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NEUROSCIENCE AND PSYCHOLOGY
Published: 30 October 2023
doi: 10.3389/frym.2023.1166183

MEMORY LOSS AND AGING: HOW CAN WE USE SMARTPHONES TO BETTER REMEMBER?

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YOUNG REVIEWERS:


ANNIE
AGE: 13


APARNA
AGE: 10


CARINA
AGE: 12


CHAITRA
AGE: 8


ELIZABETH
AGE: 13


ISAAC
AGE: 12

Our brains grant us the amazing ability to remember and relive the events from the past—however, memory for these events tend to worsen as people get older. Our memories serve several important functions, helping us to guide our future actions, connect with others, and understand ourselves. As a result, memory loss can greatly impact the lives of both those who lose their memory and their loved ones. Fortunately, there are things that people can do to help support memory as we age! For example, by combining smartphone technology and findings from decades of memory research, scientists can develop new and exciting tools to improve memory. In this paper, we will describe some of our work creating and testing a smartphone application that helps older adults better remember the unique moments from their lives.

KALLIE

AGE: 13

MEMORY AND FORGETTING: WHAT IS NORMAL AND WHAT IS NOT?

Let us try a little exercise! Take a minute to reflect upon some events from your life. Can you remember what you had for dinner yesterday? A fun day you had at an amusement park? How about when you learned about something fascinating in school?

As you reflect on these memories, you will likely find that details for these events come flooding back. This might include who was there, what you were doing, where you were, and when the event took place. The ability to remember personal events like these is called **episodic memory**. One famous scientist even called episodic memory "the time machine in the brain", because it allows people to re-experience past events in the mind's eye [1]. Episodic memories are critical for helping people make decisions in the future (e.g., "I tried hummus for the first time yesterday and it was great—I will make sure to get it next time!"), connect with others ("That was the tallest roller coaster I have ever been on—I need to make sure I tell my friend Jenny next time I see her!"), and better understand who we are ("I loved learning about the brain—I am really passionate about neuroscience!").

EPISODIC MEMORY

Memory for specific events that people have personally experienced.

Episodic memory is separate from other types of memory, such as semantic memory or procedural memory. Semantic memory is memory for facts and general knowledge about the world, such as knowing the capital city of Canada, while procedural memory is memory for how to perform actions or motor skills, such as knowing how to ride a bicycle.

One brain region that is particularly important for supporting episodic memory is the **hippocampus**, a seahorse-shaped structure buried about 1.5 inches deep inside the brain on each side of the head (Figure 1). The hippocampus is critical for preserving episodic memories as they are first being learned. If someone's hippocampus is not working properly, their semantic and procedural memory will be largely unaffected, but they will have difficulty forming episodic memories for new events. Interestingly, memories for events that took place when the hippocampus was healthy would likely still be remembered because older memories become less reliant on the hippocampus with time. If you want to learn more about a famous patient who helped us learn about the role of the hippocampus in memory, check out this Frontiers for Young Minds article.

HIPPOCAMPUS

A seahorse-shaped brain region that is important for supporting episodic memory.

Forgetting is not necessarily a bad thing though—as you were thinking back on your life events a moment ago, you likely experienced some forgetting yourself. For example, do you remember what shirt you were wearing in your memory of learning something interesting at school? Forgetting is a completely normal process that is actually useful because people do not need to hold onto every single piece of information that they encounter. However, as

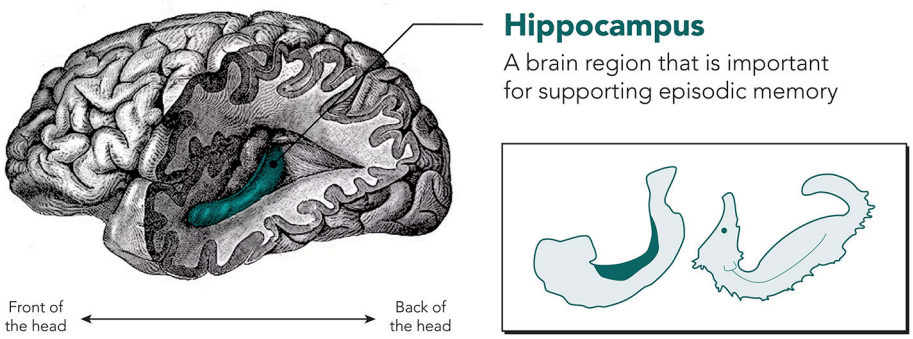

Figure 1

Figure 1

This is a side view of the brain with the hippocampus in teal. In the box, you can see an outline of the hippocampus compared to one of a seahorse—the name hippocampus comes from the Greek word for seahorse because of their similar shape. Brain image adapted from Gray's Anatomy of the Human Body (1918).

people age into older adulthood, they may notice that their episodic memory starts to decline, making it more difficult to relive past events. This is because, after approximately age 65, the hippocampus tends to dramatically decrease in size. Episodic memory problems can be especially severe for those with conditions that affect the hippocampus, including **dementias** like Alzheimer's disease. Given the importance that episodic memories hold in people's lives, losing the ability to remember past events can make people lose confidence in themselves, isolate from others, and experience depression.

DEMENTIA

A term describing decline of cognitive function, including memory, language, and decision-making, that is severe enough to affect daily living. This results from diseases affecting the brain, like Alzheimer's disease.

HOW CAN PEOPLE PRESERVE THEIR MEMORIES?

The good news is that people can take steps to protect against memory loss. It is estimated that over 40% of dementias could be prevented or delayed by lifestyle changes, such as increasing exercise, improving diet, and reducing smoking and alcohol consumption [2]. Additionally, keeping engaged with new activities can improve memory and promote healthy aging.

Moreover, people can use technologies to better remember the activities they participate in. In fact, one powerful piece of technology can be found in many people's pockets or bags—a smartphone! Smartphones can perform a wide variety of functions that can benefit memory, including keeping in contact with others, setting reminders, and making information available. One feature that people commonly use to help preserve their memories of specific events is the camera. You have probably taken a picture or video of an event that you wanted to commemorate, and with smartphones being so commonplace, many people can easily do so.

PHOTO-TAKING-IMPAIRMENT EFFECT

A phenomenon in which people show poorer memory for information that they photograph compared to information that they do not photograph.

However, research suggests that people may need to be careful, because taking photos can actually impair memory. This is called the **photo-taking-impairment effect**, where information that is photographed is remembered more poorly than information that is not [3]. What might explain this? It could be that people pay less attention to the event itself because they are too concentrated on taking a good

photo. They might also feel less motivated to focus on an event in great detail because they know they have a photo to jog their memory later—however, as we take and collect more and more photographs, it becomes harder to find a specific photo to cue a given memory.

Fortunately, using smartphones to take photos or videos of an event does not necessarily need to impair memory. For decades, scientists have been studying different strategies that people can use to improve memory. By taking what scientists know about how people best remember, scientists can actually use photos or videos to *benefit* memory.

LEVEL OF PROCESSING

A term describing the amount of effort and engagement people put into remembering something—people are more likely to remember information when they use deep vs. shallow levels of processing.

For example, one important aspect to keep in mind when first trying to remember something is the **level of processing**, which describes how much effort and engagement a person puts into remembering. This can range from shallow to deep, and people are better able to remember information if they engage with it using deeper levels of processing. As you are reading this article, let us say that you want to remember that episodic memory allows people to remember specific personal events. If you are engaging with the material at a deep level, you will focus on how what you learn relates to other things you know, such as how episodic memory compares to other types of memory. If you are engaging with the material on a shallow level, you might focus on more superficial aspects, such as the shapes or sounds of the letters in the words "episodic memory". Although it often takes more time and effort to engage in deep levels of processing, it is an effective strategy to boost memory.

MASSED PRACTICE

A learning strategy in which people review information in a single, long study session, like cramming for a test.

DISTRIBUTED PRACTICE

A learning strategy in which people review information in multiple, short study sessions over time. This is more effective for long-term retention than massed practice.

Additionally, when people need to study material, the way they study can impact memory of what they learn. To understand this, let us pretend that you have a big test in a week, for which you must remember a lot of information. One way you might study is by trying to cram—to review everything you need to know for the test on the day before. This is referred to as **massed practice**, in which you review a lot of information in a single study session. On the other hand, you could break up what you need to know and study smaller amounts every day in the week leading up to the test. This is referred to as **distributed practice**, in which you review information in multiple study sessions spaced out over time. Massed practice might be sufficient if you only need the information for a short period of time, but distributed practice helps you retain information for much longer.

COMBINING SMARTPHONE TECHNOLOGY AND MEMORY SCIENCE

Our research group developed a smartphone application called HippoCamera (Figure 2) to help overcome the photo-taking-impairment effect. With HippoCamera, users record and review cues for life events using key strategies and best practices from memory science [4]. This

makes it different from simply using a smartphone to capture photos and videos in the typical way. When a user has an event that they wish to remember, they stop to capture a video snippet and an audio description of the event. This multistep process makes users stop to think about the event and why it is important. In this way, HippoCamera forces a deep level of processing and makes people pay more attention to the events of their lives.

Figure 2

(A) HippoCamera guides users to record a video snippet and an audio description of an event they wish to remember. **(B)** HippoCamera then combines these into a powerful cue, which can be replayed using effective learning strategies. **(C)** Our experiments showed that participants recalled over 50% more details for events that were recorded and reviewed using HippoCamera. This was accompanied by changes in how memories were stored in the hippocampus. In the figures, Early Test refers to memory during or immediately after using HippoCamera, while Delayed Test refers to memory 3 months after participants stopped using the app.

To create a memory cue, HippoCamera combines the audio description and a sped-up version of the video, providing a lot of distinctive information about the recorded event. This helps people to mentally travel back in time to re-experience it. HippoCamera puts

together replay sessions that show up to five memory cues, and users can review these in their free time. Each cue is played in multiple replay sessions that are spaced out over time, meaning that HippoCamera uses the principle of distributed practice to preserve these memories for the long term. Altogether, recording and replaying events with HippoCamera can be done in a few minutes each day.

In two experiments, we had older adults use HippoCamera for either 2 or 10 weeks, to record and replay events from their daily lives. Later, when we asked them to describe these events, we found that participants were able to recall over 50% more details for events that were recorded and reviewed using HippoCamera. These memory benefits were seen even 3 months after users stopped using the app. By using functional magnetic resonance imaging to measure brain activity, we also found that reviewing memory cues with HippoCamera changed the way that participants' memories of those events were stored in the brain. Specifically, we found enhanced activity in the hippocampus, with memories being made more distinct from one another. This means that memories were less likely to be confused with one another, making them easier to recall in great detail. Our work provides an example of how new tools can be created that combine scientific research and technology to help people improve their memories.

SUMMING IT ALL UP

Memories make people who they are, so creating solutions to improve memory can significantly benefit the lives of those affected by memory loss. One way to create easy-to-use, effective, and inexpensive tools that support memory is by using the technologies that people interact with daily, like smartphones. By combining the current scientific understanding of memory with modern technology, researchers can create new and exciting innovations that complement how the memory system works, helping people to better re-experience the moments that make their lives meaningful.

ACKNOWLEDGMENTS

This work was supported by Project Grants from the Canadian Institutes for Health Research to MB (PJT-173336 and PJT-126003), a Scholar Award from the James S. McDonnell Foundation to MB, a Connaught Innovation Award to MB, a Centre for Aging & Brain Health Innovation (CABHI) Researcher Clinician Partnership Program Grant to MB, and an AGE-WELL AgeTech Implementation Response Program Grant (AWAIR-2022-01) to MB. MB was supported by a Canada Research Chair and a Max and Gianna Glassman Chair in Neuropsychology. BH was supported by a Postdoctoral Award in

Technology and Aging and an Early Professionals, Inspired Careers in AgeTech Fellowship from AGE-WELL.

ORIGINAL SOURCE ARTICLE

Martin, C. B., Hong, B., Newsome, R. N., Savel, K., Meade, M. E., Xia, A., et al. 2022. A smartphone intervention that enhances real-world memory and promotes differentiation of hippocampal activity in older adults. *Proc. Natl. Acad. Sci. U. S. A.* 119, e2214285119. doi: 10.1073/pnas.2214285119

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SUBMITTED: 14 February 2023; **ACCEPTED:** 13 October 2023;
PUBLISHED ONLINE: 30 October 2023.

EDITOR: Theodore Zanto, University of California, San Francisco, United States

SCIENCE MENTORS: Jill Crittenden and U. Kirthana Kunikullaya

CITATION: Hong B and Barense MD (2023) Memory Loss and Aging: How Can We Use Smartphones to Better Remember? Front. Young Minds 11:1166183. doi: 10.3389/frym.2023.1166183

CONFLICT OF INTEREST: BH and MB own shares in Dynamic Memory Solutions Inc., a company focused on developing digital tools to improve memory. The University of Toronto holds the ownership rights to the HippoCamera technology used to conduct the research described herein, but has given Dynamic Memory Solutions the rights to commercialize. The authors also have a patent to disclose, Patent No.: 11,397,774. No person, nor organization received any financial remuneration for the use of the HippoCamera application in the studies described here. At the time of publication, this is a research-dedicated application that we will make available to other memory scientists at no charge.

YOUNG REVIEWERS

ANNIE, AGE: 13

I am a 7th-grade student who loves learning about new things! I love learning about new opportunities. In my free time I love to make things for others, whether out of paper or clay, I love to make others happy. While in school my favorite subjects are math and science because I am fascinated by what I do not know and I feel I learn so much in those classes and I hope to learn more through Frontiers for Young Minds!

APARNA, AGE: 10

Aparna is an intelligent child, with an inquisitive mind. She loves to pursue medicine in future. During her free time she enjoys playing with her friends. She currently lives with her parents in India.

CARINA, AGE: 12

I have many interests including soccer, music, reading, math, and science. I find science very fascinating, especially biology. My dream is to work in medicine. I am very interested in how our bodies work well and malfunction; I want to help people in the future achieve their best health. I am quite intrigued about how technology will improve our abilities to detect illness earlier and track how well therapies are working.

CHAITRA, AGE: 8

Chaitra is a 8 year old girl. She is interested to watch experiments in science and visiting museums. She loves art, and dance. During her free time she enjoys reading Novels. She currently lives with her parents in India.

ELIZABETH, AGE: 13

I am a 7th grader and science and math are two of my favorite subjects. I hope to someday become an architect or engineer. Outside of this, I enjoy reading and art as well as true crime podcasts.

ISAAC, AGE: 12

I am a 7th grader. I enjoy doing math, playing and composing on the piano, and performing in musicals. I also like to code using Python, and to read. Recently, I played Pinocchio in my school's production of Shrek. Right now, chances are that I

am eating, sleeping, or at school. I enjoyed reviewing this article and am very happy with how it was changed in response to our reviews.

KALLIE, AGE: 13

I am a 7th grader. I enjoy playing lacrosse on my team! I enjoy learning about neuroscience and I am interested in iPS cells. I participate in debate workshops. Some of my other hobbies are painting, reading, using Pinterest, and creating digital art! I am fascinated by butterflies, and all cats big and small. I am a member of my school's student council and school council. I love writing poetry and even won an award for one of my poems.

AUTHORS

BRYAN HONG

I am a postdoctoral fellow at the University of Toronto interested in studying how and what we remember. I want to translate our current understanding of memory to create tools that improve the lives of those affected by memory loss. Outside of the lab, you can find me reading a book, checking out a new band, or collecting old vinyl records. *bryan.hong@mail.utoronto.ca

MORGAN D. BARENSE

I am a professor at the University of Toronto. I want to understand how our brains allow us to create memories. I believe that if we can better understand how the brain works, we will be able to better treat people who have brain diseases, like Alzheimer's disease. I love discovering new things and figuring out how complicated processes fit together, which means I am very happy being a scientist!