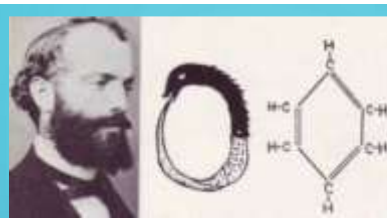

THE FUNCTION OF DREAM

TAYARD DESUDCHIT

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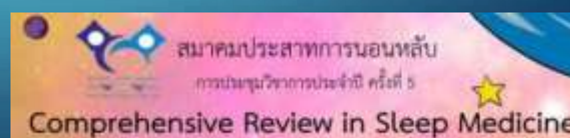


MEMORY : 3 TYPES & FUNCTIONS

- Sensory memory: Sensory input buffer from each sense, lasting only milliseconds to a few seconds.
- Short-term memory(immediate memory): lasting from several seconds to at most a few minutes
  - Sensory memory ==> short-term memory by attention
  - Working memory = information is not only stored but also processed
- Long-term memory: lasting anywhere from an hour to lifetime
  - 'procedural' (implicit) and 'declarative' (explicit) memory
  - Procedural memory: information we possess, but cannot describe verbally. eg skilled performance, such as typing, riding a bicycle and playing a musical instrument. "motor skills"
  - Declarative memory: knowledge that can be consciously accessed and expressed symbolically through speech or writing.
  - The mnemonic/rehearsal move information working memory =>long-term memory which is called "consolidation"

Jie Zhang, Journal of Theoretics Volume 6-6, December 2004

TEMPORARY MEMORY HYPOTHESIS

- The temporary memory :a system with a limited capacity.
  - Information is stored for a quickly accessible and stable form.
  - Data will stay in the temporary memory until either being deleted or transferred to the long-term memory.

Overloading the temporary memory=> interference with the data saved => impair the learning process.

- Different kinds of temporary memories are stored in separate areas.
  - Temporary declarative memory : assumed to be the hippocampus and the adjacent brain areas.
  - Temporary procedural memory

Jie Zhang, Journal of Theoretics Volume 6-6, December 2004

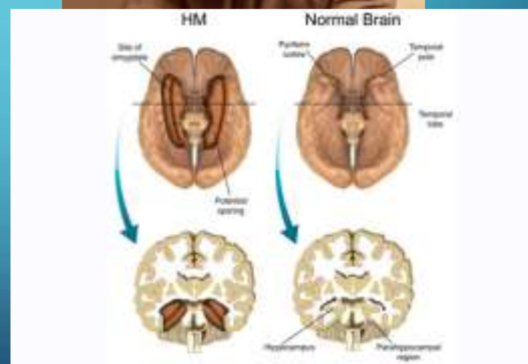
WORKING MEMORY

Alan D. Baddeley[1] and Graham Hitch[1]

UNIVERSITY OF STIRLING, STIRLING, SCOTLAND

- Three separable components:
- The central executive,
- The phonological loop, which is responsible for holding and manipulating auditory-verbal information
- The visuo-spatial sketch-pad, which performs a similar function for visual, spatial and kinaesthetic information

THE H. M. CASE



- After B/L temporal lobectomy in 1953, twenty-seven year old H.M. could only remember recent events for a few minutes. The removal of the medial temporal lobe, which includes the hippocampus and adjacent brain areas, left H.M. unable to form any new personal memories. He also suffered a partial loss of memory of events before the operation. But he had good recall of facts learned long before his operation, meaning that his long-term memory was unharmed. His working memory seemed also unaffected by the loss of his hippocampus. Researchers found that H.M.'s procedural memory was also intact

THE FUNCTION OF SLEEP HYPOTHESIS

- Data saved in the temporary memory needs to be processed, encode, and transfer that data to long-term memory
- Waking brain cannot perform this task when the working memory is busy processing large amounts of incoming information. To perform this housekeeping, the temporary memory has to be shut off from the environment to ensure the memory transfer process is uninterrupted.
- The function of sleep is to process the data saved in the temporary memory, encode, and transfer that data to long-term memory.
    - Comparing the new temporary information with old information in the long-term memory, =>identify/delete unwanted, duplicate and overlapping data.
    - The remaining information is then encoded and transferred to long-term memory.

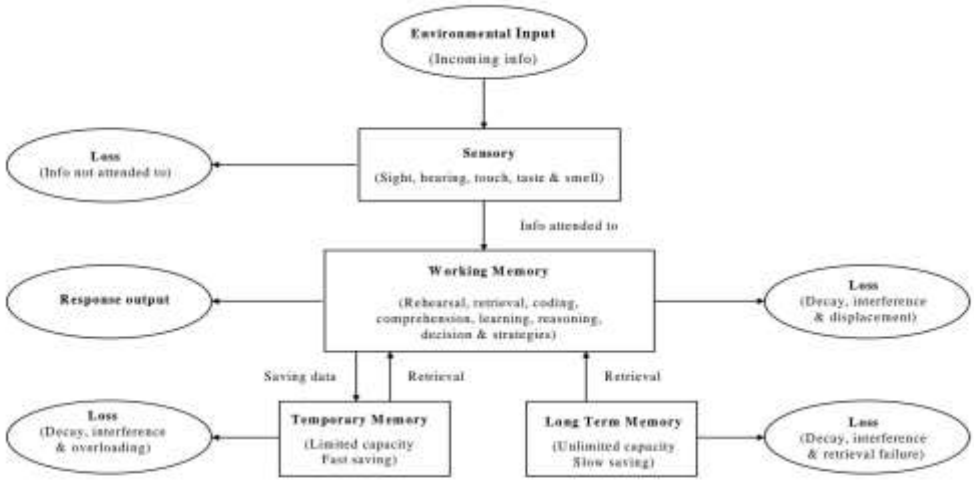


Fig. 1. **Memory model for the waking brain.**

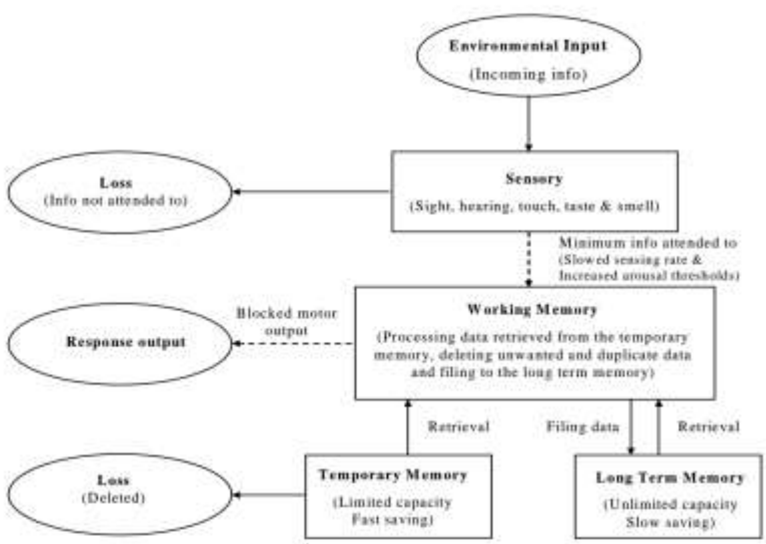


Fig. 2. **Memory model for the sleeping brain.**

WHY WE FORGET OUR DREAM

- We can seldom recollect more than a few minutes worth of our dreams after waking. Unless being recalled immediately after waking, dreams cannot be remembered.
- Our temporary memory store has been switched to retrieve-only mode in the sleeping brain for memory processing. Any brain mentation during this period could not be saved in the temporary memory store.
- Only the short-term memory (working memory) store is still available for memory storage during sleep. Since the short-term memory has a very limited capacity, decays rapidly and will be replaced by new incoming information if distracted, a sleeper can only recall the memory from the short-term memory store immediately after waking. This explains why one can recollect so little of their dreams.

DREAMS

The link between REM sleep and dreaming has opened up a new era of dream research.

WHAT WE DREAM

Manifest Content: A Freudian term meaning the story line of dreams.

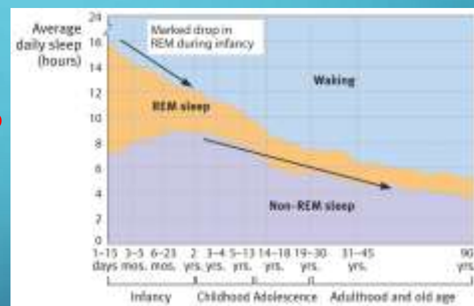
1. Negative Emotional Content: 8 out of 10 dreams have negative emotional content.
2. Failure Dreams: People commonly dream about failure, being attacked, pursued, rejected, or struck with misfortune.
3. Sexual Dreams: Contrary to our thinking, sexual dreams are sparse. Sexual dreams in men are 1 in 10; and in women 1 in 30.

WHY WE DREAM

1. Wish Fulfillment: Sigmund Freud suggested that dreams provide a psychic safety valve to discharge unacceptable feelings. The dream's manifest (apparent) content may also have symbolic meanings (latent content) that signify our unacceptable feelings.
2. Information Processing: Dreams may help sift, sort, and fix a day's experiences in our memories.

WHY WE DREAM

3. Physiological Function: Dreams provide the sleeping brain with periodic stimulation to develop and preserve neural pathways. Neural networks of newborns are quickly developing; therefore, they need more sleep.



WHY WE DREAM

4. Activation-Synthesis Theory: Suggests that the brain engages in a lot of random neural activity. Dreams make sense of this activity.
5. Cognitive Development: Some researchers argue that we dream as a part of brain maturation and cognitive development.

All dream researchers believe we need REM sleep. When deprived of REM sleep and then allowed to sleep, we show increased REM sleep called REM Rebound.

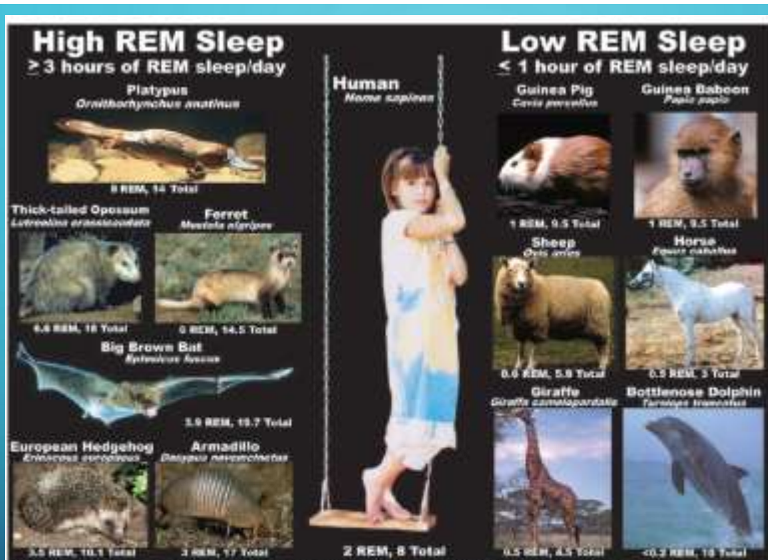


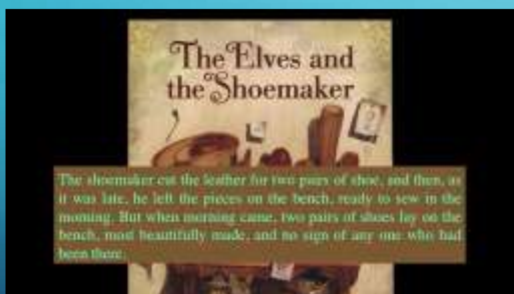
Fig. 1. Sleep durations in representative mammals. Daily REM sleep time in mammals does not positively correlate with encephalization. The highest levels of REM sleep are seen in the platypus and the lowest in the dolphin. Despite our unique learning capabilities, human REM and non-REM sleep parameters are not unusual and are in accord with our size and level of maturity at birth relative to other mammalian species. Number of hours of REM sleep and total sleep across the 24-hour cycle are listed for each animal pictured (36, 37). [Photo credits: platypus, Tom McHugh/Photo Researchers; opossum (photo is of a Virginia opossum), Alden M. Johnson, California Academy of Sciences; ferret (photo is of a black-footed ferret), © D. Robert Franz/CORBIS; big brown bat, © 1997 Merlin Tuttle, from *Bats: Shadows in the Night*, used by permission of Crown Children's Books; hedgehog, Maurizio Lanini/CORBIS; armadillo, John and Karen Hollingsworth/U.S. Fish and Wildlife Service; human, Kristi Alderman; guinea pig, Animals Animals; guinea baboon, Mickey Gibson/Animals Animals; sheep, Barbara Wright/Animals Animals; horse, Lucie R. Alderman; giraffe, Arthur J. Emmrich, California Academy of Sciences; dolphin, Gerard Lacz/Animals Animals]

DREAM THEORIES
Summary

DREAM THEORIES

Theory	Explanation	Critical Considerations
Freud's wish-fulfillment	Dreams provide a "psychic safety valve"—expressing otherwise unacceptable feelings; contain manifest (remembered) content and a deeper layer of latent content—a hidden meaning.	Lacks any scientific support; dreams may be interpreted in many different ways.
Information-processing	Dreams help us sort out the day's events and consolidate our memories.	But why do we sometimes dream about things we have not experienced?
Physiological function	Regular brain stimulation from REM sleep may help develop and preserve neural pathways.	This may be true, but it does not explain why we experience *meaningful* dreams.
Activation-synthesis	REM sleep triggers impulses that evoke random visual memories, which our sleeping brain weaves into stories.	The individual's brain is weaving the stories, which still tells us something about the dreamer.
Cognitive theory	Dream content reflects dreamers' cognitive development—their knowledge and understanding.	Does not address the neuroscience of dreams.

WE HAVE THE ELVES THAT HELP MAKE OUR SHOES



Robert Stickgold on Sleep, Memory and Dreams: Fitting the Pieces Together

To sleep: perchance to learn

Robert Stickgold

Not only can the sleeping brain perceive sensory information, it can learn from this information, leading to changed behaviors the next day: it can come to associate a sound with a pleasant or unpleasant odor and react, both while still asleep and after waking, with a deeper or shallower breath. But classic 'sleep learning' remains just a dream.

Watching the sleeping brain watch us – sensory processing during sleep

Robert Stickgold

Presentation of auditory stimuli to sleeping subjects produced distinct fMRI activation patterns. Whereas pure tones activated auditory processing regions, subjects' names additionally activated language centers as well as the left amygdala and prefrontal cortex. These studies open the way for crucial studies of sleep-dependent cognitive processing.

Memory, Sleep and Dreaming: Experiencing Consolidation

Erin J. Wamsley, Ph.D.[a] and Robert Stickgold, Ph.D.[b]
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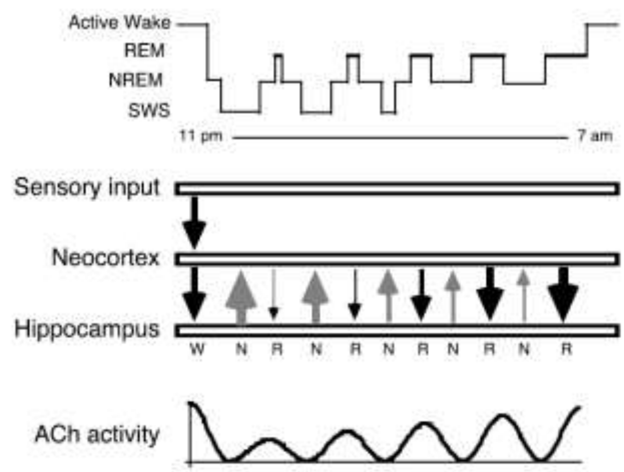
Sleep Med Clin. 2011 March 1; 6(1): 97–108.

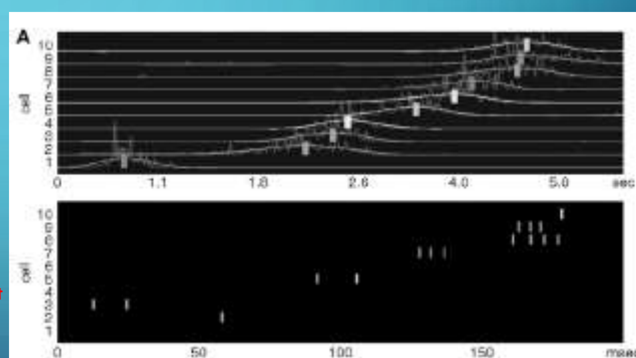
Fig. 2. The ultradian cycle and information processing. Changes in cholinergic neuromodulation and hippocampo-neocortical communication are superimposed on the 90-min human REM-NREM cycle across the night. The slow shift from SWS domination to REM domination across the night is seen in amounts of SWS and REM, as well as in the duration of REM periods and in both the amplitude and frequency of rapid eye movements within REM. The cholinergic neuromodulation is presumed to follow this pattern because rapid eye movements parallel the activity of brainstem cholinergic neurons. From Stickgold *et al.* (3).



Memory, Sleep, and Dreaming: Experiencing Consolidation

Erin J. Wamsley, PhD[a], Robert Stickgold, PhD[b,*]

- patterns of neural activity that are first seen when waking animals are exploring an environment are later reproduced when these animals sleep. This reactivation has most consistently been observed during periods of nonrapid eye movement (NREM) sleep just after learning, during brief hippocampal sharp-wave ripple burst events12,13 (Fig. 1A). This replay of memory in sleep may be critical to long-term memory consolidation. In direct support of this hypothesis, a recent study has shown that the extent of neural pattern reactivation after learning predicts subsequent gains in memory performance



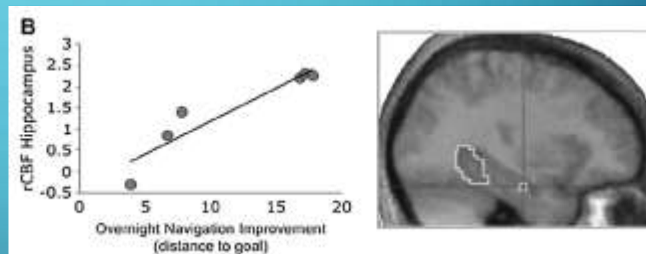
Adapted from Lee AK, Wilson MA. Memory of sequential experience in the hippocampus during slow wave sleep. Neuron 2002;1186; with permission;

Sleep Med Clin 6 (2011) 97–108

Memory, Sleep, and Dreaming: Experiencing Consolidation

Erin J. Wamsley, PhD[a], Robert Stickgold, PhD[b,*]

- Human neurophysiologic studies have linked consolidation to sleep-specific electrophysiologic and neurochemical events, and have used functional imaging technologies to show a systems-level reactivation of brain regions active in encoding new memories (Fig. 1B), roughly analogous to that which has been seen in rodents.



Peigneux P, Laureys S, Fuchs S, et al. Are spatial memories strengthened in the human hippocampus during slow wave sleep? Neuron 2004;541; with permission.)

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SLEEP AND HIPPOCAMPUS-DEPENDENT SPATIAL MEMORY

Overnight Sleep Enhances Hippocampus-Dependent Aspects of Spatial Memory

Nam D. Nguyen, MA[1]; Matthew A. Tucker, PhD[1,2]; Robert Stickgold, PhD[1,2]; Erin J. Wamsley, PhD[1,2]
[1]Department of Psychiatry, Beth Israel Deaconess Medical Center, Boston, MA; [2]Department of Psychiatry, Harvard Medical School, Boston, MA

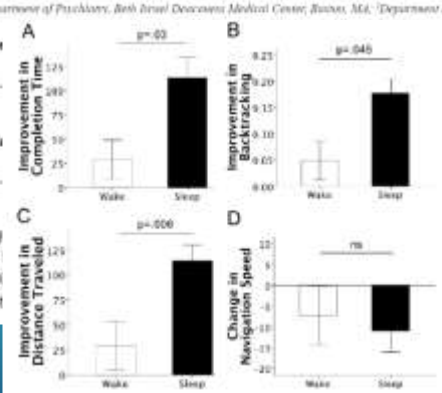

Figure 3—Overnight improvement in navigation accuracy and backtracking. (A-C) Relative to wake control participants, participants who slept after learning exhibited significantly more improvement in completion time (sec), distance traveled (number of grid squares traversed to the goal), and backtracking (unique positions/total grid squares traversed). (D) Posttraining sleep did not facilitate navigation speed (grid squares/min). Error bars = standard error of the mean.

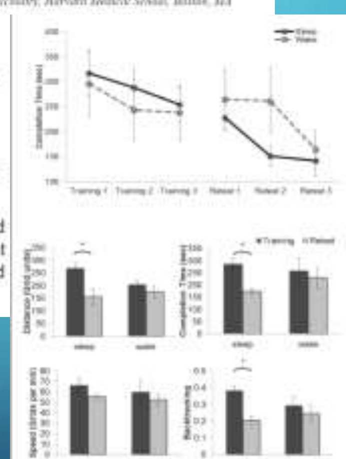

Figure 4—Detail on maze performance data. Top, Mean completion time by group. Bottom, Mean training and relearning scores for distance traveled, completion time, speed, and backtracking. Asterisk indicates significance P < 0.05. Error bars = standard error of the mean.

Memory, Sleep, and Dreaming: Experiencing Consolidation

Erin J. Wamsley, PhD[a], Robert Stickgold, PhD[b,*]

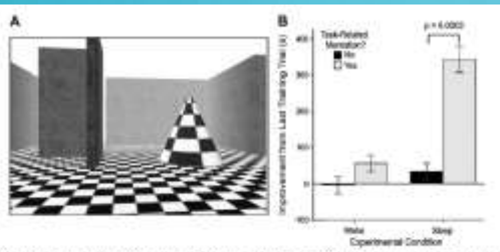

Fig. 3. (A, B) Dreaming of a spatial learning task is associated with enhanced navigation performance at delayed retest, whereas thinking of the task during wakefulness is unrelated to later performance. Error bars represent ± standard error of the mean. (*Adapted from* Wamsley EJ, Tucker M, Payne JD, et al. Dreaming of a learning task is associated with enhanced sleep-dependent memory consolidation. Curr Biol 2010;20:856; with permission.)

- After learning, waking experience is reactivated in the sleeping brain, leading to a process of consolidation by which new, labile memory traces are reorganized into more permanent forms of long-term storage. Dream experiences recalled from sleep bear a transparent relationship to recently encoded information, and provide a useful window into consolidation-related activities of the sleeping brain. Recent work has established a direct relationship between the replay of recent experience in dream content,and enhanced memory performance in humans

Sleep Med Clin 6 (2011) 97–108

Dreaming of a Learning Task Is Associated with Enhanced Sleep-Dependent Memory Consolidation

Erin J. Wamsley,[1] Matthew Tucker,[1] Jessica D. Payne,[1,2,3] Joseph A. Benavides,[1] and Robert Stickgold[1,*]
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[2]Department of Psychology, Harvard University, Cambridge, MA 02138, USA

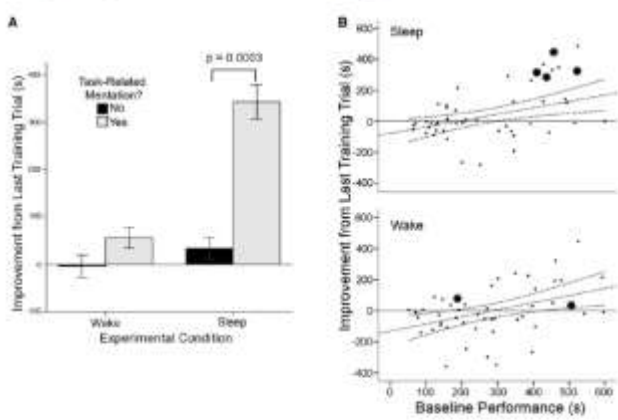

Fig. 2. After training on an engaging downhill skiing arcade game, 30% of 386 sleep onset mentation reports contained task-related imagery or thoughts. Representation of the game primarily took the form of sensory imagery as opposed to thought, and most often bore a direct, unambiguous relationship to the game. Examples of direct incorporation: "I get like flashes of that ... game in my head, virtual reality skiing game ... downhill umm race, in my head. Umm, there's this one particular corner that I haven't quite been able to master, and every time I get flashes of it, it's like that corner that umm I keep crashing into in my head." "I once again, saw the, the game, it was smooth at first, and then it went into the cave, and then it just stopped like abruptly, like the game turned off." Examples of

Figure 2. Participants with Maze-Related Verbal Reports Improved More Than Other Subjects at Retest
(A) Sleep subjects with verbal reports related to the maze improved 10-fold more at retest than did participants without task-related mentation. In contrast, thoughts about the task while awake did not provide a similar benefit. Error bars indicate standard error of the mean.
(B) Baseline performance was a strong predictor of later improvement (regression lines and 95% confidence interval lines for all subjects). Sleep participants reporting maze-related dreams (n = 4, large circles) were among those with the poorest baseline performance but improved significantly more at retest than other poor performers. In contrast, subjects who reported thoughts of the maze task while awake (n = 2, large circles) did not differ from others in terms of baseline performance and improved similarly to those with comparable baseline performance. See also Figure S1.

- A recent study suggests that sleep functions to transform memories such that the critical gist of an experience is retained, whereas specific details of the material are discarded.
- In the Deese-Roediger-McDermott paradigm, participants learn several lists of semantically related words . At a delayed test, when participants are asked to recall these words, often they also report having seen "gist" words, which describe the general theme of the memorized word lists, but which were not themselves present in the list.
- Sleep preferentially benefited (false) memory for these gist words, suggesting that one function of sleep-dependent memory processing is to extract meaningful generalities from large collections of related memories.

- Watch these words as they go by. Remember them.
- You are going to be tested on them.

- [nurse]
- [sick]
- [lawyer]
- [medicine]
- [health]
- [hospital]
- [dentist]
- [physician]
- [ill]
- [patient]
- [office]
- [stethoscope]
- [cotton]

DID YOU SEE ?

- Nurse ?
- Cotton ?
- Doctor ?

- If you saw each of these words, raise your hand, okay? [nurse] If you did see it. Okay? Cotton, you see cotton?
- Doctor? Don't say it, they were going to raise their hands. So, if I had done this competently, about half of you would have raised your hand for doctor, and you do that because the list is a gimmick list – we've put together a whole bunch of words related to doctor, but we don't include the word "doctor" in the list. And it turns out, that about half of you will falsely remember that you saw the word "doctor" because your brain is busy extracting the gist of the list.

- sleep functions not simply to strengthen memories, but in addition to transform memory traces by integrating them into mnemonic networks and preferentially maintaining the general meaning or gist of the larger experience.

CREATIVE INTRUSION WITH SLEEP

- subjects also come up with words that weren't on the list and weren't the gist words either.
- So, they come up with words like "blood," which is probably from that doctor list. Someone else came up with the word "plate," and you can see one of the lists was about cups. Or "spoon" when one of the lists was about cups.
- That's pretty common when you do this study. But with this 12-hour interval, we started to see funny words popping up, like "fuzzy". I mean, where did that come from? And we thought maybe from "rough" or from the list of words about soft, but it's really not either of those. And we get the word "swirl". Where did that come from?

CREATIVE INTRUSION WITH SLEEP

- Jessica Payne, my student, said, "Well, maybe it came from 'mountain,' like they were imagining clouds or soft, like some swirly soft fabric." But then some other people said, "Well, no, maybe it's cup – like, you know you swirl your coffee, or chair – you swirl your chair." And it started to feel

- like what these people are doing is they are coming up with words that don't just epitomize one list but are now sort of starting to bring all the lists together.
- And when she looked, she finds out you're not getting those creative intrusions, so much, when you're awake, you're getting them when you're asleep.
- The sleeping brain is doing this work of pulling everything together and seeing how it fits together and how to summarize it.

Insights into sleep's role for insight: Studies with the number reduction task

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ADVANCES IN COGNITIVE PSYCHOLOGY
2013 • volume 9(4) • 160-172

Rolf Verleger[1], Michael Rose[2], Ullrich Wagner[1], Juliana Yordanova[1,4], and Vasil Kolev[1,4]

In recent years, vibrant research has developed on "consolidation" during sleep: To what extent are newly experienced impressions reprocessed or even restructured during sleep? We used the number reduction task (NRT) to study if and how sleep does not only reiterate new experiences but may even lead to new insights. In the NRT, covert regularities may speed responses. This implicit acquisition of regularities may become explicitly conscious at some point, leading to a qualitative change in behavior which reflects this insight. By applying the NRT at two consecutive sessions separated by an interval, we investigated the role of sleep in this interval for attaining insight at the second session. In the first study, a night of sleep was shown to triple the number of participants attaining insight above the base rate of about 20%. In the second study, this hard core of 20% discoverers differed from other participants in their task-related EEG potentials from the very beginning already. In the third study, the additional role of sleep was specified as an effect of the deep-sleep phase of slow-wave sleep on participants who had implicitly acquired the covert regularity before sleep. It was in these participants that a specific increase of EEG during slow-wave sleep in the 10-12 Hz band was obtained. These results support the view that neuronal memory reprocessing during slow-wave sleep restructures task-related representations in the brain, and that such restructuring promotes the gain of explicit knowledge.

ee digits
e imple-
e arrows

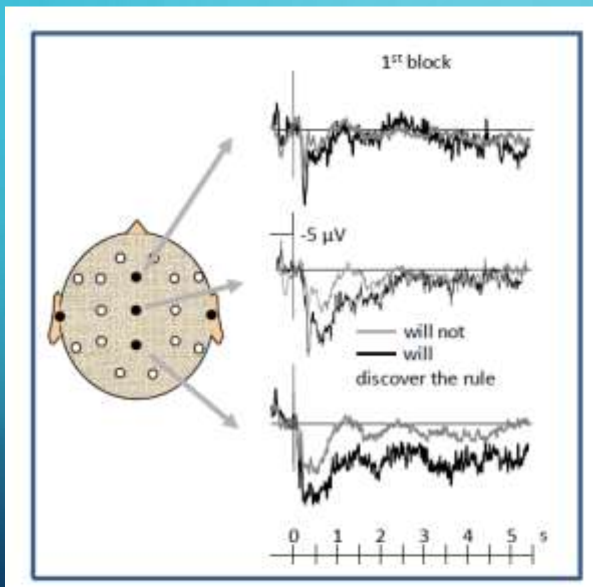

FIGURE 4.

Grand mean ERPs of the first block during the first seconds of each trial, separately averaged across the six participants who will later discover the rule (black lines) and those 20 participants who will not (gray lines). Time point zero denotes presentation of the first digit pair, 500 ms after the warning signal. Negativity is plotted upwards.

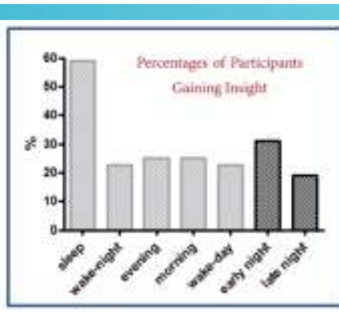

FIGURE 7.

Percentages of participants gaining insight in the second session. The leftmost five bars are from Experiment 1 (see Figure 3) and the two rightmost bars are from the present Experiment 3.

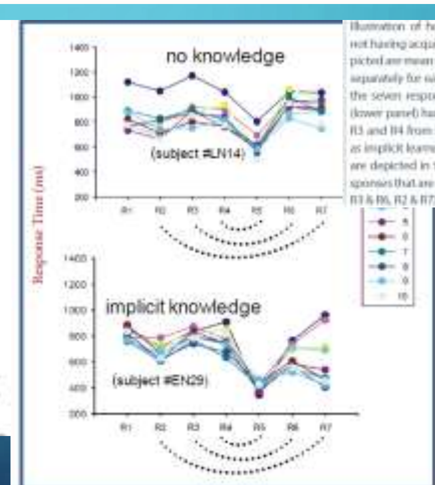

Illustration of how participants were classified as having or not having acquired implicit knowledge of the covert rule. Depicted are mean response times over the 30 trials of each block, separately for each of the 10 blocks in the second session for the seven responses R1 to R7 within a trial. Participant EN29 (lower panel) had faster response times for R6 and R7 than for R3 and R4 from Block 3 onwards and therefore was classified as implicit learner, in contrast to Participant LN14 whose data are depicted in the upper panel. The dotted arcs connect responses that are identical according to the covert rule (R4 & R5, R3 & R6, R2 & R7).

Napping and the Selective Consolidation of Negative Aspects of Scenes

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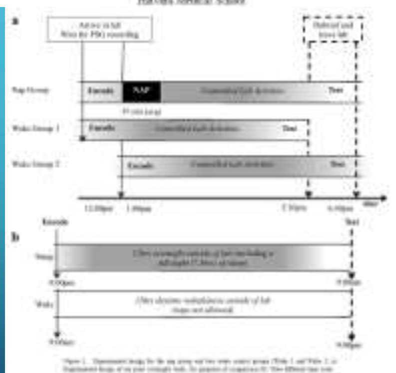
Robert Stickgold
Harvard Medical School



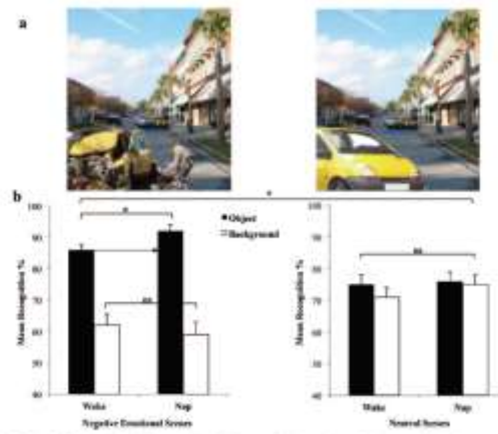


Figure 1. Sample stimuli (a). Sample stimuli with a neutral background and either a neutral object (intact car) or negative object (crashed car) in the foreground. A nap selectively benefits memory for emotional components of scenes (b). This figure depicts mean general recognition memory for objects and backgrounds in the nap and combined wake groups. Separate graphs show results for negative scenes (left), and neutral scenes (right). The arrow highlights the benefit conferred selectively to negative objects following the nap compared with wakefulness. Note, however, that no such differences emerge for the backgrounds on which these negative objects are embedded, or for either component (objects or backgrounds) of neutral scenes. Significant differences are denoted by asterisks. * $p < .05$. See the online article for the color version of this figure.

Sleep-dependent memory triage: evolving generalization through selective processing

Robert Stickgold[1] & Matthew P Walker[2]

The brain does not retain all the information it encodes in a day. Much is forgotten, and of those memories retained, their subsequent evolution can follow any of a number of pathways. Emerging data makes clear that sleep is a compelling candidate for performing many of these operations. But how does the sleeping brain know which information to preserve and which to forget? What should sleep do with that information it chooses to keep? For information that is retained, sleep can integrate it into existing memory networks, look for common patterns and distill overarching rules, or simply stabilize and strengthen the memory exactly as it was learned. We suggest such 'memory triage' lies at the heart of a sleep-dependent memory processing system that selects new information, in a discriminatory manner, and assimilates it into the brain's vast armamentarium of evolving knowledge, helping guide each organism through its own, unique life.

Figure 2 Forms of memory evolution. Categories of offline memory processing. All of these forms of offline memory processing have been shown to occur preferentially during sleep. (a) Item consolidation. Individual item-memories can be stabilized and/or enhanced, or they can be forgotten. (b) Item integration. Individual new item memories can be integrated into existing associative memory networks, extending the range of the network and enriching the information associated with the new item memory. (c) Multi-item generalization. Related item-memories encoded over a brief time interval can generate a new memory network and conceptual schema.