*

*. Significant

Table 13 - Test of Homogeneity of Variance (Levene's)

	Levene Statistic	df1	df2	Sig.
Stroop Incorrect Response	6.306	3	36	0.01*
RST Response Time	9.075	3	36	0.01*

*. Significant

Appendix N: Examples of Cognitive tests in WAIS-IV

Table 14 - Examples of Cognitive tests in WAIS-IV (Taken from https://en.wikipedia.org/wiki/Wechsler_Adult_Intelligence_Scale)

Tasks grouped by index

Index	Task	Core?	Description	Proposed abilities measured
Verbal Comprehension	Similarities	✓	Participants are given two words or concepts and have to describe how they are similar.	Abstract verbal reasoning; semantic knowledge
	Vocabulary	✓	Participants must name objects in pictures or define words presented to them.	Semantic knowledge; verbal comprehension and expression
	Information	✓	Participants are questioned about their general knowledge.	Degree of general information acquired from culture
	Comprehension			Ability to express abstract social conventions, rules and expressions

Perceptual Reasoning	Block Design	✓		Visual-spatial processing and problem-solving; visual motor construction
	Matrix Reasoning	✓		Nonverbal abstract problem solving, inductive reasoning
	Visual Puzzles	✓		Visual-spatial reasoning
	Picture Completion			Ability to quickly perceive visual details
	Figure Weights			Quantitative reasoning
Working Memory	Digit Span	✓	Participants must recall a series of numbers in order.	Working memory, attention, encoding, auditory processing
	Arithmetic	✓		Quantitative reasoning, concentration, mental manipulation

	Letter-Number Sequencing		Participants must recall a series of numbers in increasing order and letters in alphabetical order.	Working memory, attention, mental control
Processing Speed	Symbol Search	✓		Processing speed
	Coding	✓		Processing speed, associative memory, graphomotor speed
	Cancellation			Processing speed



Certificate of Ethical Approval

Applicant:

Aaron Shaw

Project Title:

Sleep, anxiety and the effects on cognition.

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

22 May 2017

Project Reference Number:

P49027

Participant Information Sheet

Study Title: Sleep, anxiety and the effects on cognition.

I would like to invite you to take part in a research study investigating how sleep and anxiety affect cognition. Before you decide whether you would like to take part, please read the following information to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully.

What is the purpose of the study?

Many studies have investigated how sleep difficulties affect cognition but there have been few studies exploring the combined effect of sleep difficulties and General Anxiety Disorder (GAD) on cognition. This study aims to investigate whether GAD or sleep difficulties have a greater impact on cognitive functioning.

There will be 3 phases:

Phase 1 – Participants will complete the Generalized Anxiety Disorder 7-item (GAD-7) scale and Pittsburgh Sleep Quality Assessment (PSQI) questionnaire via Bristol Online Survey (BoS).

Phase 2 – Participants may then be asked to wear an Actiwatch for 24 hours per day for a minimum of five days to collect a summary of their sleep.

Phase 3 – Participants will then return to Coventry University to hand in their Actiwatch and the data will be downloaded and analysed later. During this time participants will be asked to complete neuropsychological tasks.

Why have I been invited?

For the purposes of the study I will be recruiting 40 participants aged 18 to 59 within the student population, who have been identified (using the questionnaire responses) with either sleep difficulties, possible GAD, both sleep difficulties and GAD, or neither. Due to the different aspects of the neuropsychological testing involved in this study, anyone with learning difficulties or whose first language is not English will not be eligible to participate.

Do I have to take part?

No. Participation is entirely voluntary. If you change your mind about taking part in the study, you can withdraw at any point during the study and in the two weeks following Phase 3. You can withdraw by contacting the lead researcher (Aaron Shaw, shawa15@uni.coventry.ac.uk) on the stated email below and providing your participant ID number. If you decide to withdraw from the study, all your data will be destroyed and will not be used in the study. There are no consequences to deciding that you no longer wish to participate in the study and you are not required to provide a reason.

Information sheet - Version 3.6

What will happen to me if I take part?

You will be provided with a link to Bristol Online Survey where you will complete online two standardised questionnaires (GAD7 and PSIQ) to gather information on your sleep difficulties and level of anxiety. This will take approximately 15 minutes to complete. Based on the questionnaire results, you may be selected to take part in phase 2 and 3 of the study. In phase 2, you will be provided with an actiwatch (a small, wrist-worn movement monitor). You will need to pick this up from the James Starley Building, Coventry university. You will be required to wear this for 5-7 nights to record your sleep patterns based on activity levels, and to keep a sleep diary whilst you are wearing it. You will then be provided with a date to return the equipment and conduct the neuropsychological tasks at the James Starley Building, Coventry university. The testing will be conducted with a pen and a paper and a laptop to assess cognitive functioning. All materials will be provided. This session will last approximately 45 minutes.

What are the possible disadvantages and risks of taking part?

A disadvantage of participating in the study is that you may feel a little tired at the end of the neuropsychological testing.

Every effort will be made to ensure that your wellbeing is thought of before, during and following involvement in the study. At the end of your participation in the study you will be provided with signposting information to appropriate services who can help with any sleep difficulties and anxiety.

What are the possible benefits of taking part?

We cannot promise the study will help you personally, but the information we get from the study will help to increase our understanding of sleep and GAD. If you are a psychology undergraduate, you can earn upto 140 course credits.

Is there any risk of irritation / allergic reaction / discomfort associate with the actiwatch?

The actiwatch is worn on the non-dominant wrist and is made of silicone. If you have a silicone allergy than you will not be able to continue with this study. However, no allergic reaction/ irritation/discomfort has been previously reported but if this is the case the participant is to cease using the actiwatch, contact the lead researcher (Aaron Shaw, shawa15@uni.coventry.ac.uk), seek medical advice and return the actiwatch at the earliest opportunity.

The actiwatch will be cleaned before and after use with alcohol wipes.

The actiwatch contains a standard Coin Cell type battery (CR2032).

Battery is a swallowing hazard for small children – do not leave small children unattended when the device casing is open. However, the device casing should not be opened by the participant. If the device casing does come open please inform the contact the lead researcher (Aaron Shaw, shawa15@uni.coventry.ac.uk).

How do I put on and take off the Actiwatch?

The Actiwatch is to be worn as below:



Figure 1 – Actiwatch.

You should not need to take off the Actiwatch but if this is unavoidable then please put it back on as soon as possible. The Actiwatch is fastened to your wrist in the same way as any wristwatch. You will be shown on collection how to put the Actiwatch on and how to reattach it on collection. If you forget these instructions then please contact the lead researcher (Aaron Shaw, shawaj5@uni.coventry.ac.uk). The Actiwatch is waterproof.

Returning the watch

When you collect the Actiwatch you will be provided with a list of dates and times when to return the watch and begin Phase 3 of the study. This will typically be 7 days after the collection of the watch. Collection and the return of the Actiwatch will be at the James Starley Building, Coventry University. Participants will be responsible for the costs of travelling to collect the Actiwatch and the return journey to the James Starley Building, Coventry University.

What if there is a problem?

If we have to cancel the date and time of the neuropsychological testing I will attempt to contact you as soon as possible using the method indicated by you on the consent form.

If you have any questions or concerns about the research, please ask me, or one of the research supervisors who will do their best to answer your questions. If you wish to make a complaint about any aspect of the research, please contact:

Professor Olivier Sparagano
Associate Pro-Vice-Chancellor (Research)
University Applied Research Committee
Coventry University
Friary Street
Coventry
CV1 5FB
Email: pethics.hls@coventry.ac.uk

Information sheet - Version 3.6

Will my taking part in the study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential, and any results from your participation in the study which leaves the university via a password protected USB stick or laptop will have your name and contact details removed so that you cannot be recognised.

All consent forms will be stored in a separate, secure (locked) location at Coventry University. You will only be identified on the raw data by your participant ID number. The raw data from the questionnaires and neuropsychological data will be password protected and will only be associated with your participant ID number. Data will be retained for five years to allow for auditing and publications. They will then be destroyed. Planned disposal date 30/03/2023.

What will happen if I withdraw from the study?

If you withdraw from the study all the information and data collected from you, to date, will be destroyed and your name removed from all the study files.

What will happen to the results of the research study?

The results will be written up and presented as part of my Clinical Psychology Doctorate thesis. They will also be presented at academic conferences and / or written up for publication in peer reviewed academic journals.

Can I have access to my scores:

You may request the scores for any of the phases by contacting the lead researcher (Aaron Shaw, ashaw15@uni.coventry.ac.uk). If you request your scores you will also be provided with the clinical cut off scores of the questionnaires and provided with useful contacts if you are concerned with any of the scores.

Who is organising and funding the research?

The research is organised by Aaron Shaw, who is a Trainee Clinical Psychologist at the Coventry University Clinical Psychology Department. This project is not externally funded.

Who is supervising the research?

The supervision team consists of:

Dr Anna Joyce
Faculty of Health & Life Sciences
Coventry University
Friary Street
Coventry
CV1 5FB

ab8559@coventry.ac.uk

Dr Lesley Pearson
Faculty of Health & Life Sciences
Coventry University
Friary Street
Coventry
CV1 5FB
Tel: 024 768 8328

ab3840@coventry.ac.uk

Dr Magdalena Marczak
Faculty of Health & Life Sciences
Coventry University
Friary Street
Coventry
CV1 5FB
Tel: 024 768 8328

aa2127@coventry.ac.uk

Who has reviewed the study?

The study has been reviewed through the department of Clinical Psychology and has been approved by the Coventry University Research Ethics Committee.

Information sheet - Version 3.6

Contact for Further Information

Aaron Shaw
Faculty of Health & Life Sciences
Coventry University
Friary Street
Coventry
CV1 5FB
Email: shaw15@lmi.coventry.ac.uk

Information sheet - Version 3.6

Participant Debrief Sheet

Study Title: Sleep, anxiety and the effects on cognition.

Thank you for taking part in my research study investigating how sleep and anxiety affect cognition.

What is the purpose of the study?

Many studies have investigated sleep difficulties and the effect on cognition but there have been few studies into the combined effect of sleep difficulties and General Anxiety Disorder (GAD) on cognition. This study aims to investigate whether GAD or sleep difficulties have a greater impact on cognitive functioning.

Since 75% of people with GAD experience insomnia, people who report both anxiety and sleep difficulties may experience an increased impairment of their cognitive function beyond that experienced by people with GAD or insomnia in isolation. People with insomnia and GAD often report a reduction in work productivity and an increased use of mental health services (Wade, 2010; Wittchen, 2002). Therefore, having a clear understanding of the associations between sleep problems, GAD and cognitive functioning might help prioritise clinical interventions which, in turn, might help reduce the economic burden by increasing work productivity and reducing the use of mental health services. It is also important to look at the differences between the use of subjective and objective measures when exploring cognitive performance. This may lead to more clinical interventions being focused on treating sleep dysfunction based on objective measures rather than relying just on subjective accounts. Harvey and Tang's (2012) study indicates that showing people the discrepancy between their objective and subjective measure of sleep can be used as a clinical intervention to help reduce symptoms of insomnia and sleep-related anxiety. The consequence of this research could help develop specific interventions for sleep related difficulties and may reduce the possibility of developing subsequent psychiatric conditions (Mendelson, 2008). This study plans to investigate what the combined effects of anxiety and sleep are with regards to cognitive functioning by collecting measures from participants with GAD and sleep difficulties. This has been done by using subjective and objective sleep measures, anxiety measures and testing functioning in different cognitive domains: visuospatial memory, attention, processing speed, verbal functions and working memory.

What if I change my mind?

If you change your mind about taking part in the study, you can withdraw any time in the two weeks following Phase 3. You can withdraw by contacting the lead researcher on the email stated below and providing your participant ID number. If you decide to withdraw from the study, all your data will be destroyed and will not be used in the study. There are no consequences to deciding that you no longer wish to participate in the study and you are not required to provide a reason.

Some tests finished early, why?

Some tests may be terminated early due to a number of incorrect answers. This is in no way demonstrating that your cognitive functioning is 'abnormal' or that you have done anything 'wrong'. Some tests require a certain number of correct responses to continue and if this has not been reached the test will discontinue.

Debrief Sheet - Version 3.6

I am feeling very tired.

A disadvantage of participating in the study is that you may feel a little tired at the end of the neuropsychological testing. This is quite normal and is due to the testing of your different cognitive abilities. Please take time to rest after completing the testing.

Who can I contact regarding any issues that arise from the tests?

If you are concerned about your sleep difficulties or your levels of anxiety, then please contact your GP. For more information on sleep disorders and GAD please visit:

GAD – <http://www.nhs.uk/conditions/anxiety/Pages/Introduction.aspx>

Sleep disorders – http://www.nhs.uk/ivewell/sleep/pages/sleep_home.aspx

Also, Coventry University's health and wellbeing team can help. The health and wellbeing team can be contacted below:

Tel: +44 (0) 24 7765 8629

Email: counsell.ss@coventry.ac.uk

Website: <http://www.coventry.ac.uk/study-at-coventry/student-support/health-and-wellbeing/counselling-and-mental-health-service/>

Where can I read further information about the issues been studied?

To read more about how anxiety and sleep difficulties affect cognition see the links below:

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181635/>

<https://www.ncbi.nlm.nih.gov/pubmed/11164064>

Contact for Further Information

Aaron Shaw (Lead researcher)

Faculty of Health & Life Sciences

Coventry University

Friary Street

Coventry

CV1 5FB

Email: ashaw15@coventry.ac.uk

References

- Harvey, A. G., & Tang, N. K. Y. (2012). (Mis) perception of sleep in insomnia: A puzzle and a resolution. *Psychological Bulletin, 138*(1), 77-101.
- Mendelson, W. B. (2008). New research on insomnia: Sleep disorders may precede or exacerbate psychiatric conditions. *Psychiatric Times, 25*(7), 58-60.
- Wade, A. (2010). The societal costs of insomnia. *Neuropsychiatric Disease and Treatment, 2011*, 1-18.
- Wittchen, H. (2002). Generalized anxiety disorder: Prevalence, burden, and cost to society. *Depression and Anxiety, 16*(4), 162.

Appendix S: Sleep Diary

Sleep diary

Participant ID.....

Please complete the chart below to indicate as accurately as possible your sleep times on the nights of the study.

Date	Bedtime (time in bed with lights out)	Time you think you fell asleep	Time and duration of any night wakings	Time and duration of any daytime naps	Morning waking time	Was this a typical night for you?

Appendix T: Recruitment Poster

ARE YOU INTERESTED IN YOUR SLEEP

We are looking for participants with English as their first language to take part in a study

Why?

- Many studies have investigated sleep difficulties and the effect on cognition
- Very few have studied the combined effect of sleep difficulties and anxiety on cognition
- This study aims to investigate whether anxiety or sleep difficulties have a greater impact on cognitive functioning

3 Phases:

- Bristol Online Survey: sleep and anxiety questionnaires (10 minutes)
- Wear an actiwatch for 24 hours per day for a minimum of five days to collect a summary of your sleep
- Hand in the actiwatch and complete neuropsychological tests (45 minute session)

Benefits

- Increase understanding of sleep and anxiety
- Upto 140 credits for undergraduate students

Inclusion Criteria

- Coventry University Students
- Any age between 18-59 years old
- If you do not have a silicone allergy
- English is your first language



Contact: Aaron Shaw Trainee Clinical Psychologist shaw15@uni.coventry.ac.uk									
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Appendix U: Example of sleep data

Start day	Min	Average	Max	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Day of week	-	-	-	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Lights out				21:40:00	00:00:00	22:45:00	23:00:00	22:30:00	22:30:00	23:10:00
Fell asleep				22:00:00	00:45:00	23:15:00	23:20:00	22:45:00	23:00:00	23:40:00
Woke up				07:00:00	09:00:00	06:15:00	06:10:00	07:00:00	06:15:00	06:15:00
Got up				07:00:00	09:00:00	06:15:00	06:10:00	07:00:00	06:15:00	06:15:00
Time in bed	25500	28537.5	33600	33600	32400	27000	25800	30600	27900	25500
Assumed sleep	23700	26887.5	32400	32400	29700	25200	24600	29700	26100	23700
Actual sleep time	22740	24840	27630	27510	27630	23370	22740	27570	24360	22800
Actual sleep (%)	84.90740741	91.29829816	96.20253165	84.90740741	93.03030303	92.73809524	92.43902439	92.82828283	93.33333333	96.20253165
Actual wake time	900	2040	4890	4890	2070	1830	1860	2130	1740	900
Actual wake (%)	3.797468354	7.28981131	15.09259259	15.09259259	6.96969697	7.261904762	7.56097561	7.171717172	6.666666667	3.797468354
Sleep efficiency (%)	81.875	86.31806251	90.09803922	81.875	85.27777778	86.55555556	88.13953488	90.09803922	87.31182796	89.41176471
Sleep latency	900	1537.5	2700	1200	2700	1800	1200	900	1800	1800
Sleep bouts	14	20.875	40	40	23	15	18	24	19	14
Wake bouts	13	20.125	39	39	22	15	17	23	19	13
Mean sleep bout	687.75	1182.195547	1628.571429	687.75	1201.304348	1558	1263.333333	1148.75	1282.105263	1628.571429
Mean wake bout	69.23076923	96.69205883	125.3846154	125.3846154	94.09090909	122	109.4117647	92.60869565	91.57894737	69.23076923
Fragmentation Index	15.19331243	19.74415736	28.16455696	27.10866527	15.19331243	17.44588745	21.53764581	17.24666015	16.06321839	28.16455696

