Uncovering amnesiacs' hidden memories

University of Toronto researchers are tapping the unconscious memory systems of amnesia victims, enabling some patients to remember and learn certain facts for the first time since the onset of amnesia. The use of this "implicit memory" component now offers "some hope for teaching amnesiacs complex, new knowledge," psychologist Daniel L. Schacter reported this week in Chicago at the American Association for the Advancement of Science annual meeting.

Working with victims of head injury, encephalitis, Alzheimer's disease and other physiological syndromes, Schacter and his colleagues tackled the problem of "antrograde amnesia," in which people are unable to remember facts and events that have occurred *since* their injury or disease. Historically, he says, attempts to restore this type of memory to such people have been "useless." Most of those efforts involved "explicit memory": asking the person to consciously recall a word, event or fact that was presented a short time earlier.

But some promising, isolated results over the past decade suggested that in the process of learning certain skills or tasks, some amnesia patients demonstrate that they do remember, even though, when asked, they cannot consciously recall what they had been taught. In a series of recent studies, Schacter has used this unconscious, implicit memory to teach computer vocabulary and programming skills to amnesiacs.

In his latest work with three head-injury victims and one encephalitis victim, the psychologist employed a technique called "the method of vanishing cues." This involved "priming," in which the patient was asked to identify a computer-related concept — for example, "a repeated portion of a program." The patients were given the answer, "loop," just once, and were subsequently given fewer and fewer letters of the word — "loo–," "lo––," "l–––" — until finally they were given no letters.

After eight trials, Schacter reports that there was "little or no forgetting after a six-week delay." Moreover, the patients went on to be able to write computer programs, and had retained such information when tested months later.

"We've found that even severely amnesic patients perform relatively well on implicit tests of memory," he says. "They are not aware that they are remembering or learning, but we've been able to push the preserved and residual memory abilities that they do have."

Because of their short-term memory problems, many amnesiacs have been unable to get jobs and lead relatively normal lives. The next logical question, Schacter says, was, "Is it possible to build on those [implicit memory] skills to help these people in their lives?"

Schacter and his colleagues then attempted job training with one of his four latest subjects — a woman with viral encephalitis. The job was a rather complicated process, involving transferring businesss information from a card onto an eight-column display; the woman had to learn to identify multidigit numbers and such terms as "Doc. #" (document number) and "Ser. #" (serial number).

Schacter again used the method of vanishing cues. After an initially poor performance, the woman improved dramatically over the next several sessions and was completing transfers in 10 to 11 seconds, comparable to people already on the job. She accomplished this, he notes, even though "she did not recall the events of training explicitly."

Among such amnesia victims, he adds, IQ, vocabulary and skills have not been impaired—it's simply a matter of enabling the people to use those skills once again. "What we've done so far," he says, "is to shed light on some form of memory and to demonstrate that people with amnesia due to head injury [and other physiological causes] have the potential to perform useful tasks." — *J. Greenberg*

Pi wars: Dueling supercomputers

The relentless pursuit of pi (π) has now pushed computation of that elusive number's decimal expansion beyond 134 million digits. This recent effort by Yasumasa Kanada of the University of Tokyo and his colleagues, on an NEC SX-2 supercomputer, eclipses the record set last year by David H. Bailey using a Cray-2 supercomputer at the NASA Ames Research Center at Moffett Field, Calif. (SN: 2/8/86, p.91).

"The story of computing digits of pi is no longer a story of great practicality," says mathematician Peter B. Borwein of Dalhousie University in Halifax, Nova Scotia. "It hasn't been a story of great practicality since maybe the 16th century . . ., but it is a problem that has captured many, many people's imaginations." Borwein this week discussed the latest achievements at the annual meeting in Chicago of the American Association for the Advancement of Science.

Archimedes started the chase more than 2,000 years ago when he developed a method for approximating pi, the ratio of a circle's circumference to its diameter, by nesting a circle between a pair of polygons whose perimeters were easy to calculate. In the 17th century, Isaac Newton, using his own method, calculated at least 15 digits of pi. But, in a letter, he sheepishly admitted: "I am ashamed to tell you to how many figures I have carried these computations, having no other business at the time."

In 1949, a primitive computer pushed the computation to 2,037 digits. In recent years, the computation of pi has become an appealing, though not particularly useful or revealing, way to demonstrate publicly the capabilities of rival supercomputers.

The latest computation, which was done twice using two computer algorithms to check the result, took about two days each time on the SX-2. Borwein estimates that reciting the number's 134,217,700 digits, one digit every second, would take about four years.

"A reasonable question is, why does one compute pi and not compute something else to 134 million digits?" says Borwein. "Part of the reason is that pi is the most naturally occurring of the non-algebraic numbers [the next level of complexity of numbers]. And it's a number we know a little bit about but not a great deal about."

Mathematicians, for instance, proved long ago that pi is an irrational number. This means that it takes a never-ending string of digits to express pi as a decimal number. However, no one knows whether all of the digits from 0 to 9 appear infinitely often in this expansion or whether one-tenth of the digits are ones, and so on. Tests show that the first 30 million or so digits do behave regularly as expected.

Peter Borwein and his brother Jonathan developed the equations and the improved computer algorithms used for the last few record-setting computations of pi. A comparison with earlier methods shows how much these techniques have advanced. To get half a billion digits, Archimedes's method would have to be applied more than a billion times. "The current method, says Peter Borwein, "reduces that to 12 iterations." In the Borwein method, he says, "each time you take the next step, you get four times as many correct digits as you had before." Combining this with a fast way to multiply leads to a remarkably efficient procedure for computing pi.

The Borwein algorithm is close to the theoretically best possible algorithm for computing pi. "There's a very small gap between what is known and what is possible," says Borwein. On that basis, he conjectures that no one will ever know the $10^{1,000}$th digit of pi. Assuming that all of the preceding digits must be computed to arrive at this particular digit, even the age of the universe would allow too little time for the computation. — *I. Peterson*