Forget about it: Investigating how we purge thoughts from our mind

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Forgetting is not always easy. If you have ever tried to erase that annoying earworm from your mind or stop thinking about whether you locked the door after leaving the house, you know how disruptive it can

be to think about something irrelevant to the task at hand. While much work in cognitive neuroscience focuses on how the human brain remembers and retains information, some cognitive neuroscientists have instead turned to forgetting—working to track exactly how we forget a piece of information and what it means for patients suffering from neurocognitive disorders.

"It may sound surprising that people can control what and how they forget," says Marie Banich of the University of Colorado, Boulder, who is chairing a session about new research on forgetting at the Cognitive Neuroscience Society (CNS) annual meeting today in San Francisco. "But control over working memory is critical for switching between and re-prioritizing tasks. So in many ways, it is not surprising that we have control over the ability to remove information from the focus of our thoughts."

In new work that Banich and others are presenting, researchers have identified distinct mechanisms by which people remove information from their working memory and have also found that forgetting requires much effort. "We've found that intentionally forgetting no-longer-relevant information from the mind is beneficial, but it doesn't happen automatically," says Sara Festini of the University of Tampa, who will also be presenting new work at the CNS conference. The hope is that the body of work can lead not only toward better understanding attention and focus but also toward clinical targets for helping patients suffering from disorders ranging from depression and schizophrenia to PTSD and ADHD.

Tracking the Loss of a Thought

Banich became interested in understanding forgetting after losing someone to suicide. The experience got her thinking about the dangers of intrusive thoughts for people suffering from depression and related

disorders.

"The content that gets stuck in mind varies across different disorders," Banich explains. For example people with schizophrenia may be consumed with paranoid thoughts, while those who have obsessive compulsive disorder might be worried about germs, and someone with anxiety may get stuck thinking about bad things that might happen in the future. "But it's the same process," she says. "The thoughts are going round and round, becoming the focus of attention and difficult to remove."

Complicating the treatment of these disorders is the fact that so many rely on self-reporting of symptoms, and even if a patient reports improvement, they may still be negatively ruminating. That challenge led Banich, a trained cognitive neuroscientist, down a path to answer the question: How can we know whether somebody has really stopped thinking about something?

Step by step, Banich and her colleagues have been learning how to track what happens when someone tries to purge a thought from their mind. Their latest work builds upon their past peer-reviewed work that documented three neurologically distinct ways people remove information from their working memory: replacing the thought with something else, suppressing that thought, or clearing their mind of all thoughts. This seemingly simple framework has taken many years of work, with the help of fMRI imaging, machine learning, and other technological and experimental advancements. It started, Banich said, with the realization in the middle of one night that "we can actually use neuroimaging to verify that somebody stopped thinking about something."

Asking participants to think about information in different categories (e.g. faces, places, fruit) while in the fMRI scanner, Banich and her team

first trained a computer on the resulting neural patterns for the categories and examples from each. They then asked study participants to forget information in different categories, verifying whether it was removed by tracking whether the brain pattern was still present. They also identified the neural pattern of brain activation associated with each of the three mechanisms of forgetting—whether they replaced the thought of a face like Emma Watson, with an object, like the Golden Gate Bridge, suppressed the memory of Emma Watson, or cleared all thoughts.

Through this work, they have identified four brain networks that distinctly activate whether the memory is maintained or purged through one of the three mechanisms: the somatomotor network, the visual network, the default mode network, and the frontoparietal control network. Their work suggests that when the brain suppresses a thought or clears thoughts entirely, the frontoparietal control network likely plays a prominent and distinct role.

In identifying these specific brain networks, the research offers a path forward for investigating potential differences among individuals in how they forget. "Can we get some metric of people who might have difficulty controlling their thoughts?" Banich asks. "Maybe the frontoparietal network in people who are having difficulty controlling their thoughts can't differentiate between those mechanisms, or in them they are all muddled together?" In future work, Banich and her colleagues will also be looking at whether they can use biofeedback while participants are in the fMRI scanner to see if that can aid individuals in controlling the mechanism for removing unwanted information.

Putting in the Effort to Forget

An important part of this work has been looking at "proactive

interference," which can happen when the brain is trying to learn something new that overlaps in category with something already in mind—like trying to learn Emma Stone's face instead of Emma Watson's. The takeaway from Banich's work has been that, in part due to proactive interference, suppressing a thought is more efficient than replacing it.

Indeed in work by Sara Festini and colleagues being presented in San Francisco, researchers found that one benefit of voluntarily forgetting a piece of information is that it reduces proactive interference—making it easier for someone to learn something new. "Proactive interference occurs, for example, when you accidentally walk to where you parked your car yesterday instead of where you parked your car today," Festini says. "We've shown that by voluntarily removing information from working memory, it makes the information less susceptible to detrimental forms of memory interference, like false memories and proactive interference."

In Festini's studies, the researchers, following an established paradigm, direct their participants to forget through explicit instructions that include a "forget cue." These cues, she says, are not just a contrivance of the lab. In real life, a forget cue may come implicitly when gathering drive-thru orders: if someone changes their order, they might say "Oh, never mind! I don't want that anymore." Or in class, an instructor might tell their students to disregard a prior statement, if it was inaccurate or no longer relevant.

Evidence from Festini's lab suggests not only that these forget cues work but that they promote goal-directed removal of information from working memory in a process that is "different—and more beneficial than—simply curtailing processing of information," she says. "We also have evidence that other attention-demanding tasks can disrupt the efficiency of directed forgetting within working memory." That makes

the process of forgetting effortful and distinct from just discontinuing the processing of the information, echoing some of Banich's work.

In other studies, Festini and her colleagues have found that directed forgetting in older adults is impaired compared to in younger adults, but that explicit forget cues can still help mitigate interference in working memory for both younger and older adults. Although Festini's team's research has not specifically examined clinical applications, it suggests that voluntarily removing information from working memory may be more difficult for individuals with major depressive disorder or ADHD, for example.

Banich has also speculated about how the body of work could help contribute to understanding and treatment of PTSD, noting that people with PTSD tend to overgeneralize memories (e.g. when a backfiring vehicle may trigger a memory of an explosion). Because the process of forgetting appears to be effortful and best when specifically targeted, those with PTSD could potentially have challenges identifying and then suppressing the specific memory. "There is a paradoxical effect that if you're told to stop thinking about something, you actually have to identify and think about it to suppress it," she says.

Currently, Festini is undertaking a new study on how and when people remove information from working memory that is designated as less valuable or less important, without providing specific "forget" instructions. "I'm curious to understand what the tipping point is to motivate someone to engage in effortful removal of information from working memory," she says, "since there are clear benefits to the removal of less valuable information, but this removal process is attentionally demanding."

More information: The symposium "'Stop Thinking About It!': Cognitive and Neural Mechanisms of the Removal and Inhibition of

Information in Memory" is taking place at 1:30pmPT on Sunday, March 26, as part of the CNS 2023 annual meeting from March 25-28, 2023 in San Francisco. www.cogneurosociety.org/symposium-sessions/#SYM2

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