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BRAIN SCIENCE

Remembrance of All Things Past

Neuroscientists have discovered that some people can remember the details of events from 20 years ago almost as well as those experienced yesterday

By James L. McGaugh and Aurora LePort

IN BRIEF

Some 14 years ago an individual claiming to possess extraordinary recall of the distant past came forward.

Publicity about the case brought out hundreds of others who made similar assertions about their ability to remember.

Testing confirmed that a few dozen among this group can recite details of a specific date decades later.

Neuroscientists are now exploring the biological underpinnings of "highly superior autobiographical memory."

Illustration by Kate Bean

IN THE LATE SPRING of 2000 one of us (McGaugh) received an e-mail message from a woman named Jill Price who was trying to cope with the burdens inflicted by her own memory. It read, in part:

As I sit here trying to figure out where to begin explaining why I am writing you … I just hope somehow you can help me. I am 34 years old, and since I was 11 I have had this unbelievable ability to recall my past … I can take a date, between 1974 and today, and tell you what day it falls on, what I was doing that day, and if anything of great importance … occurred on that day I can describe that to you as well. I do not look at calendars beforehand, and I do not read 24 years of my journals either.

We were skeptical of Price's assertions but intrigued enough to invite her to our research center at the University of California, Irvine, where we study the neurobiological bases of learning and memory. On June 24, a few months later, Price came for an appointment. It was a Saturday. We are certain about the date because her visit was recorded on a laboratory calendar. Price, we quickly discovered, remembers such facts without any need for a calendar.

We were cautious in that first interview and looked for some objective means of evaluating her claims. There was no way to immediately check what she told us about her own past. Yet we could query her about public events that occurred during her lifetime. We had a copy of a then just published book, *20th Century Day by Day*, by Sharon Lucas, that contained articles of daily news events going back 100 years.

We started with the mid-1970s, when Price first recognized that her memory might be unusual. When we asked what happened on August 16, 1977, she quickly replied that it was the day Elvis Presley died. When we queried June 6, 1978, she told us it was the day that California's Proposition 13, limiting the state's property tax rates, passed. May 25, 1979, was the day a plane crashed in Chicago. May 3, 1991, was the last episode of *Dallas*. And so on. Price answered correctly every time.

Then we reversed the process and asked Price to name the date for a particular event: When was J.R. shot? When did police beat Rodney King? Again, each time Price came up immediately with the right answer. During our testing, she identified an error in the book of milestones for the date of the start of the Iran hostage crisis at the U.S. embassy in 1979.

Although many of the dates we tested for were public events that had received considerable media attention, Price also excelled in remembering less significant occurrences. She correctly recalled that Bing Crosby died at a golf course in Spain on October 14, 1977. When asked how she knew, she replied that when she was 11 years old, she heard the announcement of Crosby's death over the car radio when her mother was driving her to a soccer game. In one interview, she described remembering dates visually: "When I hear a date, I see it, the day, the month, the year."

In a subsequent interview in March 2003, she recalled, with one error, the dates of the previous 23 Easters and told us what she did on each of those dates—and she is Jewish. We were able to verify many of her claims by checking a diary that she kept for many years. For some of her personal memories, we consulted our own records documenting the testing of her memory. At a subsequent interview, she correctly remembered the dates for all of our previous interviews and the details about the questions we had asked about her recall of past events.

After we were convinced that Price's mental diarylike abilities were real, we wanted to know whether this skill extended to other aspects of remembering. We determined that she does not have a "photographic memory"—that is, she does not recall the minutest details of daily experience. She has trouble remembering which of her keys go into which lock. She makes lists of things she needs to do. She also does not excel in memorizing facts by rote.

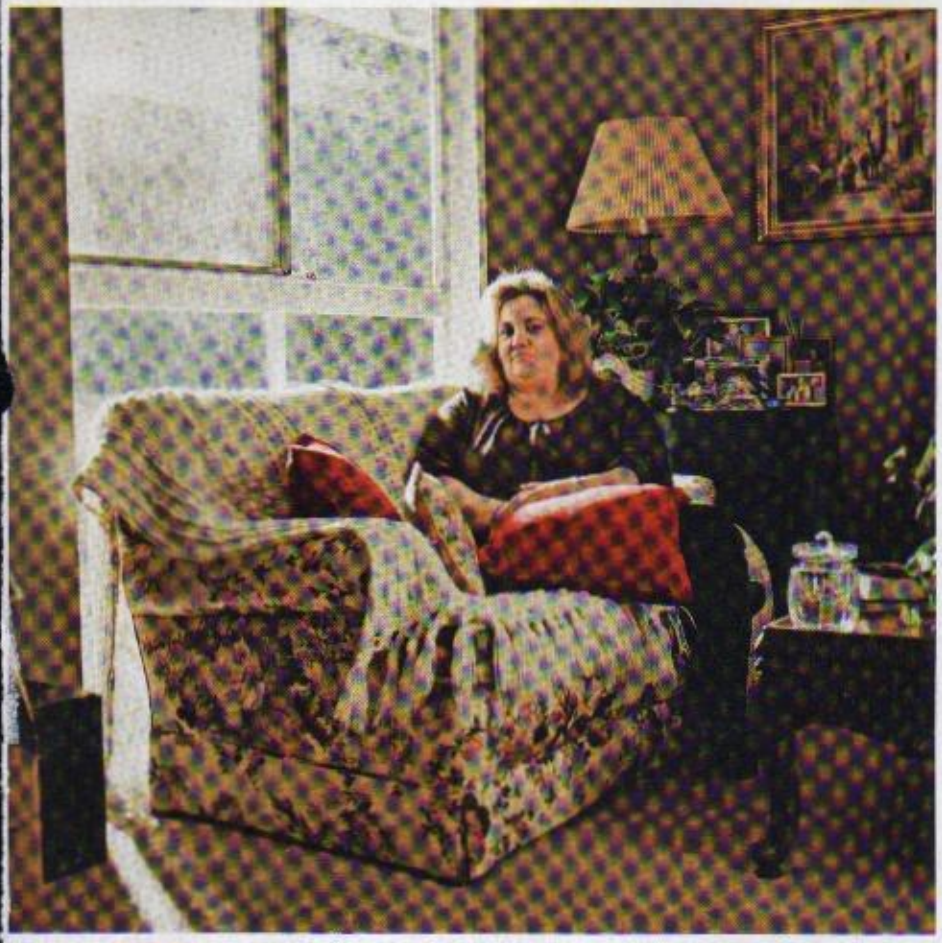
Price does have immediate recall of the day of the week for any date in her life after she was about 11 years old. Her recall is distinguished by highly organized, readily accessible and accurate memories of most of the days of her life from preadolescence onward. Until Price walked into our lab, this particular type of memory, which we call highly superior autobiographical memory (HSAM), had never been studied. We are now delving further into the psychological and biological roots of HSAM in the hope that an understanding of these processes may provide more general insight into the processes underlying memory.

IS SUPERIOR MEMORY COMMON?

FOR SEVERAL YEARS, we referred to Jill Price with the fictitious initials "A.J." because she did not wish to be identified. After publishing a paper on her extraordinary memory in 2006, our work gained national attention. We then appeared on National Public Radio on April 19 and 20, 2006. Price, who had decided to come out of the shadows, subsequently published a memoir, *The Woman Who Can't Forget*, in 2008.

Following that publicity, other individuals who thought that they have, or might have, similar memory abilities contacted us. After putting them through the rigors of testing, we identified five additional HSAM subjects. On December 19, 2010, these five individuals appeared on *60 Minutes*. Within hours of the episode's air-

PAGE 40: MITCH PAYNE [photograph]



QUERY from Jill Price to researchers at the University of California, Irvine, set off a series of events that led to identification of individuals with superior memory.

BRYCE DUFFY

ing, we received dozens of e-mails from potential subjects, and within days, many hundreds had reached our in-boxes. We contacted many of these people by telephone and tested them by asking them about sporting and political events, famous people, holidays, airplane crashes and other notable incidents.

We also began a more formal testing procedure at our center, recruiting several dozen control subjects of similar ages to that of the superior memory group—and both groups contained the same proportion of males and females. During the testing, a few of those who claimed to have exceptional memories performed more poorly than the controls. Clearly, believing that you have HSAM does not make it so.

The 40 or so subjects who did perform well then received, along with the control group, an additional test in which they had to identify the day of the week for each of 10 randomly selected dates, along with a newsworthy event that occurred on or near these dates, as well as something that had happened to them on that date. As a group, the prospective HSAM subjects very significantly outperformed the controls on all components of this test.

Eleven of the highest-performing subjects then came to our lab at U.C. Irvine for further testing. They were first asked to answer questions about five personal experiences that we were able to verify—events such as their first day at university and elementary school, their 18th-birthday celebration, the address and description of their first residence after leaving home, and the date of their last final exam in college. The 11 potential HSAM subjects outperformed the controls by a wide margin—registering an overall score of 85 percent in responding to these queries compared with only 8 percent for controls. We concluded that these 11 subjects, who ranged in age from 27 to 60, very clearly had HSAM.

We also tried to distinguish the HSAM group from others by administering a battery of lab memory tests. HSAM subjects performed better than the controls in only two of eight tests: one associating names with faces and another checking recall of visual objects. For both tests, however, the scores for the two groups overlapped considerably. A few other qualities distinguished the HSAM group. A higher than average number—five of 11—were left-handed, and they scored significantly higher on a test of obsessive personality traits. One-on-one interviews also revealed some compulsive behaviors such as hoarding of possessions and excessive efforts to avoid touching potentially germ-laden objects.

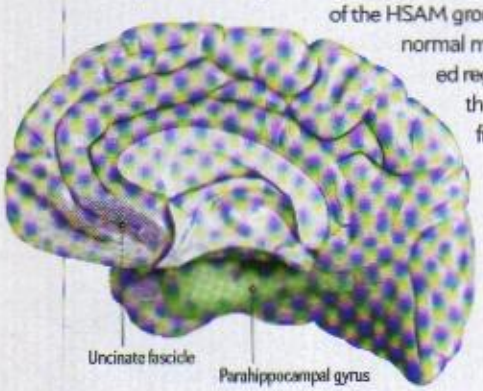
A further question in trying to understand superior memory was whether these differences in memory are related to differences in the brains of our group. Magnetic resonance imaging (MRI) scans revealed that several brain regions of HSAM subjects differed from those of control subjects. A few areas of gray matter (tissue made up of the cell bodies of neurons) and white matter (the wirelike extensions from the neurons covered with a whitish insulating material called myelin) varied from controls in size and shape. The structure of the white matter's fibers also hinted at greater efficiency in transferring information between brain regions.

Findings of other labs investigating the effects of brain lesions, as well as those using functional MRI and positron-emission tomography, have suggested that brain regions and fiber pathways that stand out in HSAM subjects are involved in remembering life events (autobiographical memory). In our group, the structure of one fiber tract, the uncinate fascicle, which transmits information between the temporal and frontal cortex, appeared to have better connections than in control subjects. This finding is intriguing because of evidence that injury to this pathway impairs autobiographical memory.

Our imaging results are, of course, merely suggestive. We do not know whether these anatomical differences in the brains of HSAM and control subjects contribute in some way to superlative memory ability or whether they might be a consequence of extensive use of that ability. To find out, we need to determine whether HSAM ability appears in early childhood. If the skill has some genetic basis, we should eventually be able to detect the genes involved. Yet we have no evidence so far of a higher incidence of this ability in relatives of those in the HSAM group.

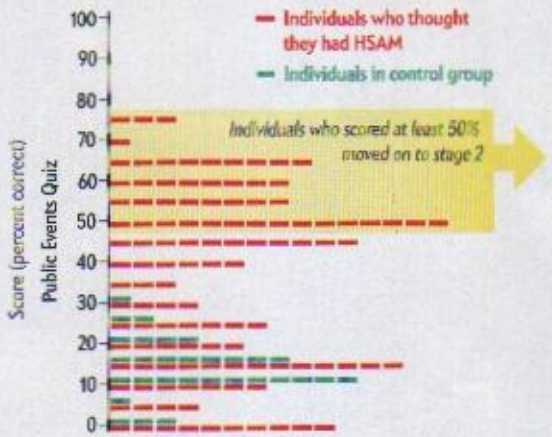
Super Memories in the Lab

The first challenge researchers faced when they encountered people claiming to have astute recall of events from decades earlier was to verify these assertions. The team at the University of California, Irvine, developed a multipart evaluation process (*graphs at right*) that led to several dozen individuals being classified as exhibiting highly superior autobiographical memory, or HSAM. A later step focused on whether the brains of the HSAM group differed from those with normal memories. Two memory-related regions stood out in brain scans: the uncinate fascicle, a nerve fiber tract that links the temporal and frontal cortices, and the parahippocampal gyrus are better connected to other brain areas.



Stage 1: Public Events Quiz

More than a third of the self-identified HSAM group recalled at least 50 percent of newsworthy items, a level unmatched by control subjects.



AN EMERGING PROFILE

OUR FINDINGS have enabled us to make a few tentative conclusions about these extraordinary people. First, HSAM subjects do not develop superior memory because they somehow learn things more readily than others who lack this talent. The members of this group distinguish themselves by their ability to retain what they do learn. Someone with an average memory can remember, for a few days afterward, many details of what happened, say, last Tuesday, but the information fades in a week or so. Not so for members of the HSAM group: their memories are considerably longer lasting.

Second, we know that the memory systems of individuals with HSAM are not precise video and audio recorders of every millisecond of their existence. Additionally, HSAM is not like the memory of "S," the subject in Alexander Luria's *The Mind of a Mnemonist: A Little Book about a Vast Memory*, a much cited 1968 account about one of Luria's patients who could readily learn and retain vast amounts of relatively meaningless material—rows and columns of numbers, for instance. Nor is HSAM like that of memory experts who train themselves by extensive rehearsal and the use of mnemonic tricks to learn material such as pi to many thousands of digits.

The HSAM group's memories are less detailed than those of Luria's subject but are highly organized in that they are associated with a particular day and date. We also know that this skill seems to occur naturally and without studied exertion. Many of the questions we have used in testing HSAM individuals have to do with subject matter, such as the weather on a particular day, recollections that they were highly unlikely to have spent time and effort rehearsing. When asked how they gained their knowledge, HSAM subjects typically responded, "I just know that." And although they enjoy mentally tying a date to an event, they generally have little, if any, interest in knowing what happened on calendar dates that arrived before they were born.

HSAM subjects typically appreciate their special skill. In this way, they are not at all like the eponymous character from Jorge Luis Borges's 1962 short story "Funes the Memorious." After being thrown from a horse, Funes acquired the ability to retain detailed memories of all his subsequent experiences; he could call up the image of every leaf on every tree he had seen. He was tortured by his recollections, which made him conclude that his life was no more than a garbage heap. Although Price told us that her memories were a burden, most HSAM subjects relish having such vivid access to their past. For the most part, they lead active professional and social lives. Several are in the entertainment industry: actress Marilu Henner and television producer and stand-up comedian Robert Petrella have HSAM. So do Louise Owen, a violinist, and Brad Williams, a radio news announcer and actor.

The extraordinary abilities of people with HSAM do not give them superhuman powers to outpace their colleagues in their chosen professions. Petrella has had occasion to use his skill when he wrote, for his own amusement, "The Book of Bob," in which he noted, for each day of the year, the best experience on that date during his adult life. But this project was merely a pastime—it had nothing to do with producing a TV show.

The work on HSAM joins a rich history of research on people with unusual psychological deficits and strengths. In 1881 French psychologist Théodule Ribot reported that brain damage impaired new memories but allowed older ones to persist—studies echoed in recent decades by the investigations of Brenda Milner of McGill University. Milner examined the famous patient Henry Molaison, for years known simply as "H.M.," helping to provide insight into what happens when a person is unable to form new autobiographical memories. After the surgical removal of a portion of the brain—the anterior medial

SOURCE: "BEHAVIORAL AND NEUROANATOMICAL INVESTIGATION OF HIGHLY SUPERIOR AUTOBIOGRAPHICAL MEMORY (HSAM)," BY AURORA K. R. LEPORT ET AL., IN *NEUROBIOLOGY OF LEARNING AND MEMORY*, VOL. 98, NO. 1; JULY 2012

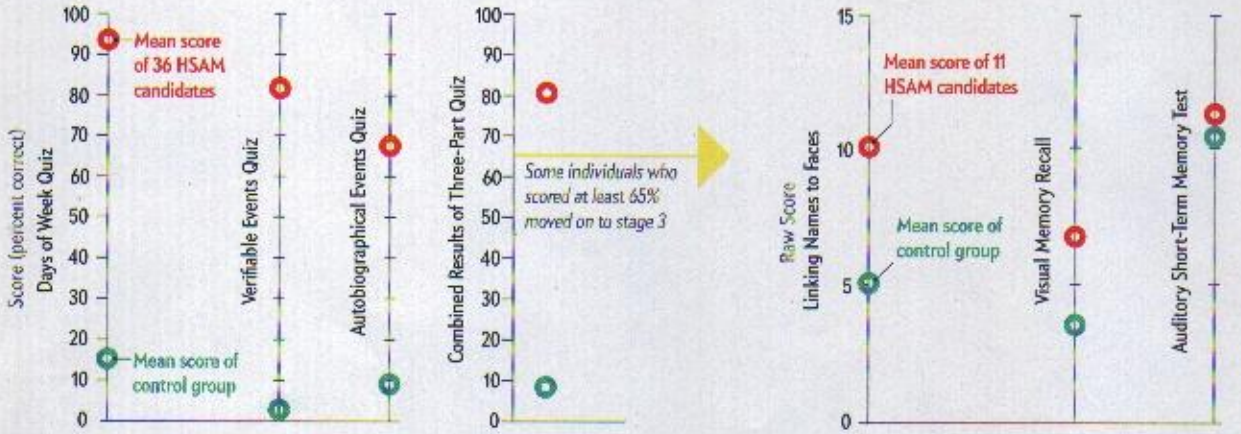
SCIENTIFIC AMERICAN ONLINE Watch interviews of people with superior recall at ScientificAmerican.com/feb2014/remember

Stage 2: Dates Test

The HSAM group excelled on a test in which they had to identify the days of the week and verifiable public and personal events that occurred on a random set of 10 dates.

Stage 3: Cognitive Testing

A subset of the HSAM group performed well on only some cognitive measures of memory—ones linking names to faces and recall of images—but not on several others, such as a short-term memory test.



temporal lobes in both hemispheres to treat epilepsy—Molaison almost completely lost the ability to learn new autobiographical information even though his memory for prior experiences remained mostly intact and motor learning of movement—known as procedural memory—remained unimpaired.

These findings forced the then novel conclusion that different brain systems are responsible for distinctive types of memory, and, as a consequence, memory research underwent dramatic change. The new discovery that some human subjects have very strong and lasting memories of both ordinary personal experiences and important public events has stimulated research that may, over time, provide new insights into the way the brain stores and retrieves recollections of past events.

LIKE A MUSCLE

EXTENSIVE EVIDENCE, beginning with psychologist Hermann Ebbinghaus's studies of human memory in 1885, has shown that repetition of material we wish to learn strengthens memory. More recent studies by Henry L. Roediger III of Washington University in St. Louis and Jeffrey D. Karpicke of Purdue University have found that memory retrieval—bringing to mind a memory for a few moments—can make recall stronger.

Even with practice, however, an individual with ordinary memory is unlikely to achieve the capabilities of our HSAM subjects, who did not rehearse for any of our tests. McGaugh has spent many years on studies that have found that we all make stronger memories of emotionally important experiences. The novel and intriguing finding is that HSAM subjects readily make strong memories of even relatively trivial events.

Despite considerable media coverage, we have so far identified only about 50 HSAM subjects out of several hundred potential candidates who have contacted us. That is a very tiny proportion of the total number of viewers and readers who learned about our research. If this ability aids in successful adaptation to the challenges of living, why is it so rare? Perhaps HSAM is a lingering trace of a once important and now almost lost skill. Before the printing press, much of human culture was preserved by stories and knowledge passed down orally from one generation to the next. In the preliterate world, a prodigious memory would have accorded the holder an elevated status among peers. The need for this type of highly organized mental capacity is waning and, with the introduction of computers and smartphones, may have already passed.

It is possible—perhaps likely—that many of the subjects whom we dismissed in our early testing as not having HSAM possess some other memory ability that we have yet to identify. Some of these people may have lucid memories of their past and simply neglect to mentally date them, as do the HSAM subjects, opening the prospects for new avenues of research. Instead of contemplating mental deficits, we and other investigators may now have an opportunity, sparked by an impromptu, 14-year-old e-mail message, to better understand the way the brain works by studying Olympians of human recall. ■

MORE TO EXPLORE

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Illustration by AXS Biomedical Animation Studio, Graphics by Jen Christiansen