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Insight and the sleep committee

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Abstract

We all spend about a third of our lives asleep, an essential but seemingly unproductive state. Experimental evidence now emerges to support anecdotal evidence that sleep can stimulate creative thinking.

Does this experience seem familiar? The solution to an unfathomable problem, left unresolved in the evening, effortlessly pops into your mind the following morning. Although many people believe that sleep plays a role in these flashes of insight, this is a hypothesis that has not been rigorously tested. On this issue [1], however, Wagner and collaborators provide evidence that sleep can have a beneficial effect on insight.
The authors have applied a clever test that allows them to determine exactly when insight occurs in the time course of learning [2].
In this task, the participants have to transform a string of eight digits into a new string, the last digit of which is the final solution (see Fig. 1). To do this, they are instructed to apply two simple rules sequentially, from one digit to the next. However, unknown to the subjects, another rule is hidden in the material: the last three responses mirror the three preceding ones. Discovering the hidden rule can speed up the execution of the task, as the final solution is known when the third digit is specified.

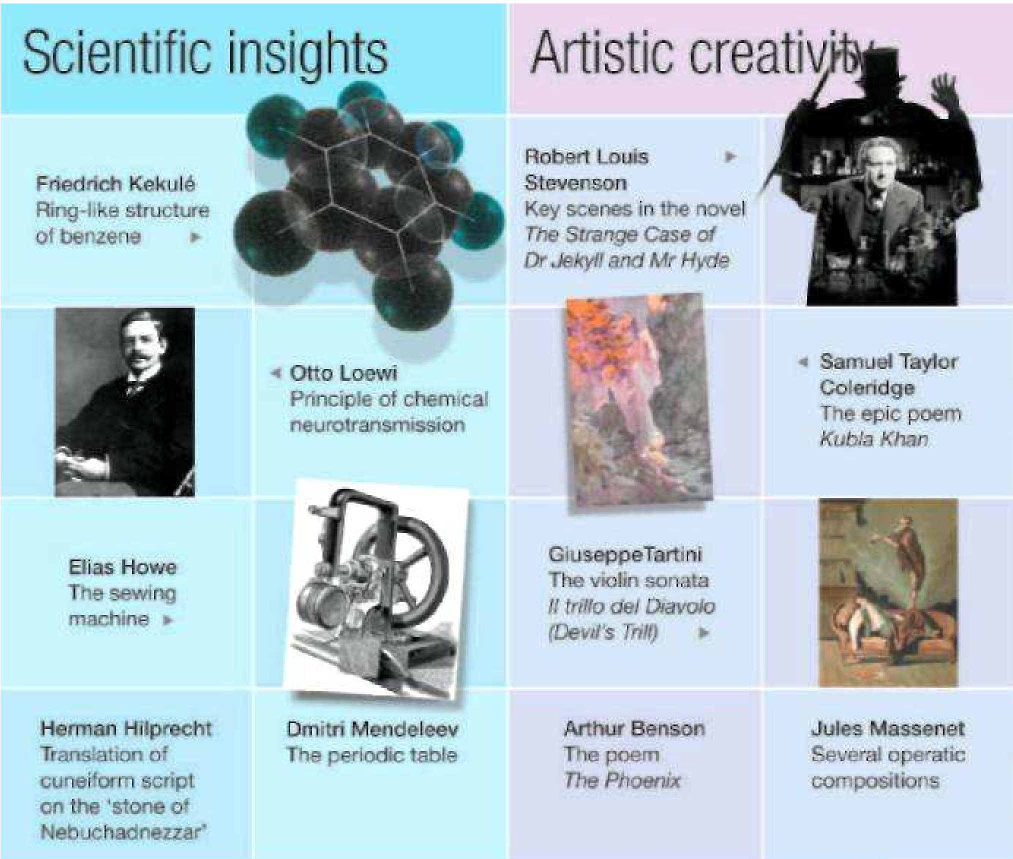

Figure 1 Instances of insight and creativity said to have followed sleep (or rather, except in the case of Massenet, occurring during or following a dream). Some may be apocryphal. But these examples foster the general feeling, tested in a controlled manner by Wagner et al. [1], that sleep may aid insight.

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All participants were trained in the task (three blocks of tasks), then retested (for ten blocks) after eight hours. During the eight-hour period the subjects were either awake (during daytime or during the night) or sleeping. When they were retested, the proportion who gained insight in those allowed to sleep (60%) was more than twice that in those who remained awake (22%). If subjects were exposed to the task continuously for 13 blocks, without having been trained the day before, the proportion who gained insight was similar to that in the awake groups. In other words, the favourable effect of sleep on insight occurred only if a memory had been formed before the sleep period.

The data further suggest that the conscious use of the hidden rule did not evolve from procedural learning — that is, from the unconscious acquisition of a skill through practice. Rather, it stemmed from separate mental representations that were rearranged during sleep after training had taken place. First, although in the sleep group the times taken to solve each sequence of the string of digits decreased overnight in both 'solvers' (the 60% who gained insight later on) and 'nonsolvers' (who did not), this overnight decrease in reaction time was much smaller in the solvers than in the nonsolvers. Second, compared with the nonsolvers, the responses to the first digits in a sequence were delayed in the solvers as early as the end of the training session. It seems that the solvers spent time analysing the task during the training and retest sessions. Nevertheless, the solvers were the fastest to find the final solution in a sequence because they were aware of and applied the hidden rule.

The primitive elements of the task that the participants gleaned during training seem to have been reorganized during sleep, eventually leading them to become conscious of the hidden rule the following morning. Sleep has been implicated in learning and memory in the adult brain and is thought to favour the 'off-line' processing of new memories [3]. Wagner and colleagues' data can be viewed as an extreme case of memory processing, in which the reorganization of primitive representations leads to a new conscious knowledge that entirely changes and improves the subject's ability to crack the problem.

This study, of course, raises plenty of questions. What are the neural correlates of the processing of the primitive representations during sleep that lead to the gain of insight the following day? During wakefulness, learning of the hidden rule is known to be related to activation of two parts of the brain in particular — the perirhinal cortex and superior parietal lobule [2]. Do these areas participate in the off-line processing during sleep? What are the neuronal interactions, reinforced during sleep, that underpin the emergence of the conscious knowledge?

There is also the issue of whether all stages of sleep participate in these processes — that is, what does the 'sleep committee' that stimulates insight consist of? Explicit memory tasks are generally thought to be more sensitive to deprivation of slow-wave sleep [4]. On the other hand, most of the famous cases of scientific insight and artistic creativity (Fig. 1) are reported as emerging from a dream, which is a mental activity that occurs more frequently during the sleep pattern known as rapid-eye-movement (REM) sleep. Another possibility is that both non-REM and REM sleep are sequentially needed to optimize the memory [5,6]. Wagner *et al.* give us the tools to explore these questions experimentally. Their paper constitutes steps forward in investigating the unpredictable and elusive phenomenon of insight, and in broadening the scope of the research on sleep, cognition and brain plasticity (the brain's ability to persistently change its structure and/or function).

The role that sleep plays in human creativity will be a mystery for some time yet. But at the very least, Wagner *et al.* give us good reason to fully respect our periods of sleep — especially given the current trend to recklessly curtail them.

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