NEUROSCIENCE AND PSYCHOLOGY
Published: 26 January 2024
doi: 10.3389/frym.2024.1147170

HOW GAMES HELP US RESEARCH AGE-RELATED MEMORY CHANGES

Charlotte Ashton and Fiona McNab**

Department of Psychology, University of York, York, United Kingdom

YOUNG REVIEWERS:

FAIRVIEW INTERNATIONAL SCHOOL—BOFA
AGE: 14

GABRIEL
AGE: 10

Working memory is the ability to hold information in our minds for a short time, often while we work on it. We need it for schoolwork, solving problems, and many aspects of life. Some people can hold more information in mind than others, and as we get older the amount we can hold tends to decline. If we understand what limits working memory and how working memory changes with age, we can figure out ways to improve it. A person's ability to focus on relevant information and ignore distraction seems to be important. Our research group looked at how well people can ignore different types of distraction, which might limit their working memory. To sample a large number of people with a range of abilities, we used a game played by 29,631 people. The results gave us clues about how our ability to ignore distraction affects our working memory, and we identified a specific type of distraction that seems to particularly affect working memory in older adults.

WORKING MEMORY AND OUR ABILITY TO IGNORE DISTRACTION

In our daily lives, we constantly need to hold information in our minds for a very short time (seconds). We must keep instructions in mind while we follow them. When reading or listening to someone talk, we must hold the first part of a sentence in mind while we process the rest of it. When solving problems or making decisions, we must keep in mind all the relevant pieces of information while we work on them. This type of memory is known as **working memory**. Some people can hold more information in working memory than others. People also seem to be able to hold less information in working memory as they get older [1], which can affect quality of life and independence in older age. With our research, we are trying to understand why working memory is limited, why it varies between people, and why it tends to decline as people get older.

WORKING MEMORY

The ability to hold information in mind for a short period of time.

Research suggests that our ability to focus on relevant information and ignore **distractors** is a limiting factor, stopping us from holding more information in mind. There is good evidence for this. Researchers showed people pictures of colored shapes and asked them to hold some of the shapes in working memory but to ignore others [2]. By measuring their brain signals using a technique called **electroencephalography (EEG)**, researchers estimated how many colored squares each person was holding in mind. They found that people who have a good working memory and could hold a large amount of information in mind only held the colored shapes in mind that they were asked to remember. In contrast, those with poorer working memory seemed to hold in mind more colored shapes than they needed to, suggesting they were failing to ignore the shapes they did not need to remember. The researchers suggested that our ability to hold only relevant information in working memory, while keeping other information out, might be what limits working memory.

DISTRACTORS

Stimuli or information that is not relevant to the task a person is completing and should be ignored.

ELECTROENCEPHALOGRAPHY (EEG)

A way of recording the brain's electrical activity.

CONTRADICTORY RESULTS

Using a brain scanner, it is possible to measure how blood flows in the brain, and to see how different parts of the brain become active when we are doing certain things. We used this type of brain scanning, known as **functional magnetic resonance imaging (fMRI)**, to measure brain activity while people were doing a working memory task [3]. We identified a region of the brain that seemed to be involved in keeping distractors out of working memory [4]. This brain region might act as a gatekeeper, letting some information into memory and stopping other information from getting into memory. Although this was an exciting finding, it did not seem to fit with some other research. For example, patients with **Parkinson's disease** (a disease that affects movement and also memory) have less of the brain chemical **dopamine** in this same brain region. If this brain region was

FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI):

A way of recording changes in blood-flow associated with brain activity.

PARKINSON'S DISEASE

A condition that affects the brain and is associated with a reduction in the brain chemical dopamine.

DOPAMINE

A brain chemical associated with memory.

indeed the gatekeeper, we would expect Parkinson's patients to be *less able* to ignore distractors compared to non-patients. However, research showed that they seemed to be *better able* to ignore distractors than non-patients [5].

Looking closely at the different experiments, we found there was a small difference in *when* the distracting images were shown. In our study, the distractors appeared *at the same time* as the information the volunteers were asked to hold in mind. This would be like hearing a dog bark just as you are trying to put a phone number into your working memory, before you enter it into the phone. In the Parkinson's disease study, the patients were first shown the images they were asked to put in mind, and then, *while* they were holding those images in mind, the distractors appeared. This would be like hearing the dog bark when you have already put the phone number in your working memory, and you are just about to enter it. We needed to find out whether this difference in timing of the distractors could explain the differing findings. Could it be that the brain deals with these two types of distractors in different ways? If there are separate brain mechanisms for ignoring these two types of distractors, how are they affected by aging and do they each limit working memory?

THE SMARTPHONE GAME

To investigate this possibility we needed to measure how well different people can ignore each type of distraction, to understand how these abilities might limit the amount of information a person can hold in mind. A large number of volunteers were needed, of different ages and with a wide range of abilities. The standard approach of inviting people to the laboratory is time consuming and expensive, so instead we used a smartphone game. We asked people to remember the positions of red circles and ignore yellow circles, which could appear *with* the red circles or *after* the red circles (Figure 1). As participants played the game, the number of red circles increased, making the game more challenging (and exciting!), until they eventually could not hold any more red circles in mind, and we had found the limit of their working memory. From this information we could estimate how well participants could ignore the two types of distraction. With this approach, we collected data from 29,631 people aged 18–69.

As we expected, performance was affected by the distractors, as players could hold fewer red circles in mind when yellow circles were present. Older people seemed to be particularly affected by the distractors, which we also predicted. However, the new finding was a striking difference between the two types of distraction. Although older adults were affected by the yellow circles shown at the same time as the red circles, they were *much more affected* by the yellow circles presented *after the red circles*, when the red circles were already in working memory (Figure 2). This suggests that there are

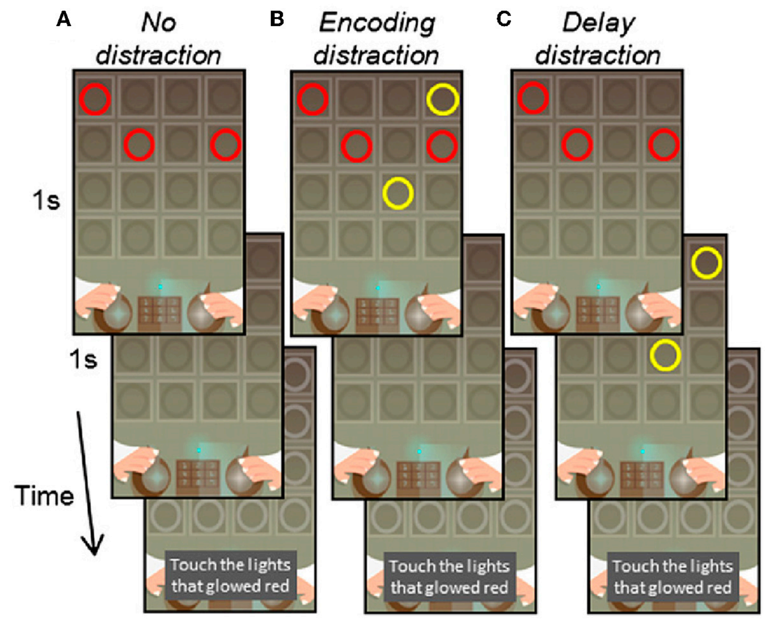

Figure 1

Figure 1

The smartphone game. Red circles were shown for 1 s and then disappeared. After a 1-s delay, the player was asked to tap where the red circles had been. **(A)** Sometimes only red circles were shown. Other times, yellow circles (distractors) appeared. The yellow circles could appear **(B)** at the same time as the red circles, or **(C)** during the 1-s delay before the players were asked to tap their response. This allowed us to estimate how many red circles the player could remember and how much their performance was affected by the two different types of distraction.

indeed separate mechanisms involved in ignoring the two types of distraction, and that age affects these mechanisms differently.

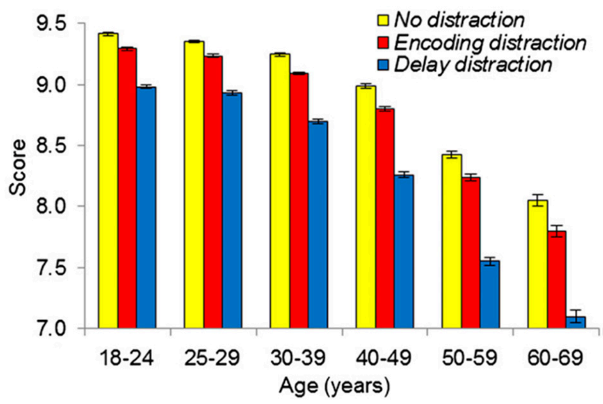

Figure 2

Figure 2

The average maximum number of red circles the players could remember is shown for each condition: no distractors, when the player was only shown red circles; encoding distractors, when the yellow circles appeared while the player was encoding the red circles into working memory; and delay distractors, when the yellow circles appeared during the delay before the player was asked to make their response. For each condition, performance declines as age increases, but there is more rapid decline for the delay distraction condition compared to the other two conditions.

AN AGE-RELATED CHANGE IN THE WAY INFORMATION IN HELD IN MIND

As we had so many people in our study, we could also explore other patterns in the data. We found that we could predict how much information a person could hold in mind by looking at the person's ability to ignore each type of distraction. However, as people got older, the relationship between these abilities changed. For older people, the ability to ignore distractors shown at the same time as the information to remember seemed to be much more important in predicting their working memory, and to have a greater limiting effect on their working memory. This suggests that, as we get older, we adapt how we hold information in working memory and rely more on mechanisms involved in ignoring distraction that occurs together with the relevant information.

There is a lot we still need to find out, but this work showed us that people seem to use separate mechanisms to ignore different types of distractors and, as we get older, these mechanisms limit working memory in different ways. It seems that aging does not just involve a decline in working memory, but a change in the way different brain mechanisms work to shape working memory. A simple working memory game made this discovery possible!

ACKNOWLEDGMENTS

This work was supported by a Wellcome Trust Research Career Development Fellowship (091826/Z/10/Z) held by FN. CA held a University of York PhD studentship.

ORIGINAL SOURCE ARTICLE

McNab, F., Zeidman, P., Rutledge, R. B., Smittenaar, P., Brown, H. R., Adams, R. A., et al. 2015. Age-related changes in working memory and the ability to ignore distraction. *Proc Natl. Acad. Sci. USA*. 112:6515–8. doi: 10.1073/pnas.1504162112

REFERENCES

1. Craik, F. I., and Salthouse, T. A. (eds.). 2000. *The Handbook of Aging and Cognition*. Mahwah, NJ: Erlbaum.
2. Vogel, E. K., and Machizawa, M. G. 2004. Neural activity predicts individual differences in visual working memory capacity. *Nature* 428:748–51. doi: 10.1038/nature02447
3. McNab, F., and Klingberg, T. 2008. Prefrontal cortex and basal ganglia control access to working memory. *Nat. Neurosci.* 11:103–7. doi: 10.1038/nn2024
4. Awh, E., and Vogel, E. K. 2008. The bouncer in the brain. *Nat. Neurosci.* 11:5–6. doi: 10.1038/nn0108-5
5. Cools, R., Miyakawa, A., Sheridan, M., and D'Esposito, M. 2010. Enhanced frontal function in Parkinson's disease. *Brain* 133:225–33. doi: 10.1093/brain/awp301

SUBMITTED: 18 January 2023; **ACCEPTED:** 10 January 2024;
PUBLISHED ONLINE: 26 January 2024.

EDITOR: Kevin T. Jones, University of California, San Francisco, United States

SCIENCE MENTORS: Susan M. Landau and Pascale Engel de Abreu

CITATION: Ashton C and McNab F (2024) How Games Help Us Research Age-Related Memory Changes. Front. Young Minds 12:1147170. doi: 10.3389/frym.2024.1147170

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

FAIRVIEW INTERNATIONAL SCHOOL—BOfA, AGE: 14
We are a group of year 10 students studying in Fairview BofA, who share common interests in neuroscience and psychology

GABRIEL, AGE: 10
Gabriel is in fifth grade. He is a swimmer and ultimate Frisbee player. He is interested in computers and science, and wants to help stop climate change and make the world more clean.

AUTHORS

CHARLOTTE ASHTON
Charlotte earned her Ph.D. at the University of York, receiving a studentship from the University to research working memory and the ability to ignore distractions. Her work included behavioral, fMRI, and EEG studies. She now works as an analyst outside of academia.

FIONA MCNAB
Fiona is a lecturer in the Psychology Department at the University of York. She began researching working memory as a postdoc at the Karolinksa Institute in Stockholm. At the Wellcome Trust Centre for Neuroimaging, UCL, with a Wellcome Trust Career Development Fellowship, she designed the working memory game in the large-scale smartphone study "*The Great Brain Experiment*," leading to studies of different types of distraction in younger adults as well as in healthy aging. Her current work includes fMRI and behavioral studies of working memory and attention from adolescence to older age. *fiona.mcnab@york.ac.uk