



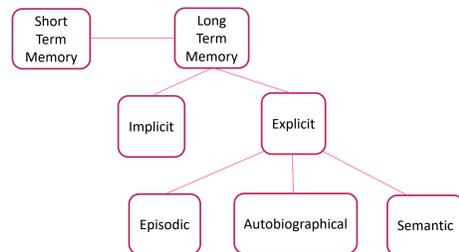
# The Impact of Technology Use Before Sleep and its Effects on Implicit and Explicit Memory Retention

Lauren Radicchi



## Introduction

- Sleep is a very important bodily process which people require in order to function properly
  - Most of the body's systems enter an anabolic state, restoring the immune, nervous, skeletal, and muscular systems<sup>1</sup>.
  - These are vital processes that maintain mood, memory, and cognitive function, and play a large role in the function of the endocrine and immune systems<sup>1</sup>
- There are two main types of memory, short term and long term.
  - Short term memory
    - Lasts for a matter of minutes<sup>3</sup> (the information at the "front" of your brain)
    - Magic number  $7 \pm 2$ <sup>4</sup>
  - Long term memory
    - Anything that can be recalled<sup>5</sup>
    - Implicit vs. Explicit
      - Implicit memory is controlled by your subconscious
        - How to ride a bike, how to speak
      - Explicit memory (Episodic, Semantic, Autobiographical)
        - Episodic<sup>6</sup> — Events (your wedding, graduating)
        - Semantic<sup>7</sup> — Facts (Capital of New York,  $2+2=4$ )
        - Autobiographical<sup>8</sup> — Memories about self (Where you live, your family)



- For over two decades, scientists have been aware of the fact that sleep improves long term memory consolidation<sup>2</sup>
  - REM sleep and slow wave sleep have each been proven to be fundamental to memory consolidation<sup>2,8</sup>.
  - Sleep has been shown to help strengthen explicit and implicit memory<sup>9,10</sup>
- Technology diminishes sleep time as well as sleep quality<sup>11,12</sup>
  - "Interactive" technology, technology with a screen that the user interacts with, are more likely to cause sleep difficulties than TVs<sup>13</sup>

## Literature Review

The capabilities of one's immune system is partially affected by the amount of sleep that a person gets.

Zager, et al. (2007)

For over two decades, scientists have known that sleep improves long term memory.

Karni et al. (1994)

Both early and late sleep help with the retention of implicit and explicit memory.

Born and Plihal (1997).

REM sleep and slow wave sleep have each been proven to improve memory.

Karni, et al. (1994)

Implicit memory can also be found to benefit from SWS

Gais et al (2016).

Sleep deprivation negatively impacts implicit memory

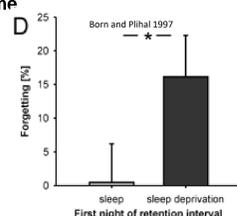
Schacter, et al. (1987)

More screen time is related to lower sleep quality.

Lemola, et al. (2014)

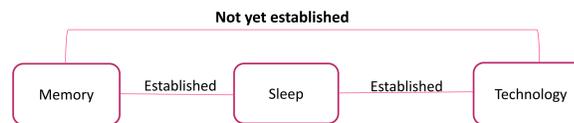
More screen time is related to shorter sleep time

Taveras, et al. (2015)



<http://learnmem.cshlp.org/content/13/3/259.full.html>

## Gap in the Research



## Hypothesis

A group who does not use technology before sleep will experience a less significant hindrance in explicit and implicit memory consolidation compared to groups who do use technology or follow their normal habits.

## Methodology

### Participants

All participants will be adolescents, from age 10 to age 19. They will be recruited from high schools and middle schools in the Dutchess and Putnam county area.

### Pre-Survey

In order to determine if participants met the inclusion criteria, all persons intending to participate in the study had to take a pre-survey. The pre-survey asked questions regarding demographic info, mental health, history of illness, and other vital information that could cause outliers in my study. The exclusion criteria includes having a diagnosed sleep disorder, memory associated learning disability, or a history of over three severe concussions.

### Sleep Tracking Technology

#### Oura Ring

- Used as a method of tracking qualitative sleep data
  - Body Temperature<sup>16</sup>
  - Amplitude and intensity of body movement<sup>16</sup>
  - Cardiovascular dynamics<sup>16</sup>



### No Technology Requirements

## Technology

- No screen technology 1 hour before sleep
- This includes TV, computers, phones and tablets

## Memory Tasks

### Word fragment completion task

- Tests implicit memory
- To-be-tested words are presented
- Ten minute distractor period to ensure the mind is using long term not short term memory
- Presented fragments of the original words, participant has to fill in missing letters

### Word pair association task

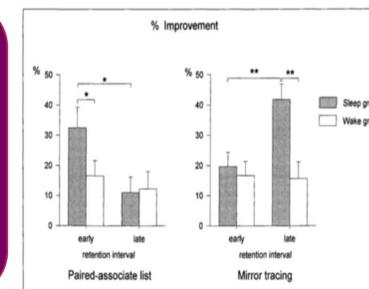
- Tests explicit memory
- Participants are given a series of sets of two words, and are allowed to study those words for five minutes
- After a ten minute distractor period, the subjects are asked to recall one of the two words, which has been removed.

## Previous Results

### Born and Plihal (1997)

**Purpose:** Looked into early and late nocturnal sleep and the impact on both explicit and implicit memory.

**Results:** Sleep generally enhanced recall when compared with the effects of corresponding retention intervals of wakefulness.



### Lemola et al. (2014)

**Purpose:** Examined changes in adolescents' electronic media use at night and sleep associated with smartphone ownership.

**Results:** Smartphone ownership was related to more electronic media use in bed before sleep compared to adolescents with a conventional mobile phone.

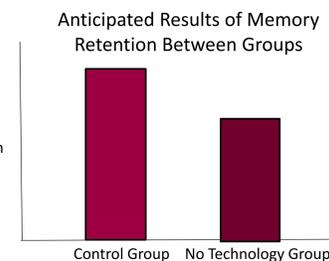
### Falbe et al. (2015)

**Purpose:** Examined associations of different screens in sleep environments with sleep duration and perceived insufficient rest or sleep.

**Results:** Presence of a small screen, but not a TV, in the sleep environment and screen time were associated with perceived insufficient rest or sleep

## Anticipated Results

- It is anticipated that there will be a significant impact caused by technology before sleep on memory.
- Previous research has shown that technology use overall worsens sleep, and poor sleep overall negatively impacts memory.



## Discussion

- If the results of my study prove that technology use before sleep has an impact on memory, it could provide helpful insights into aspects of technology that we do not yet fully understand, such as how it affects our brain.
- It is difficult to study technology, as it is constantly advancing, and older technology becomes obsolete.
- Technology hurts our sleep patterns, as it keeps our minds stimulating psychologically, making them unable to wind down, delaying the time at which people go to sleep.
- There is also an affect from the light emitted from our screens, which impacts us neurologically, keeping us awake in that aspect.
- Worsened sleep harms our memory because we do not enter the correct stages of sleep for as long as we need to, which damages memory consolidation capabilities.

## Conclusion

- Considering its prevalence in the everyday lives of adolescents, it is important to understand how it impacts their lives, especially in terms of aspects such as memory.
- There is no research on technology use before sleep and how it relates to memory.
- Based on previous results of studies relating to my project, it is expected that memory will be impacted by technology use.

## Significance

- The results of this research could have a variety of implications on adolescent life.
- Schooling
  - Standardized testing times
  - Later school start times
  - Improved study skills
- Understanding how technology impacts memory
- Can be applied to parents' technology recommendations at home, especially in younger adolescents
- As technology is very hard to study, as it is constantly changing, and so it is very important to understand how it impacts aspects of our lives as it continues to develop

## Future Research

- Research could and should be conducted in order to further this research and possibly apply it.
- Technology use before sleep affects implicit memory
- Another avenue of research could be to look into how it impacts short term memory.
  - Does it impact how the 7± 2 rule?
- Adult population
- Blue light and how it relates to memory, if at all.
- Long term impact on memory, when adolescents do not use technology prior to sleep

## Acknowledgements

I would like to thank my mentor, Dr. Schapiro, for aiding me in study design. I would also like to extend my gratitude to Ms. Gillian Rinaldo and the rest of the Science Research team at Pawling High School for their support.

## Bibliography

- "Sleep-wake cycle: its physiology and impact on health" (PDF). National Sleep Foundation. 2006. Retrieved 24 May 2017.
- Karni, A., Tanne, D., Rubenstein, B., Askenasy, J., & Sagal, D. (1994). Dependence on REM sleep of overnight improvement of a perceptual skill [Abstract]. *Science*, 265(5172), 679-682. doi:10.1126/science.8036518
- Rechtschaffen, A., Kales, A. (1968). *A Manual of Standardized Terminology, Techniques and Scoring System For Sleep Stages of Human Subjects*. US Dept of Health, Education, and Welfare: National Institutes of Health.
- Miller, G. A. (1956). THE MAGICAL NUMBER SEVEN, PLUS OR MINUS TWO: SOME LIMITS ON OUR CAPACITY FOR PROCESSING INFORMATION. *Journal of Experimental Psychology*, 42, 31-51. doi:10.1037/h0042157
- Cherry, K. (2018, October 13). How Long Does Short-Term Memory Last? Retrieved from <https://www.vivawellmind.com/what-is-short-term-memory-229348>
- Explicit Memory. (2015, August 24). Retrieved from <https://www.brainiac.com/brain-resources/memory/types-of-memory/explicit-memory>
- McRae, Ken; Jones, Michael (2013). "Semantic Memory". In Reisberg, Daniel. *The Oxford Handbook of Cognitive Psychology*. New York, NY: Oxford University Press. pp. 206-216. ISBN 9780195375746.
- Wilson, M., & McNaughton, B. (1994). Reactivation of hippocampal ensemble memories during sleep [Abstract]. *Science*, 265(5172), 676-679. doi:10.1126/science.8036517
- Explicit Memory. (2015, August 24). Retrieved from <https://www.brainiac.com/brain-resources/memory/types-of-memory/explicit-memory>
- Schacter, D. L. (1987). "Implicit memory: history and current status". (PDF). *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 13, 501-518. doi:10.1037/0278-7393.13.3.501.
- Gais, S., Lucas, B., & Born, J. (2006). Sleep after learning aids memory recall. *Learning & Memory*, 13(3), 259-262. doi:10.1101/1m.132106
- Gradisar M., Wolfson AR, Harvey AG, Hale L, Rosenberg R, Cassler CA. The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 Sleep in America Poll. *J Clin Sleep Med* 2013;9(12):1291-1299.
- Plihal, W., & Born, J. (1997). Effects of Early and Late Nocturnal Sleep on Declarative and Procedural Memory. *Journal of Cognitive Neuroscience*, 9(4), 534-547. doi:10.1162/jocn.1997.9.4.534
- Lemola, S., Perkinson-Gloor, N., Brand, S., Dewald-Kaufmann, J. F., & Grob, A. (2014). Adolescents' Electronic Media Use at Night, Sleep Disturbance, and Depressive Symptoms in the Smartphone Age. *Journal of Youth and Adolescence*, 44(2), 405-418. doi:10.1007/s10964-014-0176-x
- Sleep Duration, Restfulness, and Screens in the Sleep Environment [Abstract]. (2015). *Psychology*, 13(2). doi:10.1542/peps.2014-2306d
- Learn how Oura ring works | Go inside. (n.d.). Retrieved from <https://ouraring.com/learn-how-oura-works/>