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## A life without a past

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IN BYGONE DAYS

KARL O. NAKKEN

karln@ous-hf.no

Karl O. Nakken MD, PhD, retired neurologist from the National Centre for Epilepsy, full member of the ERN, EpiCARE, Oslo University Hospital, Oslo, Norway

The author has completed the ICMJE form and declares no conflicts of interest.

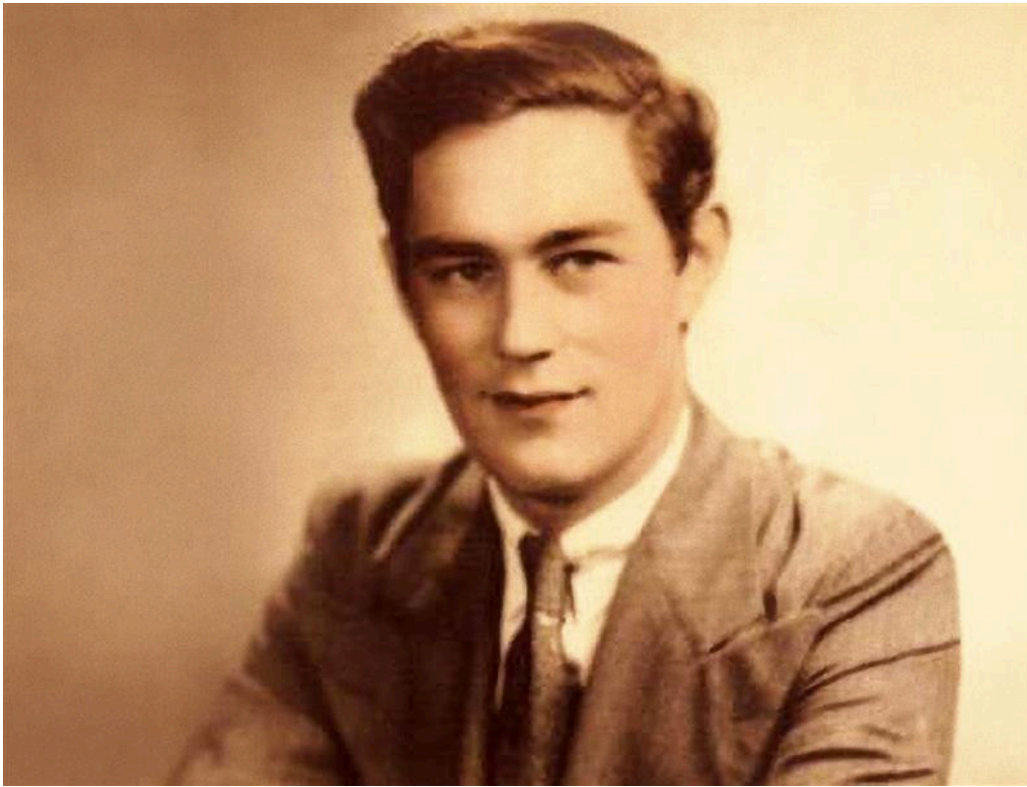
MIA TUFT

Mia Tuft, neuropsychologist and works with rare epilepsy-related diagnoses at Oslo University Hospital

The author has completed the ICMJE form and declares no conflicts of interest.

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**Henry Molaison was the patient who, without knowing it, provided crucial insights into epilepsy surgery and memory functions. He lived a life without the ability to form new memories.**



The patient who, without knowing it, provided crucial insights into epilepsy surgery and memory functions. Henry Gustav Molaison (1926–2008), in 1953. Photo: Fair use

In 1953, Henry Molaison underwent surgery for drug-resistant epilepsy. The surgeon removed the medial parts of the temporal lobes bilaterally, including most of the hippocampus and the amygdala. The procedure resulted in severe anterograde amnesia. In scientific literature, Henry is known by the initials 'HM', and within neuroscience he has become the most studied patient.

The medical literature includes numerous case reports that have led to the development of major research areas [\(1, 2\)](#). In neurology and neuropsychology, two cases in particular have been instructive [\(3\)](#): Phineas Gage (1823–60) was an American railway worker who, in 1848, was involved in a blasting accident in which an iron rod was driven straight through his head. The rod destroyed the left frontal lobe of his brain, and the injury provided insights into the role of the prefrontal cortex in personality. The second case, Henry Molaison (1926–2008), is discussed in further detail below.

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## Epilepsy in childhood

Henry Molaison grew up in a family in which three members had epilepsy. At the age of seven, he was involved in a cycling accident and sustained a mild head injury. He experienced his first epileptic seizure at around ten years of age. During childhood, his seizures manifested as brief episodes of absence and were described as 'petit mal'. They lasted between 5 and 40 seconds, and during the attacks he was unresponsive, breathed heavily, had his eyes closed and crossed his arms and legs. Occasionally, he would scrape one hand against the other arm. After the seizures, he claimed to have some recollection of what had occurred. On one occasion, twelve seizures were recorded over the course of

two hours. Two antiepileptic medications (initially phenytoin, subsequently combined with phenobarbital) had no effect on the seizures, and from the age of 15 he began experiencing repeated tonic-clonic seizures without warning (4).

*«Because of the seizures, Henry was bullied at school, and his education was disrupted by frequent absences. In the years preceding surgery, he had on average one tonic-clonic seizure per week and around ten petit mal seizures per day»*

Because of the seizures, Henry was bullied at school, and his education was disrupted by frequent absences. In the years preceding surgery, he had on average one tonic-clonic seizure per week and around ten petit mal seizures per day. His intelligence level was considered normal, and clinical neurological examination revealed no deficits. Pneumoencephalography showed no evidence of focal traumatic brain lesions. EEG recorded during an absence seizure demonstrated bursts of 2–3 Hz spike-wave activity, most pronounced over the anterior regions of the head, without clear focal features (4).

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## Epilepsy surgery with severe consequences

At the age of 27, he was offered epilepsy surgery by neurosurgeon William Beecher Scoville in Hartford, Connecticut. The surgeon emphasised that the procedure was experimental, but also noted that he had prior experience with psychosurgery (prefrontal lobotomy). To stop the seizures, the surgeon believed he would need to remove most of the medial parts of the temporal lobes bilaterally, including most of the hippocampus and the amygdala. This would prove to be a serious misjudgement, leaving Henry with severe anterograde amnesia for the rest of his life.

Following the operation, he was largely unable to acquire or retain new information, with the exception of some motor tasks. New experiences were forgotten in less than a minute. His working memory, necessary for tasks such as holding a conversation, and his procedural memory, including skills like swimming and cycling, remained intact. The amnesia effectively confined him to a life lived entirely in the present. He also exhibited retrograde amnesia, which ultimately restricted his memory to events occurring within approximately one year before surgery. Henry described his new existence as: 'like waking from a dream – every day is alone in itself' (5).

*«Following the operation, he was largely unable to acquire or retain new information, with the exception of some motor tasks. New experiences were forgotten in less than a minute»*

There was no impairment of his intellectual functions, and he exhibited no perceptual deficits; however, he had developed profound anterograde amnesia for both verbal and non-verbal material in all sensory modalities. Henry's specific memory deficits demonstrated the existence of two distinct types of

long-term memory: *explicit/declarative memory*, responsible for recalling previous experiences and information, and *implicit/non-declarative memory*, responsible for skills that do not require conscious recall, such as cycling or swimming.

Together with one of the founders of neuropsychology, Brenda Milner, Scoville published an article describing the surgery and its consequences for HM; the abbreviation by which he subsequently became known in the literature (6).

Neuropsychologist Suzanne Corkin studied him for much of his adult life, from 1962 until his death in 2008. She has since published a book on him (4). In 2009, at the Brain Observatory in San Diego, his brain was sliced into 2401 sections, each 0.07 millimetres thick. The entire 53-hour procedure was broadcast live, with each section photographed and assembled into a 3D model. One of the findings from the dissection was that slightly more of the hippocampus had been preserved than previously thought. However, the entire entorhinal cortex was absent, indicating that this region is also critical for normal memory function.

Following completion of a digital reconstruction in 2014, Henry's brain can now be studied digitally via the website of the Brain Observatory at the University of California, San Diego (7, 8). According to Corkin, this digital resource marks the beginning of a new chapter in the study of the most extensively investigated case in the history of neuroscience (9).

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## Should never have been operated on

Henry's tragic fate provided neurologists, neuropsychologists and neurosurgeons with invaluable insights into the neuroanatomical substrates of memory. In 1953, knowledge of hippocampal function was still relatively limited, and according to Scoville, HM's memory deficits were 'entirely unexpected' (6). He deeply regretted performing the procedure and warned colleagues against making the same mistake (10). Since then, no epileptic patient has undergone bilateral medial temporal lobectomy. Even when considering a unilateral temporal lobe resection, no neurosurgeon today would perform the procedure without first confirming that the patient has a fully functional hippocampus on the contralateral side (11).

*«Viewed from today's perspective, HM should never have been operated on. He most likely had a genetically determined generalised form of epilepsy, characterised by absence and tonic-clonic seizures»*

Viewed from today's perspective, HM should never have been operated on. He most likely had a genetically determined generalised form of epilepsy, characterised by absence and tonic-clonic seizures. His medical history, the pattern of his seizures, EEG findings and the lack of response to phenytoin all

indicate that he did *not* have temporal lobe epilepsy, as Scoville had assumed (4). This highlights the importance of accurate epilepsy diagnosis and classification prior to considering surgery.

His mild head injury at age seven was unlikely to have had any etiological significance. Following the introduction of CT and MRI, subsequent scans showed no evidence of focal traumatic brain injury. Consequently, epilepsy surgery was inappropriate from the outset, even for a unilateral procedure (12).

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## Ethically questionable

The numerous and repeated neuropsychological assessments Henry underwent could be considered ethically questionable. He was always friendly and willing to participate in the tests, and it was an advantage that he could not remember having taken them before. During intensive exercises with spatial tasks, which involved copying complex figures from a model, Suzanne Corkin was able to demonstrate that he could improve his spatial memory (7, 13).

Although HM forgot each testing session and every task was effectively new to him on subsequent occasions, it is the responsibility of healthcare professionals to safeguard patients who are unable to set their own boundaries. And who can say whether he would have consented to having 2401 slices of his brain published online for public scrutiny? In the years following surgery, he gradually experienced fewer seizures, but neither the absence seizures nor the tonic-clonic seizures stopped completely.

Henry lived with his memory impairments until his death at the age of 82. Thanks to Suzanne Corkin in particular, he has become the most studied and best-known patient in neuroscience (4).

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