

Effect Of Chronotype and Time of Testing on Memory Task Performance in Students

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Psychology Empirical Project: March 2025

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Acknowledgements

My greatest appreciation goes to my dissertation supervisor, Dr Kate Williams. Her constant professionalism, exceptional knowledge and guidance have helped me complete this dissertation to the best of my ability. It would not have been possible without her.

Further gratitude goes towards my other Psychology and Counselling lectures and staff at UWTSD, including Lymarie Rodriguez, Stacey Coleman, Ruth Groff and Mel Cameron, who have all helped me achieve my full potential during my time at university and helped me develop a passion for all aspects of Psychology.

Finally, I wish to thank my family, who have supported and encouraged me to achieve the best standard in my academic journey during difficult times and allowed me to disprove those who thought me not capable.

My most heartfelt thank you to everyone involved.

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Abstract

This project investigated the effects of chronotype on working memory (WM) performance at different times of the day. A chronotype is a behavioural manifestation of a person's circadian rhythm that regulates desired waking and sleeping times and influences 'peak' times for different aspects of cognition (Facer-Childs et al., 2018; Ronnenberg et al., 2003). This study utilised the Morningness-Eveningness Questionnaire (MEQ) (Horne & Ostberg, 1976) to determine participants as either morning or evening type, and participation time grouped participants into the morning test group or the evening test group. Using a modified version of the Brown-Peterson WM task, participants were tested on WM abilities. Based on the research question, the hypothesis that participants tested congruent to their chronotypes would perform better than those tested incongruently was examined in a two-way between-groups ANOVA. Results did not support the hypothesis as no statistically significant findings were drawn, yet patterns of synchronicity have implications on the appropriateness of uniform testing/learning times for students with references to study limitations and suggestions for further research.

Chapter 1 – Introduction

Quality sleep is intrinsically connected to all aspects of cognitive and physiological health and performance (McCarter et al., 2022). Sleep is divided into two primary phases: non-rapid eye movement (NREM) and Rapid eye movement (REM) (McCarley, 2007). The deeper stages of NREM sleep are considered the most restorative times for the body and mind. Declarative memories are primarily consolidated from short-term memory (STM) stores of the hippocampus and into long-term memory (LTM) stores during NREM sleep, making them more easily accessible for later retrieval, whereas REM sleep assists with non-declarative, procedural and emotional memory consolidation by giving learning context (Ackermann & Rasch, 2014). By the REM stage, most consolidation has already happened, so pathways and LTM storage areas are mostly deactivated (why we rarely remember dreams) (Grosmark et al., 2012). Personal preferences for sleep further temper levels of cognitive and physical ability as a result of sleep quality and wake activity times, known as Chronotypes (Facer-Childs et al., 2018; Klerman et al., 2017).

For the past two decades, Roenneberg and colleagues have been investigating the sleeping habits of 50,000 (and growing) participants for a sleep project to examine when they went to sleep, when they woke and how much sleep they managed, to investigate the relationship between the timings of our sleep and the impact this has on our lives and health (Roenneberg, 2013). Upon analysing the considerable database, Ronneberg assessed that everyone has a unique Chronotype (Roenneberg et al., 2003). Chronotypes are a genetic predisposition that can determine fluctuations in cognitive abilities at different times of the day, such as alertness, productivity and energy (Breus, 2016). Chronotypes are a manifestation of behaviours of an individual's internal Circadian Rhythm (Latin for "around the day") that regulates a person's sleep/wake cycle within approximately 25hrs and can be influenced by factors such as genetics, environmental cues and lifestyle choices with genetics and environmental factors accounting for about 50/50 of a person's

chronotype (Coleman, 2015; Partonen, 2015). Ronnenberg's research bridged the gap between biological rhythms and societal norms, determining that people can be categorised into one of three distinct but broad categories: Morningness (Larks), Eveningness (Owls), and neutral (Doves), challenging the traditional 9 – 5 attitudes towards work schedules and peak productivity (Roenneberg, 2012).

This literature review will first explore why some individuals have inherently different preferences for being awake and have differing peak cognitive times. It will draw from current investigations and relevant earlier research to analyse the effect that sleeping and working against our chronotypes may have on our cognitive performance and academic achievement, focusing specifically on working memory (WM) and why these effects occur and impact modern society.

From an evolutionary perspective, our ancestors would have benefitted from individuals within early communities having differing wake/sleep patterns for the consistent safety of a group. The Sentinel Hypothesis is a theory that proposes that the asynchrony of activities within a group of social creatures stems from the need for 24-hour vigilance in which group members will share the responsibility of being the “sentinel” at different times (Dement, 1966). In essence, a built-in physiological mechanism designed to keep some individuals awake at times opposite to others ensures maximum vigilance and security from external threats while also ensuring everyone gets adequate sleep. While most members of a community sleep through the night to be better prepared for the next day, other more nocturnal members would be awake and alert, watching for threats (Nunn et al., 2016; Samson et al., 2017). By studying this behaviour in modern hunter-gatherer tribes, such as the Hadza tribe of rural Tanzania, researchers have assessed that sentinel behaviour and chronotype can be predicted primarily by age. Both tribal and advanced communities consist of all ages. It is commonplace for the likes of infants and the elderly to naturally have an earlier chronotype, teenagers and young adults to prefer staying up later in the night and adults to have a

more varied but typically “normal” waking time, implying that chronotypes likely change throughout our lifespan (Samson et al., 2017).

In today's advanced society, the need for constant vigilance and sentinel behaviour is considerably less necessary. However, our innate and varying chronotypes remain, often causing havoc within individuals (usually night owls) whose hours of quality and sufficient sleep may be interrupted by the demands of shift work, artificial lighting and unnatural air conditioning (Kossowski et al., 2021). This can lead to sleep disorders such as extreme sleep inertia or Insomnia (Nunn et al., 2016). Conditions resulting from us fighting against our natural behaviour make evening chronotypes more vulnerable to mood disorders and elevated stress (Cheng, 2021; Hittle & Gillespie, 2016).

While no specific chronotype gene has yet to be identified (Vink et al., 2001). The suprachiasmatic nuclei (SCN) in the hypothalamus largely regulates our sleep timings and biological clock (Daan et al., 1984). The SCN activates when morning sunlight, among other environmental cues, travels through the optic nerve, signalling the SCN to start a new day's circadian rhythm. The SCN acts as the “master” clock which regulates other body clocks/timings throughout the day that govern other biological functions including blood pressure, hormonal flow, sex drive, energy, metabolism, etc, as well as cognitive aspects such as creativity, alertness, sociability and memory (Breus, 2016; Kalmbach et al., 2017).

Given that the sentinel hypothesis states that some individuals have vastly different preferences for waking times in a 24-hour cycle, it is assumed that these individuals' SCNs would also activate at atypical times, resulting in other biological functions occurring at different times with different peaks. Michael Breus dedicates a large section of his book, *The Power of When* (2016), to the importance of understanding your chronotype and knowing the best and most effective/optimal times for everything (eating, sex, exercise, etc,) governed by these biological

functions. Breus proposed four new chronotypes that may better reflect modern society and are instead named for and reflective of varying animals' sleeping/waking habits (Bears, Wolves, Lions and Dolphins) (Breus, 2016). This indicates that chronotype classifications are not universally agreed upon as research and understanding expands.

In our modern world, there are many circumstances in which our chronotypes can be displaced by the passing day through no fault of our own, often to the point where individuals cannot do activities at their respective peak times. For example, large samples of a population are in shift work (paramedics, nurses, police officers), requiring them to alternate their workdays and timings (Wickens, 2009). These abnormal patterns of sleep/wake not only cause constant sleepiness and fatigue but can increase the risk of health conditions (from participating in activities adverse to health due to stress such as cigarette smoking) and road accidents (Davis et al., 2001; Gold et al., 1992).

Long before Breus and Ronnenberg, the first instrument of morning and eveningness assessment was developed by Östberg and Horne in 1976 to originally investigate if a person's circadian rhythm determines their peak time through way of self-assessment on the score-based Morningness-Eveningness Questionnaire (MEQ) (Horne & Ostberg, 1976). Ronnenberg would note that the MEQ dealt more with individuals' personal preferences towards sleeping and waking times and does not factor in actual waking times around daily responsibilities. To account for this, as part of his sleep project, Ronnenberg and his colleagues designed the Munich ChronoType Questionnaire (MCTQ) that would ask individuals to specify their answers based on present circumstances on both workdays and free days as well as judge how they would perceive their chronotype changing with age (Roenneberg et al., 2003). Among other things, this survey would allow investigators to draw potential conclusions about the risks associated with lack of sleep and the effects on activities when awake. Observations showed that evening chronotypes suffer from greater sleep loss and thus increased daytime fatigue due to their work schedules (Dijk et al., 2000;

Tallard et al., 1999; Zavada et al., 2005). This fatigue harms work productivity and academic success (students) due to working at times incongruent with their chronotype (Hahn et al., 2012).

Consequently, Morningness has long been associated with greater academic success, largely in thanks to the synchronicity of work/school schedules versus an Owl's differing optimal working time (Preckel et al., 2013). At an optimal working time for respective chronotypes, individuals typically process and maintain information more systematically than at nonoptimal times as self-report measures have implied that attentional errors and mind wandering are more common, with these lapses allowing for larger amounts of irrelevant or incorrect information being encoded into memory (Carciofo et al., 2014; Hasher et al., 2014). A study of general executive function performance in adolescents has shown that in tasks of decision-making and memory, Larks outperformed their Owl counterparts when tested in the morning and Owls performed better when tested in the evening (I.e., performance is improved during a chronotypically congruent time of testing) (Hahn et al., 2012). Yet another study on adolescents found that Larks only gain an advantage academically during morning hours and being a Lark or an Owl does not influence memory performance or intelligence during evening learning (Arrona-Palacios & Díaz-Morales, 2018). A study on Finnish military conscripts aged 18 to 24 (who have strict fixed wake/sleep schedules and cannot choose their waking times) investigated the effects of sleep deprivation on the WM strategies of individuals in this group. Aligned with previous research, it was found that even when sleep-deprived, inhibitory control could be maintained but with the caveat of slower performance. A morning preference was associated with better spatial working memory (SWM) performance, and those with self-reported sleep deprivation had a worse SWM performance and strategies (this study used a variation of the MEQ) (Heimola et al., 2021).

A meta-analysis on the comparisons of extreme chronotypes on cognitive performance and academic achievement has shown that, across numerous studies, eveningness is generally positively associated with cognitive ability but negatively correlated to indicators of academic

achievement. This is opposed to Morningness which is positively associated with academic achievement but negatively associated with cognition (Preckel et al., 2011). Similarly, Natale and Lorenzetti (1997) tested the declarative memory of extreme chronotypes in a narrative comprehension task involving recalling parts of a story and found that both Owls and Larks made fewer recognition errors during their preferred testing time (Natale & Lorenzetti, 1997). The most prevalent explanation for this is the Synchronicity Effect which allows for better performance at times that match individual preferences. Synchronicity effects can be found in many studies that involve academically relevant tasks of attention and memory (Hasher et al., 2014; Intons-Peterson et al., 1998; May, 1999).

Other investigations, however, show no significant interactions between chronotype and time of assessment when applied to working and declarative memory tasks (Evansová et al., 2022). George Armitage Miller argued that STM span has a finite capacity, this number he referred to as “*The Magical Number Seven, Plus or Minus Two*” which explains that the human mind on average can hold as many as 7 ± 2 immediate objects in STM stores before being encoded into LTM (Miller, 1956). This became known as *Miller’s Law*, and the control mechanism of STM became known as Working Memory (Baddeley & Hitch, 1974). The executive control of WM filters out all but about seven attended items which can be moved to LTM. A method of bypassing this limited WM capacity is known as ‘chunking’ (also coined by Miller), which involves organising these items into categories of similar things (Thalmann et al., 2019). For example, memorising the number 897538412 as a whole would be difficult, but cutting the number into chunks of 897-538-412 might make it more manageable. Being proficient in chunking can improve memory performance, novice chess players who were briefly shown a mid-game chess board accurately recalled around four-piece locations compared to master-level chess players who accurately recalled up to 16-piece locations by using chunking (Chase & Simon, 1973).

Evidence has shown that adequate sleep is essential in post-learning memory consolidation. An experiment by Wilson and McNaughton (1994) used multi-electrode methods to record activations of clusters of neurons in a rat's hippocampus, known as place cells, during the learning phase of spatial behavioural tasks. It was found that the place cells that fired together during learning were also more likely to fire together during sleep the night after. This implies that the neurons of these rat's hippocampus are replaying/rehearsing the tasks of the previous day to encode to memory (Wilson & McNaughton, 1994). One current study of sleep duration on cognitive function according to morningness/eveningness concluded that poor quality of sleep has a greater impact on memory degradation overnight than any length of time spent sleeping (Ahn et al., 2024). This implies that poor-quality NREM sleep caused by sleeping incongruently with chronotypes likely impairs memory retention and increases memory decay.

Shortly after Miller assessed STM limits, experimental research became concerned with the decay of WM over time. Many researchers developed tests to measure this, notably the Brown-Peterson Task which refers to two experiments on WM conducted around this time, first by John Brown in 1958 (UK) (Brown, 1958) and second by husband-and-wife researchers Margaret and Lloyd Peterson in 1959 (USA) (Peterson & Peterson, 1959). Both researchers used similar cognitive exercises to assess WM capacity limits and introduce distractor tasks to prevent participants from using other cognitive strategies to improve WM and information recall. These experiments were among the first to test memory decay in a short period, previous research only focused on long-term forgetting. Brown in particular chose to incorporate decay theory into a larger framework that can describe the conditions in which decay rates can be increased or lessened (Brown, 1958). In subsequent years, this theory has been refined to assume that WM representations require rehearsal to prevent decay. Yet, the attentional mechanism needed for active rehearsal may also be required for other processing tasks. Any short time intervals in the task not requiring attention means this mechanism can be re-dedicated to rehearsal (Ricker et al.,

2016). This means that STM decay rate depends on the volume and density of other processing and attentional demands as attentional mechanisms have limited resources, referred to as “cognitive load” (Barrouillet et al., 2007).

The primary research question raised in the present investigation is as follows: Will a participant tested at a time congruent to their chronotype perform better on a WM task when compared to someone tested at an incongruent time? By extension, exploring if student participants tested at their optimal working time based on their chronotype be able to manage a greater cognitive load (the amount of WM resources required)? And do “Owls” or “Larks” perform better on WM tasks in general? Studies on students have shown that human memory capabilities fluctuate throughout the day, and to more accurately study cognitive abilities, memory or otherwise, the subject of time of testing must be considered (Esteki & Sadeghi, 2010). In pre-schoolers, it has been found that evening-type children perform better on SWM tasks when done in the evening compared to their morning-type peers, highlighting optimal times for learning opportunities even in early education (Abdul Jafar et al., 2023). This trend can also be seen in later academic institutes. A study on Italian university students found, in line with other research of this nature, that morning types had the advantage in theoretical and practical exams due to them being more aligned (synchronised) with exam and class schedules. While evening types can somewhat recover from this disadvantage on theoretical exams due to their slightly better cognitive functions, this did not benefit them during practical assessments (Montaruli et al., 2019). Up-to-date research shows that evening types tend to perform better on visual STM tasks in general, regardless of time-of-day conditions, noting that on tests of low/medium cognitive load, there was no interaction between chronotype and time of testing. It was also recorded that the subjective effort put into these tasks from both chronotypes was greater in the evenings, while the subjective difficulty of the task remained the same. This study, however, tested both evening and morning types at non-uniform times, i.e. morning types were tested earlier in the morning (09:25 – 9:55am)

than evening types (11:00 – 11:30am) and concluded that more emphasis should be placed on sex differences in the context of circadian rhythms (Ceglarek et al., 2021). Other studies report that better WM performance is observed during congruent time-of-testing on extreme chronotypes with synchronicity effects being most observable during tasks of heavy cognitive load (Schmidt et al., 2015). The findings from these studies, and others referenced within this chapter, imply that low/medium cognitive load activities have no relative differences concerning WM capabilities when different chronotypes are tested at various times of the day, only during distractor tasks with high cognitive load can the synchronicity effect be observed.

Based on most similar current research, this study hypothesises that on a WM task involving moderate to high cognitive load, participants tested at a time congruent to their chronotypes will perform better than those tested incongruently. This investigation will demonstrate the chronotype synchronicity effect in action by splitting testing times between a morning and an afternoon group.

Chapter 2 – Methodology

Participants

Participants for this study were recruited via the University of Wales Trinity Saint David's (UWTSD) online Experiment Management System (EMS). The participant sample consisted of level Four and Five undergraduate students studying Psychology at UWTSD (including counselling and criminology). Participants would use the EMS to select timeslots provided by the researcher to come into the IQ campus psychology labs between the business hours of 9 a.m. and 5 p.m., Monday to Friday. The only eligibility criteria for this study require participants to have '*normal or corrected to normal vision*' for the computer-based task and must be over the age of 18.

Potential participants on EMS would select a testing timeslot and unknowingly assign themselves to either the morning test group (tested between 9a.m. and 12p.m.) or the evening test group (between 1p.m. and 4p.m.). These times were selected as they reflect roughly the personal and self-assessed optimal cognitive working times of the day for undergraduate students of respective morning/evening chronotypes (Evans et al., 2017). Participation would be in exchange for three-course credits as participation was expected to take no longer than 30 minutes. This study recruited a total of 42 participants consisting of seven males, 34 females and one non-binary participant. This sample had an age range of 18 to 56 ($M = 31.3$, $SD = 9.63$).

Design

This experimental lab-based study employed a 2x2 Between Subjects quantitative design. There were two independent variables each with two conditions. The first controlled independent variables were the two resultant groups from participants' sign-up times, these being the Morning Group (9a.m. - 12p.m.) and Evening Group (1p.m. - 4 p.m.). Although many people would consider the hours of 1p.m. – 4p.m. to be “the afternoon”, this study will refer to this time as the “evening”

group to remain within the themes of ‘Morningness and Eveningness’. The second independent variable was the two groups of morning-preferred participants (Larks) and evening-preferred participants (Owls), which were determined by participant’s scores on the Morningness-Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976). The dependent variable for this study was the maximum trial achieved in a WM task (Minimum = 1, maximum = 15). A two-way between-subjects analysis of variance (ANOVA), 2 (testing time: morning, evening) x 2 (Chronotype: Owl, Lark), was calculated to test for main effects and significant interactions between the four conditions relating to the quantitative dependent variable of scores on the WM task (interactions seen below).

Main Effect (Groups) Main Effect (Chronotype)

Morning Group	-	Morning Person	=	Congruent
Morning Group	-	Evening Person	=	Incongruent
Evening Group	-	Morning Person	=	Incongruent
Evening Group	-	Evening Person	=	Congruent

Materials

This study utilised the 19-item Horne and Östberg score-based Morningness-Eveningness Questionnaire (MEQ) (1976). This assesses user’s personal preferences for waking and sleeping times by asking participants questions such as “*What time would you get up if you were entirely free to plan your day?*” and “*At what time of the day do you think that you reach your ‘feeling best’ peak?*”. Rather than assessing the user's actual waking times around daily commitments and schedules, it aims to assess internal chronotypes apart from external influences. Only negligible changes were made to the wording of a few questions to modernise the language to be more accessible for modern students (MEQ in Appendix A). Items in the questionnaire, presented on the Qualtrics software, consisted of both Likert-type questions, presenting four options relating to

the question (e.g. Very tired, Fairly tired, Fairly refreshed, Very refreshed), and time-scale questions, presenting up to six varying periods of time in an am/pm format of which participants can decide which applies to them (e.g. 8am-10am, 11am-1pm, 3pm-5pm, 7pm-9pm). Each response for every question is assigned a value of 1 through 4/5 with the lower values indicating eveningness and higher values indicating morningness. Seven items of this questionnaire were negatively scored so were reversed; the researcher did this manually by re-coding the values of these questions (in Qualtrics) to match the scoring of the original MEQ before data analysis. A global score was calculated by the sum of all response values. The original MEQ categorises participants into; definitely morning type (70–86), moderately morning type (59–69), neither type (42–58), moderately evening type (31–41), and definitely evening type (16–30) (Horne & Östberg, 1976). However, this study only used two groups: Larks and Owls. Participants were grouped depending on which side of the sample mean of the total score of responses their global score lies. This instrument's range of potential scores spans from the lowest score of 16, indicating extreme eveningness to the highest of 86, indicating extreme morningness. The original MEQ has a full-scale internal consistency of a sufficient .82, marking it as reliable and supporting the use of global scoring (Horne & Östberg, 1976).

This study also used a modified version of the Brown-Peterson working memory task (Brown, 1958; Peterson & Peterson, 1959), an amalgamation of two similar early WM tests. This task was constructed using SuperLab by the researcher and involved the participants progressing through a set of trials requiring them to memorise a new three-letter trigram for each trial (e.g. OKL). These trigrams were randomly generated by the researcher. Importantly, trigrams did not depict any real words or common acronyms, such as CAT or NYE. Participants were instructed to memorise these trigrams, each of which was presented for five seconds, while also completing a distractor task identifying either an EVEN or ODD number from a set (each set lasting four seconds) (examples in Appendix B). Correct or incorrect answers on the distractor task were

irrelevant and not recorded, this was only to allow a set number of seconds of non-rehearsal to pass before trigram recollection to increase difficulty. For example, trial one is 8 seconds, trial two is 12 seconds, etc. This distractor task is in place to prevent participants from using memory techniques other than WM to increase recall ability. There was a maximum of 15 trials that could be completed with each subsequent trial becoming more difficult than the previous due to an increased number of sets (non-rehearsal time) and identifiable numbers becoming more complex and numerous. The experiment would conclude after trial 15 or after one incorrect trigram recall. Participants were given a chance to redo the incorrect trial before termination and the maximum trial achieved would be shown on screen. Participants were also given one practice trial after the instructions to ensure an understanding of the task before beginning. The original versions of this task required participants to count backwards in 3s from 999 in between each trigram, this study has chosen to use a different numerical distractor task that will ensure a uniform and measurable amount of seconds pass between the trigram stimulus and recall opportunity.

Procedure

After receiving ethical approval from the Psychology department's research ethics committee (Appendix C and D), the piloting stage of this study could begin. Nine pilot participants were gathered from among the researcher's peers to test the experiment before going live on the EMS in case of errors in data collection. Several recommendations and adjustments were made, primarily concerning that most pilot participants completed the memory task without any mistakes. Changes made to remedy this included making the numbers in the distractor task more complex and numerous to prevent rehearsal. Secondly, the five seconds initially given to identify the odd/even numbers was suggested to be too long and allowed for easier rehearsal. This was changed to three seconds, which was then stated to be too fast-paced. The final experiment settled on four seconds. Considerations were also made about giving participants an 'extra life' and allowing for one mistake to be made, except all participants reached the end of the study given this

allowance. Therefore, this aspect was removed, and the experiment would cease after one mistake. Finally, there was initially an inclusion of two practice rounds. However, this was lowered to one as a single practice should be sufficient to understand the study requirements and an opportunity for questions was provided if otherwise. After the ninth pilot, the study was deemed to be working correctly, and data collection began. A full list of correct trigram answers can be found in Appendix E.

Before the start of data collection and meeting the participant, the researcher first input a unique experimental ID code depending on which test group they took part in (M = Morning group, E = Evening group) that would later be used to match questionnaire data in Qualtrics and SuperLab task data (E1, M1 etc.). The researcher then met the participants in the lab waiting area at their selected time. They were identified using their unique EMS identifier code and escorted into the labs with a lab computer and university laptop pre-loaded with the memory task and Qualtrics questionnaire respectively and a mouse for each. Data acquisition for this study was divided into two phases. Firstly, the participant was directed to the university laptop where they would be asked to read the study information sheet (Appendix F) and confirm all boxes on the consent form (Appendix G), both of which are found digitally at the start of the questionnaire. The digital consent and information forms made clear that the participant's data would remain confidential, and they had the right to withdraw their data at any point until the conclusion of the study, among other relevant ethical information from the BPS codes of conduct and research guidelines (British Psychological Society [BPS], 2021).

After consent and demographic data (age and gender) had been obtained, the participant would complete the MEQ. Questions were all presented on one page on Qualtrics where the participants scrolled through and gave their responses by ticking a box that best represented their thoughts. Participants were given unlimited time to complete this, but this usually did not take more than 10 minutes. The MEQ data would then be used to categorise each participant as either

a morning or an evening type depending on which side of the mean sample questionnaire score their data lies. A note at the end of the questionnaire would ask them to inform the researcher, who was sitting in an adjacent room when this was complete to begin the next phase.

Phase two of data collection involved the researcher directing the participant to the lab computer where the instructions for the memory task were already displayed (Appendix H). Participants were told to read the instructions to make sense of the task carefully, and the frustrating nature of the task was also stated but participants were encouraged to try their best. Participants were also informed that they would be given a practice round before the true experiment would begin. Participants were informed that if they had any questions before or after the practice, they were to ask the researcher at that point as the study could not be paused henceforth. Participants were left alone in the lab room until the study's conclusion.

The procedure of the WM task was as follows; participants would first read the three pages instructions as to how this task is to be completed, this included examples of odd and even numbers, the time given to memorise trigrams, the time given to identify odd/even numbers, how to submit answers of trigrams and numbers (type into a box on screen) and a message stating that after one incorrect trigram the study will conclude. Secondly, the participant got an on-screen countdown of three seconds before attempting the practice round and advised to *'Memorise this trigram - HBW'* with eight seconds of total distractor task time, prompting participants with *'Using the keyboard, please type the ODD/EVEN number'* in a box ready to receive an answer. Upon completion of this, participants were shown the message *'Well Done! The practice trial has now concluded, press SPACE to begin the experiment'*. The actual experiment section again included a countdown for each trial except this time, they would not be guided to *'Memorise this trigram'* or *'Using the keyboard, please type the ODD/EVEN number'*, but were simply shown the trigram and either ODD/EVEN and a selection of numbers. After each successful trial, participants were shown the message *'Well Done! Press SPACE to continue'*. After an incorrect trial, participants

were shown the message *'INCORRECT, please try again, press SPACE to continue'* before being given another attempt at the mistake. Upon correcting this response, the study would terminate and a message on the screen would state *'Thank you for participating in this study. You reached LEVEL __. Please inform the researcher to receive your debrief sheet'* (examples in Appendix I).

The researcher then verbally debriefed the participant, highlighting the study aims, briefly explaining the synchronicity effect, how their data would be used to investigate this and what implications these findings may have on students. The researcher also provided the participants with a printed debrief form (Appendix J) before being thanked and escorted from the lab. All aspects of this study took approximately between 12 and 25 minutes to complete. All materials were presented in the following order: Information Sheet, Consent Form, Demographic Information, MEQ, Brown-Peterson task and Debrief information.

Chapter 3 – Results

Before collating data for analysis, raw data stored on the Superlabs computer was copied and transferred into an Excel spreadsheet. Additionally, all data stored on Qualtrics was also downloaded into a separate Excel spreadsheet. The data on each was then cleaned, sorted and grouped, removing irrelevant data fields like user language, consent checks and so on, leaving only required data including identifier code, memory level reached, demographics and MEQ responses. Each participant's dataset was matched together using the unique identifier code (M1, E1, etc.) by the researcher.

Two participants were identified as potential anomalies. However, after deliberation, it was decided they could be included. One participant's lower-case trigram response for trial 14 was not registered as correct (all other participants did the task with caps lock on). As the correct trigram was given and this was a mistake in the task programming, this trial was recorded as achieving the maximum level of correct responses - 15. Another participant appeared to have mistimed their odd/even answer with a trigram answer prompt and gave a numerical answer where a letter should be. As the experiment experienced this as an incorrect response, the trial ended thereafter. After deliberation, this data set was also kept as this was evidence of separate cognitive errors in reaction times and attention.

As per the study design, data was grouped appropriately into four test conditions: congruent Lark, congruent Owl, incongruent Lark and incongruent Owl. Larks or Owls were determined based on whether their MEQ score was greater or lesser than the mean score of 46.1 respectively. Each condition had a similar number of participants (10 or 11). Table 1 shows descriptive statistics and average memory scores for participants in each condition and the average age and memory score of both overall chronotype groups, regardless of testing time. Please see Appendix K for a breakdown per participant.

Table 1: Descriptive statistics by chronotype and testing time.

Condition	Gender Ratio (M:F:NB)	Participant Count	Mean Age	Age (SD)	Mean Memory Score (out of 15)	Memory Score (SD)
Congruent Lark	2:9:0	11	32.55	11.55	11.64	4.76
Congruent Owl	3:7:1	11	31.55	10.78	9.73	5.31
Incongruent Lark	1:9:0	10	26.9	4.65	8.6	3.95
Incongruent Owl	1:9:0	10	34.1	9.53	8.8	5.86
Larks Overall	3:18:0	21	33.29	10.4	10.29	5.38
Owls Overall	4:16:1	21	29.33	8.58	9.19	4.63
Both Congruent Groups	5:16:1	22	32.05	10.92	10.68	5.02
Both Incongruent Groups	2:18:0	20	30.5	8.18	8.7	4.87
Totals	7:34:1	42	31.31	9.63	9.74	4.99

M=Male, F=Female, NB=non-binary

In Table 1 we can observe that, on average, congruent test groups perform better on the Brown-Peterson short-term WM capacity task than incongruently tested counterparts. Out of a maximum score of 15, congruently tested Larks outperform every other condition ($M=11.64$), followed by congruently tested Owls ($M=9.73$). Both incongruently tested groups performed about the same (Larks, $M=8.6$ and Owls, $M=8.8$). Table 1 infers that Larks generally outperform

Owls on a WM task and have a slightly higher average age. Table 2, found below, displays the descriptive statistics of the memory task scores ($M=9.54$, $SD=4.99$) and the final scores of participant's MEQ responses ($M=46.14$, $SD=12.1$).

Table 2: Descriptive statistics of Memory task scores and MEQ outcomes.

	<i>N</i>	Minimum	Maximum	Mean	<i>SD</i>
Memory Task Scores	42	2	15	9.74	4.99
MEQ Outcome	42	23	82	46.14	12.1

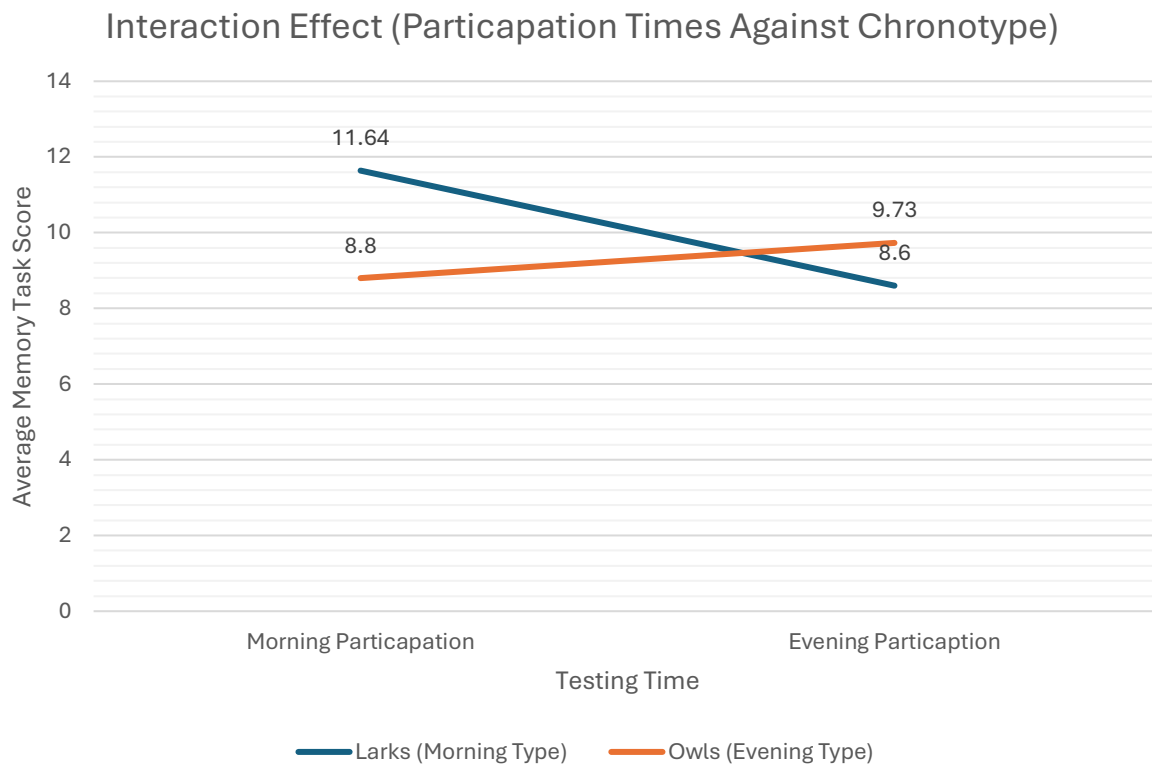
The original 19-item MEQ reported a good internal consistency with a Cronbach alpha coefficient of .82 (Horne & Östberg, 1976). This current study slightly changed the wording of some questions and responses but remained at 19 items and found a Cronbach alpha coefficient of .89, deeming it reliable (Appendix L).

A test of normality was run to explore the normality of the data before conducting the main analysis and to see if there were any outlier participants in any of the four conditions. No individual outliers were found, however, a boxplot graph of average memory scores by condition showed that while the majority of congruent Larks achieved level 15, some participants scored considerably lower and brought down the overall average of that condition, with a similar pattern being observed in the congruent Owl condition. Likewise, the opposite circumstances occurred for the incongruent Larks condition, that being many participants performed poorly, but a select few achieved the max level of 15. Outcomes of the general normality of data show that the 5% trimmed mean values were all close, Skewness and Kurtosis scores were relatively close to zero, and Kolmogorov-Smirnov statistics vary between significant and non-significant between groups. Histograms do not follow a normal distribution, and normal Q-Q plots do follow a reasonably normal distribution. Please see appendix M for an exploration/graphs of normality and boxplot graph. Based on MEQ

responses, three extreme chronotype participants were identified (two extreme Owls and one extreme Lark).

A two-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of lark/owl chronotypes and time of testing (morning/evening) on WM task outcomes. Participants were sorted into two groups based on MEQ responses, classifying them as either Lark or Owl. They were also divided into either a morning or evening test group, resulting in four conditions. The interaction effect between chronotypes and the test group was not statistically significant, $F(1, 38) = 1.63, p = .21$. Furthermore, the main effect of chronotype, $F(1, 38) = .46, p = .5$, and the main effect of testing time, $F(1, 38) = .3, p = .59$, were also found to be statistically non-significant (Appendix N for ANOVA SPSS output). Levene's test of Equality of Error Variances for memory test score based on mean showed .185, as this is larger than .05, the homogeneity of variance assumption has not been violated. (See Appendix O).

We can infer from Table 1 that a directional pattern has begun to emerge, showing that the congruent group's average memory scores are greater than those of the incongruent groups. Figure 1, shown below (Appendix P), shows an interaction effect between participation times and chronotype regarding memory performance. Although this interaction may strengthen in a study with more participants, the results of the present study are non-significant therefore, the study's hypothesis cannot be supported.

Figure 1: Line chart of interaction effect

Chapter 4 – Discussion

The primary aims of this study were to explore what effects chronotypes and time of testing have on the working memory performance of undergraduate students by exploring if participants under congruent testing conditions (based on personal chronotypes) perform better than under incongruent conditions. By extension, observing if ‘Owls’ or ‘Larks’ perform better on WM tasks of high cognitive load to evaluate the appropriateness of uniform testing and learning times for individuals in university and job roles. Primary findings for this investigation imply that, for a sample of this size and demographic, working congruently or incongruently with one's chronotype does not have a significant effect on short-term WM performance, and congruently tested groups do not have a significant advantage over incongruent groups, meaning the directional hypotheses proposed is not supported.

However, this investigation initially predicted that the synchronicity effect would be observable in the results. Although the results of the ANOVA were non-significant, the descriptive statistics of each conditional group found in Table 1 identify that a pattern of synchronicity has begun to emerge. Participants frequently noted, post-testing, that the fast-paced and intense nature of the task often caused them difficulty. This can be taken as an indicator of heavy cognitive load. It has been found that the synchronicity effect can best be observed on tasks of heavy cognitive load as both morning and evening types draw upon their respective strengths best at congruent times of the day (Schmidt et al., 2015). The outcomes of the present study, on a surface-level analysis, support these findings. Nevertheless, these results remain non-significant and inconclusive when compared to existing literature. This discussion will explore why the findings of this investigation do not co-vary with the findings of most previous studies with references to the limitations of the study design.

The primary research question asked: will a participant tested at a time congruent to their chronotype perform better on a WM task compared to someone tested at an incongruent time? The four conditions being tested consisted of a roughly equal number of participants, indicating no bias in morning types being more likely to choose morning participation or vice versa and leading to no disparities in the weighting of each group. No significant interaction was found between chronotypes and the preferred time of testing, suggesting that chronotypical congruency has no effects on WM performance. These findings reflect those of a study that also found no interaction but only an observable trend (Evansová et al., 2022). Yet considerably more research results suggest that the synchronicity effect should be observable when under congruent conditions (Manly et al., 2002; West et al., 2002).

The findings for the primary research question also influence the answers to the secondary and tertiary research questions. There is no significant evidence here that students tested at a congruent time can manage a greater cognitive load and no significant differences in the respective performances of Owls and Larks on a WM task. These conclusions do not reflect existing findings that a more complex task requires greater activation in brain areas linked to WM (thalamus, optical lobe and cerebellum) (Braver et al., 1997). These cerebral fluctuations should be better achieved at chronotypically congruent times, during which activation increases monotonically with task complexity but then decreases shortly after. This suggests that regions of the WM network have a constrained capacity but can be stabilised throughout the day when chronotype-aligned (Callicott et al., 1999; Schmidt et al., 2015).

A possibility that findings do not co-vary could be the small sample size paired with a select few outliers within each condition potentially skewing results. It has been found that extreme chronotypes have higher and more disruptive differences in homeostatic sleep-wake regulation around daily life conditions (Taillard et al., 2003), with extreme Larks having a faster decrease in N-REM slow-wave activity during the night if they sleep later than usual (Mongrain et al., 2006).

Comparatively, extreme Owls do not show these changes as much as they keep a constant sleep period through compensatory adjustments of their waking times (Kerkhof & Lancel, 1991), leading to extreme Larks reporting more subjective sleepiness and less vigilance as a result of heightened sensitivity to SCN disruptions (Schmidt et al., 2009). The present study identified three extreme chronotypes. The extreme Lark in question participated congruently and performed exceptionally, however, the two extreme Owls were in separate conditions, with the incongruity-tested extreme Owl performing poorly.

Furthermore, within each condition, several select individuals were identified as performing considerably worse than their peers in that condition. While a test of normality identified no extreme outliers that would need to be removed as anomalies, a pattern was noticed among congruent groups. The vast majority of congruent participants scored between 12 and 15 (high scores), yet participants M4, M14, E7, E15, E20 and E21 (none of which were extreme chronotypes) all scored <5 , with few participants placing in between these two score ranges. Due to the discrepancy within the congruent conditions, the average WM scores for these groups are brought down considerably to around 10 or 11 when most group participants achieved the maximum level of 15 and would likely progress much further should the experiment be extended. It is possible that the few participants who did not perform optimally at “optimal” times had other personal factors that contributed to their scores. For example, undergraduate students are disproportionally known to partake in cognitively adverse recreational activities such as binge drinking and cannabis smoking as coping mechanisms for mental health disorders (Keith et al., 2015). Both are known to cause next-day delirium and impairments in WM aspects that any given participant may have partaken in the evening prior (Molnár et al., 2010; Schoeler & Bhattacharyya, 2013). Furthermore, student participants are prone to suffering sleep loss due to the stress of academic work or volunteering/ antisocial work hours (Hartmann & Pritchard, 2018). This can result in incomplete recovery through lack of adequate sleep, leading to after-effect deterioration

in next-day mental processing (Meuman et al., 1993). These confounding and extraneous personal factors among participants are unpredictable for a researcher unless stricter sign-up restrictions are introduced.

The MEQ was used to ascertain the preferred and ‘true’ chronotypes of participants, daily responsibilities aside (Horne & Östberg, 1976). However, by using this instrument, the impact of the many daily responsibilities of undergraduate students that affect how they sleep has been neglected to be considered. Ronnenberg developed the MCTQ to determine sleeping habits concerning chronotypes on both ‘work’ and ‘free’ days and found the majority of the population is sleep deprived in the workweek due to our natural sleep timings being changed through industrialisation, with evening types being particularly affected by sleep deprivation as they are forced to compensate for sleep loss during free days (weekends) (Roenneberg et al., 2003). As the MCTQ determines chronotype based on waking times on free days rather than desired waking times, perhaps the MCTQ would have been more appropriate for the busy schedules of students. Since 2003, artificial lighting and ‘anti-chronotype’ work conditions have worsened for evening types as demands continue to increase (Zou et al., 2002).

Implications

Considerable research evidence indicates that the early fixed start times for school-aged students are detrimental to performance throughout the day and that later start times improve educational performance (Meltzer et al., 2014; Wahlstrom et al., 2014). It is also understood that biological changes occur during puberty that shift wake and sleep times for adolescence 2-3 hours later in the day with this shift reaching its greatest at age 19.5 for females and 20.5 for males and will gradually lessen after this age until the mid-20’s (Roenneberg et al., 2004). The implications here are that during the critical ages for education (GCSE, A-Levels and the typical start age for university), our bodies are naturally inclined toward a later start that would line up with our new cognitive peaks. The results found in this investigation were drawn from a relatively high mean

age of undergraduate students, yet a trend towards congruent testing times being advantageous can still be observed. Given that no significant interaction between congruent/incongruent start times and WM performance has been observed for this mean age demographic, we can assume that varied and ‘non-optimal’ test times may be more acceptable for more mature student's WM abilities when compared to the existing literature that they may be inappropriate for younger students.

As far as Larks and Owls are concerned, most findings conclude that the standard 9-5 work schedule for occupations and education alike is not desirable for a variety of cognitive measures of the majority of the population who identify as Owls or Doves (neutral) (Evans et al., 2017; Roenneberg et al., 2007). This present investigation recruited a 50/50% of Lark and Owl chronotypes, further divided evenly between conditions based on sign-up times. Of this small sample, there were found to be largely inconsistent WM scores within incongruent conditions and more consistency, but a higher degree of individual score differences for congruent groups, which indicates that learning and test timings for different personal chronotypes do not impact WM performance. These findings do not reflect those of the majority of existing literature, which finds that congruently tested groups outperform incongruently tested ones, with morning types typically performing the best on WM (Abdul Jafar et al., 2023; Ceglarek et al., 2021; Heimola et al., 2021). One investigation tested academic achievement on congruently/incongruity-tested university students and found the same as above, however, this was conducted on a considerably larger number of participants (1471) and was limited to an age range of 18 – 25, better reflecting the majority of undergraduate students ages (Beşoluk et al., 2011). By comparing this investigation to others of a similar nature, it can be assumed that the non-significant findings, contrary to existing literature, can be attributed to a low sample size and high average participant age for undergraduate students, among other study limitations.

Study Limitations

This study sample has a relatively high mean age of 31 for undergraduate students. Many studies have concluded that, generally, WM development is better as a young adult or adolescent and decreases with age (Cabeza et al., 2004; Cansino et al., 2018; Fandakova et al., 2014). Specifically, the ability to bind memory items to the context in which they were presented (key to this study) is better among young adults, resulting in better WM performance (Oberauer, 2005). Although this is not true for all individuals, performance usually depends on varying developmental factors such as attentional mechanisms, resource limitations and WM strategies (Cowan et al., 2015). Furthermore, this study recruited considerably more female participants than males (34F:7M). A study has found that men possess greater visual episodic memory (beneficial for this study), and women possess a greater auditory episodic memory with age-related losses found in both (Pauls et al., 2023). Although age and gender were collected for demographic data, they were not considered or investigated for the research question and there is a high possibility that these could be confounding variables in this investigation.

The process of this study also suffered from a notable lack of participant signups. The original design of this study aimed for 60 participants, however, the limited time frame for data collection and lack of sign-ups meant that the participant quota was not filled, and results were drawn from 42 participants. A similar study with equally similar findings also stated that a small sample of participants was the main limitation (Evansová et al., 2022). As this study was limited to 1st and 2nd year psychology students at UWTSD, many available timeslots likely clashed with lecture and exam times, impacting participation rates. Likewise, as exclusively psychology students, all participants likely had at least a basic understanding of WM, decay and distractor tasks. This means there was the potential that some participants may have predicted the aim of the study and placed more priority on remembering trigrams over answering the distractor task to perform better, impacting findings.

Further studies of this nature would benefit from drawing participants from other courses or potentially external sources to improve population/external validity. Subsequent studies may also benefit from analysing age-related differences among university students that can range from 18 to 50+ to assess if certain age groups may benefit from shifted start times, this age-related analysis could be furthered by assessing if certain age groups are more inclined to sign up congruently with their chronotypes and if this makes any difference in WM performance at desired test times rather than forced test times. Furthermore, future research may wish to consider alternate methods of assessing participant's optimal sleeping patterns. The self-reported measures used in this study only produce a participant's self-perception of their abilities concerning sleeping times and may not be a true representation of chronotype classification when applied to real scenarios, raising construct validity issues (Brutus et al., 2013). Perhaps research with access to additional resources may wish to take a physiological approach to chronotype classification over a self-reported measure. Finally, construct validity may also be impacted by the use of the modified Brown-Peterson task. A critical assessment of this WM task concludes that internal divergent and convergent validity are unsatisfactory (Geurten et al., 2016), and a new and untested modified variation of this task would likely compound these shortcomings. Further investigations by more experienced researchers might utilise different WM tasks initially considered for this study to explore variations in outcomes, such as the N-Back task (Kirchner, 1958) or Corsi block-tapping test (Corsi, 1972), that may showcase differences in congruency testing as different tasks test different aspects of working memory (visuospatial, phonological, etc.) to which different demographics, chronotypes and testing times may have advantages/disadvantages (Baddeley, 2012; Eysenck & Keane, 2015).

Conclusion

This dissertation aimed to explore the impact that working congruently or incongruently with one's chronotype has on working memory performance. Based on quantitative data collection

and analysis, this paper concludes that for a limited sample of undergraduate students, being tested congruently with your chronotype does not place you at an advantage over those tested incongruently. By comparing these findings with existing literature, it is speculated that for a high mean age and small sample size of undergraduate university students, uniform test times remain appropriate for assessments that include WM components. However, given that the synchronicity effect has begun to emerge within trends, a larger sample size and expanded demographics may make the synchronicity effect more pronounced and may provide significant results for the greater population in keeping with existing research, with age-related differences being further variables that should be investigated. Understanding the importance of being able to draw upon additional WM or other cognitive resources when being tested at optimal times of the day for each unique individual is paramount, considering that most educational or occupational institutes operate at a 9am start. Further research of this nature should aim to assess if any chronotypical group should have an advantage over others in WM or other cognitive aspects simply due to societal norms that expect all individuals to conform and work optimally at the same times when each person has a unique peak cognitive time to offer.

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Appendices

APPENDIX A – MORNINGNESS/EVENINGNESS QUESTIONNAIRE

1. What time would you get up if you were entirely free to plan your day?
 - ☐ 5 am – 6:30 am
 - ☐ 6:30 am – 7:45 am
 - ☐ 7:45 am – 9:45 am
 - ☐ 9:45 am – 11 am
 - ☐ 11 am – 12 pm
 - ☐ 12 pm onward
2. What time would you go to bed if you were entirely free to plan your evening?
 - ☐ 8 pm – 9 pm
 - ☐ 9 pm – 10:15 pm
 - ☐ 10:15 pm – 12:30 am
 - ☐ 12:30 am – 1:45 am
 - ☐ 1:45 am – 3 am onward
3. If there is a specific time at which you must get up in the morning, to what extent are you dependent on being woken up by an alarm clock?
 - ☐ Not at all dependent
 - ☐ Slightly dependent
 - ☐ Fairly dependent
 - ☐ Very dependent
4. How easy do you find getting up in the mornings? (**when you are not woken up unexpectedly**)?
 - ☐ Not at all easy
 - ☐ Not very easy
 - ☐ Fairly easy
 - ☐ Very easy
5. How alert do you feel during the first half hour after having woken in the mornings?
 - ☐ Not at all alert
 - ☐ Slightly alert
 - ☐ Fairly alert
 - ☐ Very alert
6. How is your appetite during the first half-hour after waking in the mornings?
 - ☐ Very poor
 - ☐ Fairly poor
 - ☐ Fairly good
 - ☐ Very good
7. How tired do you feel during the first half-hour after waking in the morning?
 - ☐ Very tired
 - ☐ Fairly tired

- ☐ Fairly refreshed
- ☐ Very refreshed.

8. When you have no commitments the next day, when would you go to bed compared to your usual bedtime?

- ☐ Seldom or never later
- ☐ Less than one hour later
- ☐ 1 – 2 hours later
- ☐ More than two hours later

9. You have decided to engage in physical exercise with a friend and the best time for them is between 7 am – 8am. Bearing in mind only **your own internal “clock”**, how do you think you would perform?

- ☐ I would be in good form
- ☐ I would be in reasonable form
- ☐ I would find it difficult
- ☐ I would find it very difficult.

10. At what time in the evening do you feel tired and in need of sleep?

- ☐ 8 pm – 9 pm
- ☐ 9 pm – 10:15 pm
- ☐ 10:15 pm – 12:45 am
- ☐ 12:45 am – 2 am
- ☐ 2 am – 3 am

11. You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. Which one of the four test times would you choose?

- ☐ 8 am – 10 am
- ☐ 11 am – 1 pm
- ☐ 3 pm – 5 pm
- ☐ 7 pm – 9 pm

12. If you went to bed at 11 pm, at what level of tiredness would you be?

- ☐ Not at all tired
- ☐ A little tired
- ☐ Fairly tired
- ☐ Very tired

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

- ☐ Wake up at usual time, but will not fall asleep
- ☐ Wake up at usual time, but will nap thereafter
- ☐ Wake up at usual time but will fall asleep again
- ☐ Will NOT wake up until later than usual.

14. One night you have to remain awake between 4 am - 6 am to carry out a night watch. You have no commitments the next day. Which ONE of the following alternatives will suit you best?

- ☐ Would not sleep until the watch was over
- ☐ Would take a nap before and sleep after
- ☐ Would take a good sleep before and nap after
- ☐ Would take all my sleep before the watch

15. You must do two hours of hard physical work. You are entirely free to plan your day and considering only your **internal “clock”**, which one of the following times would you choose?
- ☐ 8 am – 10 am
 - ☐ 11 am – 1 pm
 - ☐ 3 pm – 5 pm
 - ☐ 7 pm – 9 pm
16. You have decided to engage in physical exercise with a friend and the best time for them is between 10 pm – 11 pm. Bearing in mind only **your own internal “clock”**, how well do you think you would perform?
- ☐ I would be in good form
 - ☐ I would be in reasonable form
 - ☐ I would find it difficult
 - ☐ I would find it very difficult.
17. Suppose that you can choose your own work hours. Assume that you worked a five-hour day (including breaks) and that your job was interesting and paid by results. What time would you select?
- ☐ 5 Hours Starting any time between 4 AM and 8 AM
 - ☐ 5 Hours Starting any time between 8 AM and 9 AM
 - ☐ 5 Hours Starting any time between 9 AM and 2 PM
 - ☐ 5 Hours Starting any time between 2 PM and 5 PM
 - ☐ 5 Hours Starting any time between 5 PM and 4 AM
18. At what time of the day do you think that you reach your “feeling best” peak?
- ☐ 5 AM – 8 AM
 - ☐ 8 AM – 10 AM
 - ☐ 10 AM – 5 PM
 - ☐ 5 PM – 10 PM
 - ☐ 10 PM – 5 AM
19. One hears about “morning” and “evening” types of people. Which one of these types do you consider yourself to be?
- ☐ Definitely a morning type
 - ☐ More a morning type than an evening type
 - ☐ More an evening type than a morning type
 - ☐ Definitely an evening-type

APPENDIX B - TRIGRAM AND ODD/EVEN TASK EXAMPLES

Practice Trial

Using the keyboard
Please type the ODD number

3 4

Memorise this TRIGRAM

HBW

Real trials

ODD

7 16 2

EVEN

15 18 3 9

Please recall the TRIGRAM
And press ENTER

COA

UEJ

APPENDIX C – PROPOSAL FORM



ECPS6001: Psychology Empirical Project Research Proposal

Assessment Component 1: Research proposal (1,000 words) worth 10% of the overall module mark for the Psychology Empirical Project. The proposal form will be marked in line with the Level Six Grading Rubric. The boxes below will expand as you type.

Student Name and University ID number:	Aaron Young - 2205141
Proposed Supervisor's name:	Dr Kate Williams

Psychology Research Area (tick all that apply)

Social Psychology	Developmental Psychology	Biological Psychology ✓	Forensic Psychology
Health Psychology	Individual Differences	Educational Psychology	Political Psychology
Cognitive Psychology ✓	Clinical Psychology	Counselling Psychology	Occupational Psychology
<i>Other: indicate briefly (not included in word count)</i>			

Proposed Study Design (tick all that apply)

Quantitative ✓	Experimental ✓	Applied (with UWTSD students)	Online Questionnaire Survey
Qualitative	Quasi-Experimental	Focus Groups	Online
Mixed Methods	Applied (with external organisation)	Interviews	Lab-based study ✓
<i>If Applied, and involving an external organisation, please indicate your plans for gaining appropriate approvals from the organisation: (not included in the word count)</i>		<i>Other study design: indicate briefly (not included in word count)</i>	

Suggested Research Title/Area:

Effect Of Chronotype and Time Of Testing On Memory Task Performance In Undergraduate Students

Background: 250 words

The relationship between habitual sleeping patterns (circadian rhythms) and cognitive performance has been well-researched. An individual's pattern of sleep in a 24-hour day defines their chronotype, this can be influenced by genetics, social demands, development or individual preferences (Randler et al., 2017). Chronotypes are typically grouped into Larks (morning preference), Owls (evening preference) or Doves (intermediate) (Roenneberg et al., 2007). We would assume that Larks/Owls operating outside their preferred waking time would perform poorly on cognitive tasks due to fatigue. The memory aspect of cognition was tested on extreme chronotypes and found that, for declarative memory, chronotypes made fewer errors when tested during their congruent/preferred time of testing (Natale & Lorenzetti, 1997). This implies that the opposite would occur if tested during a non-preferred time, raising questions as to the appropriateness of the 9am start structure of typical academic or working institutions that often expect all people to perform well regardless of individuals differing cognitive "peaks"(i.e., some students may perform worse during a 9am exam simply by being an Owl). Conclusions remain inconsistent due to no uniform methodology or sample sizes (Evansová et al., 2020).

By conducting this study on university students within the discipline of psychology and counselling, results will have real-world implications as students stereotypically have varied and often poor sleeping patterns/habits. This will have implications on university performance, attendance and results (morning vs evening lectures) as students require an apt working memory and long-term memory for success (Moderie et al., 2020). This point can be expanded to explore if the typical 9-5 is appropriate for differing chronotypes in workers and academics (Sallinen & Kecklund, 2010; Sang et al., 2015).

Please state the main research question(s) or hypotheses(s): (100 words max)

Research Questions

1. Do “Owls” or “Larks” perform better on a working memory task?
2. Is performance on a memory task dependent on an owl/lark’s congruent time of testing?

Hypothesis:

1. Memory performance will differ significantly between larks and owls
2. Memory performance will be better when chronotype and time of testing are congruent.

Methodological Details (500 words)

Participants

Students studying psychology-related courses (UWTSD) over 18 years of age will sign up using the Experimental Management (EMS) in exchange for two-course credits, participants select a time slot based on availability. Participants must have normal or corrected-to-normal vision. This study will aim to acquire 60 participants (two IVs with two levels, means four groups with 15 participants) with desirably equal males and females. A wider pool of participants allows for a more diverse range of chronotypes to be included, many studies states lack of participants as a limitation (Evansová et al., 2020). Similar studies like Schmidt et al. (2015) used smaller groups with extreme chronotypes (16 extreme larks, 16 extreme owls). Extreme chronotypes are difficult to find as 60% of adults fall into a ‘Neutral’ chronotype (Montaruli et al., 2021).

Design

The study will employ a 2x2 between-subject quantitative experimental design. The experiment requires participants to complete the Morning-Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976), the results will be used to categorise participants into a morning-preferred group (Larks) or evening-preferred group (Owls) (IV1) depending on which side of the sample mean score their results lie. Depending on their chosen

time, participants will also be part of either the morning test group (9am–11am) or the evening group (3pm-5pm) (IV2). The dependent variable will be the participant's scores on the Brown-Peterson memory task (Brown, 1958; Peterson & Peterson).

A 2x2 between subjects ANOVA will be used to analyse the data to determine if congruently tested participants (Larks tested in morning, owls tested in evening) perform better on the memory task than incongruently tested participants (Larks tested in evening, Owls tested in morning) and the significance of this interaction ($\alpha = 0.05$).

Materials

The MEQ (Horne & Östberg, 1976) is a 19-item questionnaire categorising participants into Owls or Larks based on the sample mean results. The original survey categorised into four groups (definitely morning, preferred morning, preferred evening and definitely evening), this study will only use two due to the two grouped timings of the experimental testing sessions. The questionnaire will be transferred directly into Qualtrics.

A variation of the Brown-Peterson test will measure the dependent variable and assess participants' working memory capacity. This task will be programmed into SuperLab by the researcher. This task was selected to assess working memory span and simulate how students process fast-paced information. A quick and intense task like this will most likely challenge working memory if fatigued from an incongruent testing time (Gradisar et al., 2008).

Procedure

This study will take place in the controlled Psychology labs. After consent and gathering basic demographic details, participants will complete the 19-item MEQ survey, which will be presented on a laptop and then directed to the lab computer to complete the Brown-Peterson task. This variation of the Brown-Peterson task requires participants to memorise nonsense syllable trigrams while also engaging in a numerical distractor task involving participants selecting the EVEN number from a set to impair rehearsal. For each subsequent trigram, there will be an increased number of distractor questions each lasting 3 seconds increasing the difficulty (speed/performance on distractor task is irrelevant, maximum level achieved contributes towards the DV). After two mistakes the task and the study will conclude and participants will be debriefed.

Key Ethical Considerations (150 words)

Participants will be initially deceived as they will not be aware that the results of their MEQ will be used to categorise them into either a Lark or Owl group. This deception will be lifted as part of the debrief sheet and debrief session with the researcher. Some participants may suffer from sleep disorders (insomnia, narcolepsy) so may feel anxious, distressed, or frustrated when filling out the MEQ. Participants may feel frustrated or flustered at completing a fast-paced task, this will be countered by providing clear instructions and providing a practice round before assessed rounds.

As per BPS Ethical Guidelines for Psychological Research (3.1 & 3.3) (Oates, 2021), the participant's right to withdraw and right to confidentiality/anonymity will be emphasised in the information and consent forms, informed consent will always be obtained before data collection. Participants will be allotted times for testing and so will not be waiting. Participants will be given an opportunity after testing to ask any questions.

APPENDIX D – APPLICATION FOR ETHICAL APPROVAL



PG2 / E1 FORM

APPLICATION FOR ETHICAL APPROVAL

RESEARCH STUDENTS

This form is to be completed by the student within **SIX** months for full-time students and **TWELVE** months for part time students, after the commencement of the research degree or following progression to Part Two of your course.

Once complete, submit this form via the [MyTSD Doctoral College Portal](https://mytsd.uwtsd.ac.uk) at (<https://mytsd.uwtsd.ac.uk>).

This document is also available in Welsh.

RESEARCH STAFF ONLY

All communications relating to this application during its processing must be in writing and emailed to pgresearch@uwtsd.ac.uk, with the title 'Ethical Approval' followed by your name.

STUDENTS ON UNDERGRADUATE OR TAUGHT MASTERS PROGRAMMES should submit this form (and receive the outcome) via systems explained to you by the supervisor/module leader.

In order for research to result in benefit and minimise risk of harm, it must be conducted ethically. A researcher may not be covered by the University's insurance if ethical approval has not been obtained prior to commencement.

The University follows the OECD Frascati manual definition of research activity: "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". As such this covers activities undertaken by members of staff, postgraduate research students, and both taught postgraduate and undergraduate students working on dissertations/projects.

The individual undertaking the research activity is known as the "principal researcher".

Ethical approval is not required for routine audits, performance reviews, quality assurance studies, testing within normal educational requirements, and literary or artistic criticism.

Please read the notes for guidance before completing ALL sections of the form.

This form must be completed and approved prior to undertaking any research activity. Please see [Checklist](#) for details of [process](#) for different categories of [application](#).

SECTION A: About You (Principal Researcher)

1	Full Name:	Aaron Young			
2	Tick all boxes that apply:	Member of staff:	☐	Honorary research fellow:	☐
	Undergraduate Student	☒	Taught Postgraduate Student	☐	Postgraduate Research Student
3	Institute/Academic Discipline/Centre:	University Wales Trinity Saint David – Yr Athrofa			
4	Campus:	IQ			
5	E-mail address:	2205141@student.uwtsd.ac.uk			
6	Contact Telephone Number:	07917 847976			
For students:					

7	Student Number:	2205141
8	Programme of Study:	BSc Psychology and Counselling
9	Director of Studies/Supervisor:	Dr Kate Williams

SECTION B: Approval for Research Activity

1	Has the research activity received approval in principle? (please check the Guidance Notes as to the appropriate approval process for different levels of research by different categories of individual)	YES	☒	NO	☐
					Date
2	If <u>Yes</u> , please indicate source of approval (and date where known): <i>Approval in principle must be obtained from the relevant source prior to seeking ethical approval</i>	Research Degrees Committee	☐		
		Institute Research Committee	☐		
		Other (write in) Dr Kate Williams Dissertation Supervisor	☒	07/08/2024	

SECTION C: Internal and External Ethical Guidance Materials

Please list the core ethical guidance documents that have been referred to during the completion of this form (including any discipline-specific codes of research ethics, location-specific codes of research ethics, and also any specific ethical guidance relating to the proposed methodology). Please tick to confirm that your research proposal adheres to these codes and guidelines. You may add rows to this table if needed.	
1	UWTSD Research Ethics & Integrity Code of Practice ☒
2	UWTSD Research Data Management Policy ☒
3	UWTSD Data Protection and Storage Protocol ☒
4	BPS Code of Ethics and Conduct (December 2021) ☒
5	BPS Code of Human Research Ethics (April 2021) ☒
6	BPS Data Protection Regulation – Guidance for Researchers (December 2018) ☒

SECTION D: External Collaborative Research Activity

If there are external collaborators then you should gain consent from the contact persons to share their personal data with the university. If there are no external collaborators then leave this section blank and continue to section E.

1	Institution	N/A
2	Contact person name	
3	Contact person e-mail address	
4	Is your research externally funded?	YES ☐ NO ☒
5	Are you in receipt of a KESS scholarship?	YES ☐ NO ☒

6	Are you specifically employed to undertake this research in either a paid or voluntary capacity?	Voluntary	YES	☐	NO	☒
7		Employed	YES	☐	NO	☒
8	Is the research being undertaken within an existing UWTSD ~~Athrofa~~ Professional Learning Partnership (APLP)?	If <u>YES</u> then the permission question below does not need to be answered.	YES	☐	NO	☒
9	Has permission to undertake the research has been provided by the partner organisation?	(If YES attach copy) If <u>NO</u> the application cannot continue	YES	☐	NO	☒

Where research activity is carried out in collaboration with an external organisation

10	Does this organisation have its own ethics approval system?	YES	☐	NO	☒
If <u>Yes</u> , please attach a copy of any final approval (or interim approval) from the organisation (this may be a copy of an email if appropriate).					

SECTION E: Details of Research Activity

1	Indicative title:	Effect Of Chronotype and Time of Testing <u>On</u> Working Memory Task Performance In Undergraduate Students			
2	Proposed start date:	Oct/Nov 2024	Proposed end date:	20/05/2025	
Introduction to the Research (maximum 300 words per section) Ensure that you write for a Non-Specialist Audience when outlining your response to the points below: <i>Purpose of Research Activity</i> <i>Proposed Research Question</i> <i>Aims of Research Activity</i> <i>Objectives of Research Activity</i> Demonstrate, briefly, how Existing Research has informed the proposed activity and explain <i>What the research activity will add to the body of knowledge</i> <i>How it addresses an area of importance.</i>					
3	Purpose of Research Activity The purpose of this level six dissertation is to observe the synchronicity effect of chronotypes and testing times concerning working memory and if it improves when tested at a time congruent to a participant's cognitive peak, by extension testing the appropriateness of the traditional 9 – 5 working/academic schedule when peak performance of all individuals is desired. Recently Cognitive psychology has placed more attention on the importance of quality sleep and preferred waking hours on mental ability, thanks in largely to Ronnenberg who has undertaken a research project which tracked the sleep of 50,000+ participants (Roenneberg, 2013). Roenneberg, though not the first to investigate this, used quantitative data to determine that everyone has their own unique CHRONOTYPE, a genetic predisposition that can determine fluctuations in cognitive abilities at different times of the day (Breus, 2016). Ronnenberg, with influence from previous morning/eveningness investigations (Horne & Ostberg, 1978), created three categories of chronotypes; Larks (morning preferred), Owls (Evening preferred) and Doves (neutral). Other investigations within the field of sleep psychology have observed a "synchronicity effect, this effect can be seen in numerous studies where a Lark typically performs better on a cognitive performance task when tested				

	earlier in the day, with the same effect being observed when an Owl is tested in the evening (May, 1999; Natale and Lorenzetti, 1997). This implies that differing chronotypes also have differing cognitive "peak" times at which they perform best, this is supported by a meta-analysis of research done on school children which concluded that Morningness is more strongly associated with academic success due to the synchronicity of a young Lark's cognitive peak matched to early school hours (Preckel et al, 2013). George Armitage Miller's work on short-term memory states that working memory has a capacity of "Seven, Plus or Minus Two" items (Miller, 1956). Reference List Breus, M. (2016). <i>The Power of When: Learn the best time to do everything</i>. Random House. Horne, J. A., & Ostberg, O. (1978). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. <i>International Journal of chronobiology</i>, 4(2), 97-110. May, C. P. (1999). Synchrony effects in cognition: The costs and a benefit. <i>Psychonomic Bulletin & Review</i>, 6(1), 142-147. Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. <i>Psychological review</i>, 63(2), 81. Natale, V., & Lorenzetti, R. (1997). Influences of morningness-eveningness and time of day on narrative comprehension. <i>Personality and Individual differences</i>, 23(4), 685-690. Preckel, F., Lipnevich, A. A., Boehme, K., Brandner, L., Georgi, K., Könen, T., & Roberts, R. D. (2013). Morningness-eveningness and educational outcomes: The lark has an advantage over the owl at high school. <i>British Journal of Educational Psychology</i>, 83(1), 114-134. Roenneberg, T. (2013). The human sleep project. <i>Nature</i>, 498(7455), 427-428. (this box should expand as you type)
4	Research Question RQ1. Do "Owls" or "Larks" perform better on a working memory task? RQ2. Is performance on a working memory task dependent on an owl/lark's congruent time of testing? (this box should expand as you type)
5	Aims of Research Activity This study will aim to examine if participants who are tested at a time congruent to their respective chronotypes perform better on a working memory task compared to those participants tested at a time incongruent to their chronotypes. By extension, this study will also examine if either "Owls" or "Larks" have superior working memory than the other when tested at different times throughout the day to determine a "peak" working memory time for each. The results of this investigation will have implications on the appropriateness of the traditional 9 – 5 working day when "peak" ability is of concern and also on academic performance, attendance and results for different student chronotypes who must attend lectures/exams at different times of the day that may put them at a disadvantage. (this box should expand as you type)
6	Objectives of Research Activity The objective of this study is to use existing measures of Morningness/eveningness and working memory tasks to explore interactions between Owl and Lark chronotypes and their performance on these working memory tasks when tested at a time that may be congruent or incongruent with themselves. This data will be analysed to determine if the synchronicity effect can be observed during tasks of moderate cognitive load and by extension determine if Owls or Lark performance is dependent

	Proposed methods (maximum 600 words) Provide a brief summary of all the methods that may be used in the research activity, making it clear what specific techniques may be used. If methods other than those listed in this section are deemed appropriate later, additional ethical approval for those methods will be needed. You do not need to justify the methods here, but should instead describe how you intend to collect the data necessary for you to complete your project.
7	Participant Recruitment This study will involve the testing of students on a psychology-related course at UWTSD within a controlled lab environment on the university campus. The study will aim to recruit approximately 60 participants aged 18+ who must have normal or corrected to normal vision. Recruitment will take place via the UWTSD Psychology Department's Experimental Management System (EMS) in exchange for two-course credits (20 minutes participation time). Eligible students can volunteer to take part either between 9am – 12pm (morning test group) or 2pm – 5pm (afternoon test group). The participants will only be identifiable to the researcher by their unique EMS identification code. Participants will receive a printed information sheet that will include relevant information such as the predicted length of the experiment, the basic purpose, contact details of the researcher and supervisor and the different phases that are involved. Participants will then sign a consent form highlighting their rights during the study and if they wish to proceed. Data Collection and Materials Depending on what time is chosen through EMS, participants will be assigned to either the morning test group or the afternoon test group. However, participants will not be made aware that this is a factor. Participants will begin on a university laptop by filling out the 19-item Morning/Eveningness Questionnaire (MEQ) as taken from Horne and Ostberg (1976). The results of which will identify each participant as either a Lark or an Owl, although participants will not be made aware of this. Concluding this, participants will be directed toward the SuperLab computer with a pre-loaded task waiting. This task will be a modified version of the Brown-Peterson working memory task. It will require participants to memorise sets of three-letter Trigrams while also navigating a fast-paced numerical distractor task of moderate cognitive load. This distractor task will require participants to identify an ODD or EVEN number from a set (designed to prevent rehearsal) before being prompted to recall the Trigram (a complete description of this task can be found in SECTION F). Each trial of this task will get progressively more difficult, and data will be collected on the furthest trial a participant can achieve before making a set number of mistakes. After the conclusion of the study, an on-screen message will prompt the participants to inform the researcher that the study has finished. The researcher will then debrief the participant and provide a debrief sheet highlighting the purpose of the study and providing an opportunity to ask questions before the participant is thanked for their participation and asked to leave. Design, Data, and Analysis The study will employ a 2x2 between-subjects quantitative experimental design with two main effect IV's, these being time groups (morning or afternoon tested) and chronotype group (Lark or Owl). As such, analysis will involve creating four conditions: 1) Congruently tested Lark, 2) Incongruently tested Lark, 3) Congruently tested Owl and 4) Incongruently tested Owl. The DV of participant score on the memory task will be used to analyse, through a 2x2 between-subjects ANOVA, which condition performs best. (this box should expand as you type)
	Location of research activity Identify all locations where research activity will take place.
8	All research activities featured in this investigation will take place in the 2nd floor Psychology Labs at UWTSD SA1 (IQ) campus. (this box should expand as you type)
	Research activity outside of the UK

	If research activity will take place overseas, you are responsible for ensuring that local ethical considerations are complied with and that the relevant permissions are sought. Specify any local guidelines (e.g. from local professional associations/learned societies/universities) that exist and whether these involve any ethical stipulations beyond those usual in the UK (provide details of any licenses or permissions required). Also specify whether there are any specific ethical issues raised by the local context in which the research activity is taking place, for example, particular cultural and/or legal sensitivities or vulnerabilities of participants. If you live in the country where you will do the research then please state this.
9	N/A <i>(this box should expand as you type)</i>

10	Use of documentation not in the public domain: Are any documents NOT publicly available?	NO	☒
		YES	☐
11	If Yes, please provide details here of how you will gain access to specific documentation that is not in the public domain and that this is in accordance with the current data protection law of the country in question and that of England and Wales. <i>(this box should expand as you type)</i>		

	Does your research relate to one or more of the seven aims of the Well-being of Future Generations (Wales) Act 2015?	YES	NO
12	A prosperous Wales	☐	☒
13	A resilient Wales	☐	☒
14	A healthier Wales	☒	☐
15	A more equal Wales	☐	☒
16	A Wales of cohesive communities	☐	☒
17	A Wales of vibrant culture and thriving Welsh language	☐	☒
18	A globally responsible Wales	☐	☒
19	If YES to any of the above, please give details: This investigation will highlight the importance of quality and appropriate sleep on the mental ability of individuals and bring awareness to the best times of day for people with different sleep patterns to focus on specific cognitive tasks. <i>(this box should expand as you type)</i>		

SECTION F: Scope of Research Activity

	Will the research activity include:	YES	NO
1	Use of a questionnaire or similar research instrument?	☒	☐
2	Use of interviews?	☐	☒
3	Use of focus groups?	☐	☒

4	Use of participant diaries?	☐	☒
5	Use of video or audio recording?	☐	☒
6	Use of computer-generated log files?	☒	☐
7	Participant observation with their knowledge?	☐	☒
8	Participant observation without their knowledge?	☐	☒
9	Access to personal or confidential information without the participants' specific consent?	☐	☒
10	Administration of any questions, test stimuli, presentation that may be experienced as physically, mentally or emotionally harmful / offensive?	☐	☒
11	Performance of any acts which may cause embarrassment or affect self-esteem?	☐	☒
12	Investigation of participants involved in illegal activities?	☐	☒
13	Use of procedures that involve deception?	☒	☐
14	Administration of any substance, agent or placebo?	☐	☒
15	Working with live vertebrate animals?	☐	☒
16	Procedures that may have a negative impact on the environment?	☐	☒
17	Other primary data collection methods. Please indicate the type of data collection method(s) below.		
	Details of any other primary data collection method: This study will use a version of the Brown-Peterson memory task as adapted from Brown (1958) and Peterson and Peterson (1959). This task will be constructed using SuperLab by the lead researcher and will involve the participant progressing through a set of trials requiring them to memorise a new three-letter trigram for each trial (e.g., GSF). Participants will be instructed to memorise these trigrams while also completing a distractor task involving identifying either an EVEN or ODD number from a set. Correct/incorrect answers on the distractor task are irrelevant, and only allow for a set number of seconds of non-rehearsal to pass before the participant is asked to recall the trigram (trial 1 is 6 seconds, trial 2 is 9 seconds, trial 3 is 12 seconds, etc.). Data will be collected on the furthest trial they manage to correctly recall before making a set number of mistakes, as after this set number of mistakes the experiment will be terminated. There is a total of 12 trials and sets of trigrams. However, participants are not predicted to progress this far due to the distractor tasks gradually increasing in difficulty. (this box should expand as you type)	☒	☐

If NO to every question, then the research activity is (ethically) low risk and **may** be exempt from **some** of the following sections (please refer to Guidance Notes).

If YES to any question, then no research activity should be undertaken until full ethical approval has been obtained.

SECTION G: Intended Participants

If there are no participants then do not complete this section, but go directly to section H.

Who are the intended participants:		
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		YES	NO
1	Students or staff at the University?	☒	☐
2	Adults (over the age of 18 and competent to give consent)?	☒	☐
3	Vulnerable adults?	☐	☒
4	Children and Young People under the age of 18? (Consent from Parent, Carer or Guardian will be required)	☐	☒
5	Prisoners?	☐	☒
6	Young offenders?	☐	☒
7	Those who could be considered to have a particularly dependent relationship with the investigator or a gatekeeper?	☐	☒
8	People engaged in illegal activities?	☐	☒
9	Others. Please indicate the participants below, and specifically any group who may be unable to give consent.		
	Details of any other participant groups: (this box should expand as you type)	☐	☒

Participant numbers and source Provide an estimate of the expected number of participants. How will you identify participants and how will they be recruited?		
10	How many participants are expected?	Based on the study design with 4 study conditions, approximately 60 participants are required (15 per condition for between-subjects design). (this box should expand as you type)
11	Who will the participants be?	University Students at UWTSD, 18+ yrs from the Psychology and Counselling department (normal or corrected to normal vision) (this box should expand as you type)
12	How will you identify the participants?	All participants will be recruited from UWTSD Psychology and counselling programs. These volunteer participants will be recruited via the psychology department Experimental Management System (EMS) in exchange for course credits. Participants will be identified when they arrive at the lab using their unique EMS ID code. A different unique ID code will then be assigned to their data. (this box should expand as you type)

Information for participants:		YES	NO	N/A
13	Will you describe the main research procedures to participants in advance, so that they are informed about what to expect?	☒	☐	☐
14	Will you tell participants that their participation is voluntary?	☒	☐	☐
15	Will you obtain written consent for participation?	☒	☐	☐

16	Will you explain to participants that refusal to participate in the research will not affect their treatment or education (if relevant)?	☒	☐	☐
17	If the research is observational, will you ask participants for their consent to being observed?	☐	☐	☒
18	Will you tell participants that they may withdraw from the research at any time and for any reason?	☒	☐	☐
19	With questionnaires, will you give participants the option of omitting questions they do not want to answer?	☒	☐	☐
20	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	☒	☐	☐
21	Will you debrief participants at the end of their participation, in a way appropriate to the type of research undertaken?	☒	☐	☐
22	If NO to any of above questions, please give an explanation			
Participants in the labs will not be observed as part of the study. <i>(this box should expand as you type)</i>				

Information for participants:		YES	NO	N/A
24	Will participants be paid?	☐	☒	☐
25	Is specialist electrical or other equipment to be used with participants?	☐	☒	☐
26	Are there any financial or other interests to the investigator or University arising from this study?	☐	☒	☐
27	Will the research activity involve deliberately misleading participants in any way, or the partial or full concealment of the specific study aims?	☒	☐	☐
28	If YES to any question, please provide full details			
Participants will not be initially aware that their scores on the MEQ will be categorising them as either Lark or Owl. Additionally, participants won't be aware that their answers on the distractor tasks are irrelevant or that the time of testing is a relevant factor in the investigation (partial concealment of information). The debrief sheet will make this information clear and conformation will be sought that they are still happy to have their data included. <i>(this box should expand as you type)</i>				

SECTION H: Anticipated Risks

Outline any anticipated risks that may adversely affect any of the participants, the researchers and/or the University, and the steps that will be taken to address them. If you have completed a full risk assessment (for example as required by a laboratory, or external research collaborator) you may append that to this form.						
1	Full risk assessment completed and appended?	<table border="1"> <tr> <td>Yes</td> <td>☐</td> </tr> <tr> <td>No</td> <td>☒</td> </tr> </table>	Yes	☐	No	☒
Yes	☐					
No	☒					
2	Risks to participants For example: sector-specific health & safety, emotional distress, financial disclosure, physical harm, transfer of personal data, sensitive organisational information					
	Risk to participants: 1. The memory task used in this experiment is fast-paced and challenging by design so may cause frustration or distress when participating	How you will mitigate the risk to participants: 1. Under UWTSD and BPS research guidelines, participants will be informed of the nature of the memory task before participation, and comprehensive instructions and well as two practice trials				

	2. Some questions on the MEQ ask participants about their sleeping patterns as well as their mood and behaviour concerning sleep timing. Some participants could potentially suffer from sleeping disorders and so may feel distressed or judged by the questions 3. Risks related to participants anonymity, confidentiality and data protection rights	will also be included. Participants will also be informed of their right to withdraw at any point without penalty if they do not wish to continue. 2. As above, participants will be informed of the nature of the questionnaire prior to commencing and their right to withdraw during the study, and informed that they do not have to answer every question and may skip over any they wish. 3. Participants will be made aware that any data collected will be anonymous and confidentially handled by the researcher who will assign unique ID codes to each data set that cannot be used for identification. Data will be stored on a password and encryption-protected university computer and OneDrive account with data only being used for intended research purposes. <i>(this box should expand as you type)</i>
3	If research activity may include sensitive, embarrassing or upsetting topics (e.g. sexual activity, drug use) or issues likely to disclose information requiring further action (e.g. criminal activity), give details of the procedures to deal with these issues, including any support/advice (e.g. helpline numbers) to be offered to participants. Note that where applicable, consent procedures should make it clear that if something potentially or actually illegal is discovered in the course of a project, it may need to be disclosed to the proper authorities	
	N/A <i>(this box should expand as you type)</i>	
4	Risks to the investigator For example: personal health & safety, physical harm, emotional distress, risk of accusation of harm/impropriety, conflict of interest	
	Risk to the investigator: 1. The researcher's email will be attached to information and debrief sheets and so may receive unwanted emails from participants 2. The student researcher may be asked questions to which they do not know the immediate answer 3. Potential risk of participants accusing the researchers of harm/impropriety if they are not happy with the study. 4. Researcher's physical safety in the labs may also be at risk if the participant is dissatisfied with the MEQ or Memory task <i>(this box should expand as you type)</i>	<i>How you will mitigate the risk to the investigator:</i> 1. Only the researcher student's email will be included as part of the research and any inappropriate emails will be reported to the module lead/supervisor immediately. 2. Any queries that the researcher cannot answer will be passed on to the research supervisor, additionally, if participants have lingering questions they can email the researcher for clarification in the future. 3. It will be ensured that the student researcher will follow all the UWTSD and BPS codes of conduct and research guidelines. Additionally, the study will not go forward until all requirements have been met and approved by the supervisor. 4. If a participant begins to get agitated and the researcher's safety feels threatened, then the study will come to an end and the researcher will remove themselves and report the incident to the lab manager.

		Additionally, research will only take place during open university hours from Monday-Friday 9am – 5pm. <i>(this box should expand as you type)</i>
5	University/institutional risks For example: adverse publicity, financial loss, data protection	
	Risk to the University: 1. Adverse Publicity for the university could occur if researchers do not adhere to codes of research ethics. 2. Data leaks and exposures or data could be used for alternative purposes. <i>(this box should expand as you type)</i>	How you will mitigate the risk to the University: 1. The University Ethics and Integrity Code of Practice and the BPS Code of Ethics and Conduct will be closely adhered to throughout the whole empirical project process to minimise risks to the institution and professionalism will be maintained. 2. The data collected will be stored following UWTSD Research Data Management (RDM) rules and only used for the intended purpose. All questionnaire data will be stored securely through password protected Qualtrics software, and SuperLab data will be stored on password protected university lab and researcher OneDrive account. <i>(this box should expand as you type)</i>
6	Environmental risks For example: accidental spillage of pollutants, damage to local ecosystems	
	Risk to the environment: N/A <i>(this box should expand as you type)</i>	How you will mitigate the risk to environment: N/A <i>(this box should expand as you type)</i>

Disclosure and Barring Service				
	If the research activity involves children or vulnerable adults, a Disclosure and Barring Service (DBS) certificate must be obtained before any contact with such participants.	YES	NO	N/A
7	Does your research require you to hold a current DBS Certificate?	☐	☒	☐
8	If YES, please give the certificate number. If the certificate number is not available please write "Pending"; in this case any ethical approval will be subject to providing the appropriate certificate number.			

SECTION I: Feedback, Consent and Confidentiality

1	Feedback What de-briefing and feedback will be provided to participants, how will this be done and when? At the conclusion of the experiment, the researcher will provide a verbal debrief and a printed debrief form. Participants will be provided with further information about the research including the full purpose and aims of the experiment and will also be given a final chance to withdraw their data. On this debrief form will also be the student researcher email and supervisor email if the participant wishes to ask further questions or provide feedback on the study. Participants will be free to take the debrief form away with them. Participants will be reminded that if they wish to withdraw their data they must do so before leaving the lab as after this point their data will be anonymous and not possible to trace back to them.
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	(this box should expand as you type)
2	Informed consent Describe the arrangements to inform potential participants, before providing consent, of what is involved in participating. Describe the arrangements for participants to provide full consent before data collection begins. If gaining consent in this way is inappropriate, explain how consent will be obtained and recorded in accordance with prevailing data protection legislation. A printed consent form will be provided to the participant before the start of data collection. This consent form will include essential information regarding the experiment that participants will be required to read and sign before beginning. The consent form will also outline both tasks featured in the study as well as state the ethical rights and ensure participants that data will remain confidential and anonymous. (this box should expand as you type)
3	Confidentiality / Anonymity Set out how the anonymity of participants and confidentiality will be ensured in any outputs. If anonymity is not being offered, explain why this is the case. As per the BPS Code of Ethics and Conduct, all participant information and data will remain completely anonymous throughout the empirical project study. Participants will sign up to the study using their unique EMS identification number. Their data will then be given a different new unique ID code (i.e. M1, E1) to prevent data from being related to any specific participant. Any data collected will not be able to be traced back to the individual. Only gender and age will be collected for descriptive statistics. All participant responses will be kept confidential, and consent forms that will contain the participant's name will be stored separately from the study data. Consent forms will be stored securely within a secure locked cabinet in the psychology labs. Any electronic data will be protected by a password on lab computers and researcher university OneDrive accounts. (this box should expand as you type)

SECTION J: Data Protection and Storage

	Does the research activity involve personal data (as defined by the General Data Protection Regulation 2016 "GDPR" and the Data Protection Act 2018 "DPA")?	YES	NO
1	"Personal data" means any information relating to an identified or identifiable natural person ("data subject"). An identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person. Any video or audio recordings of participants is considered to be personal data.	☒	☐
	If YES, provide a description of the data and explain why this data needs to be collected:		
2	At the start of the study, data regarding participants' age and gender will be collected for the purpose of descriptive statistics. This data will be used to calculate the mean age score of participants and observe the gender split of the participant sample as part of the standard reporting measures in psychology research. Participant names collected on consent forms will be stored separately to study data and kept secure in a locked cabinet in the psychology labs. (this box should expand as you type)		
	Does it involve special category data (as defined by the GDPR)?	YES	NO

3	"Special category data" means sensitive personal data consisting of information as to the data subjects' – (a) racial or ethnic origin, (b) political opinions, (c) religious beliefs or other beliefs of a similar nature, (d) membership of a trade union (within the meaning of the Trade Union and Labour Relations (Consolidation) Act 1992), (e) physical or mental health or condition, (f) sexual life, (g) genetics, (h) biometric data (as used for ID purposes).	☐	☒
If YES, provide a description of the special category data and explain why this data needs to be collected:			
4	N/A <i>(this box should expand as you type)</i>		

	Will data from the research activity (collected data, drafts of the thesis, or materials for publication) be stored in any of the following ways?	YES	NO
5	Manual files (i.e. in paper form)?	☒	☐
6	University computers?	☒	☐
7	Private company computers?	☐	☒
8	Home or other personal computers?	☐	☒
9	Laptop computers/ CDs/ Portable disk-drives/ memory sticks?	☒	☐
10	"Cloud" storage or websites?	☒	☐
11	Other – specify:	☐	☒
12	For all stored data, explain the measures in place to ensure the security of the data collected, data confidentiality, including details of backup procedures, password protection, encryption, anonymisation and pseudonymisation: Paper consent forms will be stored separately to study data and kept secure in a locked cabinet in the psychology labs. University computers will be used to collect SuperLab data in the labs, this will be password-protected and located within the secure key card access lab environment. Encrypted memory sticks will be used to transfer anonymised data from the lab computers to the researcher's university OneDrive (if relevant). Once this transfer is complete then data will be deleted from the memory stick. Data collected in Qualtrics will be stored in the researcher's password-protected Qualtrics account that can be accessed through the cloud. Any raw data collected will be stored electronically. Data collected and stored through Superlab university computer will only be accessible to the researcher through a password-protected university account. Data collected through Qualtrics and SuperLabs can only be linked using participant ID codes. <i>(this box should expand as you type)</i>		

Data Protection		
Will the research activity involve any of the following activities:	YES	NO

13	Electronic transfer of data in any form?	☒	☐
14	Sharing of data with others at the University outside of the immediate research team?	☐	☒
15	Sharing of data with other organisations?	☐	☒
16	Export of data outside the UK or importing of data from outside the UK?	☐	☒
17	Use of personal addresses, postcodes, faxes, emails or telephone numbers?	☐	☒
18	Publication of data that might allow identification of individuals?	☐	☒
19	Use of data management system?	☒	☐
20	Data archiving?	☐	☒
21	If YES to any question, please provide full details, explaining how this will be conducted in accordance with the GDPR and Data Protection Act (2018) (and any international equivalents, where appropriate): Experimental data for this study will be collected using a SuperLab computer located in the UWTSD SA1 (IQ) campus psychology labs, this data will be anonymous and transferred to the researcher's password-protected university OneDrive using an encrypted memory stick after which data from the stick will be deleted. Questionnaire data will be collected using password protected Qualtrics software and will be anonymous and downloaded onto the researcher's secure and password-protected university OneDrive. <i>(this box should expand as you type)</i>		
22	List all who will have access to the data generated by the research activity: Aaron Young (2205141) (Lead Researcher) Dr Kate Williams (Supervisor) Examiners may also request access to data <i>(this box should expand as you type)</i>		
23	List who will have control of, and act as custodian(s) for, data generated by the research activity: Aaron Young (2205141) <i>(this box should expand as you type)</i>		
24	Give details of data storage arrangements, including security measures in place to protect the data, where data will be stored, how long for, and in what form. Will data be archived – if so how and if not why not. Data collected on both SuperLab and Qualtrics will be stored in an anonymous format and password protected. Qualtrics data will only be accessible by the researcher through a password-protected account Qualtrics account. SuperLab data will be stored on a university lab computer behind the researcher's password-protected university account. All anonymised data transferred between university devices and the researcher's university OneDrive account will be done using an encrypted memory stick and will be wiped after the transfer, this data will then remain secure in a password-protected file on the researcher's university OneDrive account. Data will be stored until the report for the Psychological Empirical project has been confirmed by external examiners, after which data will be deleted. All data storage will conform to the UWTSD Research Data Management Policy. <i>(this box should expand as you type)</i>		
25	Please indicate if your data will be stored in the UWTSD Research Data Repository (see https://researchdata.uwtsd.ac.uk/). If so please explain. <i>(Most relevant to academic staff)</i>		

	Any data gathered during this study will not be stored in the UWTSD Research Data Repository at this point and will not be held after the conclusion of the empirical project. <i>(this box should expand as you type)</i>		
26	Confirm that you have read the UWTSD guidance on data management (see https://www.uwtsd.ac.uk/library/research-data-management/)	YES	☒
27	Confirm that you are aware that you need to keep all data until after your research has completed or the end of your funding	YES	☒

SECTION K: Declaration

	The information which I have provided is correct and complete to the best of my knowledge. I have attempted to identify any risks and issues related to the research activity and acknowledge my obligations and the rights of the participants. In submitting this application I hereby confirm that I undertake to ensure that the above named research activity will meet the University's Research Ethics and Integrity Code of Practice which is published on the website: https://www.uwtsd.ac.uk/research/research-ethics/		
1	Signature of applicant:	AARON YOUNG	Date: 25/09/2024

For STUDENT Submissions:

2	Director of Studies/Supervisor:	Dr Kate Williams	Date: 07/10/2024
3	Signature:	<i>K.E. Williams</i>	

For STAFF Submissions:

4	Academic Director/ Assistant Dean:		Date:
5	Signature:		

Checklist: Please complete the checklist below to ensure that you have completed the form according to the guidelines and attached any required documentation:

☒	I have read the guidance notes supplied before completing the form.
☒	I have completed ALL RELEVANT sections of the form in full.
☒	I confirm that the research activity has received approval in principle
☐	I have attached a copy of final/interim approval from external organisation (where appropriate)
☐	I have attached a full risk assessment (where appropriate) ONLY TICK IF YOU HAVE ATTACHED A FULL RISK ASSESSMENT
☒	I understand that it is my responsibility to ensure that the above named research activity will meet the University's Research Ethics and Integrity Code of Practice.
☒	I understand that before commencing data collection all documents aimed at respondents (including information sheets, consent forms, questionnaires, interview schedules etc.) must be confirmed by the DoS/Supervisor, module tutor or Academic Director.

RESEARCH STUDENTS ONLY

Once complete, submit this form via the **MyTSD Doctoral College Portal** at (<https://mytsd.uwtsd.ac.uk>).

RESEARCH STAFF ONLY

All communications relating to this application during its processing must be in writing and emailed to presearch@uwtsd.ac.uk, with the title 'Ethical Approval' followed by your name.

STUDENTS ON UNDERGRADUATE OR TAUGHT MASTERS PROGRAMMES should submit this form (and receive the outcome) via systems explained to you by the supervisor/module leader.

APPENDIX E – LIST OF CORRECT TRIGRAM ANSWERS

Practice – HBW

Trial 1 – OKL (8 seconds non-rehearsal)

Trial 2 – LYE (12 seconds)

Trial 3 – MBC (16 seconds)

Trial 4 – QSF (20 seconds)

Trial 5 – KDR (24 seconds)

Trial 6 – COA (28 seconds)

Trial 7 – UEJ (32 seconds)

Trial 8 – FXI (36 seconds)

Trial 9 – ARB (40 seconds)

Trial 10 – TSH (44 seconds)

Trial 11 – GWC (48 seconds)

Trial 12 – HWI (52 seconds)

Trial 13 – MDT (56 seconds)

Trial 14 – YRC (60 seconds)

Trial 15 – BXA (64 seconds)

APPENDIX F – INFORMATION SHEET



Centre for Psychology and
Counselling
SA1 Campus

Participant Information Sheet

Title of Study: Effect of Chronotype and Time of Testing on Memory Task Performance in Students

Research Team: Aaron Young (2205141@student.uwtsd.ac.uk) and Dr Kate Williams (kate.williams@uwtsd.ac.uk)

Date:

Invitation Paragraph:

You are being invited to take part in a research project being conducted by a third-year student within the Psychology and Counselling department at The University of Wales Trinity Saint David (UWTSD) for their Psychology Empirical Project. Before you decide to take part, it is important for you to understand why the research is being conducted and what participation will involve.

Please take time to read the following information carefully and discuss it with the researcher if you wish. Ask if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part. Thank you for reading this.

Purpose of Research:

The purpose of this study is to explore how performance on a working memory task may vary between individuals with differing preferred natural waking and sleeping times (circadian rhythms) and if memory performance is affected by the time of testing for these different rhythms.

What does taking part involve:

This study will involve an experimental lab-based task in-person. During this study you will be required to do the following:

- Provide demographic information of age and gender.
- Complete a 19-item questionnaire regarding sleeping and waking habits
- Complete a computer-based memory task lasting several minutes which involves memorising and recalling three-letter trigrams while also engaging in a simple numerical task identifying Odd or Even numbers.

At the end of the study, you will be debriefed by the researcher, and you will be provided with the study debrief sheet.

How long will the study take:

This study is expected to take around 30 minutes to complete. If you have signed-up via the Experiment Management System (EMS), you can expect to receive 3 credits.

Benefits of participating:

Whilst there are no immediate benefits for those people participating in the study, it is hoped that this work will contribute to the existing body of knowledge on the areas of sleep and short-term memory retention.

Risks of participating:

There are no immediate risks to participation in this study however should a participant suffer from extreme sleep disorders such as insomnia or narcolepsy, they may feel frustrated in completing the questionnaire. Any issues regarding this should be discussed with the researcher. If you feel you would be uncomfortable engaging in a memory task, you are advised not to take part in this study.

Participation and withdrawal:

Participation in this study is completely voluntary and you also have the option of not answering any questions you do not feel comfortable answering. You can withdraw at any point during the study without penalty. If you wish to withdraw during the study, please inform the researcher. You do not need to give a reason for withdrawing. However, please note, once you leave the lab environment, it will not be possible to withdraw your data, as it will be anonymised.

How will your data be used and processed:

Your data will only be used for the purpose of the research activity. Your name will only be collected on the consent form and consent forms will not be related to study data. This study will also collect demographic data of age and gender. This is for the purpose of descriptive statistics, which form the standard reporting measures in psychology. Once the data is collected, it will be aggregated for presentation purposes by calculating the mean age and total gender numbers. This data will also not be linked to your name. The researcher will not disclose data information or use it for any other purposes.

How will your data be collected and stored:

All collected raw data will be kept in a raw format and then aggregated for analysis purposes. Computer data will be collected via SuperLab, and this data will be stored on the SuperLab computer within the Psychology labs. It will only be accessed by the researcher through a password protected university account. All SuperLab data will be anonymous and copied from the lab computer to the researcher's university OneDrive account, which will also be protected with password. If there would be a need to transfer data by a memory stick, the memory stick will be encrypted, and the data will be deleted once transfer is completed. Physical consent forms will be preserved in a securely locked filing cabinet located in the Psychology Labs and separate from the anonymised electronic data. This data will be subsequently deleted after the module assessment undergoes evaluation by the end of year examination board.

How can you contact the researchers if you have any questions:

You can contact the research student via email: Aaron Young -(2205141@student.uwtsd.ac.uk)

You can also contact the research supervisor via email: Dr Kate Williams – kate.williams@uwtsd.ac.uk
If you have any immediate questions, please ask the researcher now. If you are happy to continue, please read, complete, and sign the corresponding consent form.

APPENDIX G – CONSENT FORM



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Centre for Psychology and
Counselling
SA1 Campus

Participant Consent Form

Title of Study: Effect of Chronotype and Time of Testing on Memory Task Performance In Students

Research Team: Aaron Young (2205141@student.uwtsd.ac.uk) and Dr Kate Williams (kate.williams@uwtsd.ac.uk) .

Date:

1. I confirm that I have read and understand the Information Sheet for the above study.	Yes	No
2. I had an opportunity to ask questions and have them answered satisfactorily.	Yes	No
3. I understand that I may ask further questions at any time.	Yes	No
4. I understand that my participation is voluntary, and I am free to withdraw from the study at any time without penalty or giving any reason.	Yes	No
5. I understand that my fully anonymised data will be utilised for only this research study, which is being conducted by a third-year Psychology student for the purpose of their undergraduate Psychology Empirical project and will be deleted once external examiner approval for the project has been obtained.	Yes	No
6. I have been informed that if I feel I would be uncomfortable answering personal questions, completing a questionnaire relating to sleeping habits and completing a short computer-based task memorising trigrams and identifying odd/even numbers. that I should not take part in this study.	Yes	No
7. I understand that I may decline to answer any questions.	Yes	No
8. I understand that any data collected will be anonymised and stored in an anonymous format and once I leave the lab it will not be possible to trace the data back to me to withdraw.	Yes	No
9. I understand that the anonymised data provided will be securely stored and accessible only to the members of the research team directly involved in the study, and that confidentiality will be maintained.	Yes	No
10. I confirm that I am over 18 years old	Yes	No
11. I confirm I have normal or corrected-to-normal vision	Yes	No
12. I agree to take part in the above study.	Yes	No

Participant Name Date Participant Signature

Researcher Name Date Researcher Signature

There should be two signed copies, one for the participant, one retained by researcher for records.

APPENDIX H – MEMORY TASK INSTRUCTIONS

For this part of the study, you will be shown several TRIGRAMS (Three random nonsense letters e.g., BEP).

After a countdown, each TRIGRAM will be displayed one at a time for FIVE seconds. These letters should be memorised.

Press the SPACE BAR to continue

After viewing a TRIGRAM, you will be asked to complete a numerical task identifying ODD or EVEN numbers from a set. These will get progressively more difficult.

(ODD = 1, 3, 5, 7, etc).

(EVEN = 2, 4, 6, 8, etc).

You will have FOUR seconds to type the correct number using the keyboard.

Answer as many as you can. There is NO need to press ENTER as the screen will automatically move on even if no answer is given.

Press SPACE BAR to continue

After each set of ODD/EVEN numbers, you will be asked to recall the previous TRIGRAM in the correct order using the keyboard.

After ONE incorrect trigram recall, the study will conclude.

The first trial will be a practice (you will be given FIVE seconds to memorise the Trigram and identify the ODD/EVEN number for the practice).

Press the SPACE BAR to begin practice trial

APPENDIX I – MEMORY TASK EXTRA EXAMPLES (INCORRECT, WELL DONE, THANK YOU)

Well Done!

Press SPACE to continue

INCORRECT

Please try again

Press SPACE to continue

Thank you for participating in this study!

You reached LEVEL 1

Please inform the resercher to recieve your debreif sheet

APPENDIX J – DEBRIEF FORM



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Participant Debrief Sheet

Title of Study: Effect of Chronotype and Time of Testing on Memory Task Performance in Students

Research Team: Aaron Young (2205141@student.uwtsd.ac.uk) and Dr Kate Williams (kate.williams@uwtsd.ac.uk)

Date:

Thank you for taking part in this study.

The aim of this study was to explore how students perform on a working memory task when tested at a time congruent to their respective chronotypes (morning or evening preferred) compared to being tested at a time incongruent (opposite) to their chronotypes.

Through conducting a controlled laboratory study, we aimed to isolate specific variables to effectively explore the research questions;

3. Do “Owls” or “Larks” perform better on a working memory task?
4. Is performance on a memory task dependent on an owl/lark’s congruent time of testing?

Depending upon the experimental group that you were assigned to, you were either part of the morning test group (9am–11am) or the evening test group (3pm-5pm). Additionally, your scores on the Morning-Eveningness questionnaire would categorise you as either a morning type (Lark) or an evening type (Owl) Therefore, we have had to use slight deception in this study to accurately assess chronotype and time of testing on memory task performance.

If you wish to withdraw your data from the study, you must tell the researcher before leaving the lab. After leaving the lab, all your data will be anonymised, and we will not be able to trace it back to you.

If taking part in this study has raised any questions or concerns, please contact the researcher: Aaron Young on 2205141@student.uwtsd.ac.uk or contact the research supervisor: Dr Kate Williams on kate.williams@uwtsd.ac.uk

APPENDIX K – GROUPED DATA PER PARTICIPANT

CONGRUENT MORNING						CONGRUENT EVENING								
ID	Gender	Age	Test Group	Chronotype	Score	ID	Gender	Age	Test Group	Chronotype	Score			
M2	1	24	1	1	10	E7	2	48	2	2	3	CONGRENT MORNING	11	32.5454545
M3	2	45	1	1	15	E10	2	44	2	2	13	CONGRUENT EVENING	11	31.5454545
M4	2	35	1	1	3	E11	1	24	2	2	15	INCONGRUENT MORNING	10	26.9
M5	2	35	1	1	15	E13	2	21	2	2	13	INCONGRUENT EVENING	10	34.1
M7	2	24	1	1	15	E14	2	21	2	2	11			
M12	1	20	1	1	15	E15	3	27	2	2	4	OVERALL LARKS	21	33.2857143
M13	2	23	1	1	14	E18	2	25	2	2	15	OVERALL OWLS	21	29.3333333
M14	2	42	1	1	5	E19	2	40	2	2	15			
M18	2	21	1	1	6	E20	1	37	2	2	2			
M20	2	33	1	1	15	E21	2	18	2	2	4			
M21	2	56	1	1	15	E1	1	42	2	2	12			
INCONGRUENT MORNING						INCONGRUENT EVENING								
ID	Gender	Age	Test Group	Chronotype	Score	ID	Gender	Age	Test Group	Chronotype	Score			
M1	2	24	1	2	15	E2	1	34	2	1	2			
M6	2	27	1	2	6	E3	2	53	2	1	15			
M8	2	29	1	2	6	E4	2	38	2	1	2			
M9	2	22	1	2	15	E5	2	32	2	1	2			
M10	2	28	1	2	6	E6	2	40	2	1	6			
M11	2	31	1	2	10	E8	2	29	2	1	15			
M15	1	24	1	2	7	E9	2	21	2	1	6			
M16	2	36	1	2	11	E12	2	33	2	1	10			
M17	2	28	1	2	6	E16	2	21	2	1	15			
M19	2	20	1	2	4	E17	2	40	2	1	15			

APPENDIX L - CRONBACH ALPHA

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.893	.900	19

APPENDIX M - EXPLORATION OF NORMALITY AND BOXPLOT GRAPH

Descriptives				
MEM_SCORE	TIMEGROUP		Statistic	Std. Error
	MORNING PARTICIPATION	Mean	10.19	.994
		95% Confidence Interval for Mean	Lower Bound	8.12
			Upper Bound	12.26
		5% Trimmed Mean	10.32	
		Median	10.00	
		Variance	20.762	
		Std. Deviation	4.557	
		Minimum	3	
		Maximum	15	
		Range	12	
	EVENING PARTICIPATION	Interquartile Range	9	
		Skewness	-.119	.501
		Kurtosis	-1.784	.972
		Mean	9.29	1.192
		95% Confidence Interval for Mean	Lower Bound	6.80
			Upper Bound	11.77
		5% Trimmed Mean	9.37	
		Median	11.00	
		Variance	29.814	
		Std. Deviation	5.460	
		Minimum	2	
		Maximum	15	
		Range	13	
		Interquartile Range	12	
		Skewness	-.247	.501
		Kurtosis	-1.797	.972

Tests of Normality

TIMEGROUP		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
MEM_SCORE	MORNING PARTICAPATION	.235	21	.004	.820	21	.001
	EVENING PARTICAPATION	.186	21	.057	.815	21	.001

a. Lilliefors Significance Correction

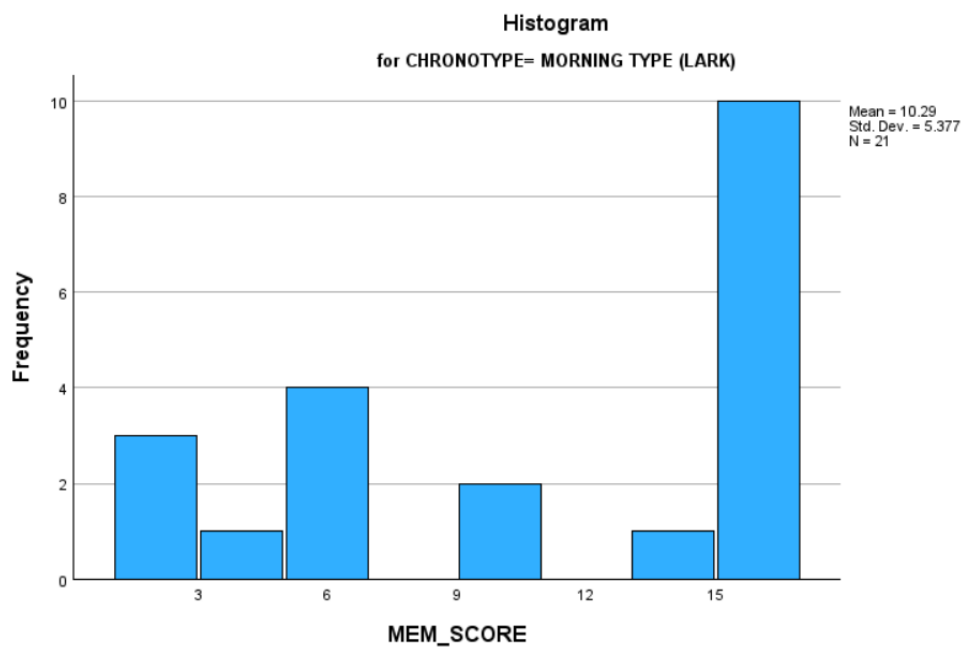
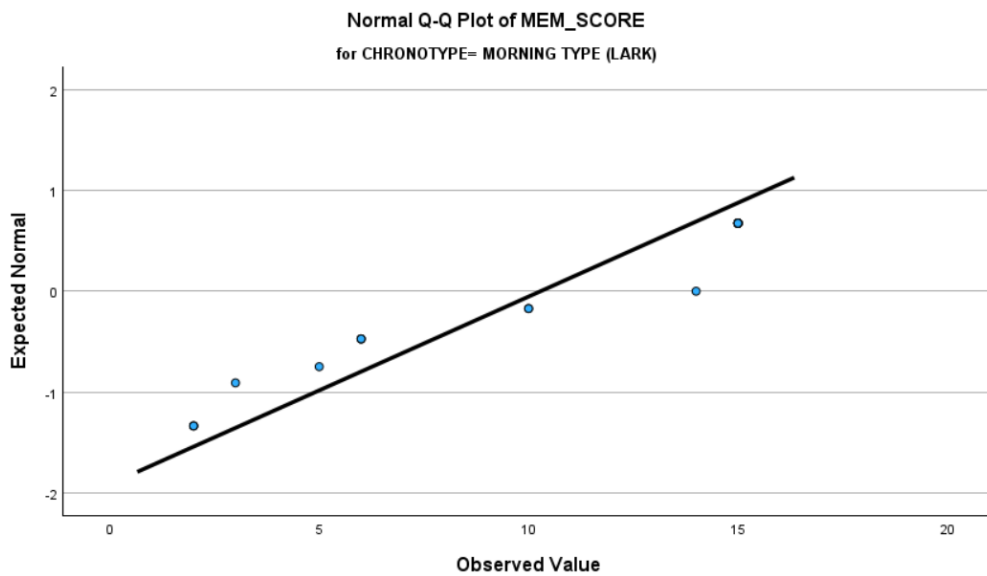
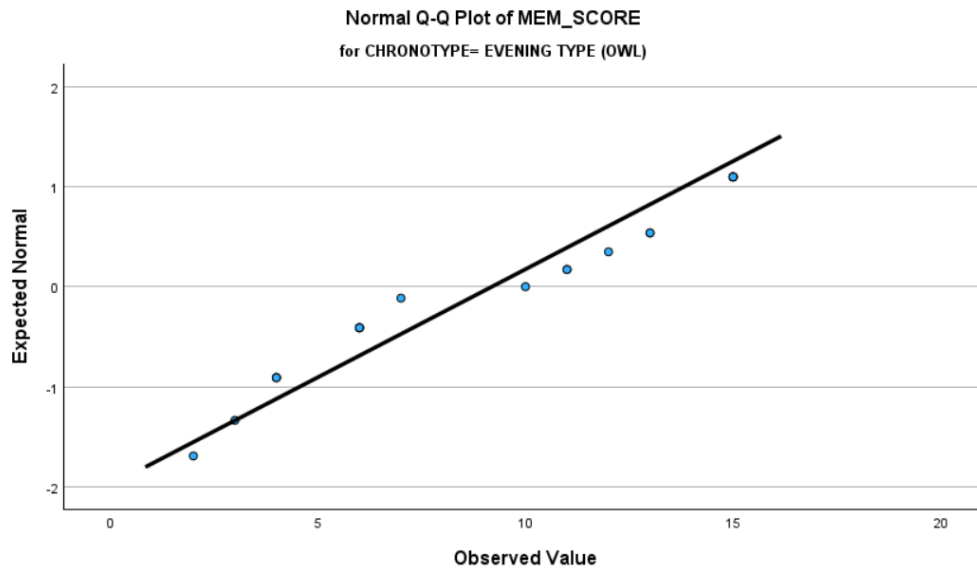
Descriptives

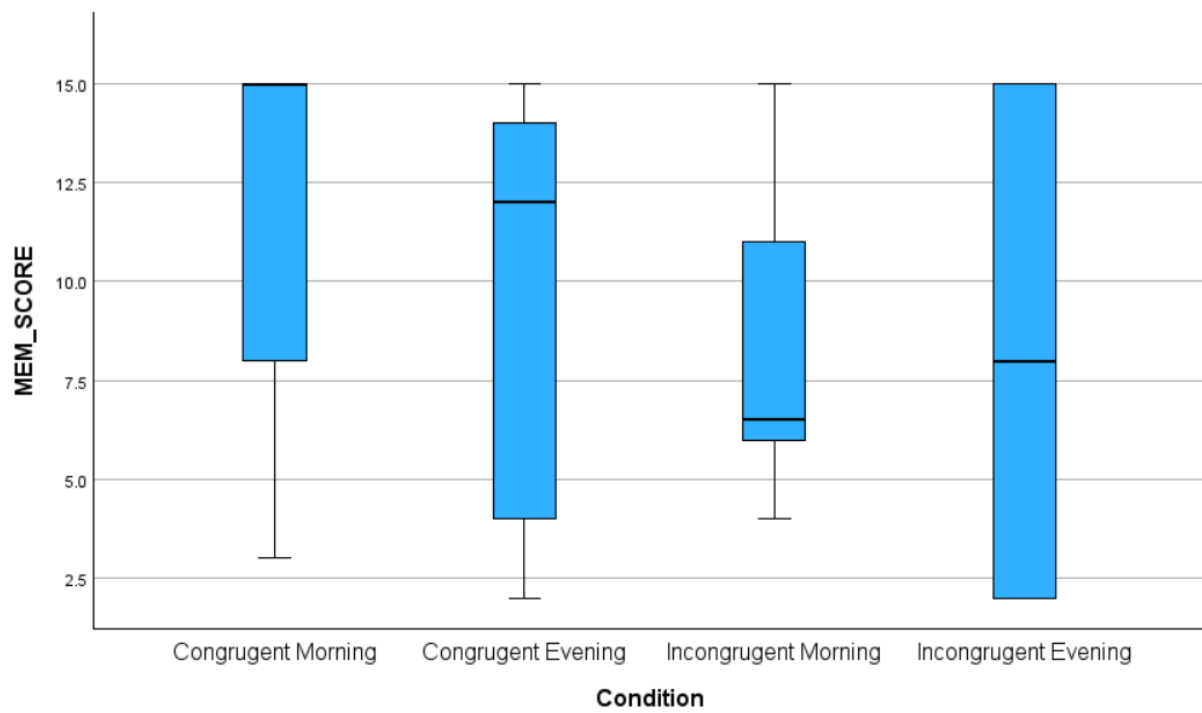
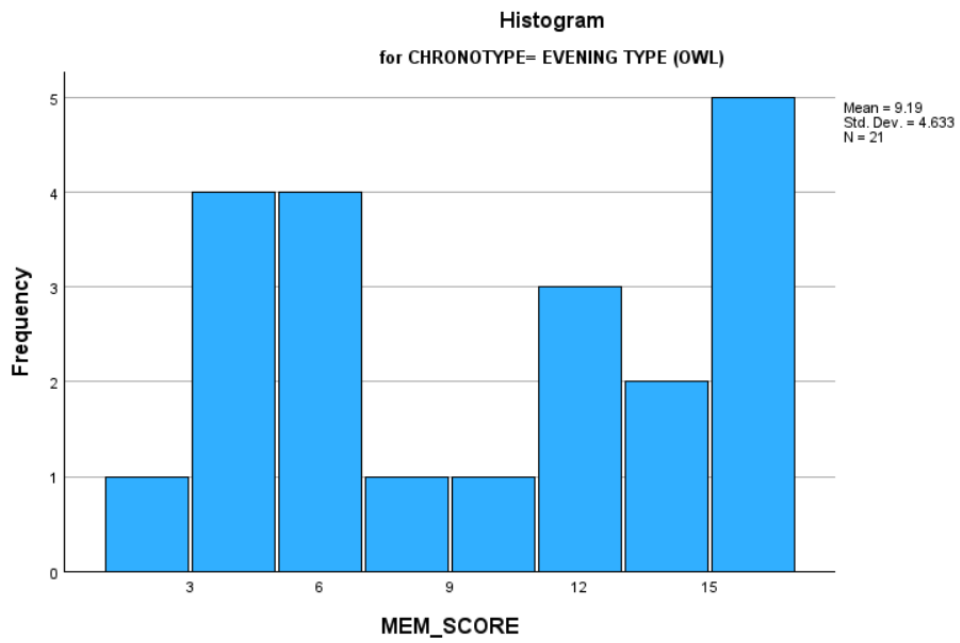
CHRONOTYPE		Statistic	Std. Error
MEM_SCORE	MORNING TYPE (LARK)	Mean	10.29
		95% Confidence Interval for Mean	
		Lower Bound	7.84
		Upper Bound	12.73
		5% Trimmed Mean	10.48
		Median	14.00
		Variance	28.914
		Std. Deviation	5.377
		Minimum	2
		Maximum	15
		Range	13
		Interquartile Range	10
		Skewness	-.490
		Kurtosis	-1.580
	EVENING TYPE (OWL)	Mean	9.19
		95% Confidence Interval for Mean	
		Lower Bound	7.08
		Upper Bound	11.30
		5% Trimmed Mean	9.26
		Median	10.00
		Variance	21.462
		Std. Deviation	4.633
		Minimum	2
		Maximum	15
		Range	13
		Interquartile Range	9
		Skewness	-.024
		Kurtosis	-1.609

Tests of Normality

CHRONOTYPE		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
MEM_SCORE	MORNING TYPE (LARK)	.286	21	<.001	.772	21	<.001
	EVENING TYPE (OWL)	.183	21	.064	.886	21	.019

a. Lilliefors Significance Correction





APPENDIX N – SSPS ANOVA OUTPUT AND ESTIMATED MARGINAL MEANS

Tests of Between-Subjects Effects						
Dependent Variable: MEM_SCORE						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	61.392 ^a	3	20.464	.811	.496	.060
Intercept	3935.432	1	3935.432	155.984	<.001	.804
CHRONOTYPE	11.650	1	11.650	.462	.501	.012
TIMEGROUP	7.650	1	7.650	.303	.585	.008
CHRONOTYPE * TIMEGROUP	41.146	1	41.146	1.631	.209	.041
Error	958.727	38	25.230			
Total	5003.000	42				
Corrected Total	1020.119	41				

a. R Squared = .060 (Adjusted R Squared = -.014)

1. Grand Mean

Dependent Variable: MEM_SCORE

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
9.691	.776	8.120	11.262

2. CHRONOTYPE

Dependent Variable: MEM_SCORE

CHRONOTYPE	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MORNING TYPE (LARK)	10.218	1.097	7.997	12.440
EVENING TYPE (OWL)	9.164	1.097	6.942	11.385

3. TIMEGROUP

Dependent Variable: MEM_SCORE

TIMEGROUP	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MORNING PARTICAPATION	10.118	1.097	7.897	12.340
EVENING PARTICAPATION	9.264	1.097	7.042	11.485

4. CHRONOTYPE * TIMEGROUP

Dependent Variable: MEM_SCORE

CHRONOTYPE	TIMEGROUP	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MORNING TYPE (LARK)	MORNING PARTICAPATION	11.636	1.514	8.570	14.702
	EVENING PARTICAPATION	8.800	1.588	5.584	12.016
EVENING TYPE (OWL)	MORNING PARTICAPATION	8.600	1.588	5.384	11.816
	EVENING PARTICAPATION	9.727	1.514	6.661	12.793

APPENDIX O - LEVENE'S TEST OF EQUALITY OF ERROR VARIANCES

Levene's Test of Equality of Error Variances^{a,b}

		Levene Statistic	df1	df2	Sig.
MEM_SCORE	Based on Mean	1.694	3	38	.185
	Based on Median	.742	3	38	.534
	Based on Median and with adjusted df	.742	3	30.835	.535
	Based on trimmed mean	1.596	3	38	.206

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: MEM_SCORE

b. Design: Intercept + CHRONOTYPE + TIMEGROUP + CHRONOTYPE * TIMEGROUP

APPENDIX P – LINE CHART OF INTERACTION

