Substantiation of the prospective beneficial impact on a person's subconscious mind by exposure to suggestive techniques of the Hypnopedia application in order to improve the psycho-emotional state of users.

Contents:

Summary

The wide-ranging research works, including those based on the use of instrumental research methods (EEG, fMRI), suggest that the brain continues to respond to external stimuli and processes when a person is asleep. This confirms the preservation of cognitive processes, starting from the recognition of familiar stimuli to the formation of new memory traces at the subconscious level.

Provided that the amount of information potentially perceived by the brain of a sleeping person should be limited to a certain extent, the best option for “downloading” information is short repetitive phrases, i.e. affirmations. Affirmations have long and successfully proved to be a fairly effective, yet simple and accessible tool for working with the subconscious mind. Such techniques can be successfully used to enhance psychological well-being, improve productivity, combat stress, etc.

However, it is worth recognizing that this technique (uploading affirmations during sleep) does not always bring the expected result.

In order to significantly increase efficiency, the user is recommended to listen to and/or read affirmations before going to bed. The fact is that during sleep a repeated reactivation, or “replaying”, of the information received during the day, as well as memory consolidation, i.e. transformation of short-term memory into long-term memory, occur in the hippocampus and medial prefrontal cortex. Moreover, the information learned just before bedtime is best consolidated.

It is worth emphasizing that the combination of two techniques (reading affirmations before going to bed + listening to them at night) significantly increases the effectiveness of suggestive impact because in this case, the effect of targeted memory reactivation (TMR) is observed.TMR allows you to trigger and significantly enhance the processes of natural reactivation, which has been demonstrated in a series of experiments, including those using neuroimaging methods.

Thus, the combination of the above techniques in the Hypnopedia application is a scientifically proven, original and simple way to improve the emotional well-being of users.

Subconscious perception and processing of information during sleep

Uploading information to the subconscious mind with a minimum of effort is a long-standing dream of mankind. According to historical notes, people have been trying to use sleep for learning since ancient times. That was how Buddhist monks and ancient Greek priests whispered sacred texts to their slumbering disciples at night in the hope that this way they would better learn the instructions.

One of the first mentions of hypnopedia (Greek: ὕπνος - sleep, παιδεία - learning) in the modern era (1911) can be found in Hugo Gernsbeck's science fiction novel "Ralph 124C 41+", describing a Hypnobioscope – a device for learning during sleep. Much more famous works are built around a similar plot, for example: "Brave New World" by Aldous Huxley and "Ugly Swans" by the Strugatsky brothers.

In parallel, the idea of learning during sleep was being developed by a community of inventors.

In particular, in 1927 Benjamin Saliger from the USA proposed the idea of a "psychophone" – a device for broadcasting audio information during sleep. Two years later, Max Sherover described a possibility of remembering information while asleep in his story "Cerebrophone, Inc.", and a little later, he together with Elmer Brown, an engineer from San Francisco, turned his idea into reality.

In the 1930s, hypnopedia eventually became a fashionable trend of scientific research both abroad and in the Soviet Union. In 1936 a famous Soviet psychiatrist Abram Svyadoshch even defended his PhD thesis on this topic named "Perception of speech during natural sleep".

The hypnopedic boom rolled the world in the 50s-60s due to the increased influence of psychoanalytic ideas.

Alas, it did not last long.

And soon after the publication of Charles Simon and William Emmons, the era of sleep-learning came to its decline. In their work, American researchers using the method of EEG (electroencephalography) studied the wave activity of the brain during hypnopedic sessions and came to the conclusion that learning during sleep is probably impossible.

Similar conclusions were obtained by a number of other scientists of that time, which in the end could not but discredit the effectiveness of the method of sleep-learning. The enthusiasm around hypnopedia began to fade rapidly and then completely disappeared into oblivion.

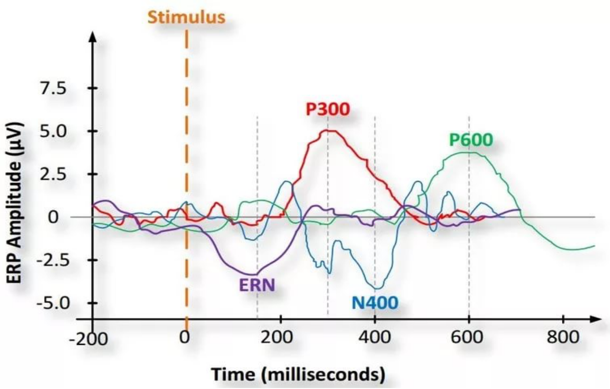
Fortunately, over time, a number of circumstances induced reconsideration of the established opinion.

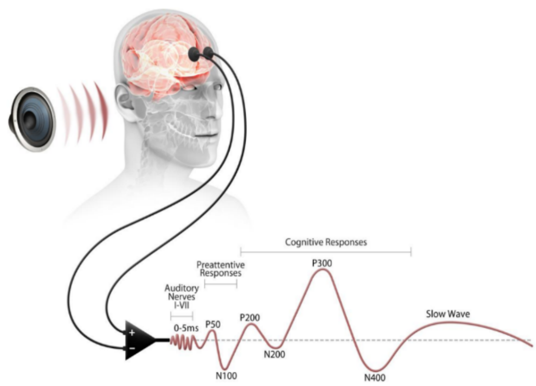
Firstly, since the time of Simon and Emmons, electroencephalographs have become much more sensitive (the number of electrodes has increased, and hence the contact area, a computer data processing unit has been added), and secondly, new and much more advanced methods of studying the functional activity of the brain have appeared, for example, fMRI. Finally, thirdly, somnologists themselves have significantly deepened their understanding of the neurophysiology of the sleeping brain.

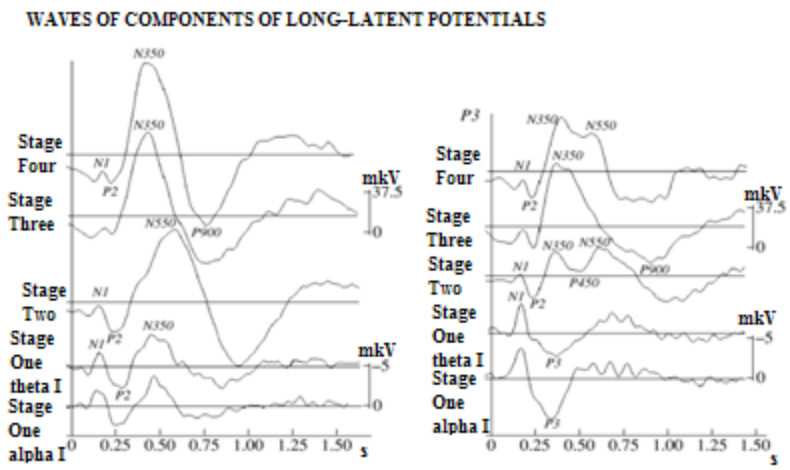
As a result, it has been found out that the brain objectively reacts to external stimuli and processes them while a person is sleeping, which proves the persistence of cognitive processes ranging from recognition of familiar stimuli to the formation of new memory traces.

In particular, it was shown:

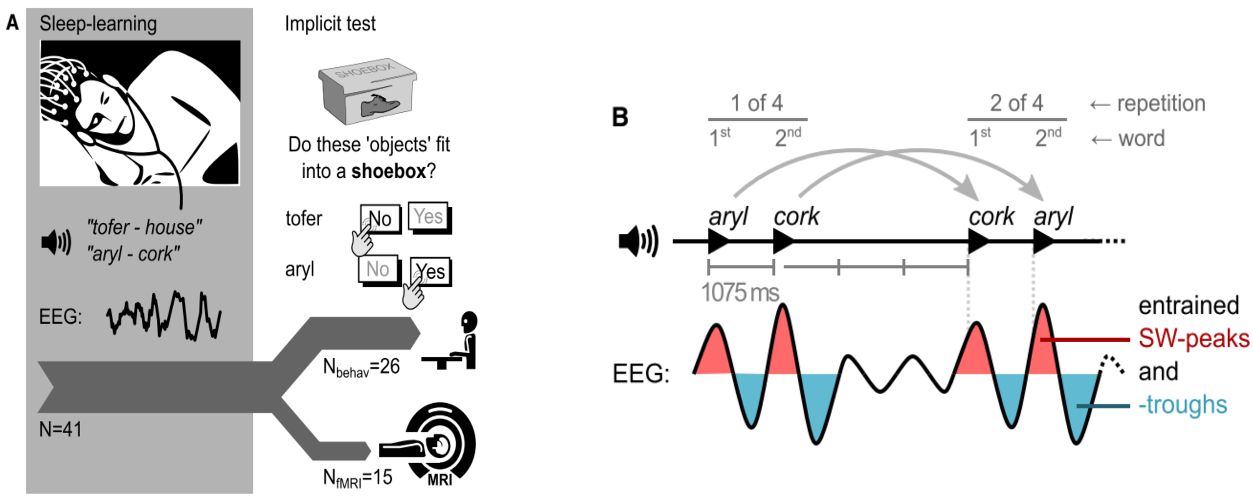
The analysis of stimuli from the external environment at the subconscious level continues during sleep because there is a need for continuous assessment of the biological significance of these stimuli. In particular, in the first stage of sleep, the component P3 = P300 can still be registered, which indicates the participation of the frontal lobes and is therefore associated with decision-making, ensuring the control of the individual over the external environment. Concurrently, lexical and semantic information is being processed and the meaning of the word is embedded in the previous context (N400). Component N350 with subsequent components P450-N550-P900 associated with the genesis of the K-complex is registered in the 2nd-4th stages of sleep. The change in the configuration of auditory event-related potentials during the transition from wakefulness to sleep and in the course of sleep deepening reflects the interaction of various brain structures at different stages of sleep and can serve as an objective indicator of the dynamics of information processes at different stages of sleep (*J Bruallaetall; Michael Czischetall; H Pratetallt; Thomas Andrillonetall*).

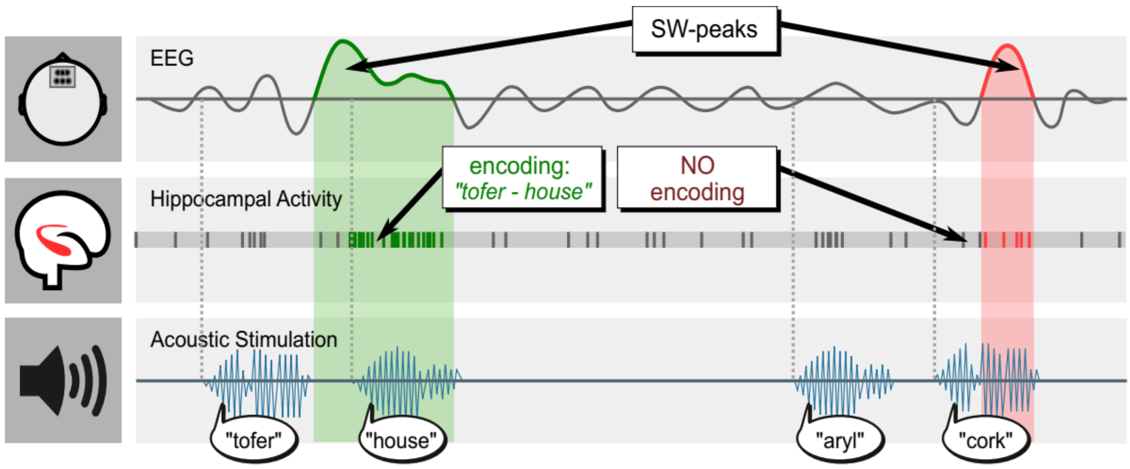




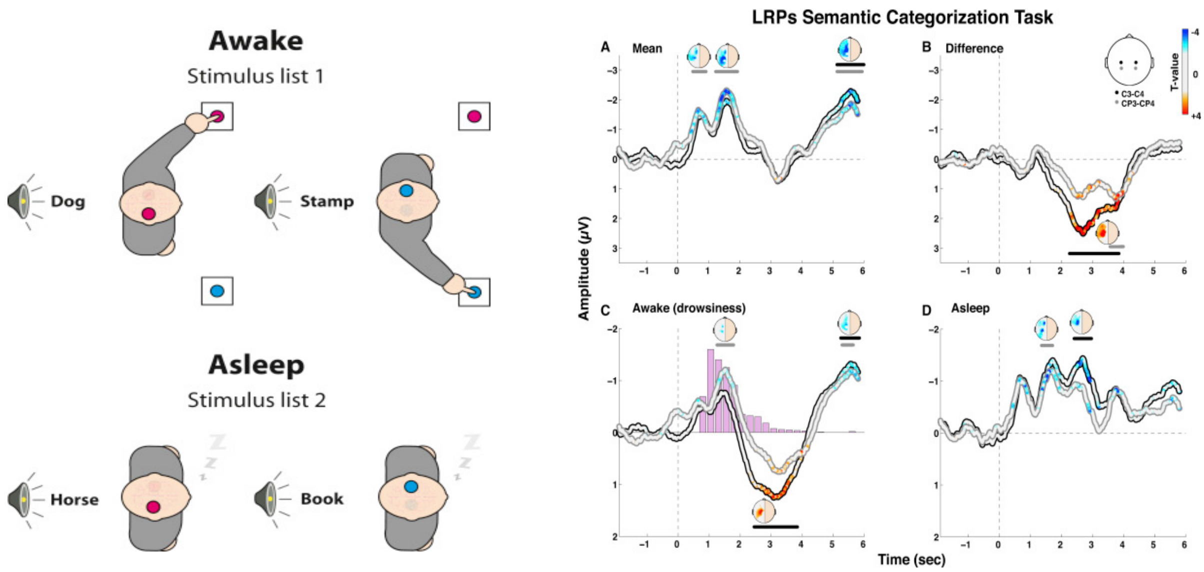


A fairly original study on testing the implicit memory of sleepers was carried on under the guidance of *Marc Alain Züst* on the example of a fictional language. During slow-wave sleep, pairs of words consisting of one real word and its fictional translation were played to the participants. For example, 'house' was 'tofer' and 'cork' was 'aryl'. After waking up, fictional words were repeated to the participants and they were asked if the word denoted an object that could fit in a shoe box? The purpose of the method was to see if such pairs would leave a trace in people's implicit memory. The researchers found that the participants, albeit slightly, but statistically more often than accidentally (by 10%) correctly classified the size of objects in unknown words. This suggests that the sleeping brain continues to process incoming information in terms of semantics. It is important to note that if the second word from the pair was presented during the ongoing peak of the slow wave, this allowed the hippocampus and neocortex to pair words. If the second word did not hit the peak, the probability of forming a pair decreased sharply. The experiment was carried out under the control of functional MRI. The scan results showed that the hippocampus was noticeably activated during the responses, which designates the work of implicit memory *(Marc Alain Züst et al)*.

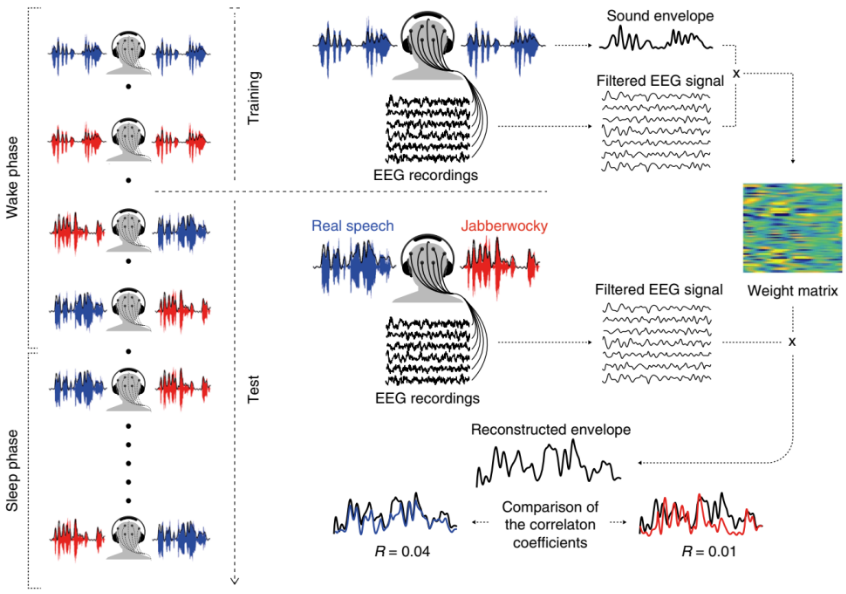




The experiment described below is another confirmation that despite the unawareness, the sleeping brain is able to recognize spoken words. With the help of electroencephalography, the activity of neurons was recorded when classifying words into specified categories. Upon presentation of animate objects, a person had to press the red button, upon presentation of inanimate objects, the blue button. When the subjects fell asleep, they continued to be presented with the sets of words. It turned out that the sleeper continued semantic analysis. Moreover, the encephalograph recorded activity in the area of the motor cortex, which meant that the subjects continued to perform the test ("to press" the keys) while sleeping *(Sid Kouider et al)*.

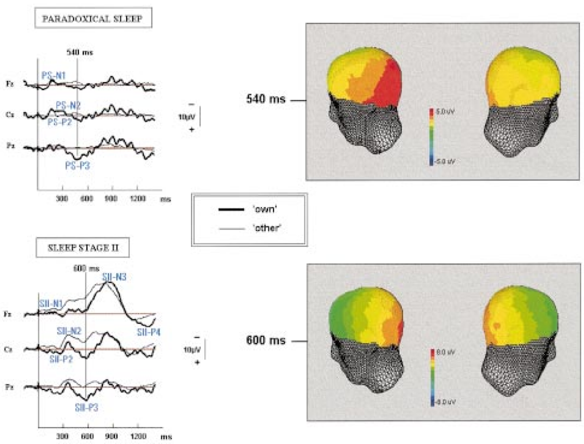


Similar results were obtained by a team of authors under the guidance of *Guillaume Legendre*. According to EEG readings, the sleeping brain enhances meaningful speech compared to fictional irrelevant signals. However, the amplification of the corresponding stimuli was transient and disappeared during the deep sleep stage.



In their work, *Jérôme Daltrozzo* and colleagues also demonstrated the possibility of partial preservation of linguistic memory during sleep.

It is noteworthy (but expected) that the most significant response of the wave activity of the sleeping brain occurs in response to the presentation of the subject's own name in comparison with other sounds *(F Perrin et al)*.



The results of experimental observations indicate that the assimilation of information provided by the hypnopedic method depends on a number of factors: the number of sessions, the scope of material, the intonation of speech and the type of memory.

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Affirmations

An essential point and at the same time the reason for the failures of the first-wave hypnopedia is the fact that, although the brain is able to perceive external information during sleep, it certainly does so within a very limited range. That is why hypnopedia cannot be a substitute for classical learning – learning a foreign language or mastering a new complex skill during sleep is unrealistic. Only individual words and phrases can be uploaded to the subconscious level. However, this may be quite enough to fine-tune the subconscious mind.

Affirmations seem to be ideal envelopes for such SMS messages sent into the depths of the human psyche.

Affirmations have long and successfully established themselves as a fairly effective, yet simple and accessible tool for working with the subconscious mind. A large volume of scientific publications indicates that affirmation techniques can be successfully used to improve psychological well-being, increase productivity and academic performance, aid the modification of personality integrity, make people more open to changing their own behavior, successfully fight rumination (obsessive thinking) *(Geoffrey L Cohen; Myoungjin Shin; Rebecca A Ferrer; Allison M Sweeney; Clayton R Critcher; Xuan Zhu)*. In addition, affirmations have been shown to be successfully used to combat stress *(Ian Robert Hadden)*, alcohol and nicotine addiction *(Phillip J Ehret)*, as well as significantly reduce the state of paranoia *(Jessica Kingston)*.

It is noteworthy that the positive effect of affirmations can persist for several months or even years.

One of the action mechanisms of affirmations is to start a positive feedback loop between the “I” system and the social system.

In addition to clinical observations, neuroimaging data including electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are a reliable confirmation of the effect of affirmations.

The results of the analysis showed that the participants of the experiment who practiced affirmation techniques demonstrated increased activity in the key areas of the brain responsible for self-analysis (medial prefrontal cortex + posterior cingulate cortex) and self-esteem (ventral striatum + ventral medial prefrontal cortex) *(Christopher N. Cascio).*

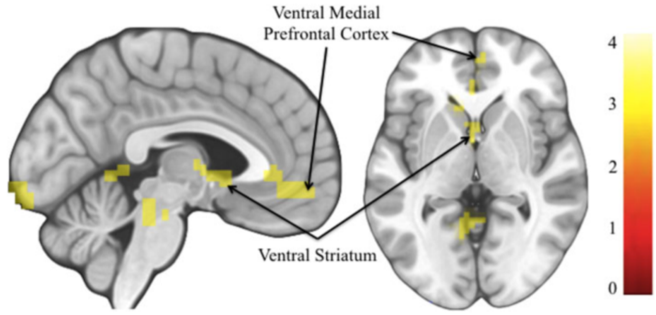
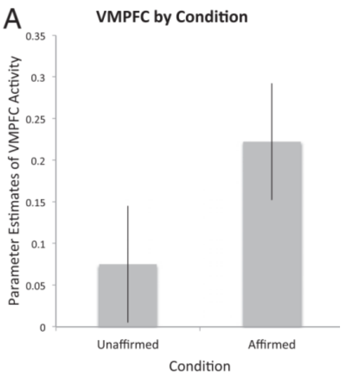


Fig. 2. Whole brain analysis comparing the contrast (future value > future control scenarios) for the affirmed group > control group.

A similar increase in the functional activity in the medial prefrontal cortex as a result of an affirmation effect was demonstrated in Emily B. Falk's research.



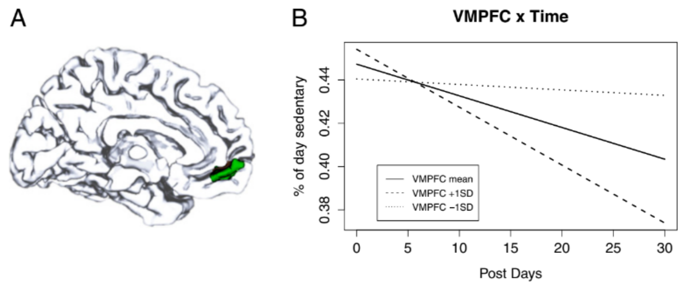
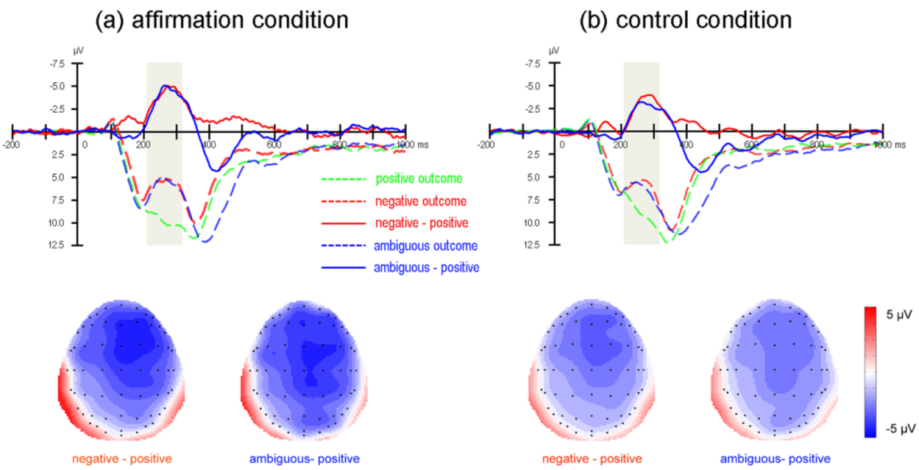


Fig. 2. (*A*) VMPFC ROI. (*B*) Participants who showed higher levels of VMPFC activity during exposure to health messages subsequently decreased their sedentary behavior more in the month following the scan, controlling for baseline sedentary behavior and demographics.

Rollei Gu and colleagues studying evoked potentials by means of electroencephalography noted a significant change in the wave activity of the participants' brain under the influence of affirmations.



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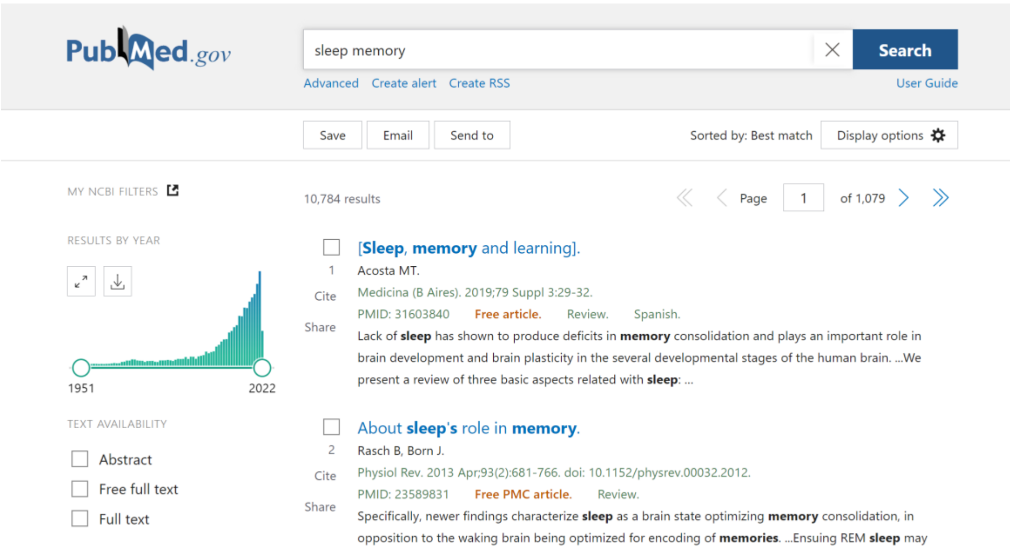
It is worth noting that the method of uploading affirmations during sleep does not always have a sufficiently pronounced effect. In order to significantly increase efficiency, the user is recommended to listen to and / or read affirmations before going to rest, because during sleep, the processes of reactivation (“replaying”) and the transfer of information from short-term to long-term memory occur.

Brief overview of the relationship between sleep and memory processes

By now, the close relationship between the processes of memory formation and sleep has been reliably established and repeatedly proven by an impressive number of scientific studies.

The PubMed medical portal gives more than 10,000 links to scientific publications on this request.



They include 1300+ articles for 2021-2022, which implies significant interest of researchers and high practical significance of this issue. The main principles are presented below.

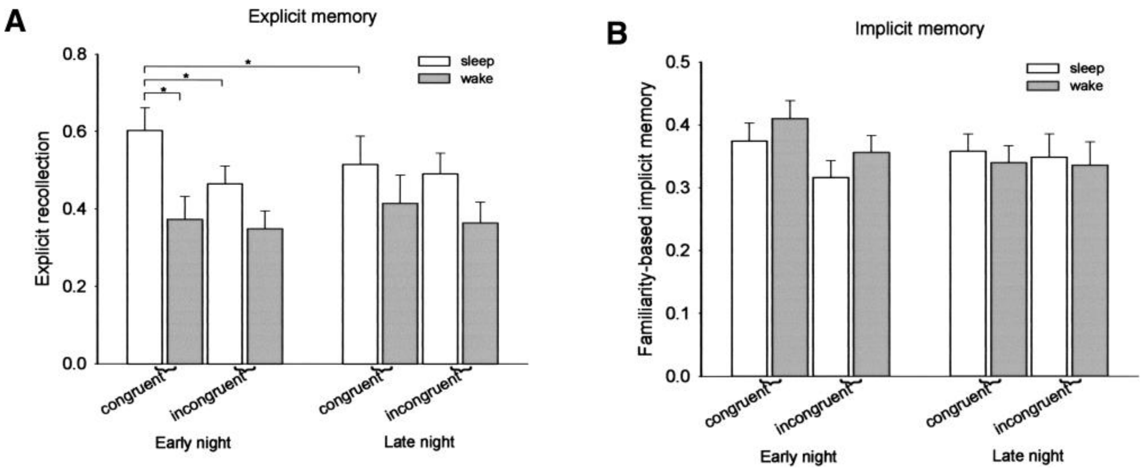
The transformation of short-term memory into long-term memory is closely related to sleep processes.

As you know, memory can be divided into short-term and long-term.

The transformation of short-term memory into long-term memory is called memory consolidation.

In turn, consolidation can be divided into stabilizing and improving.

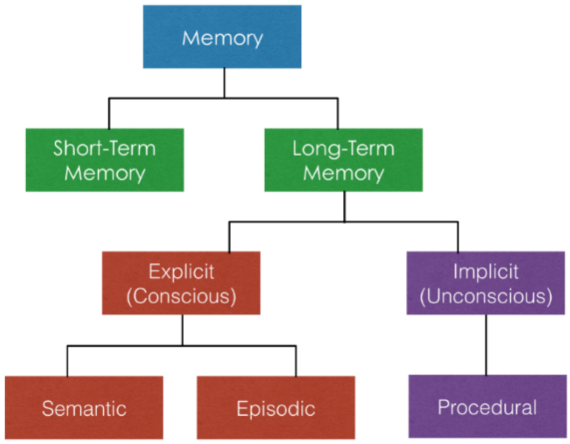
The stabilizing stage of consolidation is more associated with wakefulness *(Walker M.P., et al)*, while the improving stage is mainly associated with sleep processes (Fenn K.M., et al). There are 2 main theories explaining the effect of sleep on different memory systems.



According to the first theory, slow-wave (delta) sleep is associated with the consolidation of information in the declarative memory system, whereas the consolidation of non-declarative information depends on REM (paradoxical) sleep *(V. Plihal, et al., Drosopoulos S)*.

The second theory emphasizes the importance of proper alternation of REM and NREM sleep in the consolidation processes. Thus, both stages of sleep are mandatory for consolidation, regardless of which system the memory trace belongs to *(Giuditta A. et al)*.

It should be emphasized that in real life, certain types of memory actually never manifest themselves in an isolated form. For example, learning any skill requires the involvement of different types of memory.

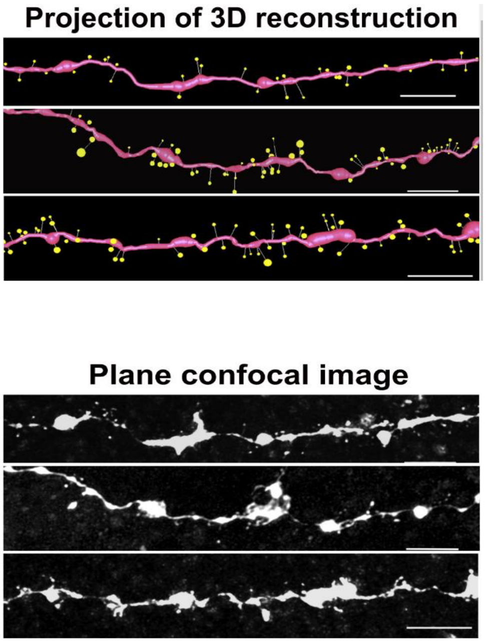


**Declarative or explicit memory is one of the two main types of a person's long-term memory responsible for the conscious intentional recollection of factual information, previous experiences and concepts.*

***Non-declarative or implicit memory refers to the knowledge of certain actions or procedures that eventually become automatic with repetition and practice. This type of memory is often used without conscious thinking or planning, and therefore it is very difficult to put into words.*

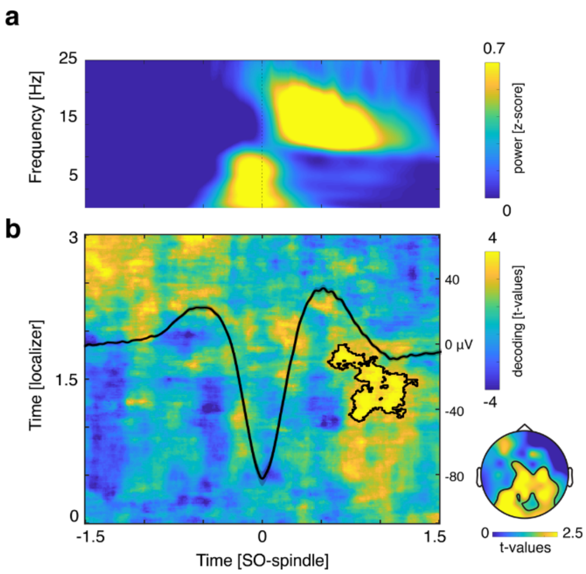
The change in the size of the dendritic spines of neurons during sleep represents the process of assimilation of information.

According to the hypothesis of synaptic homeostasis, sleep is a kind of regulator of the growth of the number and size of synapses. During sleep, more important synaptic connections are united and strengthened. At the same time, less important connections fade and lose their significance, which is called the "reverse learning theory", which says that sleep helps to get rid of a certain number of unnecessary associations and connections that are formed in the brain throughout the day, thus freeing the head from unwanted and useless thoughts.



The researchers created a genetically modified line of mice in which a special fluorescent protein was synthesized in the neurons of the motor cortex. Thanks to this, it was possible to observe the process of formation of new dendritic spines, it indicating the neuron's reaction to new information and readiness to remember it. During the experiment, it turned out that in those mice who were allowed to sleep after training, dendritic spines grew more actively. While on sleep deprivation, spikes did not form. As a result, the following scheme appeared: neurons received a certain stimulus during wakefulness, then during sleep these neurons were activated again, and such re-activation stimulated cellular rearrangements that contributed to long-term memorization of the stimulus. *(Yan mei Zhouetall)*

The relationship between the mutual arrangement of wave patterns and the quality of memorization

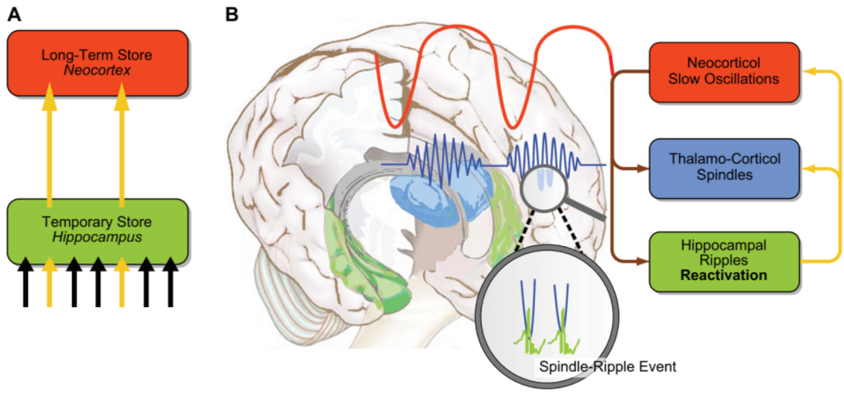


20 participants of the experiment memorized pairs of words and pictures, then passed memory tests. After that, the participants fell asleep in the laboratory for a couple of hours, and when they woke up, they were tested again. Throughout the experiment, an electroencephalographic study of the wave activity of the brain was carried out. As a result, the researchers found a connection between the mutual arrangement of wave patterns and the quality of memorization: reactivation of the learned information was associated with complexes of the appearance of sleep spindles and slow waves (delta rhythm).

It is noteworthy that the closer these patterns were located on the electroencephalogram, the better memory consolidation occurred (Thomas Schreiner).

**sleep spindles are flashes of electrical activity with a frequency of 11-15 Hz characterized by the gradually increasing and decreasing amplitude, which makes them look like spindles.*

Neuroanatomy, brain waves, sleep and memory

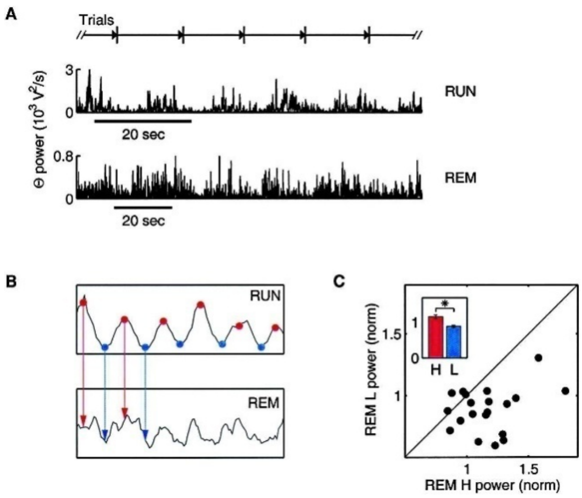


During deep sleep, groups of neurons generate brain waves in a triple rhythm: slow oscillations in the neocortex + ripples in the hippocampus (the structure of the brain in the depth of the temporal lobes responsible for short-term memory) + sleep spindles in the thalamus (subcortical center of all types of sensitivity).

The frequency of thalamus spikes is 7-15 per second, the number of spikes being associated with memorization: they become more numerous if the previous day has been full of learning.

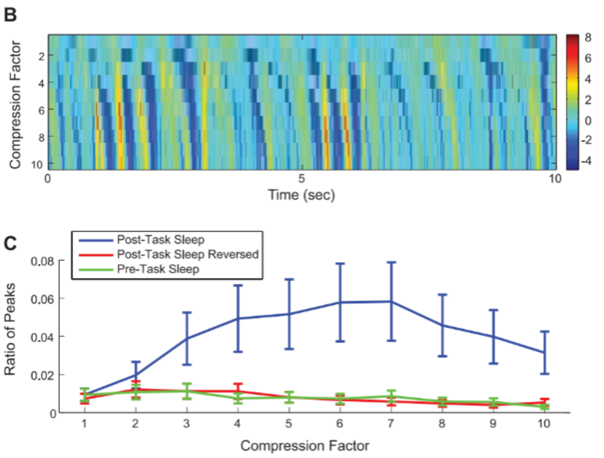
Using optogenetic techniques, the researchers controlled the neural activity of the thalamus during slow sleep, which caused the mice to remember or forget what they had learned before. Thus, it was shown that the thalamus mediates the exchange of information between the hippocampus and the neocortex. In particular, slow fluctuations of the cortex can be a signal of its readiness to receive information, thereafter, with the help of sleep spindles, the thalamus signals this to the hippocampus. If the hippocampus tries to exchange information when the neurons of the cortex are not yet ready to "listen" to it, the data is lost. *(Charles-Francois V. Latchoumane)*

Reactivation is the "replaying" of daytime events during sleep.



Reactivation in the hippocampus

A series of experiments with electrodes implanted in the brain, as well as findings of functional magnetic resonance imaging showed that during sleep a series of impulses, which have been observed during previous training in wakefulness, are reproduced in the hippocampus. It is curious that the nighttime "replaying" of daytime events in the hippocampus is carried out in the accelerated mode (on average 5-20 times faster)



Reactivation in the medial PFC

In addition, the medial prefrontal cortex (the area of the frontal lobes) plays a significant role in the activation of consolidation. During sleep in this area of the brain (like in the hippocampus) the pattern of brain activity that was observed the day before is also repeated. The greatest similarity of the graphs of neural activity during waking hours and during sleep is obtained if the second graph is "extended" 7 times in time *(David R.).*

Based on the above facts, we can conclude that sleep is a critically important component of the formation of memory processes. And even short-term (including daytime) sleep contributes to a reliable improvement in the memorization of information.

A number of tests were conducted with the following content. A group of subjects were asked to learn certain information, for example, a list of unfamiliar foreign words and then reproduce them from memory. It turned out that the group of participants who were allowed to sleep after training coped with the task significantly better than people who were tested immediately after memorization *(Stéphanie Mazza, Plihal W).*

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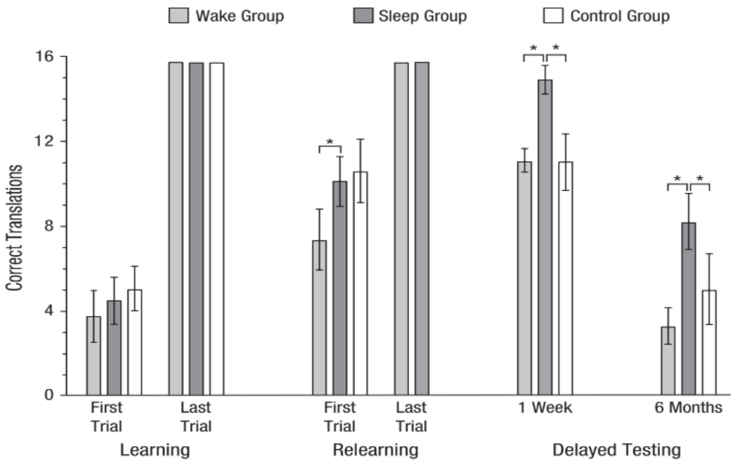

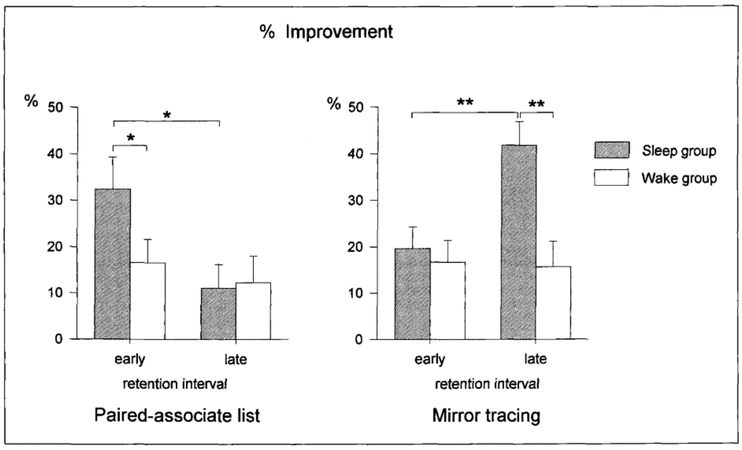

Figure 1. Comparisons of percentage of improvement in the experimental sleep (shaded bars) and the wake control (white bars) group of recall of paired-associate lists (left panel) and in mirror-tracing speed (right panel) after the early and the late retention interval (*$p < 0.05$; **$p < 0.01$).

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It is worth emphasizing that the combination of two techniques (listening and / or reading affirmations before sleeping + repeated night listening) significantly increases the effectiveness of suggestive effects because in this case, the effect of targeted memory reactivation is observed.

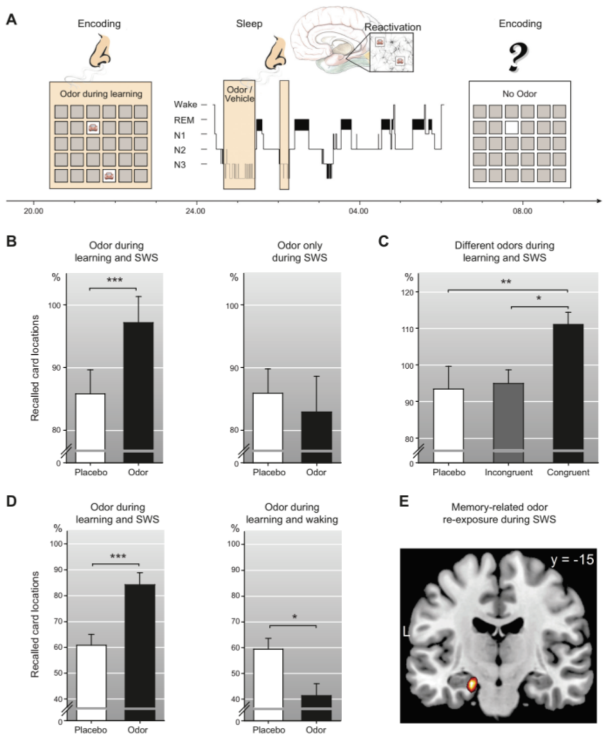
Targeted Memory Reactivation

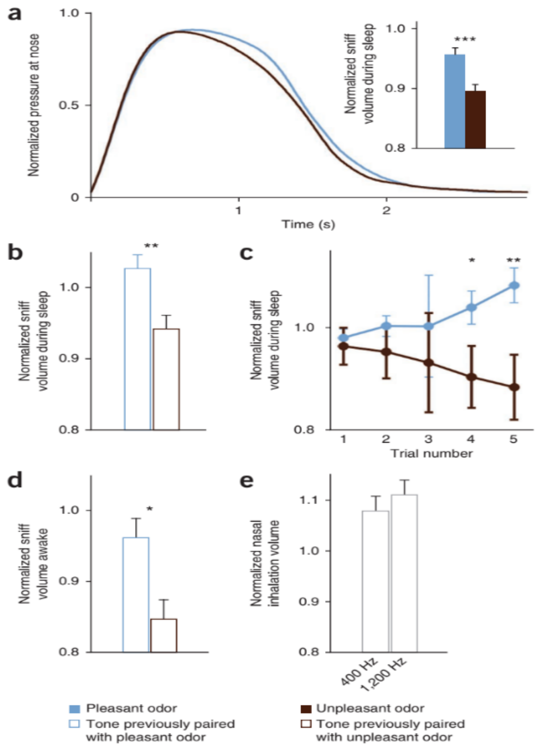
It should be noted that memory reactivation occurs not only spontaneously during sleep, but can also be triggered or enhanced by external cues. This technique is called "targeted memory reactivation" (TMR).

It is possible to start reactivation of memory during sleep by stimuli of different modalities, for example, with the help of sounds and smells *(Delphine Oudiette)*.

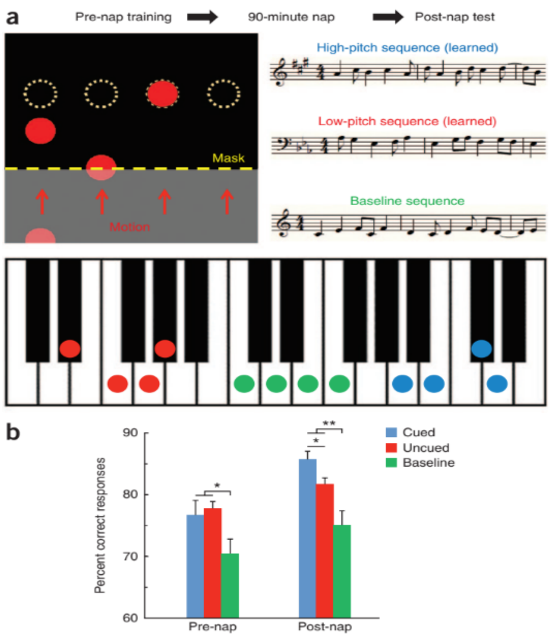
Combinations of various sounds with pleasant or unpleasant odors were used for training. To assess the pleasantness of the smell, the force of sniffing was used: if the smell was pleasant, the inhalation force was greater. After forming a stable association, the subjects went to rest. The stimuli were presented in such a way as not to wake up the participants of the experiment. It turned out that if only the sound associated with a particular smell was presented during sleep, then the inhalation force would change depending on the "pleasantness / unpleasantness" of the sound. In addition, it turned out that the memory of the sound-smell combination persisted after waking up.

The tests were conducted both in the REM and NREM sleep stages. According to the results of the study, the reaction to sound signals was more pronounced in the REM sleep stage. However, those participants who were presented the combination of the smell-sound pair in the NREM stage remembered the association more successfully. Probably, such results can be explained by the fact that it is during the slow-wave stage of sleep that there is a more intensive exchange between the associative zones of the neocortex and the olfactory structures of the brain *(Björn Rasch; Anat Arzi)*.





In James W Antony’s research, the participants of the experiment were asked to learn a few simple melodies, after which one of the compositions was played imperceptibly (so as not to wake up) during sleep. It turned out that in the morning all the subjects remembered it and performed reliably better than the one that was not accompanied by a night cue.



The effectiveness of targeted memory reactivation can also be confirmed using neuroimaging methods. Thus, in Eelco V vanDongen's research, functional MRI was used to study the activity of the brain during the registration of the night cue (TMR) of the material learned the day before.
It turned out that the sleeping brain reacts much more actively to the words learned the day before in comparison with neutral sounds. Increased activity was observed in the right parahippocampal gyrus, a part of the brain involved in memory consolidation.

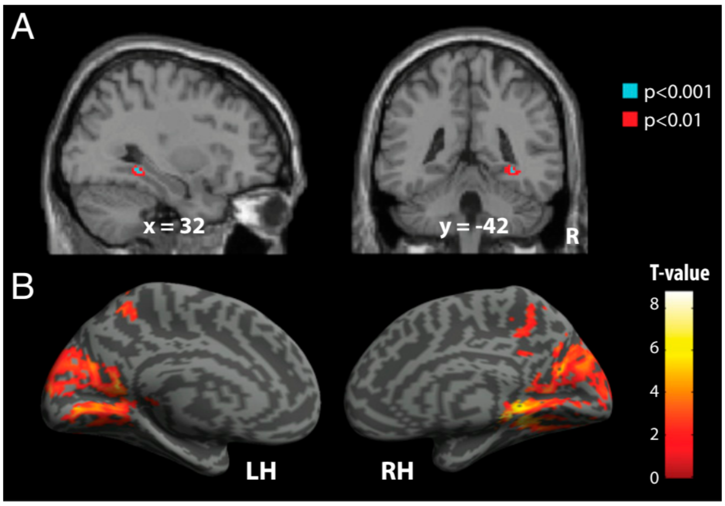
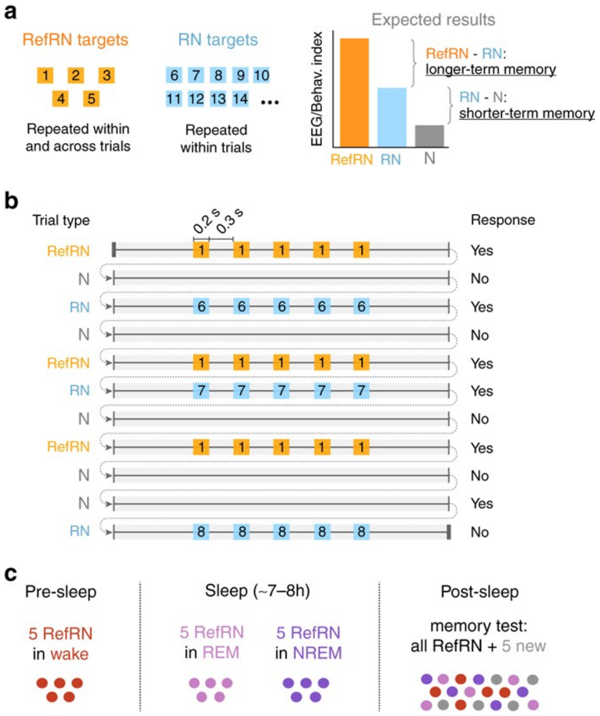
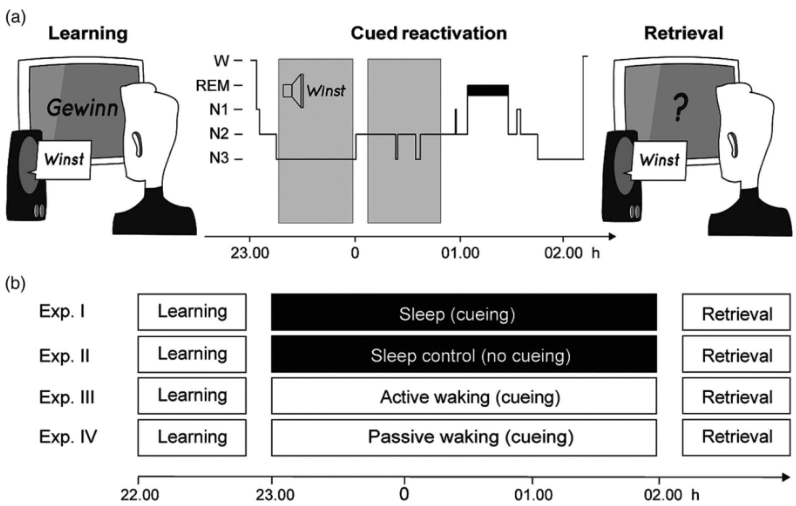


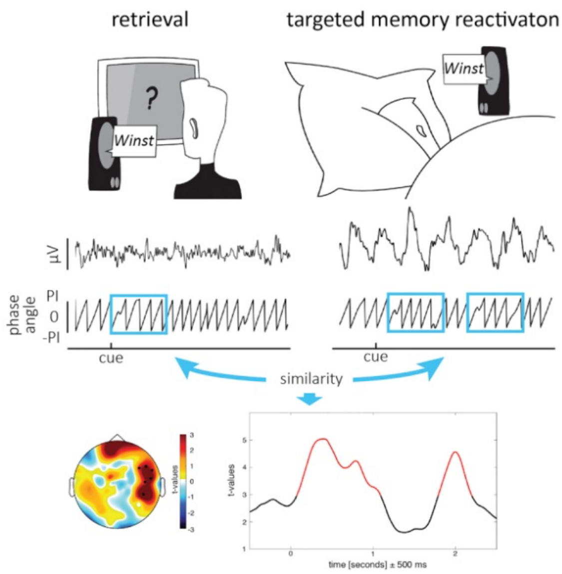
Fig. 3. (*A*) The right parahippocampal cortex is more activated during presentation of cue than control sounds in slow-wave sleep. The cluster

In another study, the subjects were asked to find a sequence of sounds hidden in white noise. To successfully solve the task, as a rule, several dozen auditions are required. Those subjects to whom noise melodies were played during REM sleep were several times faster at determining the sequence of sounds than those who did not have similar night cues. Interestingly, playing these audio recordings during the slow-wave sleep stage, on the contrary, worsened the memory of volunteers, forcing them to spend much more time searching for sequences than before falling asleep *(Thomas Andrillon)*.



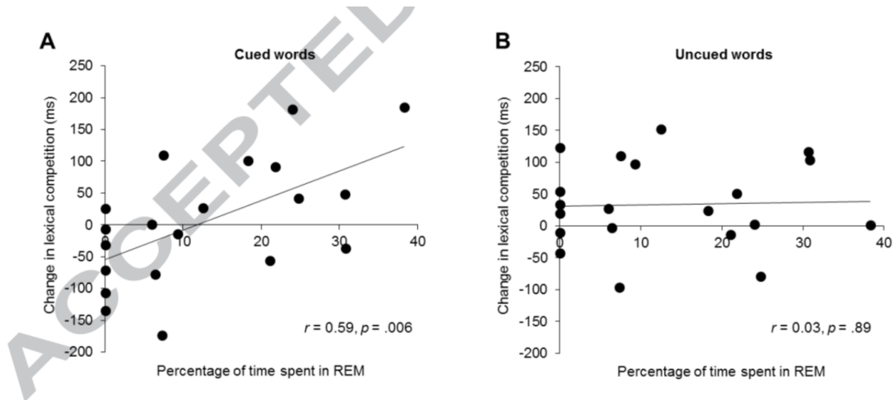
There are a significant number of scientific publications devoted to the targeted reactivation of memory using not only various sounds and melodies, but also using verbal signals. *Thomas Schreiner* used previously learned Dutch words as a night cue during the slow-wave stage of sleep, as well as (as a control) during passive and active wakefulness. Repeated presentation of Dutch words during sleep significantly improved their recall on the next day. Interestingly, verbal cues did not improve the memory of the subjects if they were given during active and passive wakefulness. As a result, it was demonstrated that verbal signals presented during slow-wave sleep reactivate related memories and facilitate the subsequent reproduction of foreign vocabulary without disrupting the current consolidation processes.





In the subsequent works of this author, the electroencephalographic analysis was used to prove that slow waves of brain activity characteristic of sleep, as well as theta waves (usually associated with successful encoding of memory during wakefulness) can participate in enhancing memories during sleep.

Similar results were demonstrated in the work of Jakke Tamminen, who, among other things, showed the importance of REM sleep in memory consolidation processes. According to the researcher, purposeful reactivation of the memory of newly learned words during sleep triggers REM (sleep with rapid eye movement) mediated integration of the new memories and existing knowledge.



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Conclusion:

The above research data were taken into account when creating the Hypnopedia application.

In particular:

- The relevant sleep stage (for presenting affirmations) is determined individually for each user using an algorithm developed by us based on data received from Applewatch sensors.

- Affirmations are read by professional speakers (in Russian and English) with an option to choose a male or female voice.

- Affirmations are carefully selected and grouped into categories, so each user will be able to choose the appropriate option for themselves.

- The user receives a notification with a recommendation to listen to and /or read the selected list of affirmations at a convenient time for them.

- With regular use of the application, the user receives a reward, which contributes to the creation of motivational reinforcement.

Hence, the combination of the above techniques in the Hypnopedia application is a scientifically proven, original and simple way to improve the emotional well-being of users.