Brain training

Can we train the brain to overcome difficulties in working memory? With the right intervention, Tracy Packiam Alloway believes we can effectively boost learning outcomes

Working memory is our ability to remember and process information over a short period. The best way to think of it is as the brain's post-it note; we make mental scribbles of bits of information we need to remember and work with. For example, we use working memory to remember directions while driving, or someone's name and phone number. Without it, we would be literally lost; we wouldn't know how to get to that important meeting and would forget vital contacts. Working memory is critical for many activities at school, from complex subjects such as reading comprehension, mental arithmetic and word problems to simple tasks like copying from the board and navigating the corridors.

We have a limited space for processing information, and the size of various individuals' post-it notes can vary greatly. For example, a seven-year-old child who has working memory problems may have a post-it note the same size as an average four year old's. This student will probably find it difficult to keep up with what the teacher says, will struggle to remember instructions, and will mix up words. In contrast, another seven-year-old child may have a working memory the same size as an average ten-year old's. This student will be the first to finish individual work, will respond quickly to questions during group time and may even be bored by school.

How do these differences in working memory capacity impact on learning? I have carried out several large scale studies to investigate the impact of working memory difficulties. In a screening of more than 3,000 primary-aged children in mainstream schools, ten per cent were identified as having working memory difficulties. There were several key findings regarding their cognitive skills:

> Working memory is even more important to learning than other cognitive skills such as IQ

- Most students with working memory problems performed below age-expected levels in reading and maths. This suggests that low working memory skills constitute a high risk factor for educational underachievement. These findings correspond with evidence that working memory impacts on all areas of learning, from early years to college. Crucially, evidence suggests that working memory is even more important to learning than other cognitive skills such as IQ. For example, while studying typically developing five year olds, I found that their working memory skills, rather than their IQs, were the best predictor of reading, spelling and maths outcomes.

- Teachers typically judged children with working memory difficulties as having short attention spans and being highly inattentive and easily distracted. Teachers said that the children failed to complete tasks and that they forgot instructions, things they had learnt, and even what they were doing right then. In everyday classroom activities, children often made careless mistakes, particularly in writing, and had difficulty solving problems. In contrast, relatively few of the children were judged to exhibit high levels of hyperactive and impulsive behaviours.
- Children with working memory difficulties took much longer to process information. They were unable to cope with timed activities and fast presentations of information. As a result, they often ended up abandoning activities altogether out of frustration. One way to overcome this difficulty is to give them shorter activities and to allow for more time during tests.

> Children with working memory difficulties are relatively common in the classroom

Studies such as these demonstrate that children with working memory difficulties are relatively common in the classroom and are at extremely high risk of making poor academic progress. Without early intervention, working memory deficits cannot be made up over time and will continue to compromise a child's likelihood of success. What can we as educators do to support these students in their learning?

What sort of training?

Exciting research is emerging on the benefits of cognitive training. Previous research outlines training programmes that ask students to remember a random sequence of numbers or locations daily for a few weeks. Improvements in students' working memory after cognitive training have been reported.

But there are clear limitations to these studies. First, while there appear to be genuine increases in working memory as a result of training, to date there is no evidence that such training also leads to improvements in learning outcomes. It is possible that some cognitive training programmes are just 'training for the test' – if students practise remembering numbers backwards for a few weeks, then it is reasonable to expect that they will perform better on a backward-digit-recall test than students who didn't practise. Similar improvements, known as a 'practice effect', have been found in studies using IQ tests. When students were tested and then retested later, their performance often improved.

The second limitation to the existing reports is that they have been restricted to special populations, such as children with ADHD. Therefore, it is not clear whether students with general learning difficulties will also benefit from similar training. It is possible that ADHD children showed gains in working memory after training because the discipline of sitting down daily led to better focus. Also, the cognitive training study on children with ADHD reported improvements in attention at home, but not necessarily at school.

Brain training program

In order to address these issues, I recently conducted a study to investigate the potential benefits of cognitive training. There were two objectives of this study. The first was to extend existing evidence about students with general learning difficulties, rather than a specific clinical problem (such as ADHD). I was also interested in investigating whether any possible gains from training working memory would ultimately transfer to learning outcomes in literacy and numeracy.

I took a group of students with general learning difficulties, none whom had any physical, sensory or behavioural impairment. Half of the students received brain training (training group), while the remaining students received individual education programme (IEP) support in school (control group). I measured their working memory, IQ and academic attainment before they began their respective support. The groups performed similarly on all of these cognitive measures; this was important as it meant that any gains the students made post-training were the result of the training, rather than because they started at different levels.

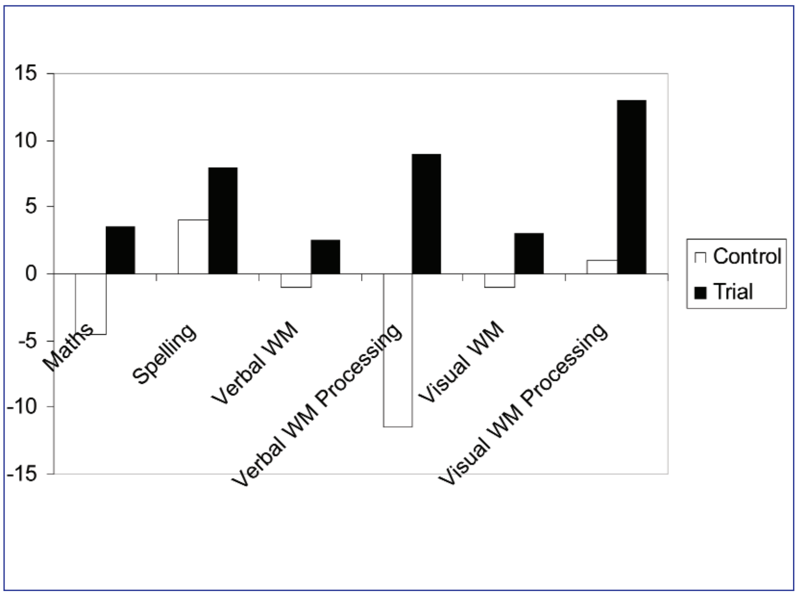
The eight-week brain training program was endorsed by the Psychological Corporation Jungle Memory. There were three games with up to 30 levels in each game. The students had to answer successfully eight out of ten trials in each level to collect enough bananas to move the title character, the Monkey, to the next level. The program adapted to the students' age and ability so that the students continued to be motivated during training.

> Without cognitive training, students with poor working memory will not 'catch up' with their peers

In Game 1, letters and words appeared on a 4 x 4 grid. The working memory component was to remember the location of the target stimuli within a set time period. In Game 2, a letter appeared on the screen with a red dot on it. The letter could also be rotated. The working memory component was to identify a letter orientation (processing) and remember the location of a dot (memory). In the final game, the students were shown maths problems of increasing difficulty and had to solve them (processing component). They then had to recall the solutions in the correct sequence (memory). The program recorded all responses made using a mouse to click on the computer display.

The graph at the top of the opposite page shows the difference in scores between the control and trial groups before and after training. Scores below 0 (marked by the line) indicate that the group performed worse when tested eight weeks later than they did at first. Scores above 0 indicate improvements.

The results were dramatic. The control group did not



perform much better without intervention, and in some instances they performed worse. In contrast, the trial group demonstrated clear gains, not only in working memory tasks but also in learning outcomes. For example, their spelling scores increased almost ten standard score points.

Are these score increases meaningful? Yes. They represent the difference between the grades of C and B, or between B and A – after just eight weeks of training. Would they have made this improvement without training? No – two pieces of evidence support this conclusion. First, the control group, who did not participate in training, showed no improvement and even performed worse in some cases. The second piece of evidence comes from a previous study. I tested a group of eight-to-ten year olds who displayed moderate learning difficulties on a range of working memory, IQ and learning (maths, reading and spelling) tests. These students were all receiving IEP support and continued to do so for two more years, when I then retested them. None of the students had improved. Two years later, they remained in the bottom-tenth percentile compared with their same-aged peers, despite receiving IEP and small group support. Both studies indicate that without cognitive training, students with poor working memory will not 'catch up' with their peers.

During the past 50 years, IQ scores have risen steadily. The cause is under discussion (some suggest it is due to better education and diet), but the documented rise is about three points per decade. Compare that with the increase reported here: the same increase (three points) in maths and a much larger rise (eight points) in spelling after just eight weeks of cognitive training, and it is remarkable.

This is an exciting step in demonstrating that the right cognitive intervention can effectively boost learning outcomes. Why did this study find gains while others did not? One possibility is that the training tactics of other programmes, such as backwards memorisation, train working memory as an abstract skill and do not directly apply to classroom learning. In contrast, Jungle Memory works in the context of key learning activities such as reading, letter decoding and maths.

Drawing conclusions

In light of the extensive evidence that working memory is linked to learning outcomes throughout a student's academic career, it is critical to support students who are struggling to learn by first identifying their working memory profile. The most effective and reliable way to do this is by using the Automated Working Memory Assessment. The AWMA is a cognitive test that takes five minutes and offers educators an informative first step in supporting students' learning. It gives educators a profile of a student's verbal and visuo-spatial working memory skills, as well as indicating how their skill level will impact on their learning. Given that ten per cent of children in a typical classroom have working memory difficulties, it is important that students are screened to determine who needs shorter classroom activities and more time for test taking. Once educators know students' working memory strengths and weaknesses, they can determine if they need cognitive training.

This study demonstrates the efficacy of using Jungle Memory, which trains working memory in the context of key learning activities. This is an exciting step in supporting students who would otherwise continue to struggle throughout their academic life. Evidence also suggests that children with developmental disorders such as dyslexia, language impairments, motor dyspraxia and ADHD would also show learning gains from cognitive training.

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For information on research in working memory contact Tracy Alloway at tracy@memoryandlearning.com. Her weekly blog – www.tracyalloway.com – addresses working memory issues from the impact of nutrition to useful classroom strategies.

Further reading

> Automated Working Memory Assessment (AWMA): www.pearson-uk.com/AWMA

> Brain Training: www.junglememory.com

> 'Working memory, but not IQ, predicts subsequent learning in children with learning difficulties' 2009. *European Journal of Psychological Assessment* 25 (2): 92–98

> 'The cognitive and behavioural characteristics of children with low working memory' by Tracy Packiam Alloway, Susan E Gathercole, Hannah Kirkwood and Julian Elliott, *Child Development*, 80 (2): 606–621