

LITTERATURE REVIEW

Ronnenberg

- Dr Till Roenneberg, who has been leading a massive ongoing sleep research project tracking the sleep habits of over 50,000 participants for the past few decades.
- He was among the first to conclude that each individual had their own unique internal biological rhythm influenced by genetics and environmental cues that determine our natural peaks in cognition and physicality – known as a chronotype.
- Dr Ronnenberg kept things simple and categorised chronotypes as either;
 - Larks – early risers
 - Owls – night owls
 - Doves – somewhere in between

MEQ

Even long before Ronnenberg's study, other investigations have created measures to categorise people into morning and evening types. For example, Horne and Ostberg created the Morningness-Eveningness questionnaire, which measures people's inclination towards evening and Morning based on how they would design their free days around their preferred sleeping schedule. This questionnaire will become a key part of this investigation shortly.

The Sentinel Hypothesis.

- The evolutionary origins of these chronotypes can be explained by the Sentinel Hypothesis, a key theory behind chronotypes
- Which states that early hunter-gatherer communities would have benefited from around-the-clock security from threats and predators.
- So while most of a community would rest for the night, ready for the next day of survival, a select few individuals would remain awake and alert to watch for danger.
- In modern life, 24/7 security is less necessary, but this innate mechanism remains.
- 9-to-5 jobs, shift work and artificial light—forces many of us out of sync with our natural rhythms, leading to sleep disorders, fatigue and underperformance.

The SCN

- Our chronotypes are governed by the **suprachiasmatic nuclei**, or SCN— which acts as our brain’s “master clock.” That influences other bodily functions, such as blood pressure, sex drive and hormone levels as well as cognitive functions like alertness, sociability, and memory.
- It is activated by light signals from the environment that trigger a new day's rhythm, but everybody's activates at different times, hence chronotype differences. which begins to cause problems.

Impact On Academic success

- Morningness is often associated with better academic performance, Largely due to their synchronicity of waking times and school timetables.
- This is known as the **synchronicity effect**: when you perform a task at your optimal time of day, you're more focused, less error-prone, and better able to encode new memories.
- However, when evening types are forced to function in the early morning, their performance suffers—not just due to tiredness, but because their brain simply isn't at its peak time.

The Synchronicity Effect

- The synchronicity effect is particularly strong in tasks that require **working memory** and can be found in many academically relevant tasks of attention and memory.
- This is where I really started to focus my research.
- **(Abdul Jafar et al., 2023)** - Found that on tasks of spatial working memory in pre-schoolers, that morning-type infants performed best in the mornings and evening type infants performed best in the evening, demonstrating the synchronicity effect even in early education
- **(Montaruli et al., 2019)** – Conducted a study on Italian university students found that morning type students have the advantage in both theoretical and practical exams due to the synchronicity of their best sleep times with university class and exam schedules.
- **(Schmidt et al., 2015)** – most importantly concluded that the synchronicity effect is most observable when performing tasks of heavy **cognitive load**. In other words, the more mentally demanding the task.

Literature Review Takeaway

- So, when students are forced to work against their natural rhythms, especially on tasks that require a lot of mental effort, like working memory, most research indicates that they're at a clear disadvantage.
- And it's this interaction between chronotype, time of day, and working memory performance that forms the core of what we're investigating in this study.

AIMS AND RESEARCH QUESTIONS

Based on this information, I set out to investigate the following primary research question

- 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?

Based on what I had discovered so far, I hypothesised that: on a WM task involving moderate to high cognitive load that participants tested at a time congruent to their chronotypes will have an advantage in working memory over those tested incongruently with their chronotypes.

Let's get into it.

METHODOLOGY

PARTICIPANTS

- Participants for this study were recruited from **first- and second-year students** studying **Psychology, Psychology and Counselling**, and **Criminology** here at **UWTSD**. Who signed up using **EMS** in exchange for 3 course credits.
- Choosing a time slot between **9-12 (which would place them in the morning test group)** and **1-5 (which would place them in the evening test group)**. The **only eligibility requirement** was that participants needed to have **normal or corrected-to-normal vision**, as this was necessary for the task being used.
- In total, **42 participants** took part in the study, with the breakdown of:
 - **7 males**
 - **34 females**
 - **1 non-binary**
- Ages ranged from **18 to 56**, with a relatively high **mean age of 31.3**.

DESIGN

We used a 2x2 **between-subjects design**, and a **two-way between-subjects ANOVA** was used to analyse the interaction of two independent variables:

- **Time of testing** (Morning vs Afternoon) – dependent on when participants signed up
- **Chronotype** (Lark vs Owl) – Determined by participants' responses to a morning or eveningness questionnaire.

On the dependent variable of **Working Memory performance**.

- The study method explained here does not contain any outstanding ethical concerns that were identified by the ethics panel that would affect participants other than the debrief for this experiment, revealing the investigation's true aims and procedure to lift any deception that may have been used to maintain the integrity of the investigation.
- Participants would give informed consent before beginning the study through use of an information sheet and consent form, all in line with the BPS code of research ethics.

INTERACTION

- This design allowed us to test the core idea of synchrony effects.
- With, for example, morning types being tested in the morning would be congruent to their chronotypes, whereas being tested in the evening would leave them incongruent with their chronotypes, the same with evening types.

MATERIALS

QUESTIONNAIRE -MEQ

- To determine participants' Chronotypes, we used the 19-item Morningness–Eveningness Questionnaire (MEQ), developed by Horne and Oseberg,
- Delivered via Qualtrics, it asks participants questions based on their sleeping habits and patterns and scores based on responses; a low score indicates a preference towards eveningness while a high score indicates a preference towards Morningness
- Using the mean global score as a cut-off, we divided participants into Larks or owls depending on their score being higher or lower than this mean.

TASK – BROWN PETERSON

- To assess **working memory**, we used a modified **Brown-Peterson task**, created in SuperLab.
- Participants were shown a three-letter trigram, followed by a distractor task of odd/even number identification, then asked to recall the trigram.
- Each trial increased the distractor delay time and got progressively harder and more complex, simulating a gradual increase in cognitive load. This task ended after one error, and the furthest trial achieved would be their working memory score

PROCEDURE

The basic procedure of this experiment is as follows

PHASE 1 – Determining Chronotype

- Each participant would enter the lab at their chosen time and first read and complete an information sheet and provide informed consent form through documents attached in Qualtrics.
- They would then be left alone to complete the MEQ on a university laptop and were asked to notify the researcher when this was completed.

PHASE 2 – Assessing working memory

- Participants would then be asked to read the instructions presented on the PC screen that would explain the process of the working memory task
- They were given one practice round of the task before beginning the recorded trials and allowed to ask questions if anything didn't make sense, but were then left alone to complete this.
- After this had been completed, the participant would receive a verbal debrief as well as a physical debrief form they could keep, and this would mark the end of the experiment.
- Depending on individual performance on the memory task, full participation would usually take between 15 and 30 minutes.
- Prior to participants entering the lab I would have assigned a unique identifier code that would later be used to match up both MEQ responses and memory task outcomes (M1, E1)

- After repeating this for all 42 participants, results were ready for analysis.

Results

- Looking at the average memory scores, we can see a clear pattern emerging that is in line with existing literature.
- Participants in congruent conditions — that is, those tested at their optimal time of day — performed better on average than their incongruent counterparts.
- Congruent Larks had the highest average score at 11.64 out of a possible 15, followed by congruent Owls at 9.73.
- In contrast, both incongruent groups scored lower, with Larks at 8.6 and Owls at 8.8. This suggests a time-of-day alignment advantage, particularly for morning types.
- Across conditions, Larks generally performed better than Owls, and were also found to be slightly older on average.
- With the combined congruent participants beating the combined incongruent by an average of 2
- Descriptive stats for the overall sample showed a mean memory score of 9.5 and an average MEQ score of 46.14, both with reasonably wide standard deviations
- However, after conducting **ANOVA** to assess the interaction between chronotype and time of testing on memory scores.
- Results showed that **neither the main interaction effect** nor the **main effects of chronotype or time of testing** were statistically significant. The F-values were low, and **p-values were well above .05**,
- This means that although a pattern has been observed, the data did not reach statistical significance and so our initial hypothesis is not supported.

Discussion

- The non-significant findings drawn from this investigation are in direct contrast to most past studies that demonstrated a synchronicity effect when working memory is tested at congruent times of day. (Manly et al., 2002; West et al., 2002).
- **Participants often stated that the task fast-paced and intense — indicative of high cognitive load, where synchronicity effects are usually more detectable (Schmidt et al., 2015).**
- Instead, these findings almost exactly reflect a study by Evansová et al. (2022), who also found a trend but no significant interaction.
- **Research suggests early school/work times harm performance, especially for Owls (Evans et al., 2017).**
- **And to support that, this study showed more consistency in congruent groups and more variability in incongruent ones, though without statistical significance.**

Limitations and influences

- The primary influence on the non-significant outcome appears to be the small sample size.
- **Larger studies of this nature (e.g., Beşoluk et al., 2011, N=1471) have found significant results in student populations — so sample size here may be a key limiting factor.**
- In almost an identical fashion to Evansová's study, a trend was notated but the small sample size of only 42 participants that were able to be recruited during the time frame meant that it simply wasn't reflective of a larger population.
- Perhaps a study with a larger sample size will yield a more significant pattern of synchronicity.
- This study also recruited considerably more males than females which also may have skewed results as research shows that typically it is men who possess greater visual episodic memory, which would be beneficial for the task used in this investigation. (Pauls)

Implications

- Despite non-significance, results support emerging synchronicity trends, especially for older undergrads (mean age = 31).
- Suggests chronotype mismatches with academic and work schedules may affect younger students more, as cognitive flexibility improves with age.
- Adds to the case that Roenneberg himself originally pitched about the importance of flexible start times in education, particularly during adolescence when natural wake times are typically later anyway (Roenneberg et al., 2004).

Conclusion & Final Thoughts

- This study set out to investigate whether working memory performance is affected by whether someone is tested at a time that matches their chronotype.
- Based on the data collected, we did not find statistically significant evidence that being tested at your optimal time gives you a clear advantage—at least within this small sample of undergraduate students.
- The results suggest that, for groups with similar characteristics—such as age and academic background—standardised testing times may still be fair for assessments involving working memory.
- That said, a directional trend did begin to emerge. So with a larger, more diverse sample, it's likely the synchronicity effect might become more apparent and significant.
- This opens up an important discussion:
- Should society continue to expect everyone to operate at the same schedule, when biology tells us we all peak at different times?
- Could we one day tailor education or work schedules to better match people's cognitive rhythms?
- I did find meaningful patterns that suggest our internal clocks deserve a lot more attention—especially in environments built around performance and memory.