

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



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

Psychology Empirical Project: 2205141

Background - Chronotypes

- What is a Chronotype? - Ronnenberg
- Larks and Owls
- MEQ (Horne & Östberg, 1976)
- Evolutionary Roots - The Sentinel Hypothesis
- Suprachiasmatic Nuclei (SCN) and Circadian Rhythms
- Chronotype & Academic Performance
- The Synchronicity Effect
- Working Memory

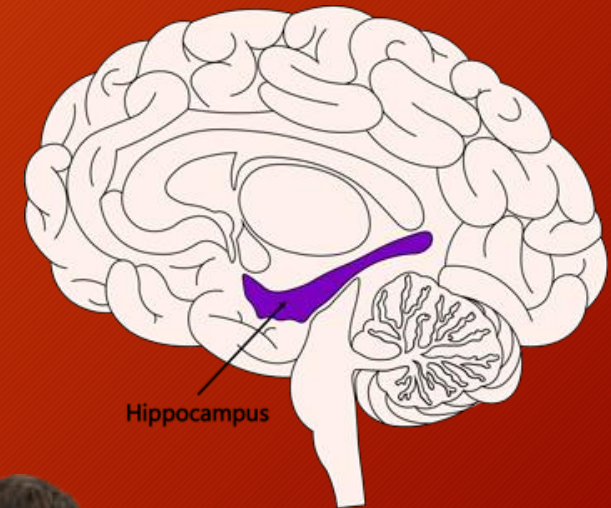
(Arrona-Palacios & Díaz-Morales, 2018; Breus, 2016; Hahn et al., 2012; Hasher et al., 2014; Kossowski et al., 2021; May, 1999; Nunn et al., 2016; Roenneberg, 2013; Samson et al., 2017; Schmitt et al., 2009)



Background - Working Memory (WM)

- **Working Memory Key Studies**

- (Abdul Jafar et al., 2023) – Synchronicity effects for WM can be observed even in infants
- (Montaruli et al., 2019) - Morningness has the advantage in theoretical and practical exams
- (Schmidt et al., 2015) - synchronicity effects are most observable during high *WM Cognitive Load*



- **Literature Review Takeaway**



Aims and Research Questions

- **RESEARCH QUESTION**

“Will a participant tested at a time **congruent to their chronotype** perform better on a working memory task when compared to someone tested at an **incongruent time**?”

- **HYPOTHESIS**

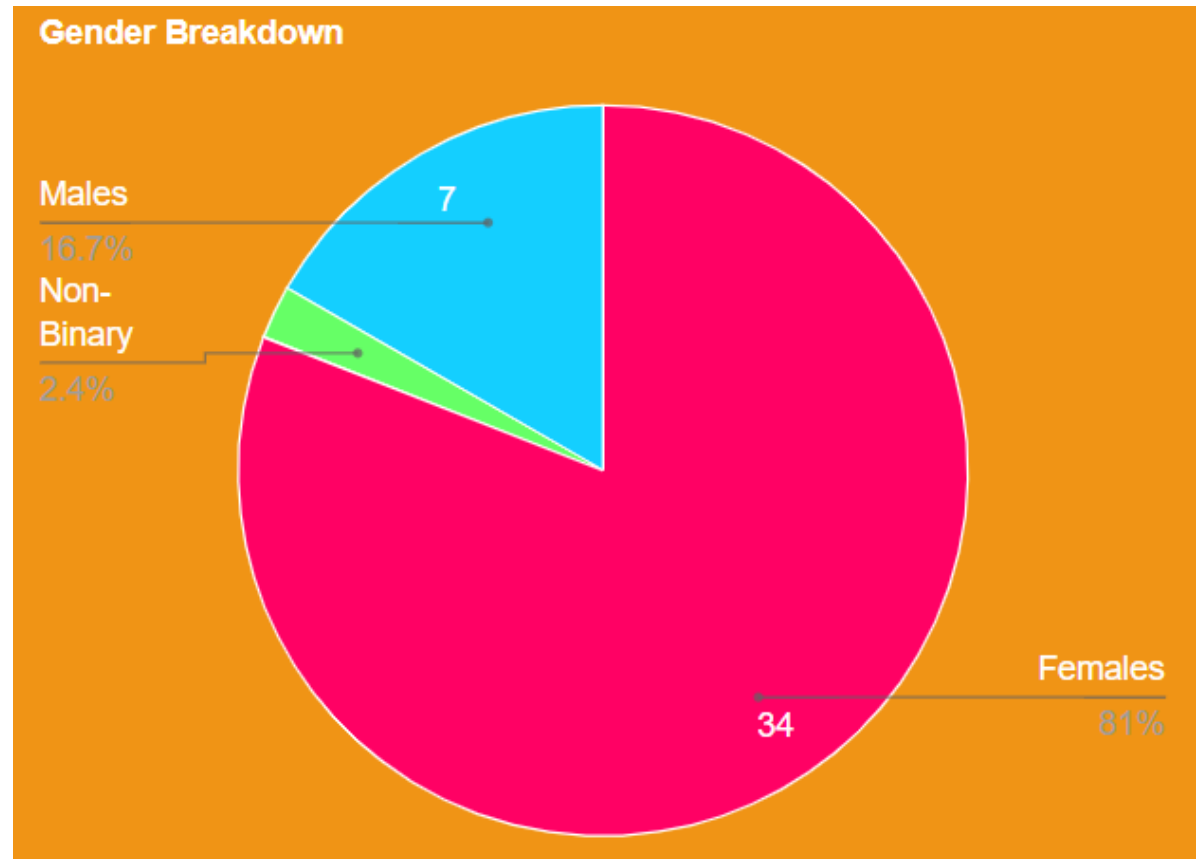
“On a **working memory** task involving moderate to high **cognitive load**, participants tested at a time congruent to their chronotypes will perform better than those tested incongruently, demonstrating the **synchronicity effect**”



Methodology - Participants

- 42 participants - UWTSD Psychology students
- 7 Males, 34 Females, 1 Non-Binary
- Age Range: 18 - 56
- ($M = 31.3$, $SD = 9.63$)
- *'Must have normal or corrected to normal vision'*
- Ethical Considerations

(BPS, 2021; Evans et al., 2017)



Design

- Lab-based 2x2 between-subjects quantitative experimental design
- Independent Variables
 - IV1 - Chronotype (Lark vs Owl)
 - IV2 - Time of testing (Morning vs Afternoon group)
- Dependent Variable
 - **Working Memory Performance**
- Two-way between-subjects **ANOVA**



Main Effect (Groups)		Main Effect (Chronotype)		
Interaction				
Morning Group	+	Morning Person	=	Congruent
Morning Group	+	Evening Person	=	Incongruent
Evening Group	+	Morning Person	=	Incongruent
Evening Group	+	Evening Person	=	Congruent

Methodology - Materials

Chronotype Measure

- **Morningness-Eveningness Questionnaire (MEQ)** - (Horne & Östberg, 1976)
 - *“What time would you get up if you were entirely free to plan your day?”*
 - *“At what time of the day do you think that you reach your ‘feeling best’ peak?”*
- 19 items | Qualtrics
- Chronotypes categorised by global mean
 - Low score = Evening Type (OWL)
 - High Score = Morning Type (LARK)

Methodology - Materials

Working Memory Task

- **Modified Brown-Peterson Task**
 - Brown (1958) and Peterson & Peterson (1959)
- **Three Letter Trigrams**
- **Odd or Even Distractor Task**
- Simulates an increasing Cognitive Load
- Furthest trial achieved without a mistake = **WM score**

Memorise this TRIGRAM

HBW

Using the keyboard
Please type the ODD number

3

4

EVEN

15

18

3

9

Please recall the TRIGRAM
And press ENTER

Trial 1 – OKL (8s)

Trial 2 – LYE (12s)

Trial 3 – MBC (16s)

Trial 4 – QSF (20s)

Trial 5 – KDR (24s)

Trial 6 – COA (28s)

Trial 7 – UEJ (32s)

Trial 8 – FXI (36s)

Trial 9 – ARB (40s)

Trial 10 – TSH (44s)

Trial 11 – GWC (48s)

Trial 12 – HWI (52s)

Trial 13 – MDT (56s)

Trial 14 – YRC (60s)

Trial 15 – BXA (64s)

Methodology - Procedure

PHASE 1 - MEQ

- Introduction to labs
- Information sheet
- Consent Form
- MEQ
- Notify the researcher for phase 2

(10 minutes)

PHASE 2 - Brown-Peterson Task

- Verbal Explanation of WM task
- Read the instructions
- Practice Trial
- Recorded Trials
- Debrief Sheet
- Exit

(5 - 20 minutes)

Morning Group - M1, M2, M3 ...
Evening Group E1, E2, E3 ...

Results

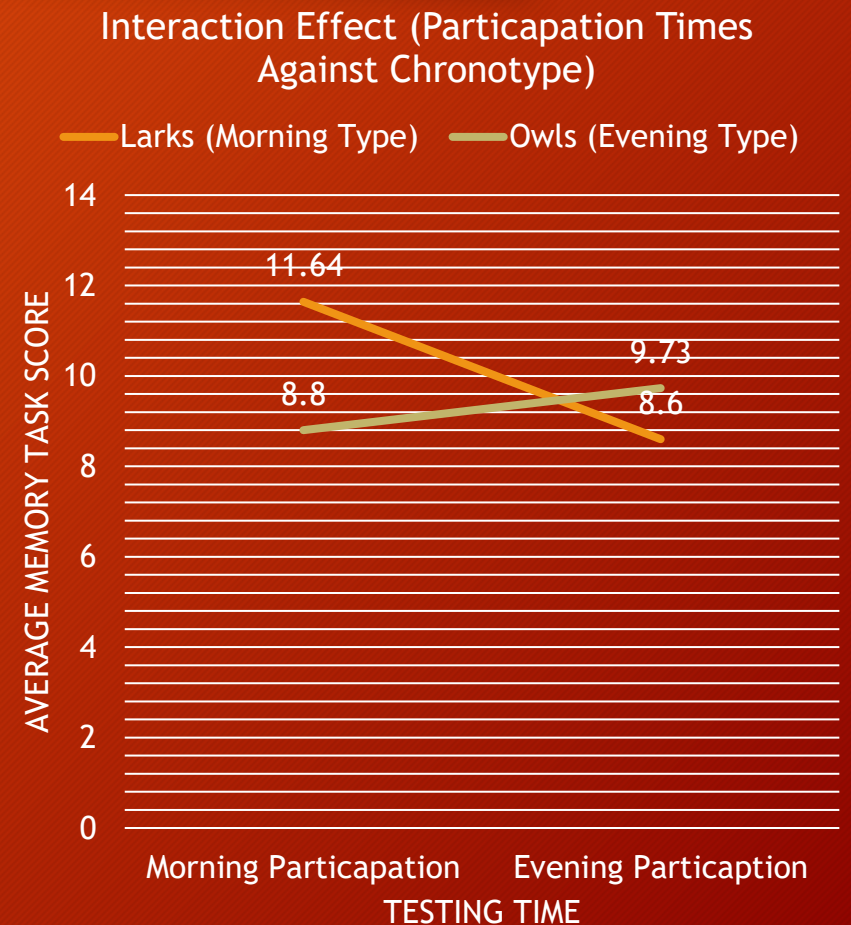
Mean WM score	- 9.5 / 15	Congruent Larks - 11.64
Mean MEQ response	- 46.14	Congruent Owls - 9.73
Lark's overall	- 10.29	Incongruent Larks- 8.6
Owl's overall	- 9.19	Incongruent Owls - 8.8
Both Incongruent Groups	- 8.7	
Both congruent Groups	- 10.68	

ANOVA

Main interaction effect - $F(1, 38) = 1.63, p = .21$ (non-significant)

Main effect Chronotype - $F(1, 38) = .46, p = .5$ (non-significant)

Main effect testing time - $F(1, 38) = .3, p = .59$ (non-significant)



General Discussion

- The Outcome
- Findings do not reflect the majority of existing research
- Task had a high Cognitive Load
- Limitations and Influencing Factors
 - Small Sample size
 - Men possess greater visual episodic memory
- Implications
 - Incongruency affects younger students more
 - Need for flexible start times

(Beşoluk et al., 2011; Evansová et al., 2022; Manly et al., 2002; Pauls et al., 2013; Schmidt et al., 2015; West et al., 2002)



Evaluation and Conclusion

- Is WM performance affected by congruent testing time with one's chronotype?
- Small sample size, age and psychological background
- Directional trends
- Implications of 9-5 work and academic schedules
- How important are our internal clocks?

(Pauls et al., 2013; Ronnenberg et al., 2004)



Thank You



Any Questions?

References

1

- Abdul Jafar, N. K., Tham, E. K., Eng, D. Z., Rifkin-Graboi, A., Gooley, J. J. & Goh, D. Y. (2023). Chronotype and time-of-day effects on spatial working memory in preschool children. *Journal of Clinical Sleep Medicine*, 19(10), 1717-1726. <https://doi.org/10.5664/jcsm.10650>
- Arrona-Palacios, A., & Díaz-Morales, J. F. (2018). Morningness–eveningness is not associated with academic performance in the afternoon school shift: Preliminary findings. *British Journal of Educational Psychology*, 88(3), 480-498. <https://doi.org/10.1111/bjep.12196>
- Beşoluk, Ş., Önder, İ., & Deveci, İ. (2011). Morningness-eveningness preferences and academic achievement of university students. *Chronobiology international*, 28(2), 118-125. <https://doi.org/10.3109/07420528.2010.540729>
- Breus, M. (2016). *The Power of When: Learn the best time to do everything*. Random House.
- British Psychological Society. (2021). *BPS Code of Human Research Ethics* (2nd ed.). <https://www.bps.org.uk/news-and-policy/bps-code-human-research-ethics-2nd-edition-2014>
- Brown, J. (1958). Some tests of the decay theory of immediate memory. *Quarterly journal of experimental psychology*, 10(1), 12-21. <https://doi.org/10.1080/17470215808416249>
- Esteki, M., & Sadeghi, D. (2010). Comparison of short term memory efficiency (visual and audio) at circadian rhythm (chronopsychology). *Procedia-Social and Behavioral Sciences*, 5, 2002-2005. <https://doi.org/10.1016/j.sbspro.2010.07.404>
- Evans, M. D., Kelley, P., & Kelley, J. (2017). Identifying the best times for cognitive functioning using new methods: matching university times to undergraduate chronotypes. *Frontiers in human neuroscience*, 11, 1-11. <https://doi.org/10.3389/fnhum.2017.00188>
- Evans, M. D., Kelley, P., & Kelley, J. (2017). Identifying the best times for cognitive functioning using new methods: matching university times to undergraduate chronotypes. *Frontiers in human neuroscience*, 11, 1-11. <https://doi.org/10.3389/fnhum.2017.00188>

References

2

- Evansová, K., Červená, K., Novák, O., Dudysová, D., Nekovářová, T., Fárková, E., & Fajnerová, I. (2022). The effect of chronotype and time of assessment on cognitive performance. *Biological Rhythm Research*, 53(4), 608-627. <https://doi.org/10.1080/09291016.2020.1822053>
- Hahn, C., Cowell, J. M., Wiprzycka, U. J., Goldstein, D., Ralph, M., Hasher, L., & Zelazo, P. D. (2012). Circadian rhythms in executive function during the transition to adolescence: The effect of synchrony between chronotype and time of day. *Developmental science*, 15(3), 408-416. <https://doi.org/10.1111/j.1467-7687.2012.01137.x>
- Hasher, L., Goldstein, D., & May, C. P. (2014). It's about time: Circadian rhythms, memory, and aging. In *Human Learning and Memory* (pp. 199-217). Psychology Press.
- Horne, J. A., & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of chronobiology*, 4(2), 97-110.
- Kossowski, B., Drozdziel, D., Rode, K., Michałowski, J., Jankowski, K., Wypych, M., Wolska, A. & Marchewka, A. (2021). The influence of light exposure and chronotype on working memory in humans. *Acta Neurobiologiae Experimentalis*, 81(2), 111-120. <https://doi.org/10.21307/ane-2021-011>
- Manly, T., Lewis, G. H., Robertson, I. H., Watson, P. C., & Datta, A. K. (2002). Coffee in the cornflakes: time-of-day as a modulator of executive response control. *Neuropsychologia*, 40(1), 1-6. [https://doi.org/10.1016/S0028-3932\(01\)00086-0](https://doi.org/10.1016/S0028-3932(01)00086-0)
- May, C. P. (1999). Synchrony effects in cognition: The costs and a benefit. *Psychonomic Bulletin & Review*, 6(1), 142-147. <https://doi.org/10.3758/BF03210822>
- Montaruli, A., Castelli, L., Galasso, L., Mulè, A., Bruno, E., Esposito, F., Caumo, A., & Roveda, E. (2019). Effect of chronotype on academic achievement in a sample of Italian University students. *Chronobiology international*, 36(11), 1482-1495. <https://doi.org/10.1080/07420528.2019.1652831>
- Nunn, C. L., Samson, D. R., & Krystal, A. D. (2016). Shining evolutionary light on human sleep and sleep disorders. *Evolution, medicine, and public health*, 2016(1), 227-243. <https://doi.org/10.1093/emph/eow018>

References

3

- Pauls, F., Petermann, F., & Lepach, A. C. (2013). Gender differences in episodic memory and visual working memory including the effects of age. *Memory*, 21(7), 857-874. <https://doi.org/10.1080/09658211.2013.765892>
- Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, 58(3), 193-198. <https://doi.org/10.1037/h0049234>
- Roenneberg, T. (2013). The human sleep project. *Nature*, 498(7455), 427-428. <https://doi.org/10.1038/498427a>
- Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Merrow, M. (2004). A marker for the end of adolescence. *Current biology*, 14(24), 1038-1039.
- Samson, D. R., Crittenden, A. N., Mabulla, I. A., Mabulla, A. Z., & Nunn, C. L. (2017). Chronotype variation drives night-time sentinel-like behaviour in hunter-gatherers. *Proceedings of the Royal Society B: Biological Sciences*, 284(1858), 1-8. <https://doi.org/10.1098/rspb.2017.0967>
- Schmidt, C., Collette, F., Leclercq, Y., Sterpenich, V., Vandewalle, G., Berthomier, P., & Peigneux, P. (2009). Homeostatic sleep pressure and responses to sustained attention in the suprachiasmatic area. *Science*, 324(5926), 516-519. <https://doi.org/10.1126/science.1167337>
- Schmidt, C., Collette, F., Reichert, C. F., Maire, M., Vandewalle, G., Peigneux, P., & Cajochen, C. (2015). Pushing the limits: chronotype and time of day modulate working memory-dependent cerebral activity. *Frontiers in neurology*, 6, 199-208. <https://doi.org/10.3389/fneur.2015.00199>
- West, R., Murphy, K. J., Armilio, M. L., Craik, F. I., & Stuss, D. T. (2002). Effects of time of day on age differences in working memory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57(1), 3-10. <https://doi.org/10.1093/geronb/57.1.P3>
- Wilson, M. A., & McNaughton, B. L. (1994). Reactivation of hippocampal ensemble memories during sleep. *Science*, 265(5172), 676-679. <https://doi.org/10.1126/science.8036517>