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HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES

The Influence of Brain Training Video Games on The Working Memory of the Human Brain

Elfi Kühndorf | Semester 8 | Summer Term 2020

+animation game
B.A. ANIMATION AND GAME
AG.MEDIENCAMPUS.H-DA.DE
M.A. ANIMATION AND GAME DIRECTION
AGD.MEDIENCAMPUS.H-DA.DE

Abstract
While brain training games are developed to increase cognitive abilities, different researchers are skeptical if they truly fulfill their goal. For the research paper behind this poster, different studies are compared to find a consensus of the actual effects of brain training games on the working memory (WM). One part of the paper is the discussion of the "Brain Age" game series from Dr. Kawashima, whose goal it is to increase processing speed and capacity of the working memory.

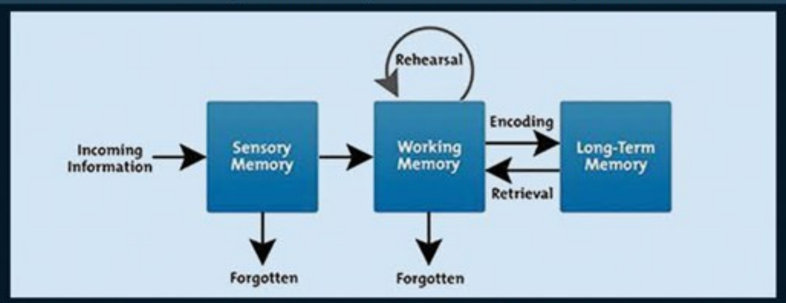
The human brain is the center of the memory. It consists of neurons, which transmit, and process the information they receive from our senses. For the analysis of information, the cooperation between different parts of the human brain plays an important role. One such part is the hippocampus, a part of the human brain that is important for the transfer of short-term memories into the long-term memory and for WM processes.

Furthermore, the human brain possesses neuroplasticity. This means the brain is versatile - it can change through experiences. Depending on the experience, pre-existing brain structures can be strengthened. Are brain training games like the "Brain Age" game series able to strengthen brain structures, responsible for the working memory (WM) of a person, and like that able to increase cognitive abilities? For answering this research question, scientific knowledge, about which promising approaches there are for training the WM will be compared with the claims and actual results of Dr. Kawashima's "Brain Age" game series.
Over twenty studies of the current century from researchers with more than five years of expertise within the field of neuroscience were compared to answer the research question.

The Memory

Seen in a scientific way our memory is the ability to save sensations or psychic processes within the brain, so that they can enter the consciousness once they are needed. Human memory is a complex brain wide process [1]. Different parts of the brain work together to create the system of recollections from our memory. What we perceive as a single memory is in reality the complex construction of different sensations. The name, the shape, the function, and the sound of an object, all this information comes from different parts of our body. Mainly the memory works through three different phases: encoding, storage and retrieval [1, 2].

Key parts of the memory are the sensory memory, working memory and the long-term memory. The sensory memory describes the immediate, initial record of sensations. It can only hold information for some milliseconds. Most sensations, which we experience from our surroundings, are filtered out [2]. Otherwise, we would experience an information overload. Only few stimuli pass into the WM, also called short-term memory, which is an essential transition from information into the long-term memory. The WM is critical for learning, reasoning and comprehension [3]. Theories assume that complex reasoning and learning tasks require a mental workspace to hold and manipulate information. Not all the information it keeps will transfer into the long-term memory. A part of it will fade away after some seconds. The long-term memory allows remembering distant recollections.

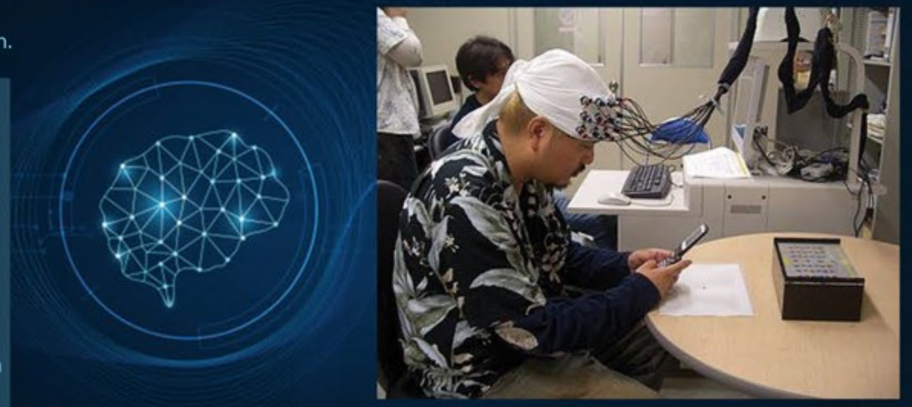


Improving the Memory

Connections between brain cells are changing every day. The physical structure of the brain rewires with every new experience. Older people often lose their cognitive abilities due to the lack of use of their brain. Rewards and challenges can train the brain and keep it fit. So does physical training and mental exercises like brain training games. Stimulating the brain can stop cells from shrinking and even increase them in some cases. Nutrition and lifestyle choices are also important factors for the functionality of the brain [4].

Brain Training Games

Brain training games are activities based on a set of rules and challenges that aim to strengthen the brain within specific disciplines that may be the intelligence, the memory or the cognition. They strengthen the brain through playful and engaging activities. The effect of brain training games is controversial. Some researchers argue that cognitive improvements after playing brain training games are merely a placebo effect. Any new experience will produce changes in the neural system, but there is little proof that playing brain training games strengthens underlying broad cognitive abilities. However, they can inspire additional research regarding cognitive abilities. One reason that some results are not credible is that control groups are not given a placebo and like that do not prepare for cognitive tests. It is also not clear if improvements within brain training tasks transfer to real-world tasks [5].



Dr. Kawashima's Game Series

The "Dr. Kawashima Brain Age" game series is a series of video games specifically designed to train cognitive abilities. The game is based on the research and publications of the Japanese neuroscientist Dr. Ryūta Kawashima who also appears as a character and mentor within the series. This game series from the "Edutainment" section of the games industry has the goal to keep the brain fit through exercising various tasks on a daily basis.

The series had its first appearance in 2006 with "Dr. Kawashima's Brain Training: How Old Is Your Brain?" for Nintendo DS. With 19.01 million purchases the game was a huge commercial success. It was one of the most successful games for the Nintendo DS [6]. The first title of the series aims to increase the processing speed of the working memory through core training, a type of training that typically involves repetition of demanding WM tasks that are designed to target domain-general WM mechanisms. Kawashima claimed that the game increased capacities of the prefrontal areas in both left and right lobes and levels of creativity [7].

Results

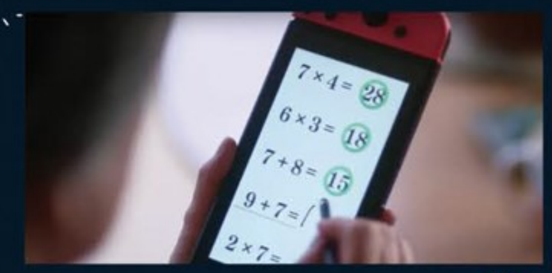
In 2014, a declaration from over seventy neuroscientists [5] stated that there is no compelling evidence that brain training games improve cognitive abilities. The claims of companies who sell brain training software are frequently exaggerated and often misleading. With their own open letter, 133 scientists and therapists countered [8], how mounting evidence shows that certain brain training can improve cognitive functions including in ways, which can be useful for everyday life. Different standards while evaluating the results may be one reason for the disagreements. [9].

There is concrete evidence that brain training games better the proficiency on trained tasks and very similar tasks (near transfer), but sparse evidence that training enhances performance on distantly related tasks or improvement on cognitive performance in the daily life (far transfer) [9].

Core training can lead to improvements in a variety of areas of cognition like cognitive control or reading comprehension. Congruent with neuroimaging studies, activation changes in regions associated with domain-general cognitive performance are demonstrated.

An increasing number of literature shows that the capacity of the WM can be expanded. By focusing on the strengthening of domain-general WM processes, core training seeks to produce increased WM capacity [10]. Thus, core training may represent a favorable approach to achieve broad cognitive improvement.

Researchers argue that studies show how PS training can improve performance of non-trained PS tasks in the elderly [11].
A study of Kawashima states that the effect of brain aging could be undone. The test group of Kawashima experienced an increase after training. The control group, which did not receive any learning therapy, experienced a slight decrease in their scores. [12]



Conclusion

Brain training can serve as cognitive stimulation, which can help to maintain cognitive abilities if otherwise a person is not challenging their mind on a daily basis. An optimal design guideline for brain training games does not yet exist. Far transfer of taught skills is less likely, though it is more desirable for that it increases the chance to use achieved skills in daily life.

Further methodical research is needed to clarify, strengthen, and expand knowledge about the influence of brain training games on the WM. It is important that researchers try to minimize the error-proneness of their studies with elaborated strategies (e.g. having active-control groups with suitable training replacements to equalize placebo effects between different study participants).
Research shows that brain training games can improve aspects of the WM, but how far these improvements go are strongly discussed. In addition, the long-term effect of these games varies depending on the age of the user and the kind of brain training used.

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