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

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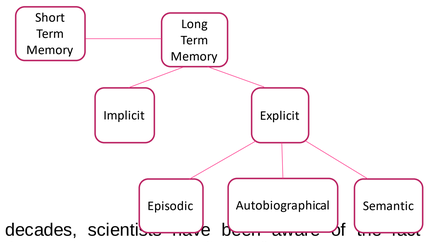
Introduction

- 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[1].
  - 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[1]
- There are two main types of memory, short term and long term.
  - Short term memory
    - Lasts for a matter of minutes[3] (the information at the "front" of your brain)
    - Magic number 7± 2 [4]
  - Long term memory
    - Anything that can be recalled[5]
    - Implicit vs. Explicit
      - Implicit memory is controlled by your subconscious
        - How to ride a bike, how to speak
      - Explicit memory (Episodic, Semantic, Autobiographical)
        - Episodic[6] — Events (your wedding, graduating)
        - Semantic[7] — Facts (Capital of New York, 2+2=4)
        - Autobiographical[6] — 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[2]
  - REM sleep and slow wave sleep have each been proven to be fundamental to memory consolidation[2,8].
  - Sleep has been shown to help strengthen explicit and implicit memory[9,10]
- Technology diminishes sleep time as well as sleep quality[11,12]
  - "Interactive" technology, technology with a screen that the user interacts with, are more likely to cause sleep difficulties than TVs[13]

Literature Review

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)

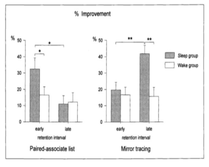
Implicit memory can also be found to benefit from SWS
Gais et al (2016).

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)

Exposure to a screen before sleep leads to poorer perceived rest.
Falbe et al. (2015)



Gap in the Research

Not yet established

Memory — Established — Sleep — Established — Technology

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 were adolescents, from age 10 to age 19. They were recruited from middle and high schools in Dutchess County. They filled out informed consent forms.

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 the 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 quantitative sleep data
  - Body Temperature[16]
  - Amplitude and intensity of body movement[16]
  - Cardiovascular dynamics[16]

https://ouraring.com/products/

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

Results

Sleep Diaries

Descriptives

	Groups	Word Pair Association Task	Word Fragment Completion Task	Total Sleep Time	Rate sleep 1-5	Changes to daytime sleepiness
N	0	3	3	3	3	3
	1	3	3	3	3	3
	2	3	3	3	3	3
Mean	0	8.67	26.3	462	3.67	2.33
	1	8.33	27.3	438	3.33	2.67
	2	9.67	30.3	451	3.67	2.00
Median	0	10	21	461	4	2
	1	10	36	461	3	3
	2	10	37	440	4	2
Mode	0	10.0	20.0[a]	445[a]	4.00	2.00
	1	10.0	8.00[a]	378[a]	3.00	3.00
	2	10.0	16.0[a]	417[a]	4.00	2.00
Standard deviation	0	2.31	10.1	17.0	0.577	0.577
	1	2.89	16.8	52.8	0.577	0.577
	2	0.577	12.4	40.6	0.577	0.00
Variance	0	5.33	102	289	0.333	0.333
	1	8.33	281	2786	0.333	0.333
	2	0.333	154	1651	0.333	0.00
Minimum	0	6	20	445	3	2
	1	5	8	378	3	2
	2	9	16	417	3	2
Maximum	0	10	38	479	4	3
	1	10	38	476	4	3
	2	10	38	496	4	2

[a] More than one mode exists, only the first is reported

- Analyzed using descriptive statistics
- No technology group generally scored higher

Memory Tasks

- Ran ANCOVA tests
- Only one memory task had significant results

ANCOVA

ANCOVA - Word Fragment Completion Task

	Sum of Squares	df	Mean Square	F	p
Nap	0.00	NaN			
Groups	422.49	2	211.24		0.520
How many times woke up	6.25	1	6.25		0.874
What is your gender?	35.84	1	35.84		0.716
How old are you?	450.00	1	450.00		0.339
Groups ✻ What is your gender?	579.40	2	289.70		0.461
Residuals	156.25	1	156.25		

Note. Singular fit encountered; one or more predictor variables are a linear combination of other predictor variables

[3]

ANCOVA

ANCOVA - Word Pair Association Task

	Sum of Squares	df	Mean Square	F	p
How old are you?	0.000	NaN			
Nap	−3.56e−15	0			
Groups	16.298	2	8.149		0.030
What is your gender?	10.028	1	10.028		0.024
Groups ✻ What is your gender?	26.596	2	13.298		0.018
Residuals	0.500	2	0.250		

Note. Singular fit encountered; one or more predictor variables are a linear combination of other predictor variables

[3]

- Word Pair Association Task was significant when analyzed alongside technology grouping and gender

Post-Survey

ANOVA

ANOVA - Rate how you felt on a scale of 1–5 - Focus

	Sum of Squares	df	Mean Square	F	p
Groups	0.000	NaN			
Changes to daytime sleepiness	−1.78e−15	0			
Groups ✻ Changes to daytime sleepiness	2.083	1	2.083		0.015
Residuals	0.500	4	0.125		

Note. Singular fit encountered; one or more predictor variables are a linear combination of other predictor variables

[3]

- Ran ANOVA tests
- Positive correlation between technology group and improved feelings of focus

Discussion

- It is possible that technology use before sleep worsens explicit memory but not implicit memory.
- Provides helpful insights into aspects of technology that we do not yet fully understand, such as how it affects the developing brain.
- It is difficult to study technology, as it is constantly advancing, and older technology becomes obsolete making research using that technology obsolete.
- Technology harms our sleep patterns, as it keeps our minds stimulating psychologically, making them unable to wind down, delaying the time at which people to 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 previous research on technology use before sleep and how it relates to memory.
- Technology use before sleep has a significant impact on explicit memory but not implicit memory.

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 should conducted in order to further this research and possibly apply it to a population such as small children.
- 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 works?
- 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

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