

NEUROSCIENCE

A Memorable Device

Wearable cameras offer help to people with memory problems and provide a tool for studying how the brain creates and retrieves personal histories

It was over drinks at a local pub in the spring of 2006 that cognitive psychologist Martin Conway of the University of Leeds in the United Kingdom first told his colleague Chris Moulin about using a wearable camera for memory research. But it took more than a few pints of beer to convince Moulin that SenseCam, a camera that periodically takes still photos while worn on the user's chest, might be a game-changer in the study of what psychologists call autobiographical memory. Although skeptical of the small device's usefulness, Moulin did finally agree to take one for a test drive.

Or rather, he took it on a test walk. Moulin regularly wore a SenseCam on a series of walks. When he reviewed the images 6 months later, to see how well his memories matched the camera's visual record, Moulin says he experienced an unexpected feeling of "mental time travel." One of the images triggered the memory of the song—Thom Yorke's "Black Swan"—that was playing on his iPod when the image was taken.

Conway says that many SenseCam users likewise report a sudden flood of memories of thoughts and sensations, what he calls "Proustian moments," when they review images taken by the device. SenseCam's images "correspond to the nature of human memory—they're fragmentary, they're formed outside your conscious control, they're visual in nature, they're from your perspective. All these features are very like what we call episodic memory," says Conway.

That's why he, Moulin, and dozens of other researchers have begun to test whether the images can help resolve how the brain handles personal memories. Cognitive experiments, however, represent just one line of inquiry supported by Microsoft Research, the scientific arm of the software giant and the inventor of SenseCam. Medical researchers are also evaluating whether the device can help people with memory problems due to illness or injuries.

In 2004, Narinder Kapur and Emma Berry, neuropsychologists at Addenbrooke's Hospital in Cambridge, U.K., were the first to use a SenseCam for memory rehabilitation work. They found that the device significantly helped Mrs. B, an elderly woman with memory problems due to brain damage from an infection. Mrs. B normally forgot

events after 3 to 5 days, and even keeping a diary that she periodically reviewed helped her remember events for only about 2 weeks. But when she regularly reviewed SenseCam images of events, she could recall more details—and her memories persisted for months after she ceased reviewing the past images. Encouraged by that data, Kapur says he and Berry grew hopeful that "periodic, regular review of visual images of personal events ... really does help long-term [memory] consolidation."



Shooting in the rain. The SenseCam (left) snaps dozens of wide-angle, low-resolution images from chest level on even a short walk.

They and others are getting a chance to test that hypothesis. After the pair reported the results from Mrs. B, Microsoft Research decided to provide more than \$550,000 in funding to seven research groups, most of them focusing on people with memory problems, and to loan hundreds of cameras to other scientists. SenseCam has "very obvious applications in a whole range of clinical disorders," says one of the grant recipients, psychologist Philip Barnard of the University of Cambridge.

Personal black boxes

SenseCam grew out of a Microsoft Research project that aimed to create a "black box for the human body" which would record data that doctors might find useful if a person were

in an accident, says Ken Wood of Microsoft Research Cambridge. In 1999, computer scientist Lyndsay Williams, then also at the same lab, suggested adding a camera to the device so it could double as a memory aid for mundane tasks such as finding lost keys.

In 2002, Kapur heard then-Microsoft CEO Bill Gates mention the project in a talk. Because his hospital is just a few miles from Microsoft Research Cambridge, it was easy enough for him and Berry to suggest using SenseCam prototypes for patients with memory problems due to Alzheimer's or brain injuries.

Clinicians who work with such people have typically focused on helping them with their prospective memory, i.e., remembering tasks to be completed in the future, such as keeping appointments. For this, the best aids are still simple tools such as checklists and alarm clocks. But for patients with difficulty recalling past events, clinicians have had little to offer beyond diary-keeping, a task many



people, such as Mrs. B and her husband, complain is onerous.

In contrast, SenseCam records images passively, permitting a person to go about their day without interruption. The latest version is about the size and weight of a clunky mobile phone and appears to observe the world through two unmatched eyeballs. One is a passive infrared sensor, tuned to trigger the camera whenever another person passes by. The other is a wide-angle camera lens, set to capture most of the user's field of view. The device is also equipped with an ambient light sensor that triggers the camera when its user moves from one room to another, or goes in or out of doors. The camera can also be set to snap an image if the sensors haven't triggered a photo after an arbitrary number of seconds. A typical wearer might come home with 2000 to 3000 fragmentary, artless images at the end of a day.

It may be just those characteristics of the SenseCam images that make them so useful for memory rehabilitation and research, Kapur

says. Like Conway, he suspects that the reason the images stimulate memory retrieval and possibly consolidation is because they mimic “some of the representations that we have” of past events in our brains.

To move beyond the initial case study of Mrs. B, the Addenbrooke’s team, under the direction of neuropsychologist Georgina Brown, has followed five additional people with memory problems over a nearly 3-year period, exploring the difference between the memory boost provided by visual and written diary-keeping. Establishing a baseline of how fast these people lose their memories, the team asked each about an event every other day for 2 weeks after the event, and then again after 1 month and after 3 months. Then they asked the patients to keep a diary of a separate event and review it every other day during an initial 2-week assessment, but not during subsequent months. Finally, patients reviewed their SenseCam’s images for 2 weeks following a third event.

The Addenbrooke’s work represents just a few patients with varying causes of memory loss, but Berry notes that worldwide there are about 30 ongoing SenseCam studies of memory patients. Adam Zeman of the University of Exeter in the United Kingdom leads one. “I think the main interest [in SenseCam] is that it gives you an opportunity to look at memory in what you might call a more ecological fashion than laboratory stimuli generally do,” he says, and “it gives an opportunity to support and rehabilitate memory.”

Memory walks

Normally, basic research precedes clinical studies, but the history of SenseCam has been the reverse. “The initial studies had a strong pragmatic aim,” says Kapur, “but certainly once we started to collect data, [psychologists] began to look at these things from a theoretical slant.” The question for cognitive scientists is whether SenseCam, or any similar wearable, point-of-view photographic device,

Duke University in Durham, North Carolina, who is also working with the device.

Despite SenseCam’s more personal touch, there are no guarantees it will break new ground in memory research. “Whether or not it will tell us different principles or something novel is unclear,” says Larry Squire, a psychologist at the University of California, San Diego, who hasn’t yet worked with the device.

William Brewer of the University of Illinois, Urbana-Champaign, notes that nobody really knows how best to evaluate SenseCam as a memory-consolidation aid or a retrieval cue. He and his graduate student Jason Finley have tested different aspects of memory using SenseCam images as cues, asking individuals how certain they are that they’ve seen an image before, or inquiring what they did after a certain image was taken. Such baseline studies, says Brewer, should help identify the most appropriate memory tests.

In addition to the seven Microsoft Research grants handed out in 2007, dozens of groups in



The preliminary results suggest that SenseCam use strengthened these patients’ memories more than diary-keeping did. A full analysis of the data is in preparation, says Brown, whose team plans to submit it to the journal *Memory* for a special issue devoted to SenseCam research.

In a recent, separate study, Mrs. B has repeated a version of her trial, this time incorporating a brain scanner. Researchers compared the activity in her brain as she tried to remember events she had either reviewed in her written diary or with personal images from her SenseCam. Mrs. B recognized about 50% of images taken at an event she had studied using a diary, but 90% if she had studied images instead. And brain regions associated with autobiographical memory were more active when she recalled events she had studied using SenseCam images than when she recalled the diary-studied event, Berry and colleagues report online on 13 March in the *Journal of Neurology, Neurosurgery and Psychiatry*.

can illuminate how healthy autobiographical memory works. Moulin, for example, has engaged volunteers to undertake memory walks in which they read a list of words while wearing the SenseCam. His student Katalin Pauly-Takacs has tested the participants’ recall of the words on the day of their walks and then again 3 months later, with and without the help of SenseCam images. Their preliminary results suggest that volunteers remember more of the words from walks that they reviewed using SenseCam images.

Moulin’s experiment is a nod to decades of autobiographical memory research, in which volunteers were tested on their ability to recall standard images or word lists they had previously seen. Some researchers suggest that the more personal nature of SenseCam images will be key to better studying autobiographical memory storage and retrieval. “Using SenseCam we can first, have more interesting stimuli and second, test [memory] processes that can generalize more easily to real life,” explains Roberto Cabeza, a neuroscientist at

cognitive psychology, clinical neuropsychology, education, and computer science are conducting research with borrowed SenseCams and independent funding. But there are no current plans to commercialize the hardware or the software from the SenseCam project—a fact that puzzles some fans of the device. In fact, to keep up with the growing demand for the devices, Microsoft would like to find another manufacturer willing to mass-produce the cameras, says Wood. Microsoft currently provides the cameras to only a limited number of patients under clinical supervision.

Even though he lobbies colleagues such as Moulin to try the device, Conway remains cautious about overselling SenseCam. There is still at least a decade’s work ahead before “we can maximize its use for research and its use as an intervention scheme in helping failing memories,” says the 56-year-old investigator. “By that time, I’ll need to wear one permanently, myself.”

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