In theFlow theTime

How does the brain create its sense of time? The answer may hold the key to understanding consciousness.

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Simagine listening to a piece of music. Let's say Beethoven's Symphony No. 5. The melody rings out in your head, over and over again, played first by the strings, then varied by the horns. Now imagine hearing the notes of the symphony one after the other, unrelated to each other, one after the other. Would you even hear the symphony? No. Single tones only. In order to hear the melody, tones that have already been heard must still reverberate in consciousness while a new one rings out.

As in music, so in literature, so in life. For a reader of this text, it is the relationship of the words to one another that matters, not the individual words. For a person who walks through the world, it is important to relate their perceptions and feelings to one another. Awareness means not just living in the immediacy of the single moment, but linking the moments into a continuum. "If you want to understand how the mind and brain are related, you have to understand how they produce their time", says the philosopher and neuroscientist Georg Northoff, who teaches at the Canadian University of Ottawa. Northoff and other researchers have recently uncovered some important pieces of the puzzle to solving this riddle.

The search for the essence of time is a classic of science and philosophy. It has always occupied mankind. The ancient Greeks, who had gods for everything imaginable, named two for time: Chronos and Kairos. Chronos was in charge of time, which flows evenly and steadfastly. Kairos for the time experienced, for the right and wrong moments, boredom and rushing events. Augustine of Hippo asked around the year 400: "So what is time? if nobody me ask for it, I know. If I want to explain it to someone who asks, I don't know." At the beginning of the 20th century, the French philosopher Henri Bergson developed his own concept of time, which he called "durée" (duration) to name the phenomenon: that we do not experience time as a loose sequence of individual points in time, but as a constant, coherent flow.

time and feeling

Humans can experience time in two different ways: immediate and retrospective. The immediate sense of time is experienced by pausing for a few seconds and paying attention to the passage of time. When there is an awkward silence, it seems to stretch. A lively conversation lets them fly away.

The retrospective perception of time extends over much longer periods of time. A person can review the last hour or the past day. A centenarian can look at her whole life. The stuff of this retrospective perception of time is the memories. And

COMPACT

- No matter whether in the immediate moment or looking back in memory: time can compress or stretch. That depends on what we are experiencing or have experienced.
- Researchers locate the perception of time in the brain: the insula is significantly involved in this. In addition to brain scans, they are also investigating the phenomenon using observational studies.

"If you want to understand how mind and brain are connected, must understand how their produce time."

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you too can the time jam chen or stretch. If more emotionally charged things happened in a period of time - for example, a stimulating, happy conversation or an anxious, anxious wait - it seems longer in retrospect. If hardly anything of the events in this period is remembered, it seems shorter.

What is striking here is that the effects of congestion chens and elongations are exactly

This is the case if you look at the same situation in a comparison of the two ways of experiencing time. Periods of time that, when we are in them, seem like half an eternity appear particularly short in retrospect. During the corona pandemic, many people involuntarily became acquainted with this so-called time paradox. The weeks and months of lockdowns have been tough – meanwhile. In retrospect, however, they shrink. And both for the same reason. Little happened. One day was like the other. Time passed slowly. In retrospect, the many days blur into one.

How does this subjective perception of time come about? The psychologist Marc Wittmann, who conducts research at the Institute for Border Areas of Psychology and Mental Health in Freiburg, has a fascinating theory on this. It connects our sense of time to a brain region called the insula (island cortex), well hidden in a temporal crease of the cortex, responsible among other things for bodily sensations: the sense of balance, the perception of pain and the touch find. The insula is closely connected to the auditory cortex. Those who "listen to themselves" use theirs insula. Wittmann and colleagues speak of "interoception" (internal perception). A man's body is his chronometer. We experience time by comparing external events with internal ones.

Wittmann tests this theory with experiments in which he has subjects hover in a floating tank. This is a cabin in which you are largely cut off from outside stimuli. It's pitch black, they're wearing earplugs and are floating in the water. They see nothing and hear nothing, feel almost nothing of their surroundings. But they feel themselves: their heartbeat, their breathing, their digestion. Even if the outside world "stands still", the inner processes continue. When more is happening inside than outside, the time initially seems longer. Then, after a while, you lose track of time.

Anyone who is sitting in the doctor's waiting room with an empty mobile phone battery or is impatiently waiting at the bus stop for a delayed bus is in some respects similar to the subjects in the floating tank. He is fixated on himself, rather tense and bored, nothing distracts him from his physicality. That stretches time.

On the other hand, if the same person remains relaxed, perhaps distracting themselves with daydreams, many minutes will pass quickly. Wittmann checked this connection in laboratory experiments, in which test persons assessed the same waiting times very differently depending on their inner state. He also experiences this connection himself when he goes jogging on Sundays. "First, when my legs aren't in motion, I feel every step," he says, "time passes slowly. Then I get into the flow and time flies."

In an extraordinary study, Wittmann also examined >

the influence of alcohol on the perception of time. In previous experiments on this question, subjects had to consume alcoholic beverages in a laboratory setting - no wonder they remained unrelaxed. Like in the waiting room. Or at a party where you feel out of place. Wittmann, on the other hand, recruited his test subjects in a natural habitat: a bodega in Lisbon. He asked more than a hundred people about their perception of time, before and after drinking - and found the opposite of what his colleagues in the lab had observed. After a glass of red wine, the subjects became more open, social and emotional, and felt closer to their fellow human beings. The Time passed much faster than when sober. So alcohol helps to get into the flow. "People experienced more," says Wittmann. In retrospect, according to the time paradox, time seemed richer to them, therefore passing more slowly.

Wittmann has theorized that the posterior parietal insula has a key role in time-feeling plays, significantly advanced, but not set up. The American neuroanatomist Bud Craig, who has done a lot of research on interoception and the insula, first formulated the hypothesis that the brain generates its perception of time from body signals. Meanwhile umpteen studies prove connections between the perception of time and bodily processes.

time and room

Certainly, the insula is not the only brain area involved in time perception. American neurologist Aaron Boos and his collaborators worked on patients with injuries in a region called the precuneus in the that their sense of time is disturbed. "Minutes seemed like hours," Boos described the experience of a patient undergoing precuneus surgery, "every time he looked at his watch he was amazed at how little time had passed." It is noteworthy that the precuneus also plays an important role plays in spatial perception. Space and time are closely connected in human thinking and in our language. We speak of one event coming "before" or "after" another. We speak of "periods" which can be "long" or "short".

If you sit in the doctor's waiting room with an empty cell phone battery, nothing distracts you from your physicality. That stretches time.

One might mistake these vocabulary for mere metaphors: linguistic devices to express what we otherwise have no words for. But there is more behind them. How deep the connection between temporal and spatial thinking is can be seen in patients with a so-called visual neglect. One of the hemispheres of the brain is damaged. Because the left hemisphere controls the right side of the field of vision and the right side of the body, and the right hemisphere controls the left side, people with right brain damage orient themselves more to the right. For example, they no longer consciously perceive things to their left, only shave the right side of their face, only slip on the right sleeve of their jacket.

Another thing people with an injured right brain overlook is the past. They no longer understand earlier events such as “Karl was a cyclist ten years ago”. On the other hand, they can still well imagine that Karl will be a cyclist in ten years. In our western culture, the past is traditionally associated with the

connected on the left. It is customary to draw the arrow of time from left to right - like writing from left to right. In contrast, Arabic and Hebrew are written from right to left, Chinese from top to bottom. Similarly, Arabs draw their lifelines from right to left, Chinese from top to bottom. How affects them

does visual neglect affect the perception of time? "As far as I know, there are no studies on this yet," says Wittmann.

For physicists, time is simply a geometric dimension, as are the dimensions of space. This is the time for which im ancient Greece the god Chronos was responsible for the objective time measurable with clocks. The riddle of the time of the god Kairos remains: the experienced, subjective time.

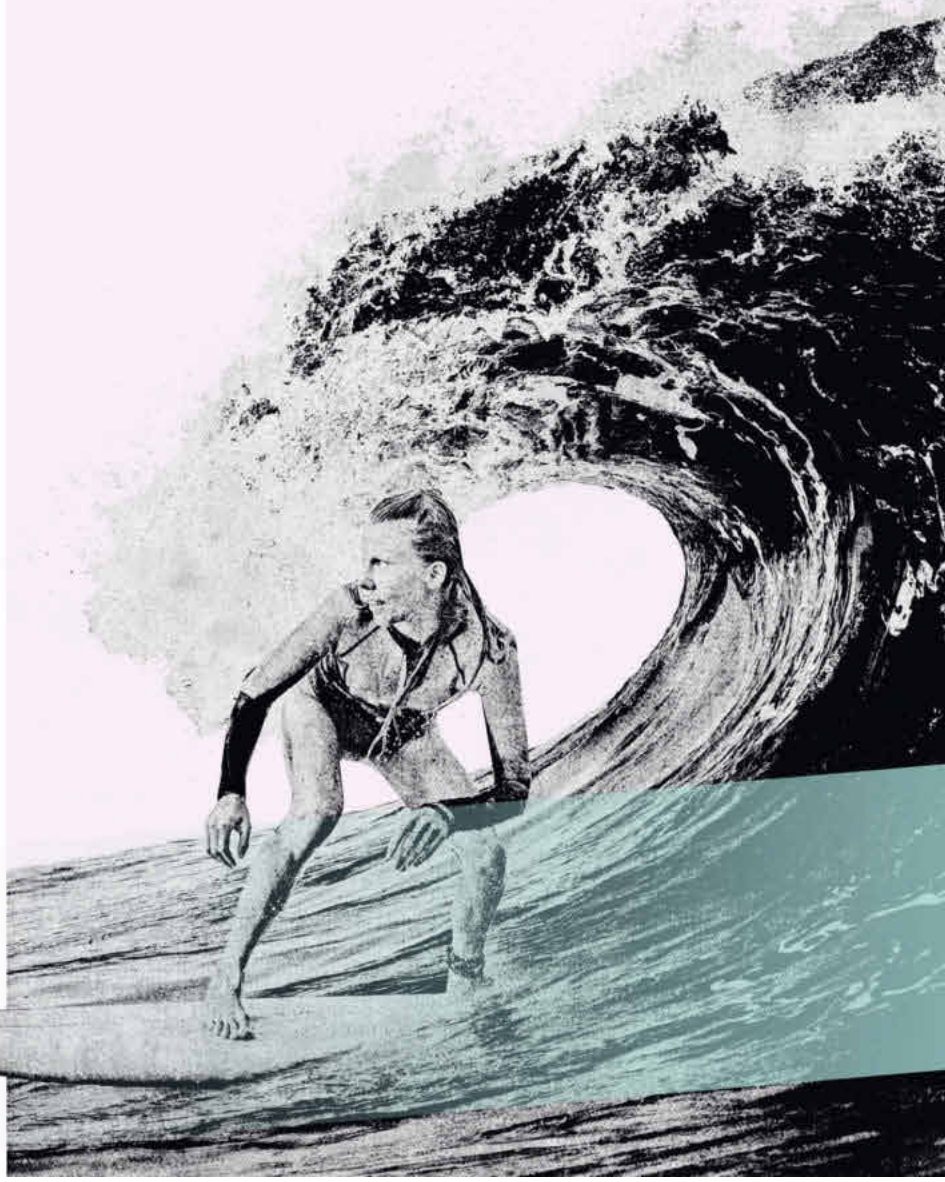
When listening to music, the brain activity is similar to the rhythms at – like if a surfer becomes one with the wave.

time and consciousness

How does a sequence of acoustic vibrations in the head become a melody? How does a tangle of electromagnetic waves become the experience of a landscape or a work of art? Why do we experience anything at all? These are the questions one hears again and again when researchers and philosophers speak of the unsolved mysteries in this field. Northoff believes the solution lies in understanding how the brain synchronizes its internal time with that of its environment. "Time is an essential condition of consciousness," says Northoff.

What does Northoff mean by that? He explains it with an analogy: A surfer rides a wave in the ocean surf. With the movements of her body she keeps herself on the board, just in such a way that she uses the power of the wave to gain momentum herself. The better she surfs, the finer she responds to the movement of the wave. Almost like becoming one with the wave.

It's very similar, says Northoff, when people listen to music. you surf



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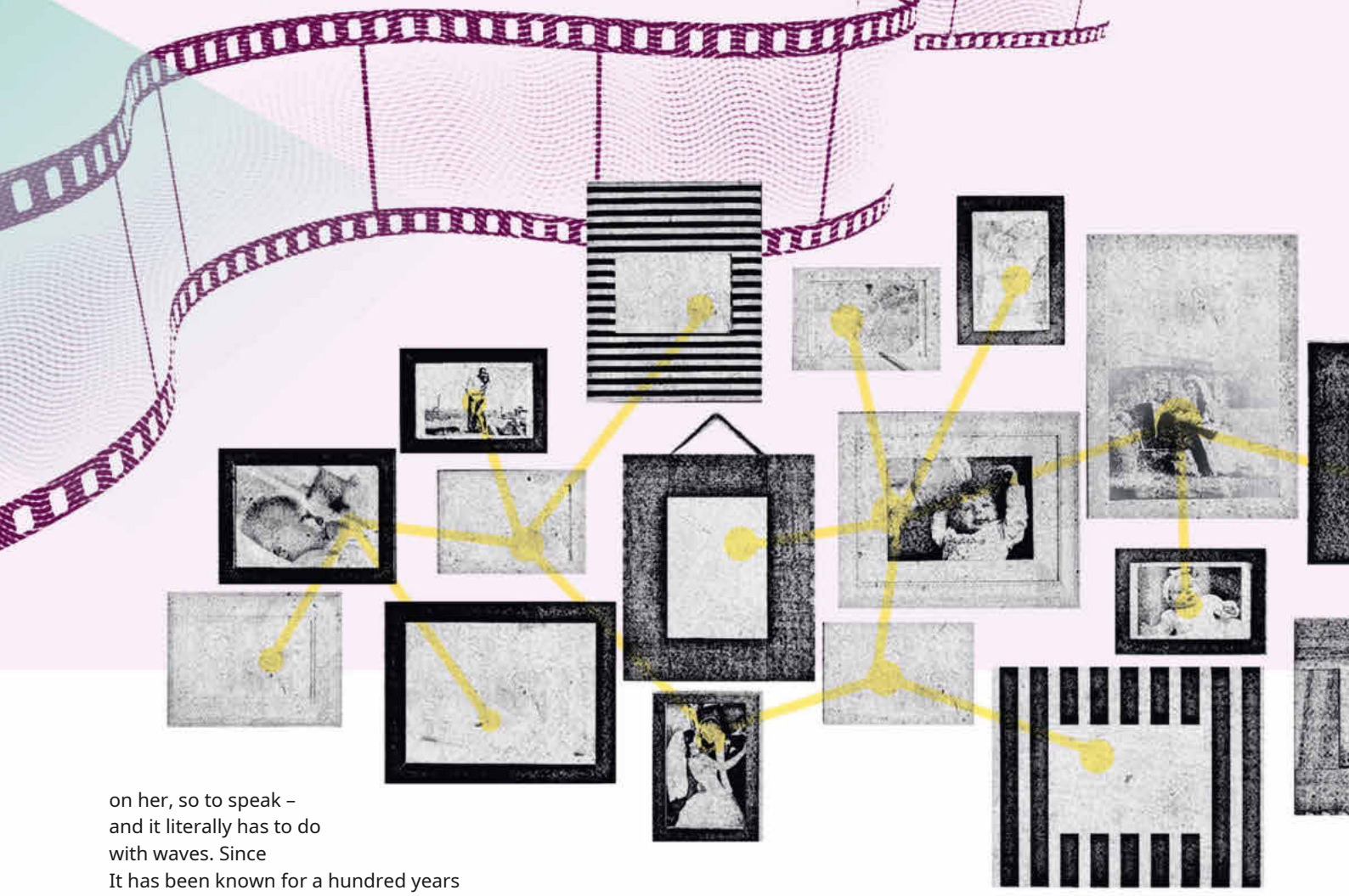


on her, so to speak – and it literally has to do with waves. Since It has been known for a hundred years that the activity of the brain fits into rhythmically repeating patterns, often called "brain waves". The German psychiatrist Hans Berger discovered these waves in 1924 when he placed electrodes on a patient's exposed brain and measured rhythmic oscillating voltage fluctuations, the frequency of which changed as Berger presented the patient with various cognitive tasks. Berger is considered the father of electroencephalography (EEG).

If a person now listens to music, one can observe in the EEG how the temporal structure of his brain activity adapts to the style of the music - just like the surfer synchronizes her movements with the wave. "We can measure how the groove of the music captures the brain," says Northoff, "it's bathing in the music, so to speak." The technical term for this is "spatio-temporal alignment": the brain waves resonate in unison the sensory stimuli. When you record an EEG, you can see how the brain vibrates with the music. You can also feel it without an EEG if you tap the rhythm with your foot.

It's not just like listening to music. It's the same when people walk, run, swim, bike - or inline skate, a sport that Northoff discovered for himself during the time of the corona restrictions. "When things are going well, when the brain gets into rhythm, its internal processes synchronize with the processes in its environment. It becomes part of the environment to which it is connected through its senses. "That's what consciousness is," says Northoff.

time and depression

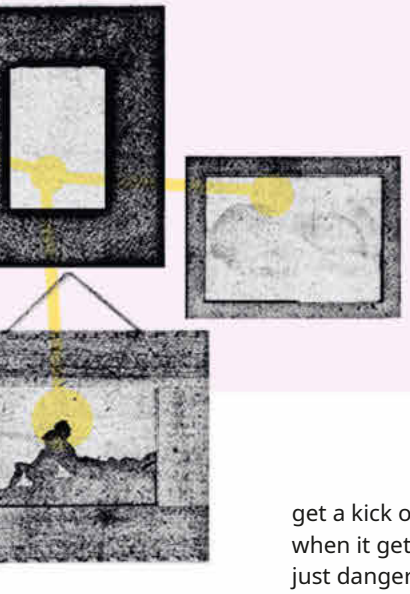
Northoff also practices as a psychiatrist and considers it the litmus test of his theory as to whether it can help to diagnose and treat mental illnesses: a disturbed synchronization with the environment is characteristic of depression, mania and schizophrenia.

One day, a 16-year-old patient with severe depression came to him, says Northoff. She didn't say a word. Her mother, on the other hand, who accompanied her, spoke at a normal pace. Later Northoff asked the young patient why did you not speak during your recording? Everything had gone too fast for her, she replied. It was clear to her that her mother had spoken at the usual pace. Still, she couldn't follow her. So she switched off.

"Depressed patients perceive their own time as too slow," says Northoff. The thoughts seem to freeze. Affected patients' movements also become slow, a symptom called psychomotor retardation. The visual perception of depressive patients is disturbed: they experience the world as static, without dynamics. Brain scans show an activity deficit in their visual cortex. "They're too slow in their brains," says Northoff. "For me, depression is a lack of speed." And anyone who constantly feels too slow is inevitably sad and listless.

The opposite is mania: the patients are in hyperdrive. The world moves too slowly for them. As if they were racing down the freeway at full throttle. “You like it at 200 kilometers per hour

Memories are not stored as film strips - the brain has to go between pictures close connections.



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get a kick out of it, but when it gets to 300 it's just dangerous," says Northoff. For manic Patients observe that Northoff and colleagues have brain activity that is too fast.

Whether the brain finds the right beat is a signal for its state of consciousness - and for whether it is even conscious. When the mix of frequencies the brain is working with stops changing, when there is no difference in intensity between slow and fast timescales, "if you just see white noise, then you can say there's no consciousness," says Northoff . For example, in patients under general anesthesia or in a very deep coma.

A conscious brain is like an instrument made to sound by its surroundings. However, even healthy brains are limited in their sound spectrum. For short-term memory, a minute is an eternity. "The time scales of the brain are very limited," says Northoff. In addition, humans can only perceive narrow sections of the electromagnetic and acoustic spectrum. They have no ears for earthquake waves and ultrasound, no eyes for infrared light. Not for a long time everything in the world is music to them. Humans experience the world from a human mode of consciousness that differs significantly from that of whales and bats. Northoff therefore advocates a "Copernican turn" in brain research. Just as Copernicus once recognized that the earth is not at the center of the universe, and Darwin showed that man is not the crown of creation but only a side branch of evolution, so we should now say goodbye to the idea that the brain has a very special special position in the physical-biological world, because it produces the spirit. “No,” says Northoff, “look at the properties that the brain shares with the physical-biological world. See it as part of the world.”

time and memories

The span of human consciousness, on the one hand, is only a few seconds. Humans, on the other hand, can do mental time travel. When they remember something from the past, they connect to something they experienced earlier that is still represented somewhere in their mind. A team from the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig has researched how memory establishes such temporal relationships between memories in memory.

Memories are not stored in memory as a video of past events, but as mental constructs with holes and gaps. In order to form a coherent picture of the past, the brain has to make connections between the building blocks of these constructs, the individual memories. A team led by the Leipzig scientists Jacob Bellmund and Christian Doeller played experimental imagine everyday scenes of a Sims family from the computer game of the same name, how they read the newspaper, clean or play table football. In the brain scanner, the researchers tracked how the subjects put their memories together. They saw that similar sequences of memories - for example workdays with similar processes - are represented by similar activity patterns in the hippocampus. That's why it can be difficult to think back: For example, if you're used to leaving for work at 8:30 a.m., you'll remember leaving for that time last Wednesday - even if you didn't look at the clock back then and may have come off a little later. Memories that are close together in time are also represented in the brain in a similar way, and the closer they are, the more similar: for example,

In Alzheimer's patients, whose memory is impaired by metabolic disorders in the brain, these processes are disrupted. They lose the connections between the individual memories. They mix memories from different days, months or years. You lose your inner time. And with it their connection to the world. The melody breaks up into individual notes. Awareness takes time.-

TOBIAS HUERTER For his research, he read, among other things, the book “Chronos” by Guido Tonelli. Find his review see page 70.

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