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# HOW SLEEP CAN MAKE YOU SMARTER

THE AMAZING SCIENCE OF HOW YOU LEARN WHEN YOU'RE NOT EVEN AWAKE



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HOW SLEEP CAN  
MAKE YOU SMARTER

## By careful manipulation of your slumber, you can turn it into the ultimate cognitive enhancer

Words: Dr. Penelope Lewis

**P**EOPLE DO ALL kinds of things to get ahead in today's competitive world. The struggle for jobs and promotions is cut-throat, and the use of performance-enhancing drugs such as Modafinil and Ritalin is on the rise. But ironically, nature's best cognitive enhancer is often entirely overlooked.

What makes you feel great when you have it and a complete basket case when you miss out? That's right—sleep. Something we should all spend roughly one-third of our time doing, but which we actually tend to squeeze at both ends, with tiredness and underperformance the result.

But sleep is not only critical for staying alert and attentive. We're now beginning to understand the extent to which it influences our ability to learn new things—everything from riding a bike to learning Spanish. And this new understanding is showing us how we can use sleep to enhance our memories.

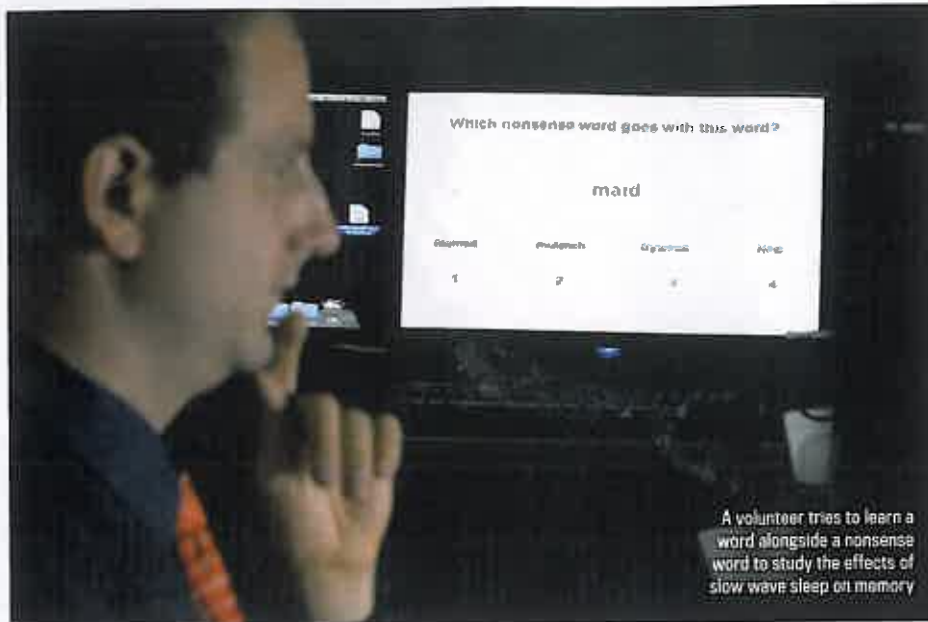
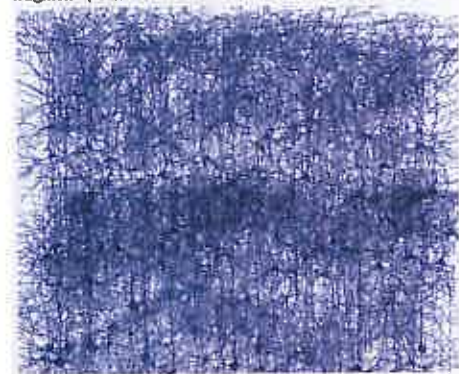
The idea that sleep and memory are linked is nothing new. Back in 1924, two American psychologists, John Jenkins and Karl Dallenbach at Cornell University, enlisted a pair of

## “Sleep can work wonders with our ability to learn motor skills - from riding a bike to typing faster”

→ students to learn nonsense syllables. The researchers then tested the students' memories one, two, four and eight hours later. What they found was that students could remember more of the syllables when they had been to sleep between the learning session and the test than when they had been awake. In other words, sleep had somehow improved their memories.

But it was only when we started to understand the different phases of

The microcircuitry of the neocortex, which stores memory fragments, can be seen as a forest of neurones



sleep – different stages in our slumber characterised by a different depth of sleep and different patterns of electrical activity in our brain – that we started to fully grasp exactly how sleep affects memory. What became clear is that the different phases consolidate different types of memory.

### MORE NONSENSE

Earlier this year, researchers at the University of California carried out some research with echoes of that performed by Jenkins and Dallenbach almost 100 years earlier in that the participants were asked to learn nonsense. A bunch of young adults – whose average age was about 21 – and a group of older adults – whose average age

was about 75 – were instructed to learn word pairs consisting of real words, such as 'birds', and made-up words, such as 'jubu'. They found that both the younger and older participants were able to recall the pairings better the more 'slow wave sleep' (SWS) – characterised by a slow pulsing of brain activity – they had at night (see 'Phases of sleep', on p37).

Another piece of research that was perhaps a little more traumatic for its participants proved that sleep also helps us remember events that fire our emotions. A group of students at the University of Bamberg in Germany were given emotionally charged texts to read, such as one that detailed the killing procedures of a child murderer. When the students were only able to sleep over the second half of the night, so they had more 'rapid eye movement' (REM) sleep, they were much better at recalling details of the text than when they had non REM sleep (in the early part of the night) or no sleep at all.

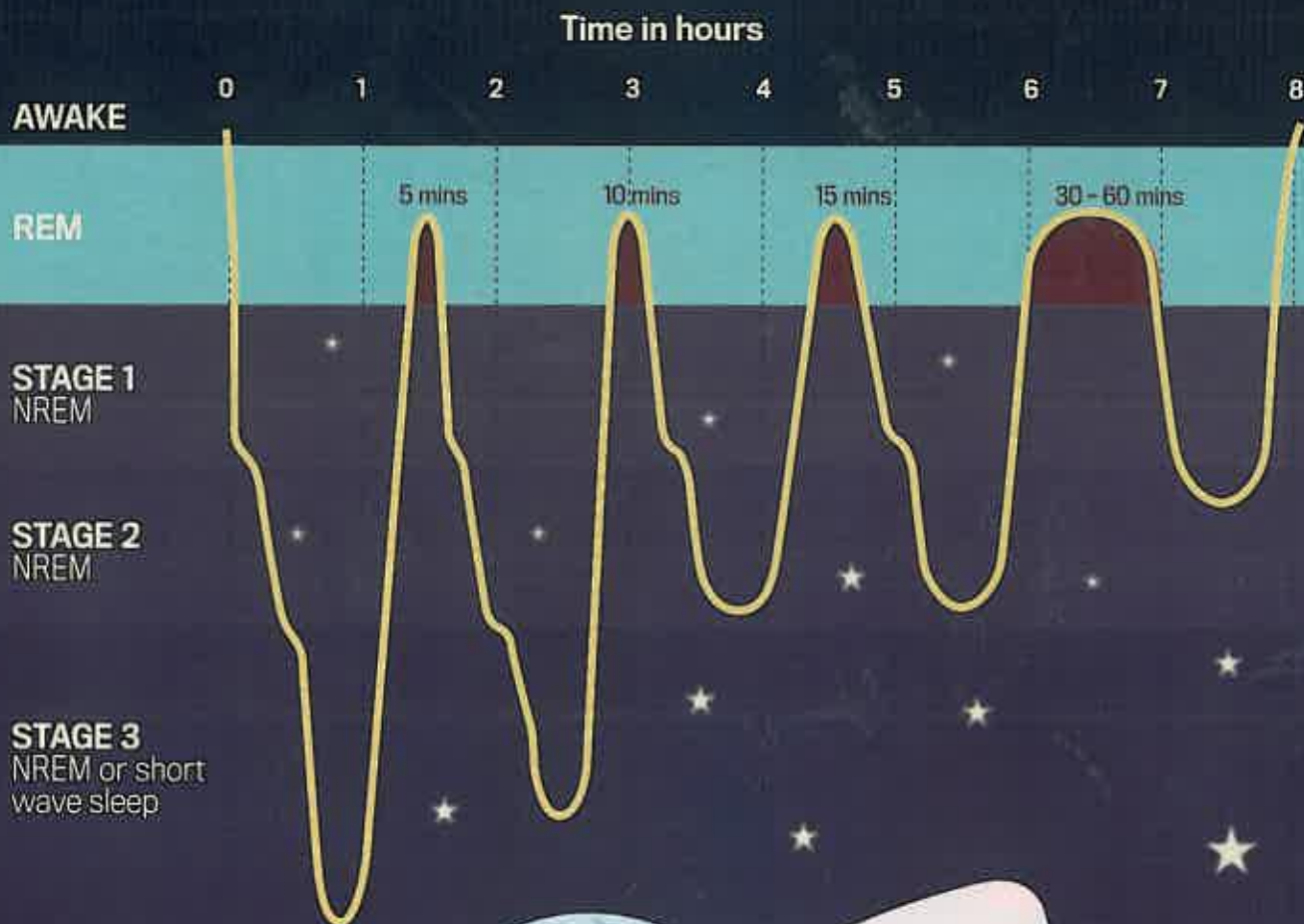
Sleep can also work wonders with our ability to learn motor skills – anything from riding a bike to typing faster. Neuroscientist Dr Matthew Walker, then at Harvard Medical School, trained people to tap a complex series of keys on a computer keyboard and tested them 12 hours later. Those who did not sleep between the two sessions improved their performance by two per cent, whereas those who did were 20 per cent quicker without a loss of accuracy. This type of memory forming seems to occur during a lighter phase of sleep called stage two NREM.

But how does sleep achieve all this? One answer relates to memory replay. We know from recordings of brain activity that the patterns our nerve



# PHASES OF SLEEP

The brain typically cycles through four sleep stages in the same order every 90 minutes - the amount of time spent in each varies across the night



## NON-REM SLEEP (NREM):

As you move through these three stages, activity in the brain gets slower and slower, and your brain's neurones fire in greater and greater synchrony.

### Stage 1 NREM

People awoken from this stage often believe they have been awake. They don't remember falling asleep. It's during this phase that we experience hypnic jerks - involuntary twitches.

### Stage 2 NREM

This makes up the majority of our sleep. Dreaming is less common than in deeper stages and the sleeper is easily awakened.

### Stage 3 NREM or short wave sleep (SWS)

This is the deepest stage of non-REM sleep. EEG readings show high-amplitude slow oscillations in electrical activity (there are big differences between the peaks and troughs of the graph), reflecting the fact that

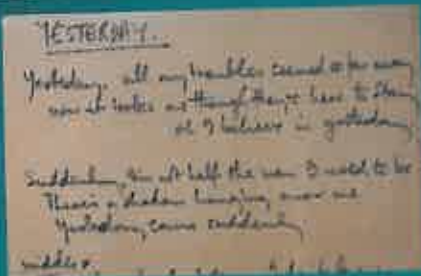
many neurones in the brain are acting in synchrony.

### Rapid eye movement sleep (REM)

You may already know this as the stage most associated with darting movements of your eyes under closed lids and emotional dreams. In contrast to SWS, the different areas of the brain are not synchronised but are instead each 'doing their own thing', just as they would when we're awake.

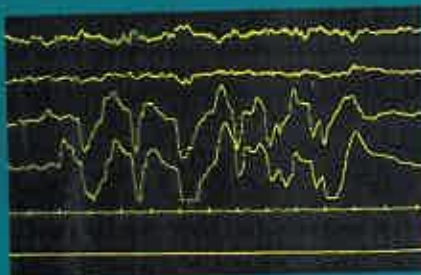
# 5 THINGS YOU DIDN'T KNOW ABOUT SLEEP

We all do it, yet it's still full of surprises



## 1. REM SLEEP BOOSTS CREATIVITY

During REM sleep the concentration of neurotransmitter acetylcholine is twice what it would be when awake. This promotes the altering of connections between neurones, facilitating new links between disparate pieces of information. The Beatles classic *Yesterday* (pictured) and *Frankenstein* are said to be products of sleep.



## 2. DREAMS PERVADE OUR SLEEP

The idea that dreams only occur in REM sleep (EEG reading pictured) simply isn't true. We actually have dreams throughout all stages of sleep and even when we're awake, as daydreams. However, it is fair to say that dreams are more common in REM than non-REM sleep as well as being more vivid, emotional, and bizarre.



## 3. SLEEP DEPRIVATION IS AN ANTIDEPRESSANT

Sleep deprivation leads to a sort of semi-euphoric state and has been used to treat depression since the early 1970s. Unfortunately, low mood often returns as soon as the patients are allowed to get some sleep. It also has to be used with caution as a treatment - prolonged sleep deprivation leads to impaired working memory and other health problems.



## 4. OUR SLEEP REQUIREMENTS VARY WIDELY

Measures of alertness by testing reaction times have shown big differences in how much sleep we need. In research carried out at the University of Pennsylvania, eight hours did the trick for most people, helping them to maintain their reaction times. But an estimated 5 per cent of the population, including, famously Margaret Thatcher, can get away with five hours or fewer.



## 5. THERE IS AN EXCUSE FOR LATE NIGHTS (FOR SOME)

Early to bed, early to rise doesn't suit everyone - research has shown that some people are genetically predisposed to stay up later at night and get up later in the morning. For roughly 40 per cent of us, this is the optimum pattern, and we will feel better and be more productive if we stop trying to force ourselves out of bed at 6am.

## "Need to memorise Spanish? Try an intense study session in the late afternoon, followed by a SWS-filled nap"

→ cells or 'neurones' fire in when we're learning during the day are frequently replayed when we're asleep. It's as if the brain carries out a rehearsal.

In slow wave sleep, there's a synchronised firing of millions of neurones in the neocortex - the outer part of the brain. These slow pulses of electrical activity have been found to determine when other neurones can fire, ensuring that memory replay occurs at the same time across all of the relevant brain structures. So if you're recalling a meeting with a friend, it might ensure the visual and auditory cortices replay her face and voice at the same time so they match up.

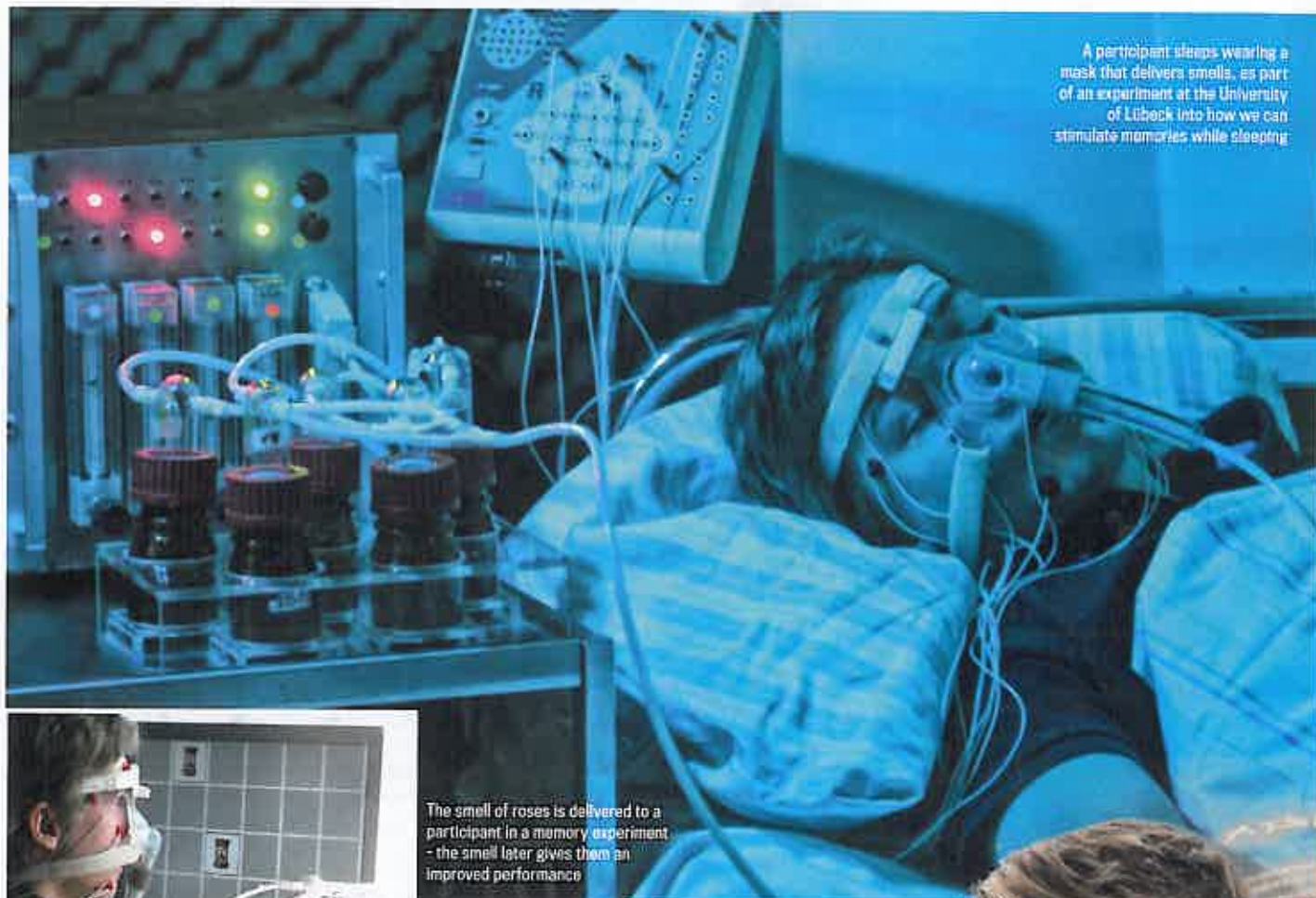
This co-ordinated replay is thought to strengthen memories just as it would if you mentally rehearse something while you're awake. As neuroscientists say, 'neurones that fire together wire together'. Concurrent neural activity strengthens the connections between the neurones involved, shoring up the physical basis of the memory.

## SLEEP TO REMEMBER

But it isn't just the replaying of memories that underpins sleep's memory magic. Sleep's various stages are associated with dramatic changes in the levels of neurotransmitters - chemical messengers that carry or modulate signals between neurones and other cells in our bodies.

Acetylcholine, which plays an important role in keeping the brain awake, drops to half its normal concentration during SWS. This may help to strengthen individual memories, since low concentrations are thought to promote the transfer of information from a fragile short-term storage network that relies heavily on the hippocampus deep within our brains to a more robust long-term storage system that instead depends upon neocortical areas.

Of course, there's a big catch to all of this. On the face of it, we don't have much choice about the proportions of the



A participant sleeps wearing a mask that delivers smells, as part of an experiment at the University of Lübeck into how we can stimulate memories while sleeping.



The smell of roses is delivered to a participant in a memory experiment - the smell later gives them an improved performance.

different sleep phases our brain obtains in a typical night. Nor do we choose which memories are replayed and strengthened. So how can we use sleep as a cognitive enhancer? The answer is that we actually have a lot more control over these things than you might think.

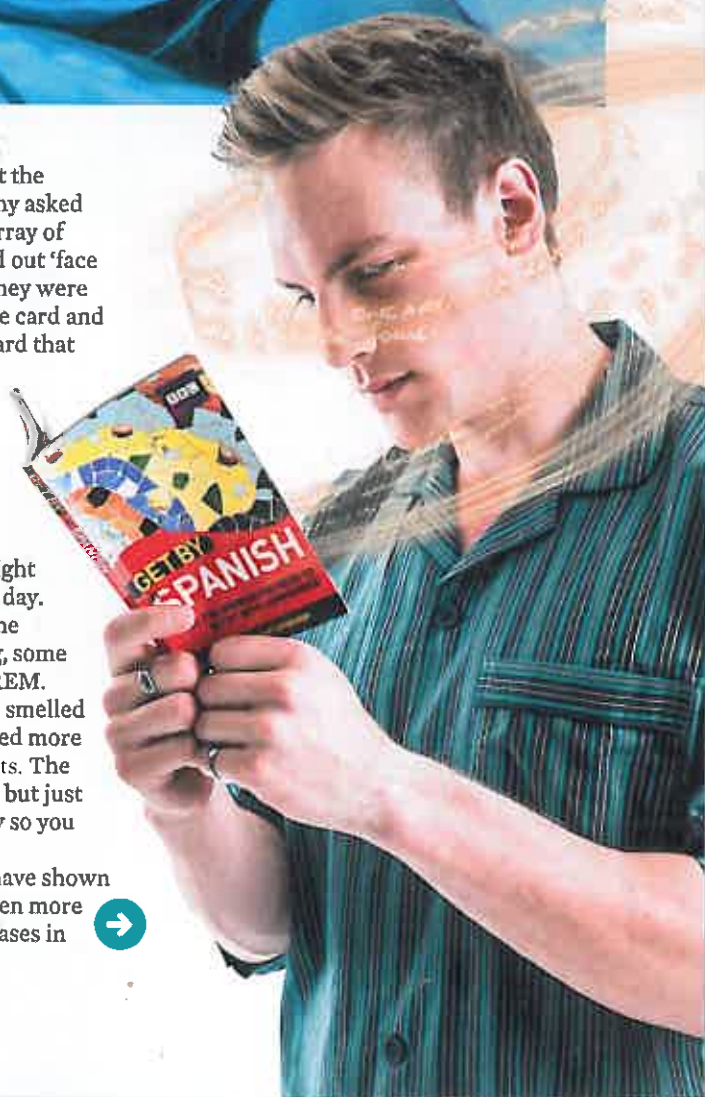
Sleep is locked to the circadian cycle, the natural 24-hour rhythm of our bodies, and you're likely to get more REM in the morning and more SWS in the afternoon or evening. This means strategically planned naps can help to ensure you get the kind of sleep you want. Need to memorise a load of Spanish vocabulary? Try an intense study session in the late afternoon, followed by a SWS-filled nap. Want to remember a highly emotional wedding or christening? A nap in the morning should help out with a super-duper dose of REM.

As well as controlling the phases of sleep, we can also cause specific memories to be replayed when we've nodded off.

Sleep researcher Björn Rasch at the University of Lübeck in Germany asked volunteers to play a game. An array of matched card pairs were spread out 'face down' on a computer screen. They were then tasked with flipping up one card and trying to remember the other card that matched it. The volunteers played this game several times until they had a good memory of where every card was. While doing this, the smell of roses was wafting in their noses. After playing the game, everyone had a normal night of sleep before a retest the next day. Some people were exposed to the rose smell again before sleeping, some during SWS, and some during REM.

Interestingly, the people who smelled roses again during SWS improved more than any of the other participants. The same trick works with sounds - but just make sure they are played softly so you don't wake up!

Exciting new developments have shown that we might be able to take even more direct control over our sleep phases in



# THE POWER OF DREAMS

Our in-sleep experiences and memories are inextricably linked

HAVE YOU EVER noticed that your dreams contain memories? Some scientists suggest that dreams may actually be indicative of the memory replay that takes place when we're asleep and is important for memory consolidation. They hypothesise that only some elements of a replayed memory, the tip of the iceberg, make it into consciousness and these are manifest as dreams.

Evidence supporting the link between dreams and memory includes the observation that people tend to improve at new skills more if they dream about them. Dr Erin Wamsley, Associate Professor Bob Stickgold and colleagues at Harvard Medical School found that undergraduate students who had dreamt of a computer game maze they had earlier been challenged to learn, improved more than those who had slept but didn't dream of the game.

The memories we experience in dreams are usually fragmentary - a face, a place, an image. Only rarely do dreams replay a complete scenario that was experienced. This could be because only a small part of the memory being replayed reaches



The steroid cortisol, pictured here as crystals, gradually builds up and disrupts your brain from recalling memories while you sleep

awareness, but it could also be because specific aspects of sleep physiology prevent the various elements of a memory from being bound together. The most coherent memories occur during the more mundane dreams of non-REM sleep early in the night - it was this sleep that the Harvard students were experiencing. Memories that happen during the vivid dreams that characterise REM sleep, a phase that increases through the night, are much more fragmented.

There's a possible reason for these increasingly fragmented memories. A steroid called cortisol builds up gradually across the night. When the levels have become high during the early morning REM sleep, it disrupts communication between the neocortex, which stores individual memory fragments, and the hippocampus, which helps to bind these together to form complete memories. This also explains why our morning dreams can often be bizarre.

➔ future. Professor Lisa Marshall, again at the University of Lübeck, has found that if an electrical current is injected into the head at the same frequency that this firing normally happens in SWS - just a little slower than once a second - it produces the rhythmic activity in the brain that even continues after the current has been switched off.

Although technically fake, this 'stimulated' SWS dramatically improves memory consolidation. But not everyone will feel comfortable about having their brain artificially stimulated in this way. The good news is that researchers at both Lübeck and Wisconsin have found that simply playing tones at the right frequency while asleep has a similar effect.

People who take Modafinil or Ritalin should be drooling at natural ways to boost the brain. But they aren't the only ones who would benefit. As we age, the amount of SWS we obtain in a night declines. By 75 or so, many of us will get none at all.



Importantly, it's been found that the greater the decline in SWS, the greater the cognitive decline and some scientists believe the absence of this critical sleep stage may be a factor in the further degeneration of the brain. If this is the case, then the artificial stimulation could be a panacea for older people, helping to restore their SWS and stave off further cortical ageing. Who knows, we could all be getting a dose of sound therapy while we sleep to keep our minds sharp in old age. ■

DR PENELOPE LEWIS is a lecturer in neuroscience at the University of Manchester

Find out more

**The Secret World Of Sleep**

by Penelope Lewis

is on sale 27 August

(Palgrave Macmillan, £17.99)

