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CAN BRAIN TRAINING TRAIN YOUR BRAIN? USING THE SCIENTIFIC METHOD TO GET THE ANSWER

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Brain-training games are becoming more and more popular. Brain-training games are supposed to help people become better at thinking, remembering, and paying attention. The companies that make these games say their games will help with day-to-day activities, such as school. But do we know whether these games actually work? In this article, we talk about the scientific method and discuss important terms such as sample size, control groups, random assignment, and double-blind studies. Using these terms, we then discuss whether there is good evidence that brain-training games work. We conclude that more research using the scientific method is needed before we can say that brain-training games help you in school.

Sofia really likes to play video games and hears that brain-training games are a fun way to get smarter. She plays one of these brain-training games – a memory game – for a few minutes every day for one week. Sofia tells you that she thinks her memory has gotten better and that she remembers things she learns in school *more easily. From what Sofia has told you, do you have enough information to know the brain-training game works?*

WHAT IS BRAIN TRAINING?

The goal of brain-training games is to help people get better at various ways of thinking. The goal of some games is to make you better at remembering things, the goal of others is to help you get better at paying attention longer. Companies that sell brain-training games say that playing their games make people do better at school, work, or even sports [1]. However, scientists disagree about whether these games work, and whether brain-training games can actually help you be a better thinker in everyday situations, such as in school [2].

USING THE SCIENTIFIC METHOD TO DISCOVER WHETHER BRAIN-TRAINING GAMES WORK

Remember how Sofia said that playing a memory brain-training game helped her improve her memory? Did she have enough information to *know* the game worked? When researchers want to know whether a brain-training game works, they follow the **scientific method**. The scientific method has rules about how these kinds of studies should be designed, so that information we learn during the study gives us an accurate answer as to whether brain-training games actually help people to get better at something. First, we will talk about four of the most important parts of the scientific method: sample size, the **control group**, random assignment, and double-blind designs (Figure 1). Then, we will use what we know about the scientific method to decide whether there is enough evidence to show whether brain-training games help people.

SCIENTIFIC METHOD

Rules for researchers to carefully design and then carry out a study so that they can learn information.

CONTROL GROUP

The group that does not receive the training being studied. They may do a different activity.

LARGE SAMPLE SIZE

Sofia told us about her own experience with the memory game (Figure 1A). However, not everyone is the same, and we cannot be sure the game will work for someone else. Therefore, it is important to test the game with a large group of people. This is called using a large sample size. A sample is the scientific word for the group included in the study—because it is a sample of the population. Although we cannot ask every person in the world to take part in the study, using a large sample size helps us make sure that the results we find are true for more than just one person. If our sample is large enough it will be a good example of the whole population. If the brain-training game helps many people in the group to get better at remembering, we can be more sure the game will work for people in general. Also, using a large sample size means that any result that we find is more likely to be a real, true result; if the study

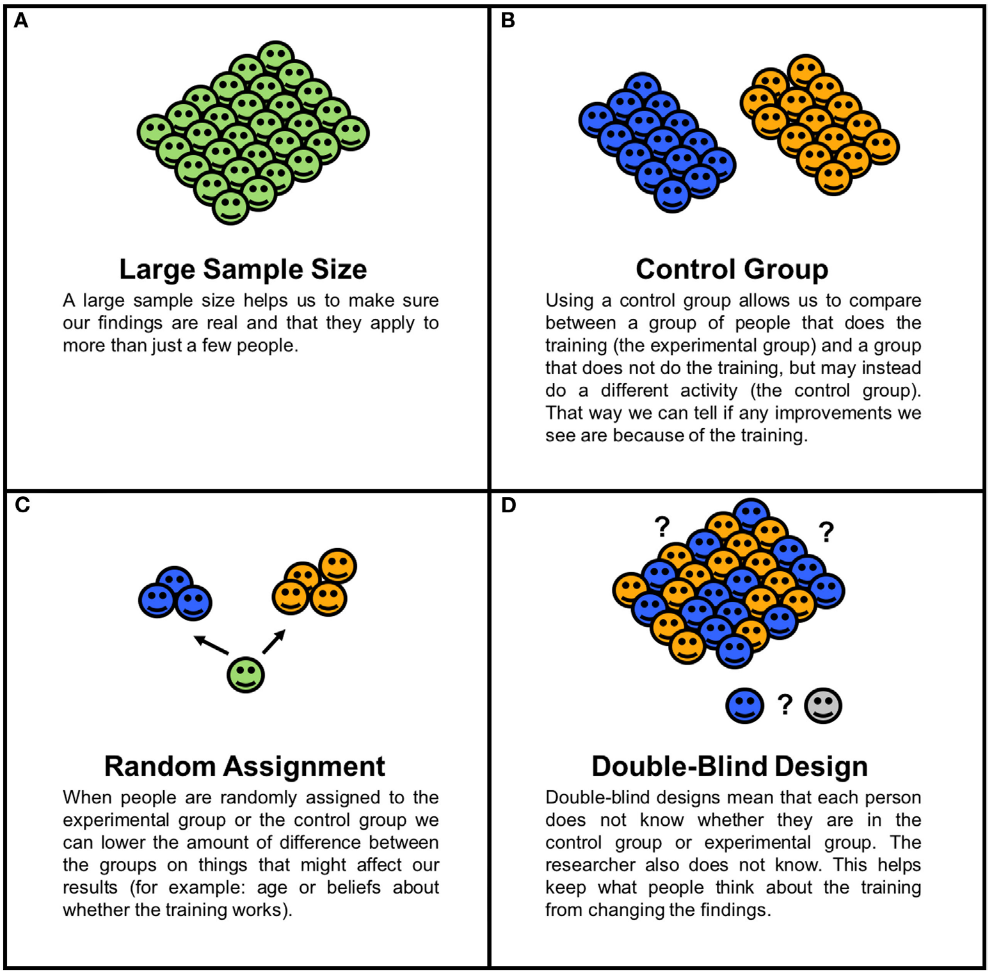

FIGURE 1

FIGURE 1

Researchers use the scientific method to design studies that test whether or not a brain-training game works.Large sample size **A.** a control group **B.** random assignment **C.** and double-blind design **D.** are four key parts of the scientific method.

is only done with one person, it could just be a coincidence that the training worked for them.

CONTROL GROUP

Sofia said she remembered things better after using the game (Figure 1B). What if her memory got better because of *something else* she was doing at the same time? For example, what if she was also practicing something in school, or what if playing the game just made her more interested in learning? Maybe her memory did not improve because of the brain training at all. Even if a large sample size is used and most people who play the game improve, we still do not have proof that brain training is the thing that improved memory and not something else. This is the reason having a control group is very important. A control group is another group that does not play the brain-training game but might play a different game instead. We call the group that does the actual training the **experimental group**.

EXPERIMENTAL GROUP

The group that receives the training. This group is compared with the control group to see if training led to improvement.

To measure whether brain training improves memory, researchers give the people in the study a test of memory before the brain training and after they finish the training. This test is called an **outcome measure**. Researchers check whether people do better on the outcome measure after training compared with how they did before the training. To show that the brain training works, it is important that the experimental group does even better at the end of the study than the control group (Figure 2). If the experimental group does better on the outcome measure after training and improves more than the control group (Figure 2B), we can be more sure that the improvement in memory is because of the brain training.

OUTCOME MEASURE

A tool used by researchers to measure whether training improved what it is supposed to improve.

RANDOM ASSIGNMENT

By now, you can see that Sofia was missing key parts of the scientific method when she said brain training helped her memory (Figure 1C). All training studies should have experimental and control groups, and they should use large sample sizes for each group. What if Sofia and all students in her grade were put in the experimental group, while all students in the grade below were put in the control group? If we then found the experimental group had better memory than the control group, there could be a few reasons for this. Maybe, since students in the experimental group were older, they were better at the memory game, and it had nothing to do with the brain training. This shows why it is important to randomly assign people to the experimental and control groups. In random assignment, each person is as likely to be put in the experimental group as the control group. For example, researchers might flip a coin to decide whether a person is put in the control group or the experimental group. With a large sample size, this means that the characteristics (for example, the ages of the children) of the groups should be about equal [1]. If students in Sofia's grade and the grade below had been randomly assigned to the experimental or control group, the groups would have been similar in age overall. Therefore, if the experimental group does better, we have more evidence that the improvement is because of brain training, not because of another reason, such as age.

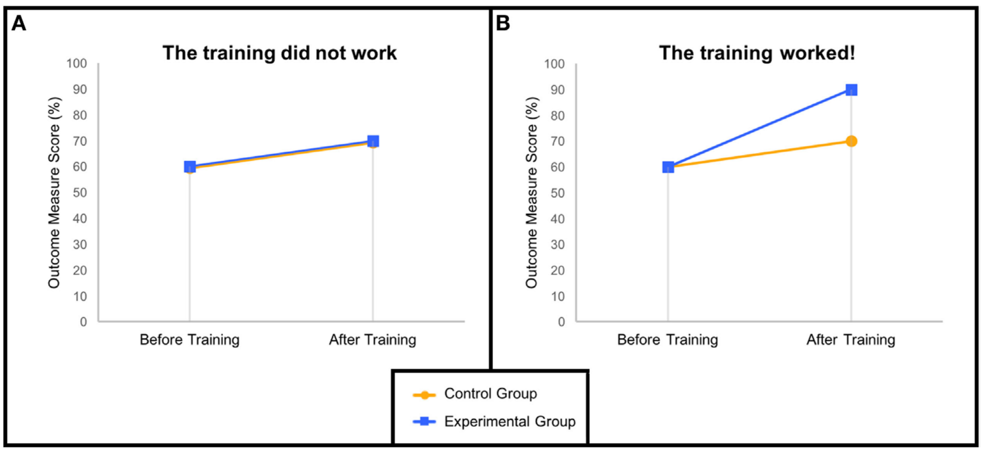

FIGURE 2

FIGURE 2

To test whether the training helped the experimental group, researchers measured both the control group (orange) and the experimental group (blue) using an outcome measure before the training.Then, after the experimental group trained on the brain-training game and the control group trained on a different game, the researcher measured both groups again, using the same outcome measure. For the training game that did not work **A.** the experimental group and control group both got better on the outcome measure after training (in other words, the experimental group did not do better than the control group). For the training game that worked **B.** the experimental group showed a higher score after training compared with before training, and a higher score than the control group. Therefore, the training task made the experimental group better at this outcome measure.

DOUBLE-BLIND DESIGN

Sofia thought her memory had gotten better, but this does not mean we know brain training worked. Sofia may have thought her memory improved because of something called a placebo effect. A placebo effect is when a person thinks that a treatment will work, and then after they try the treatment, they believe it has worked, even though it might not actually have been effective. In other words, their expectations may have led to the improvement in the outcome measure. Researchers use something called a double-blind study to help prevent placebo effects. In a double-blind study, none of the people in the study know whether they are in the experimental group or the control group (Figure 1D). They are "blind" to the group type. Also, the researcher measuring improvement does not know which group the people in the study are in. The double-blind design helps guard against the placebo effect.

DO WE HAVE ENOUGH EVIDENCE TO KNOW THAT BRAIN-TRAINING GAMES WORK?

Now that we have talked about the scientific method (Figure 1), we can look at how good the evidence for brain training is—was that evidence collected properly, using the important parts of the scientific method we have described? There are many goals of brain training, but as an example we will look at whether there is evidence to support the idea that brain training improves **working memory**.

WORKING MEMORY

The part of your memory that helps you hold information in your mind so that you can use it.

Working memory training aims to improve working memory and help children in school. Working memory is the ability to hold information in mind so you can use it [3]. For example, when playing a new game that your friend just explained to you, you need to remember the rules and use them on your turn. Some of the evidence that working memory training companies talk about comes from studies done with a group of kids who have attention deficit hyperactivity disorder (ADHD). Children with ADHD often find it very challenging to pay attention and keep still [4]. This study found that children with ADHD who did working memory training did better in things like working memory, problem solving, and paying attention [5]. However, other studies on the same brain-training games did not show the same good results [1]. Quite a few studies did not use a control group or had small sample sizes. The best improvements after practice with working memory games are seen on working memory games that are like the training games. For example, if you practiced a game where you got better at remembering the order that a grid of circles lights up in, you may also get better at the same game using a different set of objects.

In general, most studies on brain-training games are missing important parts of the scientific method. Many studies use small sample sizes, which we know means findings might not be true for a larger group, and they might not be real [1]. Some studies do not use control groups. Without a control group, we cannot know if people are getting better at something specifically because of the training. Even in the brain-training game studies that have a control group, many do not use a good control group. A good control group does an activity that is as similar as possible to the training the experimental group does, but without the part we think works [1]. A good control group does an activity that is as hard as the actual training, which takes the same amount of time and that is in the same format (also a computer game, for example). Often brain-training studies do not give the control group an activity, or the activity is very easy. Therefore, we cannot know that it was definitely the training that caused improvement—it could have been a placebo effect.

As we have discussed, outcome measures are needed in brain-training studies to measure improvement. However, oftentimes, researchers give many outcome measures and check to see which ones show that the experimental group improved. For example, to see if certain training improves working memory, a researcher may check five outcome measures of working memory and find only one measure that shows improvement. This is a problem if researchers then say their brain training improves working memory, because although this is true for one of the working memory outcome measures, there were four measures that did not show improvement.

Finally, before brain-training games should be recommended to people, it is important to be able to rely on the studies that have been done. A key part of research is replication—doing the same study again to see if you get the same results [6]. If several studies that use the scientific method find similar results, we can be pretty sure that their results are true. Unfortunately, many findings from brain-training games have not been replicated. In summary, studies for brain-training games often have small sample sizes, no control group or a control group that is not very good, many outcome measures, and no replication of their findings. Therefore, the evidence we have for the benefits of brain-training games so far is not very convincing. What does this mean for the claim that brain-training games help you in day-to-day activities, such as school?

BRAIN TRAINING AND TRANSFER OF SKILLS TO OTHER SITUATIONS

Can we say brain-training games help you in real life, beyond the games you practice? Imagine you practiced the guitar every day. You would expect to get better at guitar. Later, at your friend's house, you try playing the bass guitar and find that your guitar practicing has helped you also play the bass guitar. A lot of skills are the same between the two instruments. This is an example of what researchers call near-transfer. In near-transfer, training on one set of skills also leads to improvement in a similar skill (Figure 3A). Some brain-training

FIGURE 3

We can look at whether brain-training games help us to learn other tasks that are similar to the tasks learned in the game, or perhaps to learn tasks that different from those learned in the game. **A.** In near-transfer, what we are trained on helps us get better at something very similar. **B.** In far-transfer, what we are trained on helps us get better at something more different. Brain-training games say they can help with far-transfer, improving things such as your attention in school, but the evidence for this is not strong [1].

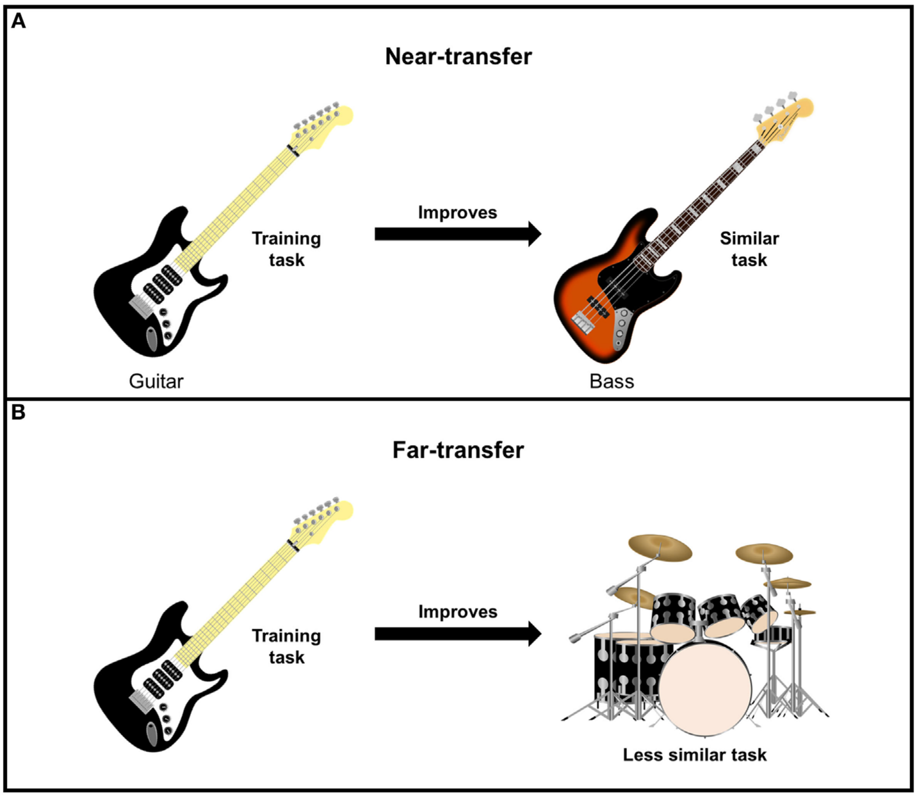

FIGURE 3

games have evidence for near-transfer. For example, training with working memory games has improved working memory measured by similar tasks. In other words, practicing working memory games has been shown to make people better at working memory games.

Would you expect that practicing the guitar would also help you be a better drummer? If it did help, that would be an example of far-transfer. In far-transfer, training on one skill leads to improvement in a less similar skill (Figure 3B). Overall, brain-training games do not have good evidence for far-transfer [1]. For example, working memory brain-training games do not tend to improve math or other real-world abilities. If you would like to read about how we learn math, here is an interesting article [7].

CONCLUSION

Brain-training companies often say their games can help you do better in school. However, research on these games often is missing important parts of the scientific method, such as large sample sizes, a good control group, and can have problems with placebo effects. Research showing that brain training works has often not been replicated. Currently, the evidence for brain training is not convincing. Some brain-training games show near-transfer, but there is little evidence for far-transfer. Brain-training games can be fun, but so far, we cannot say that they train your brain!

Studies of brain training have shown something that we experience everyday: practicing a task makes us good at that task but does not necessarily make us good at other tasks. And that is not a bad thing! Therefore, practice the things that you want to become better at, but do not expect there is something you can do to improve your performance on things you are not practicing.

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I was born in São Paulo, Brazil. I love my animals and my school. In my free time, I like playing handball and relaxing. My favorite classes are math and biology, because I love learning about nature and solving math problems.

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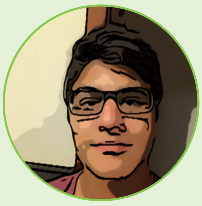

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