DO NAPS STILL MATTER: 4-YEAR-OLDS AND WORD LEARNING

By

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Abstract

The purpose of this study is to determine if there exists a relation between a child's napping status and performance in a word-learning task. In determining such a relation we can better understand the mechanisms that assist children with learning information allowing us to accordingly contribute to their success. To assess word learning we employed an object-context task where 34 children aged 48-53 months were trained on two labeled objects presented on colored fabric. During testing, these objects were simultaneously presented (on the same or a different fabric) and asked to identify the correct object. After applying a two-way ANOVA of sleep (no nap, nap) and context (same, different) on word learning performance, a significant main effect of nap on word learning performance was found, $F(1, 30)= 6.53$, $p=.02$. This finding is crucial as children this age are transitioning to fewer or no naps, which can impact their ability to learn new words.

Do Naps Still Matter: 4-Year-Olds and Word Learning

Introduction

Many studies have been done on adults to understand the complexity of learning and memory. This research has provided information about what regions of the brain meditate memorization. As Hayes, Nadel, & Ryan (2007) demonstrated the parahippocampal cortex plays an important role in encoding and retrieving information. Establishing what regions are responsible for memory is important, but even more important is discovering what assists in successful, prolonged consolidation of memories. Diekelmann, Born, and Wagner (2010) show that during sleep, qualitative and quantitative changes in the brain that lead to enhanced memory can be observed, which displays the relevance of sleep to memory. Discoveries help us understand how memories are consolidated; however, difficulties exist when trying to generalize these memory concepts to children and their memorization process. For example, methods used to test adults have proven inadequate for the purposes of testing children due to differences in attention spans as well as comprehensive abilities. Furthermore, the structural and neurological discoveries made on adults cannot possibly be translated to a child whose brain is still undergoing fundamental brain development. For these reasons, developmental researchers as well as sleep researchers have developed new methods to assess learning and memory in children.

Literature Review

Memory

Memory stands as a diverse and complex mechanism of survival. Memory can be subcategorized into declarative/explicit and nondeclarative/implicit memory. Declarative memory consists of conscious facts and events while nondeclarative memory deals with nonconscious learnt capacities such as habits and/or skills (Squire & Zola, 1996). Unlike nondeclarative memory, declarative memory entails recollection, which is achieved through three pertinent steps: acquisition (or encoding), consolidation, and retrieval. Acquisition/encoding refers to the initial learning process where information is encoded into a neuronal trace while consolidation entails the processes that occur post-learning that stabilize, transform, or enhance the initial memory trace by integrating into preexisting knowledge networks, and lastly retrieval is the access and recall of the stored memory (Born, Rasch, & Gais, 2006; Rasch & Born, 2013).

Declarative memory is essential to this study as it encompasses recognition memory, which has the ability to retrieve information for naming and categorizing learned objects (Carlini, 2011). For a task involving the recognition of object-context pairs two types of recognition memory are in play: 1) associative memory to remember the specific pairing of two items and 2) item memory for the remembering of the individual item (Ngo, 2013). For associative memory, memory binding is needed at the time of encoding. For this specific task, the type of memory binding that is crucial to further investigate is interobject binding, which refers to the association between a given object and its context (object-context binding) (Ngo, 2013).

For such binding, the context effect can be observed. This refers to better recognition of an object when presented on the original background. Markopolous and colleagues' (2010) study exemplifies this effect with word-background associations where they replaced objects with words. In this experiment, word recognition relied on the context effect resulting in higher performance for items tested on the same background it initially was studied on. This finding implies that word and background might be bound at time of encoding (Markopolous, Rutherford, Cairns, & Green, 2010).

In terms of object recognition and the context effect, Hayes et al. (2007) demonstrated that object recognition was significantly higher for "same context" conditions as opposed to conditions where the context was changed at time of testing (Hayes et al., 2007).

Anatomical structures involved in memory

For declarative memory, the medial temporal lobe (MTL) plays a significant role in acquisition and consolidation. Specifically, structures such as the hippocampal formation, and peririnhal and parahippocampal cortices are associated with this type of memory (Squire et al., 1996). As Hayes et al. (2007) observed the parahippocampal cortex participates in the process of binding an object with a context, which results as an automatic process. After several encoding trials, the participants exerted a context shift decrement (CSD: decreased recognition of objects when context is changed) demonstrating that binding occurs automatically and showing great activity in the parahippocampal region during the retrieval phase.

Furthermore, the hippocampus seems to be the final stage of convergence within the MTL as input from perirhinal and parahippocampal cortices ends up being associated there (Carlini, 2011). With reference to object-context memories, the perirhinal structure processes the physical traits of an object while the parahippocampal cortex processes the contextual information regarding the visual (Ngo, 2013). These processes are conveyed to the entorhinal cortex, which then sends them to the hippocampus to integrate this information.

Overall, the major structures for an object-context task such as the one presented in this study are the hippocampal formation, and perirhinal and parahippocampal cortices. However, we predict that even though the perirhinal cortex has the ability to retain those associative memories it will not be the dominant structure supporting the context shift for this task since its primary associative memory ability does not allow for a flexible representation of object-context pairs. It instead forms a unitized, rigid representation (Ngo, 2013).

Night sleep and napping

For the aforementioned structures, sleep plays a crucial role in assisting them in the consolidation and retrieval of declarative memory. Sleep happens as a natural and reversible state of reduced responsiveness to external stimuli and loss of consciousness. Two core sleep stages exist: rapid eye movement (REM) and slow wave sleep (non-REM/SWS). These two stages occur at different times during sleep. SWS predominates during the early part of sleep decreasing in intensity and duration as the night proceeds (Rasch et al., 2013).

Multiple studies have been conducted to understand the role sleep has in memory for children. Gomez, Bootzin, & Nadel (2006) demonstrate that sleep plays a crucial role for generalization of child memory. Hupbach, Gomez, Bootzin, and Nadel (2009) as well present the importance of sleep on the promotion of generalizing and retaining the information acquired. Such studies have established sleep as a major component in the way children memorize and retain information. Establishing the significance of sleep directs researchers to concentrate on this aspect of memory and potentially discover how the manipulation of it can benefit a child.

As Born et al. (2006) proposes hippocampus-dependent memories, present in this object-context word-learning task, rely on slow-wave sleep, specifically slow oscillations associated with it. Furthermore, Gomez et al. (2006) investigates the role of naps in the process of abstraction. This study provides insight on how sleep (its duration and point in time) can augment or hinder a child's ability to undergo abstraction. First and foremost, the ability for abstraction, a feature of hippocampus-related memory, is enhanced by sleep. Naps that occurred four hours prior to a lab visit in 15 month old infants promoted more generalization than not napping, which served as a demonstration that sleep methods can be utilized when teaching a child.

Continuing with the concept of napping and learning, Hupbach et al. (2009) further supports the idea that naps promote the retention of language information. Following the same set up, 15 month olds were asked to come in and learn an artificial language then either sleep or stay awake. This experiment resulted in the discovery that naps help retain information of languages if done soon after acquisition. Similarly, Diekelmann et al. (2010) show that qualitative and quantitative changes in memory develop as a result of consolidation during sleep (both REM and SWS). The timing of sleep proves crucial in terms of recall.

Sleep is also important for encoding information. Subjects who are rested before learning remember more on immediate test, reflecting better encoding. Yoo, Hu, Gujar, Jolesz, and Walker (2007) demonstrated that sleep is crucial for the "subsequent consolidation of memory" as their results showed better memory performance in individuals who had regular sleep cycles as opposed to the individuals who were sleep deprived. More interestingly, their findings support the notion that sleep appears to be not only essential for memory consolidation after learning, but also as a mechanism of preparation for new memories in upcoming days (Yoo et al., 2007).

Könen, Dirk, and Schmiedek (2015) similarly show a significant interaction between children who usually sleep better or longer and their ability to score higher on measures of cognitive performance compared to children who sleep less or a lower quality sleep. Research shows that the duration of sleep is positively related to cognitive performance in 5-12 year old children. Even a one-hour reduction of sleep has the ability to impair children's working memory performance (Sadeh, Gruber, & Raviv, 2003; Vriend et al., 2013).

Childhood is a crucial learning phase and understanding why performance fluctuations occur in this population should lead to better encoding success, which ultimately impacts knowledge acquisition. This study focuses on the habitual napping patterns of children to assess relations between performance and sleep for retention immediately after encoding. Our study may serve as a foundation to understand the advantages, if any, already present for those children who nap more. As Lam, Mahone, Mason, & Scharf (2011) suggest non-REM sleep sets the foundation for more efficient consolidation of newly learned material. Since childhood is characterized by greater amounts of SWS (Wilhelm, Diekelman, & Born, 2008), it is possible that habitual nappers receive more SWS; therefore exceling at tasks that require hippocampus-dependent memory.

We tested thirty-four 4-year-old children on a word-learning task involving object-context pairs. This task trained the children on two labeled objects on a fabric context, which at time of testing was either kept consistent or changed. During the appointment, a sleep questionnaire was distributed among the paperwork. This questionnaire provided information regarding napping patterns that allowed to categorize the children as either habitual nappers (4 or more naps/week) or nonhabitual nappers (3 or fewer naps/week).

Hypotheses

Given findings showing that better sleep is associated with better encoding, we predicted that habitual nappers would perform better than non-habitual nappers in an object-context word-learning task. We also asked whether changes in context affect performance levels differently for habitual and non-habitual nappers. We were particularly interested in testing 4 year olds because this is an age when many children begin transitioning out of naps.

Methods

Participants

Subjects were selected from the laboratory participant database. These 34 participants, 18 females and 16 males, which balanced well for gender, were recruited at various events as well as referred to the lab over a number of years. Subjects were scheduled through phone if they met the following inclusion criteria: age 48-53 months, no history of the child in speech therapy or any immediate family members, English as their primary language with 50% or more daily exposure, and no ear or eye infections within the month of the appointment time.

The average age of these participants was 49.99 months old with the maximum age being 53.59 and the minimum age being 44.49 months. Furthermore, 16 of the children were categorized as nappers meaning that they nap at least once 1 nap per day. 18 of the participants were categorized no nappers showing 0 naps per day. Nine of the nappers were females and 7 were males. For the no nappers 9 were males and 9 were females. Interestingly enough, the average age of the children considered nappers was 50.06 months while no nappers' average was 49.92.

Fifteen participants were run in the SAME condition where the context remained the same from training to testing. Moreover, eight were no nappers and 7 were nappers. Nineteen participants were tested in the DIFFERENT condition where the cloth was changed from training to testing. Furthermore, eleven were no nappers and 8 were nappers. To further analyze the data, out of the 15 participants under the SAME condition 9 were tested on blue and 6 on orange. For the DIFFERENT condition 8 were trained on blue and tested on orange while 11 were trained on orange and tested on blue.

Materials

The training and test materials involved two toys created from different materials so as to not resemble any toys seen by the child before (*See Figure 1*). The toys were both given names: bame and gart. Both materials were created using craft materials such as foam, paint, and pipe cleaners. The colors were intentional as to provide the children with a balanced presentation of both light colors (pink and yellow) and darker color (purple). These colors balanced well with the fabrics, which were as well chosen due to their middle ground luminosity and opposition in the color scale. The two colors of fabric used were blue and orange. For training purposes, two 18.75" x 18.5" squares of each colored fabric were used. During test, 37.5" x 19.5" rectangles were used to display both toys at the same time (*See figure 2*). During the criterion testing, a white sock and a metal spoon were used (*See figure 3*).

Figure 1: Objects used in task. Both were presented at separate times during training.

Figure 2: Objects were simultaneously presented at time of testing on either the blue or orange cloth depending on the condition.

Figure 3: Criterion test using spoon and sock. This was used to establish child understood the task at hand.

Conditions

Thirty-two counterbalancing conditions were used to expose subjects to all combinations of materials and mappings to labels. Out of these 32, two were repeated to accommodate 2 children. The conditions were created and randomized according to the color of the fabric both during training and testing (orange or blue), order of exposure to objects during training, and orientation of objects on testing cloth. Conditions 1 and 2 referred to the use of orange cloth during training while conditions 3 and 4 were blue. Conditions A-D referred to the color of cloth at testing in this case orange. E-G refer to the use of blue cloth during testing. The 1 and 2 also referred to the order of presentation of objects. 1 presented the bame first while 2 presented the gart first. Same applied for 3 and 4. Lastly, conditions A-D refer to the location and inquiry order of the objects. A and C both presented bame on the left and gart on the right on the first cloth, but A would ask for bame first while C would ask for gart first. B and D, in turn, would have the gart on the left and the bame on the right, but B would ask for bame first while D asks for gart first. These factors resulted in 32 unique stimulus-test combinations.

Procedure

Appointment

Once children arrive to the appointment, the participants (both the parent and child as well as any other siblings accompanying them) were greeted at the parking lot and brought back up to the lab into the lab playroom. The playroom is a vivid colored room with multiple toys for the children to play with. There the parent was informed about the study details such as video recording, length time, purpose, and process of study and signed the consent form. Among the paperwork administered to the parent were consent form, basic information sheet asking for demographics and details about the child's health history, and a sleep questionnaire with questions about naps, regular wake up and night sleep times, and other questions that touch on quality of sleep.

After answering any questions regarding the paperwork, the child was tested in a room where there was already a toy box and a green or blue pad for the child to sit on. The door to the room, which is attached to the playroom, was left open so the parent could see inside the room if they wished to do so. The child could see the parent, which usually made them more comfortable doing the task.

Word Learning Task

Before going into the room, the experimenter turned on the recorder. Once in the room, the child was instructed to sit on the blue or green pad already placed. The pad is placed according to the camera recording above and the experimenter sitting across from the child on the floor as well. Once the child was sitting and attentive, the experimenter started off with: "Today I brought my toy box (pointing at the toybox) and I'm going to show you some of my new toys". The child was instructed to stay sitting down at all times and once the toys were presented not to touch them.

Each toy was presented only once during training. The toy was brought out from the toy box wrapped in colored cloth (either blue or orange), placed on the floor in front of the child, and unwrapped completely and named. The toy was exposed for approximately 4 seconds while announcing: "Look a bame!". After the end of the statement, the toy was wrapped and put back in the toy box. The next toy was presented in the same manner right after.

After the child was exposed to both toys, the experimenter would change the instructions of the task to pointing. The child was given a pointer to point at objects the experimenter named. For practice, the child was asked to point to the lights, camera, and mommy with the pointer. Once the child understood the task, the experimenter placed a sock and a spoon in front of the child on the floor and was asked to point to the spoon *(See Figure 3).* Once the child pointed, the experimenter retrieved the items and put them back in the box. The experimenter would then bring out the same items and place them in the same orientation and ask for the sock. This task served as criterion and once the child completed the tasks at 100% the actual test phase began.

The child then was instructed: "Now we're going to see how many of the names of my new toys you remember". With this, the experimenter retrieved the toys wrapped in either blue or orange cloth, placed it in front of the child, and unwrapped it. For the test phase, both toys were exposed to the child at the same time on the same cloth side by side (*See figure2 above).* Once both toys were visible and the cloth completely flat on the floor, the experimenter asked: "Which one is the bame? Can you point to the bame?". Once the child pointed, the answer was marked and the toys wrapped back up and put into the box. The same pair would then be brought out and the other toy would be asked for. Overall, the child saw the toys a total of 4 times during test. The first 2 times the orientation of the toys remained the same (if the bame was on the left the first time, it was on the left the second time). After those 2 times, the orientation switched. So then the bame would be on the right for both the 3rd and 4th exposure to ensure the child didn't have a preference for sides when choosing. Once the 4 exposures occurred and the child pointed, the test phase was over. The child was then taken back into the playroom.

At this point, the experimenter turned of the recorder. The parent then was debriefed and the child picked out a toy for coming in.

Data Analysis

For the data analysis, we used the software Statistical Package for the Social Sciences. A 2 (context: same vs. different) X 2 (nap status: habitual vs. non-habitual) analysis of variance was conducted for a between-subjects design. The major independent variables analyzed were nap and context and their effect on the dependent variable: their performance.

Results

Sleep Data

The 16 nappers that participated had an average of 12.06 hours (SE=.25) total sleeping time as opposed to the 10.88 (SE=.16) hours of total sleeping time of the 18 no nappers (*See figure 4)*.

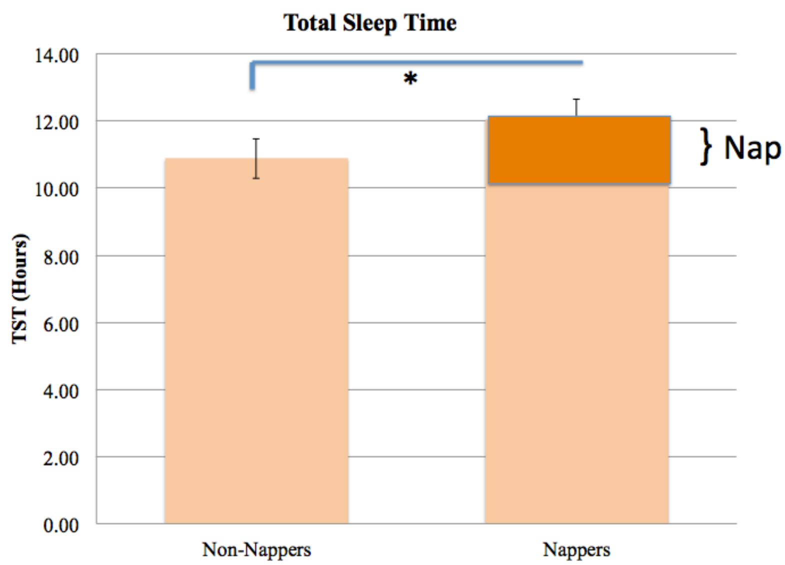

Figure 4: Total sleeping time for both no-nappers and nappers.

Nappers have about an hour more of sleep during a 24-hr period.

Memory Performance

A two-way ANOVA of sleep (no nap, nap) and context (same, different) on word learning performance was conducted *(See Figures 5 and 6).* A significant main effect of nap on word learning performance was found, $F(1, 30)= 6.53$, $p=.02$. This statistically significant advantage for the nap group allows us to reject the null hypothesis of sleep not having a significant effect on performance. No significant main effect of context on word learning performance was found, $F(1,30)=.82$, $p=.38$ allowing us to accept the null hypothesis, which assumed that context would not have a significant effect on the performance of children regardless of napping status. Nor was there an interaction between context and nap, $F(1,30)=.01$, $p=.91$.

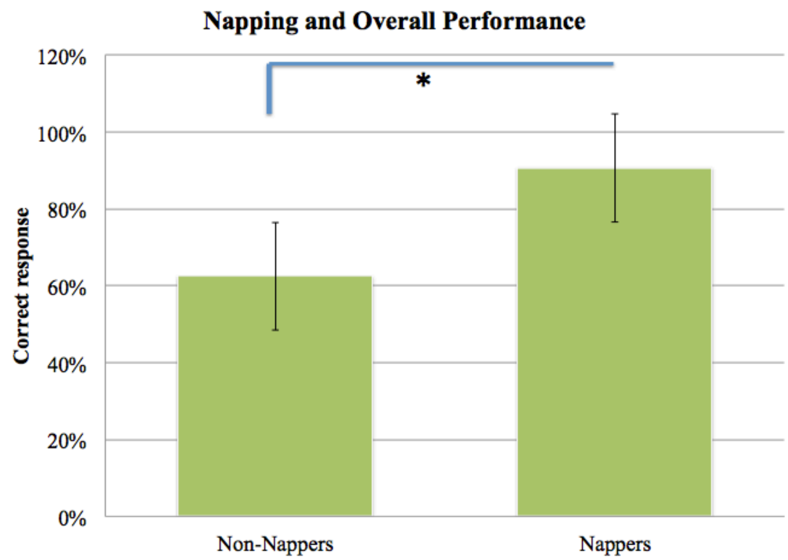

Figure 5: Performance analysis for napping. Nappers performed significantly better than no nappers, t(32)=2.73, p=.012.

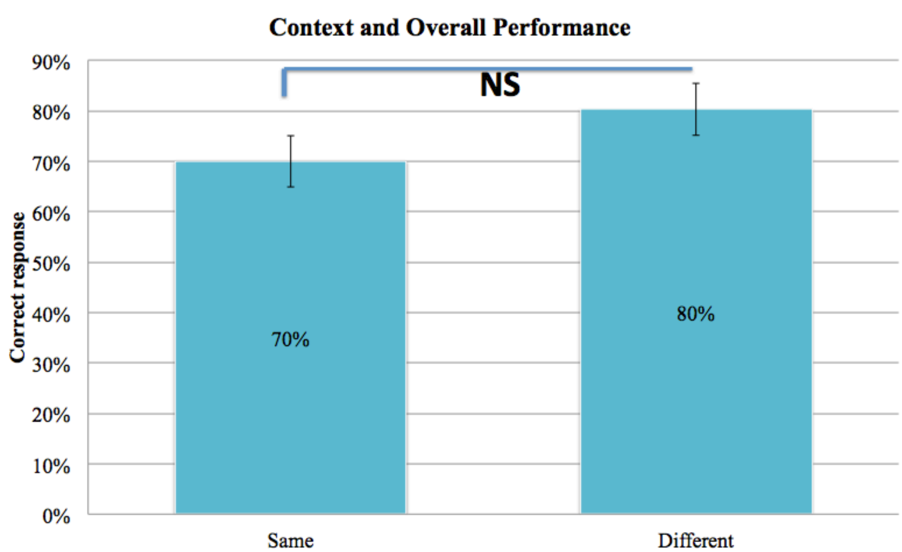

Figure 6: Performance analysis for context. There was no difference in performance for same vs. different context, t(32)=.87, p=.39.

General Discussion

Much research has been conducted on adults and there exists substantial understanding of memory in that population; however, these discoveries cannot be translated to explaining the memorization process of a child. Since the maturity level of a child's brain differs from an adult's, it is crucial to develop methods for successfully understanding the general memory process of a child as well as the impact of regular napping behavior. In understanding how sleep affects memory, better behavioral methods can be developed to promote better memorization in children. This allows us to potentially enhance the way children acquire and learn information specifically language. Furthermore, sleep deprivation during childhood can also have future implications. Friedman, Corley, Hewitt, and Wright (2009) demonstrate that sleep problems during childhood (4-16 years) had predictive value for inhibition and working memory later on in adulthood. In their 916 twin study, Friedman et al. (2009) found that those whose sleeping problems decreased more with age exhibited better general executive control during adolescence.

As research shows, sleep has a significant impact on memory performance and consolidation (Gomez et al., 2006; Hupbach et al., 2009; Diekelmann et al., 2010; Born et al., 2006; Yoo et al., 2007; Könen et al., 2015; Sadeh et al., 2003; Vriend et al., 2013). To better assess the effects of regular sleep on children, we ran 34 habitually and non-habitually napping 4 year old children in a word learning object-context based task.

Context had no significant difference on the child's ability to perform above chance on this task. This suggests flexibility of the hippocampus when encoding an object-context pair. For 4-year-old children it can be assumed that the hippocampus is substantially mature enough to allow for a flexible representation of this task; therefore, there was no interference when context is changed. Furthermore, it can be concluded from the results that habitual nap status affects children's ability to learn new words. Since the total sleep time is greater for nappers, they have more exposure to SWS, which contributes to hippocampus-dependent memories (Born et al., 2006).

However, the difference in performance can be attributed to a number of factors involving attention levels, developmental advantages for nappers, and/or word learning abilities. To assess these factors, we will test children further using the Connors test to measure ADHD symptoms, the Peabody picture vocabulary test to assess present vocabulary and IQ, and Ages and Stages assessment. If none of these factors differ between groups we can conclude that habitual napping is still crucial for new learning at this age despite the fact that it does not seem to matter for executive function (per Lam et al., 2011).

In conclusion, worse performance for non-habitual nappers might indicate developmental differences in the groups with overall advance attributed to those who still habitually nap. Alternately, transitioning out of napping or the already completed transition might hinder a child's ability to sustain new learning without sufficient sleep discrediting the notion that a transition in sleep is result of brain maturation at this stage (Lam et al., 2011).

References

Born, J., Rasch, B., & Gais, S. (2006). Sleep to remember. *The Neuroscientist* 12(5), 410-424.

Carlini, V.P. (2011). The Object Recognition task: a new proposal for the memory performance study, object recognition. *Intech,* 27-42.

Diekelmann, S., & Born, J. (2010). The memory function of sleep. *Nature Reviews Neuroscience*, 11(2), 114–126.

Friedman, N.P., Corley, R.P., Hewitt, J.K., & Wright, K.P. (2009). Individual differences in childhood sleep problems predict later cognitive executive control. *Sleep*, 32, 323–333.

Gomez, R. L., Bootzin, R. R., & Nadel, L. (2006). Naps Promote Abstraction in Language-Learning Infants. *Psychological Science*, 17(8), 670-675.

Hayes, Scott M., Lynn Nadel, and Lee Ryan (2007). The Effect Of Scene Context On Episodic Object Recognition: Parahippocampal Cortex Mediates Memory Encoding And Retrieval Success. *Hippocampus* ,17(9), 873-889.

Hayne, H., Boniface, J., & Barr, R. (2000). The Development of Declarative Memory in Human Infants: Age-Related Changes in Deferred Imitation. *Behavioral Neuroscience* 114(1), 77-83.

Hupbach, A., Gomez, R.L., Bootzin, R.R., & Nadel, L. (2009). Nap-dependent learning in infants. *Developmental Science*, 12(6), 1007-1012.

Könen,T., Dirk, J., & Schmiedek, F. (2015). Cognitive benefits of last night's sleep: daily variations in children's sleep behavior are related to working memory fluctuations. *Journal of Child Psychology and Psychiatry,* 56(2),171–182.

Lam, J. C., Mahone, E. M., Mason, T. B. A., & Scharf, S. M. (2011). The Effects of Napping on Cognitive Function in Preschoolers. *Journal of Developmental and Behavioral Pediatrics : JDBP*, *32*(2), 90–97.

Markopolous, G., Rutherford, A., Cairns, C., & Green, 1. (2010). Encoding instructions and stimulus presentation in local environmental context-dependent memory studies: *Memory,* 18(6),610-624.

Ngo, C.T. (2013). Associative recognition memory and context effects using objects on natural backgrounds. *Seton Hall University Dissertations and Theses (ETDS),* Paper 1860.

Rasch, B. & Born, J. (2013). About sleep's role in memory. *Physiological Reviews* 93, 681-766.

Sadeh, A., Gruber, R., & Raviv, A. (2003). The effects of sleep restriction and extension on school-age children: What a difference an hour makes. Child Development, 74, 444–455.

Squire, L.R. & Zola, S.M.(1996) Structure and function of declarative and nondeclarative memory systems. *Proc. Natl. Acad. Sci. USA* 93(24), 13515-13522.

Vriend, J.L., Davidson, F.D., Corkum, P.V., Rusak, B., Chambers, C.T., & McLaughlin, E.N. (2013). Manipulating sleep duration alters emotional functioning and cognitive performance in children. Journal of Pediatric Psychology, 38,1058–1069.

Wilhelm, I., Diekelman, S., & Born, J. (2008). Sleep in children improves memory performance on declarative but not procedural tasks. *Learning Memory* 15, 373-377.

Yoo, S.S., Hu, P.T., Gujar, N., Jolesz, F.A., & Walker, M.P. (2007). A deficit in the ability to form new human memories without sleep. *Nature Neuroscience,* 10(3), 385-392.