

# Relations Between Aging, Memory, and Language in Amnesia: H.M.'s Longitudinal Recall of Phonological, Orthographic, and Lexical-semantic Information



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## Research Question

Does aging impair retrieval of familiar semantic, phonological, and orthographic information at the same rate for amnesics and normal older adults?

## Participants

### Amnesic Patient H.M. (1926-2008)

To control his epilepsy in 1953, H.M. had an operation that removed part of his hippocampal region but caused almost no neocortical damage. This resulted in severe anterograde amnesia.

### Memory-Normal Control Participants

Controls were carefully matched with H.M. on characteristics such as:

- Age
- IQ: Verbal and Performance
- Educational degree
- Background
- Native language

## Cross-sectional Studies

Performance was compared for H.M. and same-age controls in each of the following tasks.

### Word Definition Task

e.g., What does *squander* mean?

### Lexical Decision Task

e.g., Is *squander* a word?

### Word Reading Task

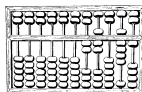
e.g., Read this written word aloud: SQUANDER

### Spelling Task

e.g., Spell this spoken word: SQUANDER

### Boston Naming Test

e.g., Name the object in this picture:



## Results Summary: Cross-Sectional Studies

In all five tasks, H.M. showed deficits relative to same-age controls when processing low frequency (LF) but not high frequency (HF) information.

## Longitudinal Studies

To evaluate effects of aging, we compared H.M.'s cross-sectional deficits with his performance at a younger age in three earlier studies that used similar or identical stimuli in Lexical Decision, Word Reading and Picture Naming tasks.

### Lexical Decision Task

Ages: 57 vs. 73

Tested at age 57 by Gabrieli et al.<sup>1</sup> and at age 73 by James and MacKay<sup>2</sup>

**Results:** At both ages, H.M. showed no deficit for HF words relative to controls. However, he showed a small but reliable deficit for LF words at age 57 that progressed to a significantly larger deficit at age 73.

### Reading Post-1965 Words Aloud

Ages: 67 vs. 71 vs. 73

Tested at age 67 by Postle and Corkin<sup>3</sup> and at ages 71 and 73 by MacKay and Hadley<sup>4</sup>

Participants read words that entered English after 1965, following H.M.'s 1953 surgery.

**Results:** Compared to controls, H.M. made reliably more reading errors from age 67 to 71 and from age 71 to 73.

### Boston Naming Test

Ages: 54 vs. 72 vs. 73

Tested at age 54 by Corkin,<sup>5</sup> at age 72 by Kensinger et al.,<sup>6</sup> and at age 73 by MacKay and Hadley<sup>4</sup>

Participants named pictures of objects, ranging from *bed* (easy, HF) to *abacus* (difficult, LF). If there was no response, the experimenter gave phonological cues (e.g., "oc" for *octopus*), followed by a verification question (e.g., "Is this an octopus?").

**Results:** At age 54 H.M. performed "in the normal range", while at age 72 he was "within 1 SD of controls". At age 73, he showed a reliable deficit for LF-name pictures, but not HF-name pictures. H.M. also made unusual errors, including neologisms with fewer than 30% of the target phonemes (e.g., "sideon" for *snail*)

## Results Summary: Longitudinal Studies:

In all three tasks, H.M.'s deficits relative to controls for LF but not HF information became progressively worse with aging from 57 to 73.

## Discussion

### Empirical Conclusion:

#### Supra-normal Age-linked Retrograde Amnesia

H.M.'s retrograde amnesia for previously familiar LF phonological, orthographic, and lexical-semantic information worsened from age 57 to 73, progressing at a much faster rate than in normal older adults. This exaggerated effect of aging on memory for previously familiar information is called *supra-normal age-linked retrograde amnesia*.

### Theoretical Conclusions:

#### Binding Theory

Binding mechanisms in the hippocampal region are necessary to rapidly create cortical representations for novel concepts.

H.M.'s anterograde amnesia reflects impaired binding mechanisms for forming new cortical representations.

Non-use and aging causes cortical representations to become defunct (unusable), resulting in normal retrograde amnesia for that information. Normal people with intact binding mechanisms can form new cortical representations to replace defunct ones, but H.M. cannot.

H.M.'s supra-normal retrograde amnesia reflects an interaction between a) normal degradation (due to non-use and aging) of pre-formed cortical representations, and b) the inability to form new cortical representations to replace the degraded ones.

## General Conclusions

Aging degrades memories for rarely used semantic, phonological, and orthographic information at a faster rate for amnesics than normal older adults. The supra-normal age-linked retrograde amnesia that amnesics experience reflects their inability to relearn information forgotten due to normal aging processes.

## References

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