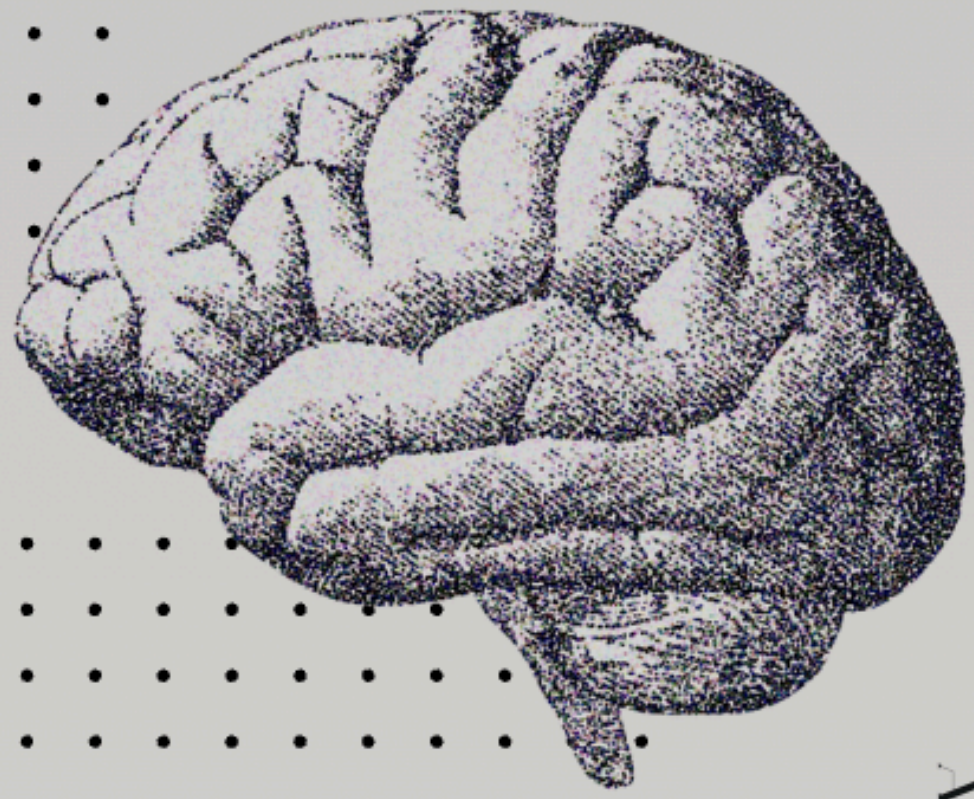
VOL 1

NEURO FRONTIERS



SLEEP AND THE BRAIN

Sleep Secrets: Discover How Brain Chemistry and Circadian Rhythms Shape Your Rest and Well-Being.

ISSUE NO 1

AUGUST 2024

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

About the Journal

Our Mission

Neuro Frontiers is a student-run research journal that empowers high school students to delve into the captivating field of neuroscience. One of the key focuses of Neuro Frontiers is to shed light on the critical intersections between neuroscience and mental health, particularly in the context of adolescence. By delving into these complex connections, the journal aims to not only expand our understanding of the brain but also raise awareness about the importance of mental well-being among young individuals.

Upcoming Issues

Music and the Adolescent Brain: Effects on Cognitive & Emotional Development

Neuroscience of Emotions: How Feelings Affect Our Brain

Resources

If you wish to continue your reading, here are a few credible resources:

https://pubmed.ncbi.nlm.nih.gov/

https://www.nlm.nih.gov/

https://scholar.google.com/

https://europepmc.org/

Contact Us

neurofrontiersjournal@gmail.com

www.neurofrontiers.wixsite.com/neuro-frontiers-1

@neuro_frontiers

@neuro.frontiers

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Table of Contents

Introduction

Works

Supplementals

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Letter from the Editor-in-Chief

Dear Readers,

Welcome to the very first issue of Neuro Frontiers! We're excited to kick things off by diving into a topic that affects us all—sleep and its impact on the brain. As high school students, understanding sleep is crucial for our daily lives and overall well-being. This issue will uncover how sleep influences our brains and bodies, and why getting quality rest is essential for our growth and success.

In this issue, we present a comprehensive look at sleep through three distinct scientific reviews. Our first review delves into the molecular aspects of sleep, unraveling the complex biochemical processes that govern our nightly rest. Next, we explore the physiological side, examining how sleep affects bodily functions and overall health. Finally, our behavioral review investigates how sleep patterns influence behavior and cognitive performance.

Additionally, we are excited to feature an exclusive interview with a board-certified neurologist who specializes in sleep medicine Dr. Mangala Nadkarni. This expert will share insights into current research and practical strategies for improving sleep, offering valuable advice for students navigating the challenges of balancing academics, extracurriculars, and rest.

To complement our scientific reviews and expert interview, we provide practical tips to enhance your sleep hygiene. These actionable recommendations are designed to help you get the most out of your rest, contributing to better focus, mood, and overall well-being.

We hope this issue not only broadens your understanding of sleep but also informs you with the knowledge to improve your own sleep practices. Dive into these pages to discover how sleep shapes our lives and how we can make the most of its benefits for better health and performance.

Thank you for joining us on this journey. Here's to an enlightening exploration of sleep and the brain!

-Varsha Senthilkumar

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Team Directory

Editors

Varsha Senthilkumar.....Editor-in-Chief

Lois Oppong.....Co-Editor

Nikhil Bogam.....Co-Editor

Marketing & Media

Niku Joshi.....Head of Marketing

Sowmya Venkatesh.....Head of Social Media

Ananya Shanabag.....Head of Graphic Design

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Molecular Dynamics of Sleep and Brain Health

Varsha Senthilkumar

ABSTRACT: This review examines the molecular mechanisms of sleep with a focus on pathways and neurotransmitters crucial for sleep regulation in adolescents. Key factors include the adenosine pathway, which signals the brain to rest by binding to A1 and A2A receptors, and neurotransmitter systems like GABA, which promotes sleep, and orexin, which maintains wakefulness. Disruptions in these systems can lead to disorders such as insomnia, narcolepsy, and hypersomnias. Insomnia is often linked to stress and genetic factors, narcolepsy to the loss of hypocretin-producing neurons, and hypersomnias to excessive GABAergic activity. The review also highlights the glymphatic system's role in clearing neurotoxic molecules during sleep and its impact on cognitive functions. Understanding these mechanisms emphasizes the importance of good sleep hygiene for adolescent well-being.

INTRODUCTION

Sleep is a fundamental biological process essential for the health and well-being of adolescents. Despite its importance, many teenagers struggle to get enough quality sleep due to various biological, social, and environmental factors. The intricate mechanisms that govern sleep are crucial for understanding how to improve sleep health among adolescents, who are particularly vulnerable to sleep disturbances during this critical developmental period. Research into the molecular mechanisms of sleep has revealed a complex dynamics of genetic, epigenetic, and neurochemical factors that regulate sleep patterns. Key genes such as DEC2 and ADA, along with various neurotransmitters and their receptors, play significant roles in sleep regulation.

Given the thoughtful impact of sleep on the health and development of adolescents, there is a pressing need for a deeper understanding of the molecular mechanisms underlying sleep and its disorders. This review aims to provide a comprehensive overview of the current knowledge on these mechanisms, with a particular focus on the role of neurotransmitters and the molecular basis of sleep science. By bringing light to these complex processes, this review aims to enhance our understanding of sleep regulation and its disorders, this review aims to enhance our understanding of sleep regulation and its disorders, ultimately contributing to

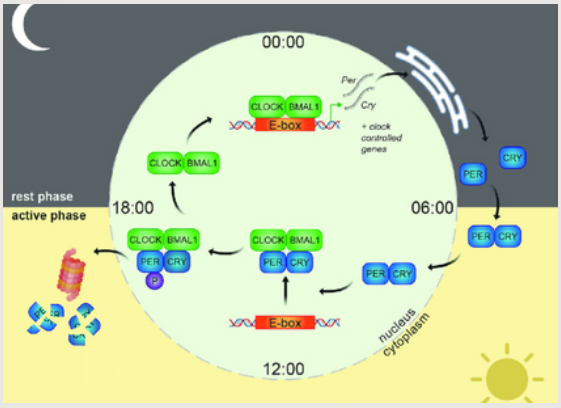
the development of more effective strategies for improving sleep health among adolescents.

CIRCADIAN RHYTHMS AND MOLECULAR CLOCKS

1. CLOCK and BMAL1 Proteins

The circadian rhythm, our body's internal clock that regulates the sleep-wake cycle, relies on specific proteins, notably CLOCK and BMAL1. These proteins are like the "gears" in the clock, keeping everything running on time.

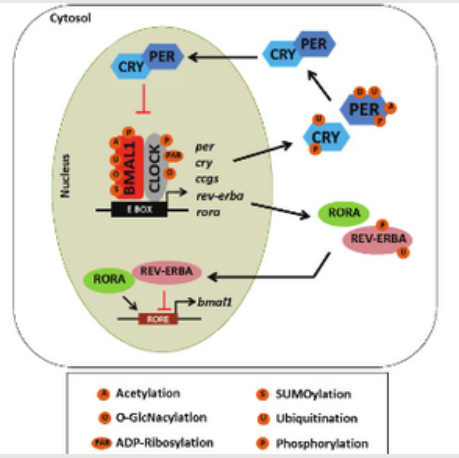
CLOCK and BMAL1 form a duo that attaches to DNA in our cells, turning on the genes that produce other CLOCK proteins like PER and CRY. These PER and CRY proteins eventually build up in the cell, move back to the nucleus (the cell's control center), and stop CLOCK and BMAL1 from working, thus turning off their own production. This process repeats roughly every 24 hours, creating our circadian rhythm[1]. PER and CRY proteins accumulate and form a complex that travels back to the nucleus. Here, they inhibit the CLOCK complex, effectively creating a feedback loop that turns off their own production until they degrade and the cycle starts again.



2. Interaction of Core Proteins in Circadian Rhythm Regulation. The diagram illustrates the role of key proteins in maintaining and modulating circadian rhythms.

To ensure the circadian clock remains precise, the CLOCK, BMAL1, PER, and CRY proteins undergo several chemical changes after they are made, known as post-translational modifications.

Phosphorylation, which involves adding a phosphate group to these proteins, can change their activity. For instance, phosphorylation of PER proteins by an enzyme called casein kinase 1 (CK1) marks them for destruction, allowing the cycle to restart. Ubiquitination tags proteins for degradation by attaching a small protein called ubiquitin. It ensures that PER and CRY are broken down at the right time, preventing the feedback loop from being blocked indefinitely.[3]

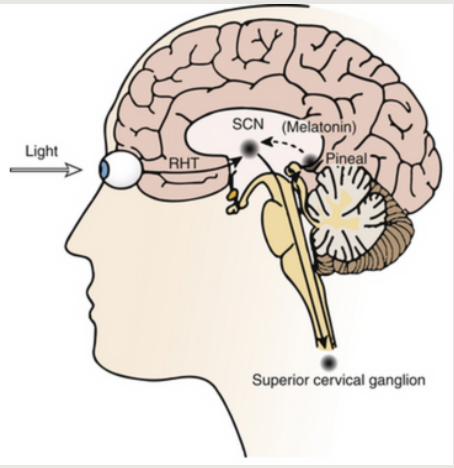


4. Post-Translational Modifications of Clock Proteins. This diagram illustrates the effects of phosphorylation and ubiquitination on clock protein function.

These modifications help maintain the stability and timing of the circadian rhythms, ensuring our body's processes stay in sync with the 24-hour day.

2. Environmental Regulation

One of the most important environmental factors influencing our circadian rhythm is light. Light exposure, particularly blue light, is detected by special cells in our eyes that contain the protein melanopsin. These cells send signals to the brain's master clock, the suprachiasmatic nucleus (SCN), adjusting our circadian rhythms to match the day-night cycle (PMC). Melanopsin-containing cells in the retina (the light-sensitive layer at the back of the eye) are crucial for this process. When they detect light, they send signals through the optic nerve to the SCN. The SCN then adjusts the production of clock proteins to keep our internal clock aligned with the external environment[5]. This synchronization helps regulate the release of sleep-inducing hormones, such as melatonin, making it easier to fall asleep at the appropriate time.

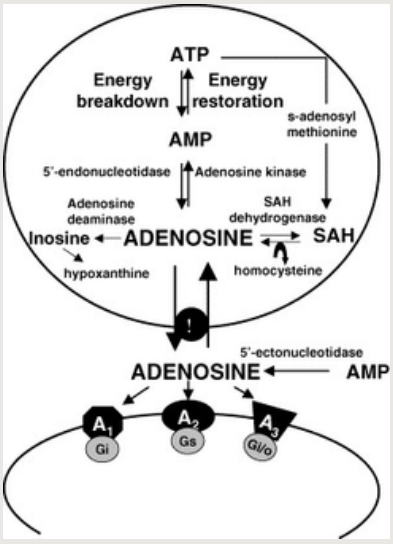


6. Regulation of Circadian Rhythms by the Suprachiasmatic Nucleus.

SLEEP HOMEOSTASIS

1. Function of Adenosine During Wakefulness

Adenosine is a crucial molecule in the regulation of sleep and wakefulness. During periods of wakefulness, adenosine levels gradually increase inthe brain, particularly in areas like the basal forebrain. This accumulation results from the breakdown of adenosine triphosphate (ATP), the energy currency of cells, which is more active during wakeful activities. As adenosine levels rise, they act as a signal to the brain that it is time to rest and recover.



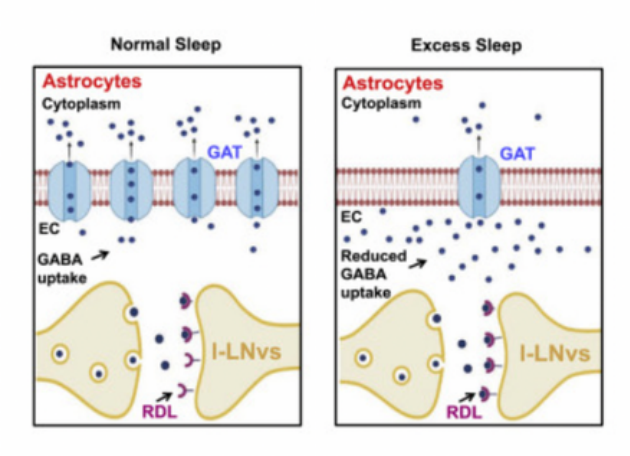
7. ATP Breakdown and Adenosine Accumulation in the Transition from Wakefulness to Sleep.

Adenosine affects sleep through its interaction with A1 and A2A receptors. A1 receptors, distributed throughout the brain, reduce neural activity, promoting sleep by lowering alertness. A2A receptors, located mainly in the basal ganglia, interact with the dopaminergic system to regulate sleep and wakefulness. These receptors and neurotransmitters work together to ensure proper sleep regulation[8].

NEUROTRANSMITTER REGULATION

1. GABAergic Signaling

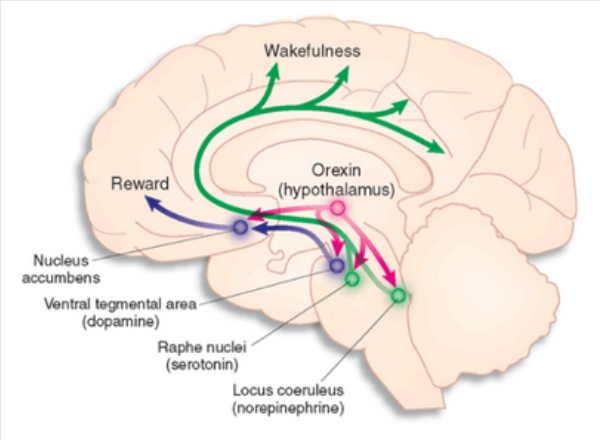
Gamma-aminobutyric acid (GABA) is the brain's primary inhibitory neurotransmitter, crucial for promoting sleep. When GABA binds to its receptors, it causes an influx of chloride ions, hyperpolarizing the cell membrane and reducing neuron activity. This process helps transition from wakefulness to sleep. Medications like benzodiazepines enhance GABA's effects, aiding in sleep onset and maintenance.



9. GABAergic Signaling and Re-Uptake During Sleep Regulation.

1. Orexin System

Orexin, or hypocretin, is a neuropeptide that promotes wakefulness. Produced in the hypothalamus, orexin stimulates various brain regions involved in maintaining alertness, essentially acting as the brain's natural coffee. Inhibition of orexin signaling, therefore, is a key mechanism for inducing sleep.[10] Drugs that block orexin receptors, known as orexin receptor antagonists, are being developed as treatments for insomnia. These drugs work by preventing orexin from binding to its receptors, thereby reducing arousal and promoting sleep onset.



11. Orexin Pathways in Sleep-Wake Cycle Regulation.

CONCLUSION

This review has explored the molecular mechanisms underlying sleep regulation, emphasizing the significance for adolescents who are at a critical stage of cognitive and physical development. Understanding the molecular mechanisms of sleep, such as adenosine's role in signaling sleep onset and neurotransmitter systems like GABAergic and orexin signaling, is crucial for adolescents. Disruptions in these systems can lead to significant sleep disorders affecting cognitive and academic performance. Future research should focus on these areas to develop more effective treatments for sleep disorders and enhance overall health outcomes. As we continue to unravel the complexities of sleep, it is crucial for students to recognize the importance of good sleep hygiene and adopt habits that promote restful and restorative sleep.

REFERENCES

1. Kaur, S., & Jaggi, A. S. (2014). Sleep deprivation and its consequences: A review. Current Neuropharmacology, 12(1), 92-104

https://pubmed.ncbi.nlm.nih.gov/24560196/
2. Smith, J., & Corsi, P. (2020). *Clock-in, clock-out: circadian timekeeping between tissues*. *Biochemical Journal*, 42(3), 207-215. https://doi.org/10.1042/BIO04202007
3. Walker, M. P., & Stickgold, R. (2004). Sleep, memory, and plasticity. PLoS Biology, 2(12), e412. https://doi.org/10.1371/journal.pbio.0020377
4. Udoh, U. S., Valcin, J. A., Gamble, K. L., & Bailey, S. (2015). *The molecular circadian clock and alcohol-induced liver injury*. *Biomolecules*, 5(4), 2504-2521. https://doi.org/10.3390/biom5042504
5. Monti, J. M., & Pandi-Perumal, S. R. (2022). Sleep and neurodegeneration: A review of recent advances. Journal of Neurochemistry, 165(4), 456-468. https://doi.org/10.1111/jnc.15132
6. Malkani, R., & Zee, P. C. (n.d.). *FIGURE 5.2 Schematic diagram of the neural pathways for light input to the circadian system*. In *Basic circadian rhythms and circadian sleep disorders*. https://neupsykey.com/basic-circadian-rhythms-and-circadian-sleep-disorders/
7. Basheer, R., Strecker, R. E., Thakkar, M. M., & McCarley, R. W. (2004). *Adenosine and sleep–wake regulation*. *Progress in Neurobiology*, 74(2), 111-128. https://doi.org/10.1016/j.pneurobio.2004.06.004
8. Young, M. W., & Kay, S. A. (2008). Timekeeping in the brain: The circadian clock. Cold Spring Harbor Symposia on Quantitative Biology, 72, 413-418. https://doi.org/10.1101/sqb.2008.72.055
9. Chaturvedi, R., Stork, T., Yuan, C., Freeman, M. R., & Emery, P. (2022). *Astrocytic GABA transporter controls sleep by modulating GABAergic signaling in Drosophila circadian neurons*. *Current Biology*, 32(6), 1464-1476. https://doi.org/10.1016/j.cub.2022.02.066
10. Brzezinski, A., & Swanson, L. W. (2023). The role of circadian rhythms in brain function and behavior. Brain Research Reviews, 125, 45-62. https://doi.org/10.1016/j.brainresrev.2023.08.005
11. Scammell, T. E., & Saper, C. B. (2007). Orexins: Looking forward to sleep, back at addiction. Nature Reviews Molecular Cell Biology, 8(2), 126. https://doi.org/10.1038/nm0207-126

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Sleep, Memory, and the Essential Nature of Rest

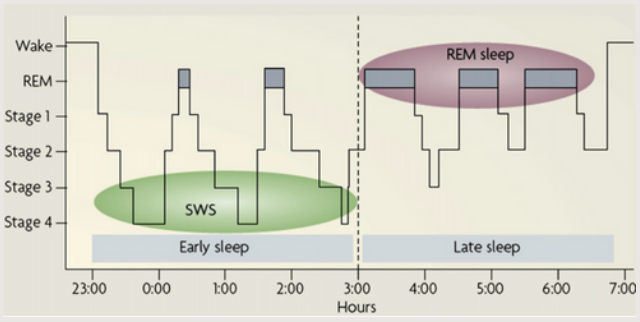
Lois Oppong

ABSTRACT: Sleep is one of the most important parts of human life, impacting memory and emotions, while being a great way to consolidate information received during a period of wake. Sleep has a great impact on all aspects of memory. While everyone says that 7-9 hours of sleep every night are important for your health, students still pull all-nighters all the time. Although some believe that all-nighters may be useful, in reality, students are cramming information into their brains without a way to remember any of it. Sleep helps to consolidate some of that memory so that you will have a way to remember it the next morning and for a long time to come. Sleep loss can be characterized by different diseases as well, emphasizing the impact that sleep actually has on people, especially students learning a lot of new information in short periods of time. The importance of sleep cannot be overstated, relating to brain growth and stimulation, but especially as it pertains to memory.

INTRODUCTION

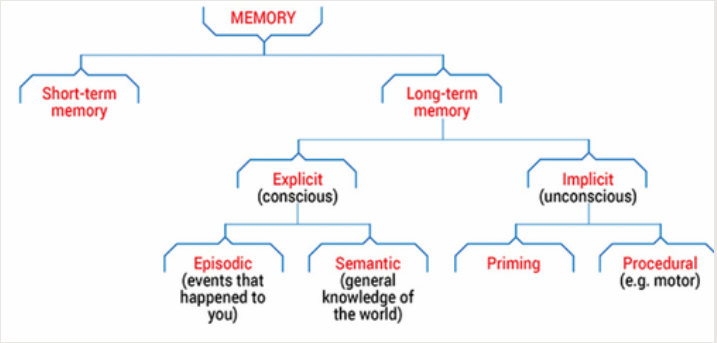
Sleep has four different stages, including three different stages of NREM sleep, listed by numbers one through three, and REM sleep, each characterized by the time that they occur throughout sleep and the different effects that they have on the brain. Sleep goes from lighter to deeper sleep through these stages of NREM sleep, while REM sleep is the closest stage before one wakes up, classified by the rapid eye movement from which this stage is named after.

1



NREM sleep, and slow wave sleep, characterized by the amplified slow waves that occur within it,[2] is generally associated with the consolidation of explicit, episodic, and spatial memories.[3,4] In contrast, REM sleep is associated with procedural and emotional memories.[5,6] Each stage is characterized by the different areas in sleep in which they occur, and the different types of memory that it impacts.

These different types of memory fall under short term memory and long term memory.
7



Long term memory is the type of memory that this review falls under, with different types of implicit and explicit memories, also known as nondeclarative and declarative memories. Explicit memory includes the conscious things that we remember and can recall, and declarative memory is a type of explicit memory which is the memory of facts and events. There are two different types of declarative memory, the first being episodic memory, the memory of events and experiences, and the second being semantic memory, the memory of facts and concepts.
There is also implicit memory, or unconscious memories. There is one type of implicit memory which is procedural memory, the memory of tasks and skills, or knowing how to do something. Sleep is necessary for building memory in all different aspects. Different stages of sleep build different types of memory, emphasizing the importance of sleep when preparing for tests, or studying in general.

EXPLICIT MEMORY

Explicit memories are impacted by the retention intervals of slow wave sleep, during the first 3-4 hours of the sleep cycle, and recall improves more significantly during this time than when someone has 3-4 hours of REM sleep. This was used in a study with word pair recall, while another study had the opposite effect with mirror tracing. This emphasizes that both slow wave sleep, and REM sleep have a positive impact on explicit memory, depending on the type of memory needed for recall. In both studies, people were told to take naps, also emphasizing the importance of getting just a bit of sleep instead of no sleep at all.[8]

1. **Declarative Memory**

Declarative memory falls under one of the biggest memory sections impacted by sleep. The declarative memory of humans can continue to be consolidated post-learning, for months.[8] Usually dependent on the hippocampus, the reactivation of declarative memories can support consolidation in different ways. Studies used people with different types of sleep loss disorders, including amnesia, to determine the impact that the hippocampus has on declarative memories, eventually finding that after declarative memories are acquired and consolidated, they depend on the hippocampus and the conscious retrieval of the memories to keep this memory consolidation.[8]

IMPLICIT MEMORY

Implicit memories are impacted by slow wave sleep, predominant in stage 3 of NREM sleep.

1. **Procedural Memory**

Data shows that procedural skills are acqu

-ired slowly, throughout the learning process and not through the initial learning period. When these periods contain sleep, there are steady improvements within the learning of these long term procedural tasks. [3]
In a study, people were tested in a study involving a visual texture discrimination task, or a VDT task. This task involved looking at a screen with different patterns and finding a specific letter such as an L or a Q within the pattern. Time with the task was a factor for improvement, but both REM sleep and SWS sleep proved necessary for further improvement in this task. This was found using selective deprivation of REM sleep on people within the study.
Found through multiple studies, stage 2 NREM sleep and the spindles that characterize stage 2 sleep are very important for learning simple motor tasks. Not only does sleep help memory consolidation during the night, but it has also been shown that after initially learning a motor skill, the enhancement of those skills are entirely independent on sleep.[3] This is also proven by the fact that people with conditions relating to sleep loss like insomnia, have a much harder time with procedural memory consolidation compared to people who have a normal amount of sleep each night.

CONCLUSION

Sleep is a crucial part of our everyday life. Whether it's taking naps or getting a full 9 hours, the presence of sleep in our daily life is essential to living a healthy life. With the many different types of memory affected by sleep, it is more beneficial to get 7-9 hours of sleep during the night to consolidate all the things that one has learned throughout the day, or to remember all of the things that have occured. Sleep's ever-reaching impact reminds students that all-nighters aren't worth it. Studying, taking breaks and sleeping for at least a few hours will help students remember the information that they are studying with better accuracy than pulling an all-nighter the night before a big test. Lack of sleep has a more detrimental impact than anything that you could've learned within the time that you decided not to sleep.
As students enter this next school year, they should focus on balance, not pushing themselves into overwhelming amounts of work, while finding time to take breaks and sleep, especially when there are tests coming up. As managing time and finding new ways to learn is part of one's daily life, change up the after-school schedule a bit, create more time for yourself, make a conscious goal to procrastinate less, and you might find that your experience in school and studying at home may become better.

REFERENCES

1. Payne, J. (2011). [A sleep histogram showing the typical distribution of SWS and REM sleep.] [Chart]. University of Notre Dame. https://samlab.nd.edu/assets/329680/payne_2011b.pdf
2. Poe, G. R., Walsh, C. M., & Bjorness, T. E. (2010). Cognitive neuroscience of sleep. Progress in Brain Research, 1-19. https://doi.org/10.1016/b978-0-444-53702-7.00001-4
3. Marshall, L., & Born, J. (2007). The contribution of sleep to hippocampus-

dependent memory consolidation. Trends in Cognitive Sciences, 11(10), 442-450. https://doi.org/10.1016/j.tics.2007.09.001

4. Payne, J. D. (2011). Learning, memory, and sleep in humans. *Sleep Medicine Clinics*, *6*(1), 15-30. https://doi.org/10.1016/j.jsmc.2010.12.005
5. Nishida, M., Pearsall, J., Buckner, R. L., & Walker, M. P. (2008). REM sleep, prefrontal theta, and the consolidation of human emotional memory. *Cerebral Cortex*, *19*(5), 1158-1166. https://doi.org/10.1093/cercor/bhn155
6. Walker, M. P., & Stickgold, R. (2010). Overnight alchemy: Sleep-dependent memory evolution. *Nature Reviews Neuroscience*, *11*(3), 218. https://doi.org/10.1038/nrn2762-c1
7. Types of memory]. (n.d.). Queensland Brain Institute. https://qbi.uq.edu.au/brain-basics/memory/types-memory
8. Paller, K. A., Creery, J. D., & Schechtman, E. (2021). Memory and sleep: How sleep cognition can change the waking mind for the better. *Annual Review of Psychology*, *72*(1), 123-150. https://doi.org/10.1146/annurev-psych-010419-050815

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Sleep Plays a Crucial Role in One's Cognitive Functions

Nikhil Bogam

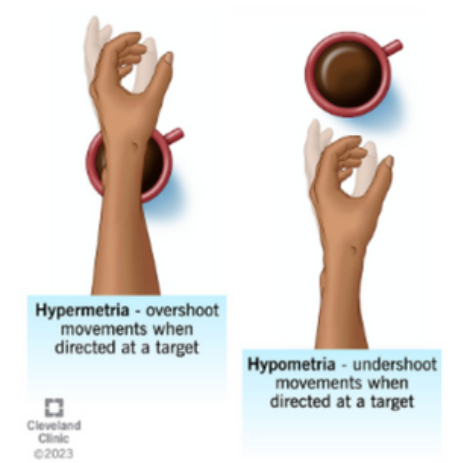
ABSTRACT: Sleep plays a vital role in one's cognitive function, where a lack of high quality sleep, or not sleeping consistently, can impair one's cognitive functions. Attention, executive functions, praxis, language, and visual orientation are examples of cognitive functions that can be impaired through poor sleep. Through many research articles and studies, it is clear that poor sleep has led to poor performance in these cognitive functions mentioned before. In these studies, people of all ages and medical conditions were shown to be impaired cognitively if they were poor sleepers or experienced problems sleeping. This demonstrates the importance of sleep in one's daily life and how it contributes to someone's well-being. Sleep is one of the most important things that can determine one's well-being, which is why it is imperative that everybody makes sure they get enough high-quality sleep and seeks out help if they have trouble sleeping.

INTRODUCTION

Sleep is an important part of anyone's life, as it has a major impact on one's daily life and well-being. One aspect of human life that is impacted by sleep is one's cognitive functions. Cognitive functions are the different processes your brain makes in order to be able to complete actions. Cognitive functions are used all the time during one's daily life, like when someone brushes their teeth or walks their dog. The main cognitive functions in this article are attention, executive functions, praxis, language, and visual orientation. Attention is defined as being consciously aware of things in an environment and being in the right state of mind to be able to react to that environment.

Executive functions are processes completed while performing an action, like planning or regulating one's behavior. Praxis is related to the movement of one's body while performing an action, language is being able to understand and produce vocabulary and phrases, and visual orientation is the ability to understand information about one's surroundings. However, there are many more cognitive functions, like gnosis, memory, and social cognition. Cognitive functions can be impaired through a lack of sleep or through poor quality of sleep, which is detrimental as cognitive functions are so important to one's life and well-being. The importance of sleep on cognitive function and the correlation

between poor sleep and worse cognitive functions have been shown through multiple studies focusing on different cognitive functions and sleep.



An example of an impairment in visual orientation that makes it hard to grab a cup of coffee ([Dysmetria], 2023)

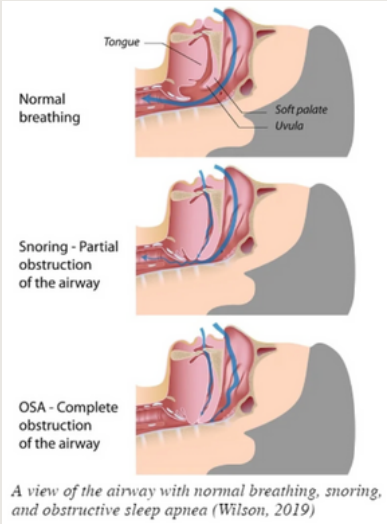
COMPREHENSION AND THE ABILITY TO LEARN

1. Attention

A lack of sleep can make one feel less focused throughout the day. In one study, participants who had a 24 hour period of sleep deprivation, as compared to participants with a period of sleep, had worse tonic alertness, worse selective attention, and worse sustained attention. (Garcia et al., 2021). Tonic alertness is the alertness to any and all stimuli in an environment, selective attention is the awareness of one specific stimulus, and sustained attention is the ability to be alert for a long period of time. For instance, in a classroom, a student may notice everything that's happening, like kids being on their phone, students coming into the class, or kids talking all at the same time (tonic alertness). An example of selective attention is just narrowing in on one aspect, like a student just focusing on finishing their own work, and an example of sustained attention is being focused on an hour-long lecture from a teacher. Additionally, students who were reported to be sleep-deprived had shown more displays of inattentive behaviors, such as keeping their eyes closed or having their head down (Beebe et al., 2011).

1. Language

Sleep is an incredibly important factor in vocabulary, and it is even more significant for children and adolescents who are still developing their language skills. For instance, the amount of sleep infants get during their first 6-month period of life affects the development of their language from 18 months to 30 months and has long-lasting effects, shown through worse language skills up to 3 and a half years later for children who did not get enough nighttime sleep (Dionne et al., 2011).



A view of the airway with normal breathing, snoring, and obstructive sleep apnea (Wilson, 2019)

Furthermore, preschoolers who were diagnosed with obstructive sleep apnea, a condition where the airway is blocked during sleep, were found to have lower comprehension skills than preschoolers who were not diagnosed with obstructive sleep apnea (Honaker et al., 2010). A study

looking back on children who had delays in their speech also found that these children have had worse sleep ratios, meaning they had gotten less sleep during the night than during the day as compared to other children who were not found to have delays in their speech (Dionne et al., 2011).

This is not only true for typical children, but also atypical children. One study showed that children with Down syndrome who were poor sleepers were worse at combining words together in sentences, with 31.6% of poor sleepers combining words while 80.0% of good sleepers were combining words (Egdin et al., 2015). Another specific aspect of language is vocabulary. In a group of children with Down syndrome, the vocabulary of the poor sleepers within the group was much worse than the vocabulary of good sleepers in the group (Egdin et al., 2015). In addition, children who slept for less than 10 hours until age 6 were found to do worse on the Peabody Picture Vocabulary test as compared to children who got 10 or 11 hours of sleep habitually (Touchette et al., 2007). This pattern is also true for adolescents, as high schoolers with habitual snoring or obstructive sleep apnea showed lower levels of vocabulary development as compared to high schoolers who did not have sleep problems (Honaker et al., 2010). It is clear that the lack of adequate sleep has caused problems in the development of language for both children and adolescents, further highlighting the importance of getting enough sleep.

ABILITY TO MAKE DECISIONS & EXECUTE ACTIONS

1. **Executive Functions**

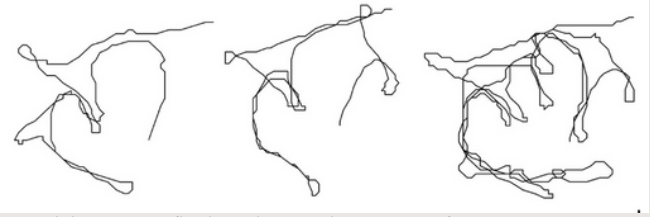
Both children and adults with sleeping problems have impairments in their executive functions. For instance, children and adults with insomnia disorder had been reported to have worse executive function. A lower sleep duration during the night and more nighttime awakenings & wakefulness were correlated with worse executive function in preschoolers with insomnia (Bruni et al., 2020). Preschool children with insomnia disorder, when compared to preschoolers without insomnia disorder, were found to struggle with inhibition (the ability to control impulsive actions), emotional control, planning/organizing, shifting (ability to adapt), working memory (memory used during cognitive tasks), inhibitory self-control (the ability to control desires), and emergent metacognition (ability to be aware of and control one's thinking) (Bruni et al., 2020). To add on, patients with insomnia disorder had worse reaction times than good sleepers (Zhao et al., 2018).

In addition, patients with obstructive sleep apnea took longer to complete the Trail Making Test, suggesting worse psychomotor functions (processes relating to motor function or kinesic behavior), processing speed, cognitive flexibility (multitasking), divided attention, response monitoring (monitoring one's actions), and task switching (Sui et al., 2024). Furthermore, after a period of 24-hour sleep deprivation, participants in one study had less cognitive inhibition and also had less efficient inhibition, while after a period of sleep, those same participants had the same inhibition as they did normally (Garcia et al., 2021). It is apparent

that sleep has a huge effect on executive functions, which can impair the decision-making process and make completing tasks & actions harder to do.

1. **Visual Orientation**

Two aspects of visual orientation are one's ability to navigate as well as their ability to locate things accurately. Both of these aspects improve with better sleep and more hours of sleep. In one study, men who had slept for longer had better navigation performance and a shorter wayfinding distance, the distance it takes for someone to reach a location (Yavuz et al., 2023). The study reported that shorter hours of sleep were associated with worse navigational skills (Yavuz et al., 2023).



Participants wayfinding distance in the study from best to worst (left to right) (Yavuz et al., 2023).

In another study testing for location accuracy, it was found that between two trials, participants who had a period of wake did worse in the second trial, while participants who had slept had similar results in the second trial as the first one (Simon et al., 2022). This supports the idea that getting enough hours of sleep and more importantly, getting those hours consistently, is essential in order to maintain one's location accuracy and keep their ability to locate things accurately sharp. Visual orientation is so important, with it being used in one's daily life, which is why it is crucial that one gets enough sleep and consistently to make sure their visuospatial abilities (abilities that use visual and spatial awareness) don't deteriorate.

CONCLUSION

It is apparent that sleep impacts cognitive functions enormously, where bad quality sleep has been proven to be negatively correlated with poorly functioning cognitive functions. Cognitive functions like attention, learning, executive functions, praxis, and visual orientation are examples of cognitive functions that have been negatively correlated with poor sleep. These cognitive functions are used throughout one's daily life, which is why it is imperative that they work well and efficiently. Therefore, a little impairment in one's cognitive functions can influence their life a lot. This impact sleep has on cognitive functions, as well as many other systems and processes in the human body demonstrates how significant sleep is to one's well-being. Sleep has such a massive role in one's life, which is why it is important that people prioritize getting enough hours of quality sleep consistently. It can be tough for people to get enough quality sleep, whether it is because they are busy with school or work, or just have trouble falling asleep, and it can be hard to fight against that. However, it is essential that people have systems in place that can help them save enough time for sleep and help them prioritize their sleep. For instance, making a schedule to get your work done sooner can help a student go to bed earlier. If people have problems with sleeping, they can and should reach out to medical professionals who can help them fight these problems and help them get enough quality sleep. Getting enough

sleep consistently is incredibly impactful to one's body and well-being, which is why finding ways to prioritize one's sleep is very important.

REFERENCES

1. Beebe, D. W., Rose, D., & Amin, R. (2010). Attention, learning, and arousal of experimentally sleep-restricted adolescents in a simulated classroom. The Journal of adolescent health : official publication of the Society for Adolescent Medicine, 47(5), 523–525. https://doi.org/10.1016/j.jadohealth.2010.03.005
2. Bruni, O., Melegari, M. G., Esposito, A., Sette, S., Angriman, M., Apicella, M., Caravale, B., & Ferri, R. (2020). Executive functions in preschool children with chronic insomnia. Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine, 16(2), 231–241. https://doi.org/10.5664/jcsm.8172
3. Dionne, G., Touchette, E., Forget-Dubois, N., Petit, D., Tremblay, R. E., Montplaisir, J. Y., & Boivin, M. (2011). Associations between sleep-wake consolidation and language development in early childhood: a longitudinal twin study. Sleep, 34(8), 987–995. https://doi.org/10.5665/SLEEP.1148
4. Dysmetria (2023). Cleveland Clinic. https://my.clevelandclinic.org/health/symptoms/25232-dysmetria
5. Edgin, J. O., Tooley, U., Demara, B., Nyhuis, C., Anand, P., & Spanò, G. (2015). Sleep Disturbance and Expressive Language Development in Preschool-Age Children With Down Syndrome. Child development, 86(6), 1984–1998. https://doi.org/10.1111/cdev.12443
6. García, A., Angel, J. D., Borrani, J., Ramirez, C., & Valdez, P. (2021). Sleep deprivation effects on basic cognitive processes: which components of attention, working memory, and executive functions are more susceptible to the lack of sleep?. Sleep science (Sao Paulo, Brazil), 14(2), 107–118. https://doi.org/10.5935/1984-0063.20200049
7. Honaker, S. M., Gozal, D., Bennett, J., Capdevila, O. S., & Spruyt, K. (2009). Sleep-disordered breathing and verbal skills in school-aged community children. Developmental neuropsychology, 34(5), 588–600. https://doi.org/10.1080/87565640903133582
8. Shin, H. Y., Han, H. J., Shin, D. J., Park, H. M., Lee, Y. B., & Park, K. H. (2014). Sleep problems associated with behavioral and psychological symptoms as well as cognitive functions in Alzheimer's disease. Journal of clinical neurology (Seoul, Korea), 10(3), 203–209. https://doi.org/10.3988/jcn.2014.10.3.203
9. Simon, K. C., Clemenson, G. D., Zhang, J., Sattari, N., Shuster, A. E., Clayton, B., Alzueta, E., Dulai, T., De Zambotti, M., Stark, C., Baker, F. C., & Mednick, S. C. (2022). Sleep facilitates spatial memory but not navigation using the Minecraft Memory and Navigation task. Proceedings of the National Academy of Sciences, 119(43), e2202394119. https://doi.org/10.1073/pnas.2202394119

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Q & A with Dr. Nadkarni

Dr. Nadkarni leads the physician team at The Center for Sleep Disorders and Cooperman Barnabas Medical Center. She has extensive training and experience in the field of epilepsy as well as sleep medicine. Dr. Nadkarni is a fellow in the American Academy of Sleep Medicine and serves on New Jersey Sleep Society and the Professional Advisory Board of the Epilepsy Foundation of New Jersey. She has co-authored articles that have appeared in prestigious peer-reviewed medical journals.

Hello Dr. Nadkarni, and thanks for joining us! To start off, can you explain the different stages of sleep and why each stage is important for overall health?

There are a total of four stages of sleep, but I categorize one as the REM stage of sleep when we dream. That's a rapid eye movement.
And then the other category of the state is the non REM stage of sleep.

1. Non- REM stage of sleep, there are three stages, stage one, stage two and stage three. Stage one is just drowsiness. It's not, you know, when we go to bed, when we go to sleep, it's not like a switch gets turned off. It's a process, right? So the drowsiness is when you're actually falling asleep. So that's a stage one sleep. Stage two sleep is thought to be helpful with what we call a motor function, meaning, in sports, like athletes, there were studies done and that showed that, you know, the stage two sleep actually helps them in terms of, you know, their motor performance. Then stage three sleep is thought to be helpful immunologically, that helps us. It is the deepest of the non REM stage of sleep. And it helps us too, there are certain white blood cells that are working in that particular stage of sleep.
2. The REM stage of sleep is thought to be more helpful in terms of your cognitive area.
3. Performance, like your memory and attention, is subconsciously replayed in our REM stage of sleep, and that's what solidates our memory.

What are the neurological consequences of chronic sleep deprivation?

With sleep deprivation, there are two things.
One is quality of life, which is if you're pulling an all nighter, you're going to be tired. You're not able to focus properly. Teenagers require more sleep than adults. And again, everybody's different. Some people may need nine hours of sleep. But even as an adult, there are some people who say they feel fine with seven hours of sleep. And even as an adult, some people may say they need nine hours of sleep. So if there is some variation, everybody's not exactly the same. So depending on what your innate need is, then obviously the person will have more symptoms of not able to function or not able to concentrate. Currently, there is research saying

that stage three of sleep has to do with the immunological function as I said before. So there are some cases where patients may get sicker if they continue with consistent all-nighters. One night is not going to make a big difference, but if it continues, then it can affect you.

What are the most common sleep disorders you encounter in your practice, and how do they affect brain function?

One common disorder is insomnia. It becomes more prevalent as people get older. Sometimes some people can have difficulty falling asleep. Sometimes they can have difficulty staying asleep. So there could be different reasons. Sometimes it's psychological. It could be related to sleep apnea, or there is another condition, something called restless leg, which can prevent people from falling asleep. Especially in younger women, if they have a heavy menstrual cycle.
For example, in Indian mythology, there is a character called Ashwatthama, who was likely to have severe insomnia. So, the sleep disorders weren't invented anytime recent, they've been there forever.

How does exposure to light right before sleep affect teenagers?

In general, with any stimulation with light, melatonin levels increase, which is what helps us to fall asleep. And so that depends on how much light exposure you have. If you have too much light exposure, just before going to bed, melatonin concentration will be suppressed, affecting your ability to fall asleep. Something that doesn’t hold true, is the use of blue-light glasses. They used to think it works, but it doesn't really.
Especially with the pandemic, sometimes kids were attending class and doing homework from their bedroom. So you're converting their bedroom into a think tank, which is not a very relaxing kind of atmosphere there.

What advice would you give to high school students interested in pursuing a career in neuroscience or sleep medicine?

It’s a great choice, and it’s good to gain some exposure early on. A good tip is to visit senior homes, where you can encounter patients with neurological conditions. Of course, you also have to have a passion for the field. Doing volunteer work, and getting engaged with the field in general is a notable starting place.

NFRJ
NEURO FRONTIERS RESEARCH JOURNAL

Practical Sleep Tips

Based on the interview with Dr. Nadkarni:

1. No caffeine after **3 pm**
2. Refrain from consuming **energy drinks** excessively
3. Stay off the screen at least **1 hour** before sleeping
4. Get a **meditation app**, keeping the audio and sound on without looking at the screen
5. Limit naps to **20-30 minutes** and avoid late afternoon naps
6. Ensure your mattress and pillows provide proper support for a **restful sleep posture**
7. Make **gradual adjustments** to your sleep schedule if needed, rather than abrupt changes
8. Manage academic, extracurricular, and social activities to **avoid overloading your schedule** and impacting sleep
9. **Spend time outside**, especially in the morning, to help regulate your internal sleep-wake cycle
10. Aim for the **same bedtime** and wake-up time daily, even on weekends