Dreams Bring **Lucidity to Our Thinking**

"I think, therefore I am" – René Descartes' thinking gave him the certainty that he did, in fact, exist. At the same time, he was aware that he was thinking, and he was able to contemplate his own thoughts. Scientists call this reflection on one's own thinking "metacognition" – a skill that so-called lucid dreamers have, as well. **Elisa Filevich** and **Simone Kühn** at the **Max Planck Institute for Human Development** in Berlin are studying which brain regions are particularly pronounced in lucid dreamers, and whether it is the same ones that are also related to metacognition.

TEXT **INGA RICHTER**

Photo: iStockphoto – sdominick

Our brains can't stop thinking. They constantly produce thoughts. Sometimes they wander involuntarily and focus on trivialities like the weather, and sometimes we direct our thoughts deliberately. Often, our minds consciously categorize impressions, feelings and decisions. They judge what we see, hear and feel, or the things we remember.

"Metacognition – it sounds philosophical, doesn't it?" asks Simone Kühn, a Group Leader at the Max Planck Institute for Human Development, and explains the term with an example from everyday experience: "A car passes you on your way to work – an event you barely noticed. Later, when you're asked to describe the car, you have to call up your memory of it. But how certain are you that your memory is accurate?" This is where metacognition comes into play; in other words, in this case, questioning your own memories. Normally, the more intensely a situation is perceived, the more convinced we are about it.

MAGNETIC RESONANCE MAKES ACTIVE BRAIN REGIONS VISIBLE

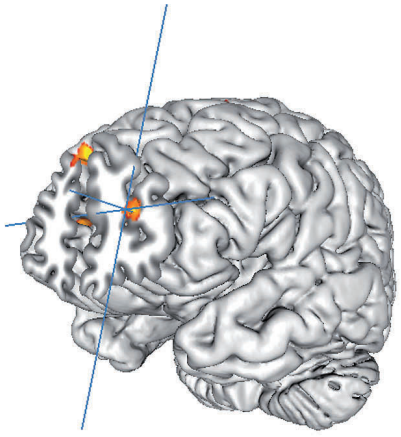
Our thinking about our own visual perception can be measured in the lab using functional magnetic resonance imaging (fMRI). This method can't make the activity of neurons directly visible, but it shows the oxygen consumption in a region. Neurons that are actively involved in thought processes are particularly hard at work and therefore withdraw a lot of oxygen from the blood. Consequently, in active brain regions, there is a higher share of oxygen-poor blood. From the different magnetic properties of oxygen-rich and oxygen-poor blood, the scanner can generate an image that shows the brain's activity. >

Consciousness works differently during sleep. When we dream, we perceive events consciously, but we can't reflect on them. Lucid dreamers, in contrast, are capable of self-reflection during dreams.

» Lucid dreamers know they are dreaming and are self-aware.

Researchers worldwide are attempting to fathom metacognition in various ways. In an earlier study, scientists from London, for example, presented the participants with two dim gray circles in succession for just a couple thousandths of a second. Afterwards, the subjects had to make two decisions: Which of the two circles was brighter? And: How certain am I? Subsequent measurements in the MRI scanner have shown that people with strong visual metacognitive skills have a slightly larger Brodmann area 10, a region in the anterior prefrontal portion of the cerebral cortex. "Right here," says Kühn, tapping herself on the forehead.

For Elisa Filevich and Simone Kühn, lucid dreamers are one of the keys to understanding metacognition.



Special feature in the frontal lobe: Individuals who often have lucid dreams have a larger Brodmann area 10 (orange) than those who seldom or never have lucid dreams.

"Lucid dreamers know they are dreaming," explains Filevich. "They reflect on their own dreams and are self-aware." Some lucid dreamers can even control the course of their dreams. In a joint project with colleagues from the Max Planck Institute for Psychiatry in Munich, Kühn and Filevich want to use this ability to learn more about metacognition.

MESSAGES FROM THE REALM OF SLEEP

One of the first scientists to move lucid dreams out of the corner of fringe-scientific phenomena and into the light of serious science 35 years ago was American psychologist Stephen LaBerge. LaBerge himself was a lucid dreamer and, for his doctoral dissertation, went into a sleep lab. He demonstrated that he could move his eyes back and forth in a previously agreed manner in his sleep as soon as he slipped into a lucid dream.

Consciously controllable communication while asleep, which has since been scientifically validated through multiple studies, offers a great opportunity for research. It's the only way researchers can see, under controlled conditions in an fMRI experiment, which brain regions become active during the transition from an unconscious to a conscious state. After all, even modern imaging methods can't visualize when and where exactly consciousness sets in upon waking.

From measurements of the electrical brain activity using an electroencephalogram (EEG), we know that the basic activity of the brain is sharply reduced during sleep. The prefrontal cortex, for instance, and particularly the frontopolar regions of the cerebral cortex, located behind the forehead, are only weakly active. Although people dream intensely in the REM phases of sleep, and the eyes move behind the lids and the EEG patterns resemble those in the waking state, we don't have the capability of self-reflection in these phases.

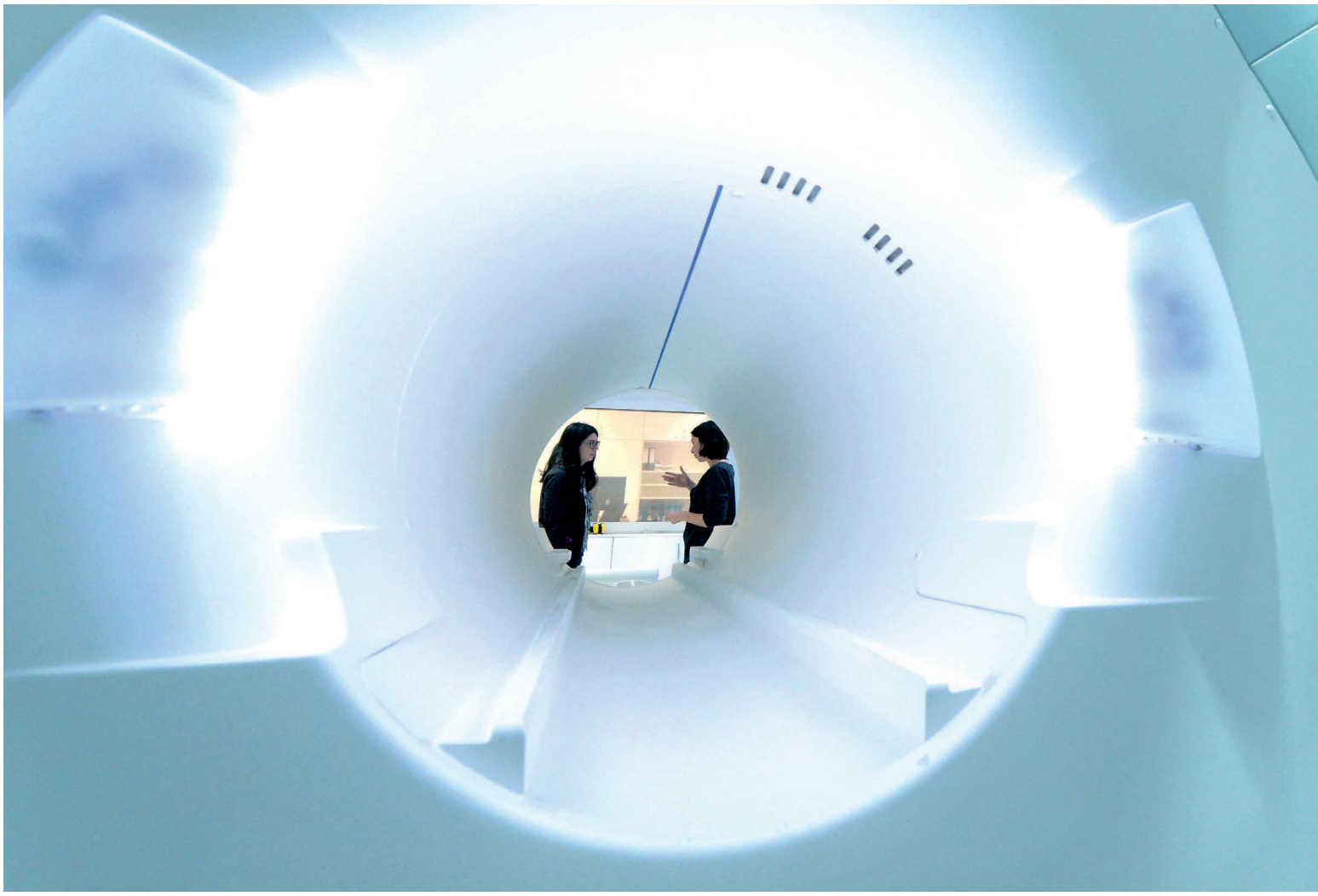
Precisely what takes place in the brain during lucid dreaming was long unknown. In 2012, scientists at the Max Planck Institutes for Psychiatry in Munich and for Human Cognitive and Brain Sciences in Leipzig, as well as at Berlin's Charité hospital, discovered that various brain regions become active within seconds of a lucid dream being signaled. Among these regions are the prefrontal cortex, including the frontopolar region. In contrast, during REM sleep and the usual dreams that occur then, these regions aren't very active. EEG analyses have also shown that, although the prefrontal cortex is more active during lucid dreams than during REM sleep, it doesn't approach the activity levels during wakefulness. In other words, it's an intermediate state. "But this could still be called metacognition," says Kühn.

Building on this, Filevich and Kühn wanted to examine this phenomenon further in a study. The problem with lucid dreamers, however, is that there aren't very many of them. Only a few lucid dreamers experience this phenome-

Photos: MPI for Human Development (left page); David Ausserhofer (2) (right page)

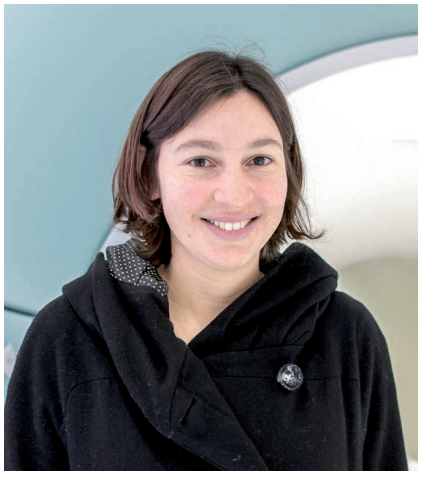
Left: In order to participate in a study on metacognition, participants provide information about what kind of dreams they have.

Below: Participants in Elisa Filevich's study shouldn't be claustrophobic: they have to spend some time lying motionless in the narrow tube of the MRI machine.



Above: Looking through the tube of the MRI machine at a test subject and Elisa Filevich (right). MRI images show that the brain structures of lucid dreamers and people with high metacognitive abilities are similar.

Below: Elisa Filevich is from Argentina and studied biology in Buenos Aires. Her research focuses on questions relating to human consciousness.



non almost daily, while most don't experience it more than once a year.

But there are quite a few people who have lucid dreams once in a while – and these were precisely the individuals the Max Planck researchers were interested in. It didn't take them long to find their test subjects: "Many students volunteer for psychological studies, and provide personal details as part of the process. I myself often participated in experiments as a subject when I was a student, and I learned a lot from it," says Filevich.

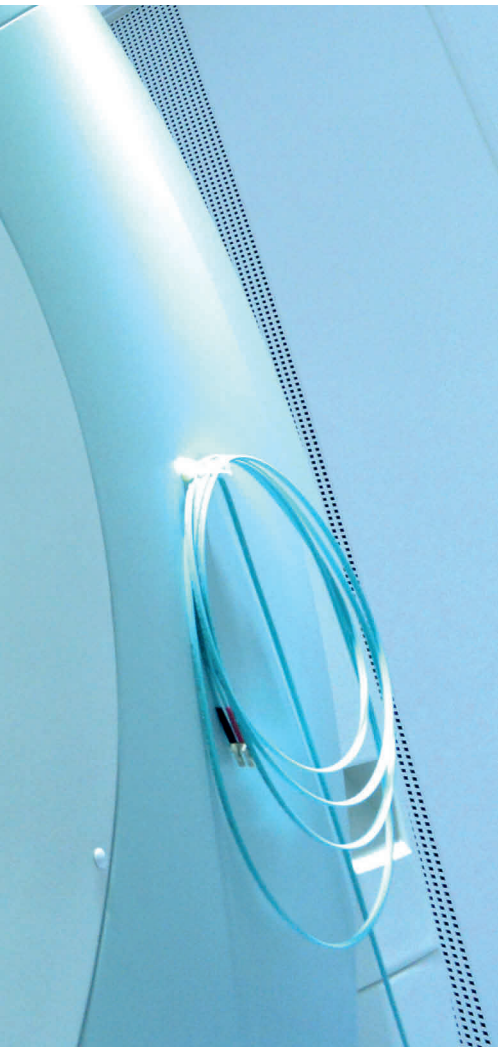
The two researchers were able to identify around 70 candidates who were suitable as subjects for their lucid dream study. In order to be able to categorize the dreams, the participants were asked to describe their dreams by answering questions on a scale from one to six: Did I have control over other characters or the environment? Did I observe myself in the dream from outside? Was it clear to me that the events in the dream would have no influence on my waking life? In addition, for one week, the participants documented how often they dreamt like this or in a similar way. Using these details, Filevich split them into two groups: people who have lucid dreams relatively often, and those who rarely or never have these dreams.

LARGER AREA IN THE FRONTAL LOBE

First, the researchers surveyed the brain structure of the study participants. The MRI can distinguish two different elements of the brain: the so-called gray matter – the regions in which the cell bodies of the neurons lie – and the white matter – the nerve fibers. If the neurons of a region are challenged for a sustained period of time, or are insufficiently challenged, the volume of the gray matter can potentially change there.

The MRI findings show that the frontopolar region of the cerebral cortex is larger in lucid dreamers than in non-lucid dreamers. This is one of the regions that in the earlier study had proven to be active when a metacog-

Photos: David Ausserhofer (top), Michael Sattler (bottom)



nitive thought occurs. "Accordingly, the frontopolar cortex is larger both in lucid dreamers and in people with strong visual metacognitive skills. We thus found, for the first time, a connection between metacognition and lucid dreams," explains Filevich.

Not all people are equally capable of metacognitive thought. Some can judge their mental state better than others. Is it possible to train metacognition? Unfortunately, metacognitive training has so far proven to be difficult. An initial attempt to train the metacognitive abilities of test subjects for one week showed no measurable success. "People find the usual tasks to be simply too boring. Who wants to spend weeks assessing their own perception of dim gray circles?" says Kühn. The researcher was able to show, in the context of a study on video games, that the enjoyment factor affects the measurement results. "The more fun the subjects had, the more pronounced the changes in the brain were," says Kühn.

INTERNET GUIDES FOR LUCID DREAMING

Lucid dreaming is in fashion these days. A Google search returns countless tutorials, courses and videos. In principle, it's quite easy to train lucid dreaming: throughout the day, just regularly ask yourself whether you are dreaming at that moment. By repeatedly directing your awareness to dreams and real-

SLEEPING AND DREAMING

Dreams are defined as conscious experiences that occur in our sleep. People probably dream during all phases of sleep, but dreams during so-called REM sleep are particularly "dream-like." In this phase, dreams have a visuo-spatial structure similar to that in our waking consciousness, although often with surreal storylines. In these dreams, thinking is limited in a typical manner, and feelings are particularly pronounced.

In REM sleep, both the visual cortex and the brain areas that are involved in processing emotions are activated. In contrast, prefrontal regions of the cerebral cortex, including the frontopolar cortex, which governs particularly higher thought processes, are deactivated. Only in lucid dreams are these regions active.

There is still some disagreement among sleep researchers regarding the function of dreaming. While some consider dreams to be simply random and functionless side effects of neural information processing, a lot goes on during dreams. Newly acquired memory contents are presumably stored permanently and integrated into existing neural circuits during sleep and, as associated experiences, during dreams. Also, REM sleep could help to process emotions. In addition, numerous historical anecdotes, as well as studies and theoretical deliberations, lead us to suspect a role in creative processes. The subjective side of REM sleep can also prepare us for real situations in the waking state: dreams offer a virtual reality in which situations that are normally dangerous or significant for our social life can be played through with no danger, and in which new behaviors can be tested.

Ultimately, these different functions are not mutually exclusive: sleeping and dreaming presumably have different functions that support our waking lives in a variety of ways.

Author: Martin Dresler, Max Planck Institute for Psychiatry, Munich/ Donders Institute for Brain, Cognition and Behaviour, Nijmegen

Interpreting MRI images requires great care and experience. Elisa Filevich and Simone Kühn (right) must therefore plan their studies carefully and select a sufficient number of participants in order to obtain meaningful results.

ity, the question will eventually also turn up in your sleep. This is the first step to having a lucid dream. Filevich and Kühn want to test, in a further study, whether this really works, and whether one's metacognition will benefit from training in lucid dreams.

OVERCOMING LIMITS IN LUCID DREAMS

The particular appeal of lucid dreaming consists in doing something that isn't possible in real life. Motor skills could be practiced in a dream and then used in the waking state. Thus, athletes, for example, could essentially train in their sleep. For others, this kind of dream is a way to avoid nightmares. Furthermore, logical thinking works differently in dreams. "We believe that problems could also be solved by new logical approaches available in dreams," says Elisa Filevich.

And learning how to lucid dream could shed light on yet another aspect: it is known that, in visual tasks, metacognitive processes take place in the frontopolar cortex. But metacognition relates not only to sight, but also to hearing, feeling emotions and remembering. Are these processes controlled by other brain areas? In other words, is the frontopolar region responsible for us knowing what we see, and another area for us knowing what we hear? Are people who know exactly what they see also good at knowing how much they can recall? Is there a higher-level module that controls all the other regions?

To find answers to these questions, it is likely that many more volunteers will have to look at gray circles and reflect on their thoughts in an MRI machine. ◀

TO THE POINT

- **Lucid dreamers may also be better able to think about their own thoughts in everyday life.**
- **Different brain regions, like the prefrontal cortex including the frontopolar region, are more active during a lucid dream than in a normal dream.**
- **The size of the frontopolar cortex differs between lucid dreamers and non-lucid dreamers. Since this region is also involved in metacognitive thinking, this suggests that lucid dreams and metacognition are connected.**

GLOSSARY

Brodmann areas: In the early 20th century, German psychiatrist Korbinian Brodmann divided the cerebral cortex into 52 areas. As the basis for this, he used differences in the cellular structure that were visible under the microscope. The original organization has since been further refined.

Prefrontal cortex: Part of the frontal lobe of the cerebral cortex. It is connected to a wide variety of brain regions and integrates their signals. These regions include areas that are involved in the emergence of feelings, that control movements and that process input from the sensory organs. Among other things, the prefrontal cortex is involved in planning and executing complex actions, and influences some aspects of an individual's personality, such as self-control and impulsiveness.

Photo: David Ausserhofer

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