IQ Tests,
IQ Augmenting
Technologies &
How To Join Mensa

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2015

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Chapter 2.

IQ Augmenting Technologies

Computerized Cognitive Training (CCT)

Generally what we understand by 'brain training is **computerized cognitive training (CCT)** – apps usually designed to improve your attention, processing speed, memory, reasoning and so on. In this chapter I shall be reviewing what is known about the effectiveness of this kind of training for cognitive performance.

Working Memory Training

Over the past 10 years there has been a growing body of scientific evidence that a specific type of computerized cognitive training (CCT) has the potential to raise IQ significantly - namely **working memory training**. Commercial CCT comes in many forms. Many brain training companies divide training between different types of cognitive processing such as speed, memory, attention, and so on. In the light of all the studies done on these different types of training, it is only working memory training that has demonstrated real potential for increasing intelligence and executive functioning.

What Is Working Memory?

Working memory is a short-term memory and attention focus system – your 'mental workspace'. It can be defined as a brain system that keeps information in mind temporarily while using it to think something through, make a decision, pursue a goal or comprehend something. It involves a pre-frontal – parietal brain circuit called the cognitive control network.
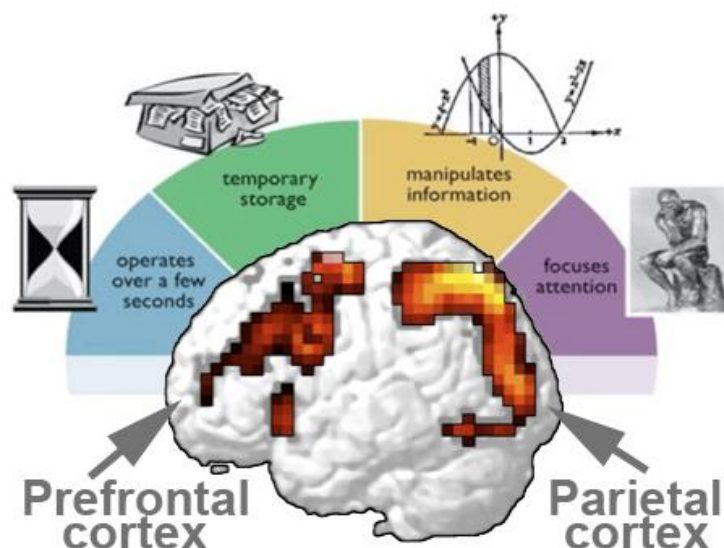
Working memory is necessary for staying focused on a task, blocking out distractions, keeping you updated and aware of what is going on in this process, and applying relevant thinking strategies to process the information.

Working memory deficits result in loss of attentional focus (e.g. difficulty keeping track while reading a text), or memory problems such as forgetting what to do in the few seconds of walking from one room to the another, or being easily distracted while trying to focus on a task and not being able to finish an activity according to plan.

In general the larger your working memory capacity (mental workspace) the better your focus and the greater your capacity for focus, self-control, problem solving and comprehension. There is a strong correlation between working memory and IQ as well as emotion regulation.

What is Working Memory Brain Training?

Working memory brain training is currently the most scientifically credible, effective brain training that is available. The aim of all working memory (WM) training programs is to expand working memory capacity.

The most widely studied brain training exercise targeting WM capacity is the **dual n-back**. This game involves viewing a continuous stream of both visual and audio items and deciding whether each item matches the stimulus presented n stimuli back. In the example shown here, the 2-back matches (targets) are shown.
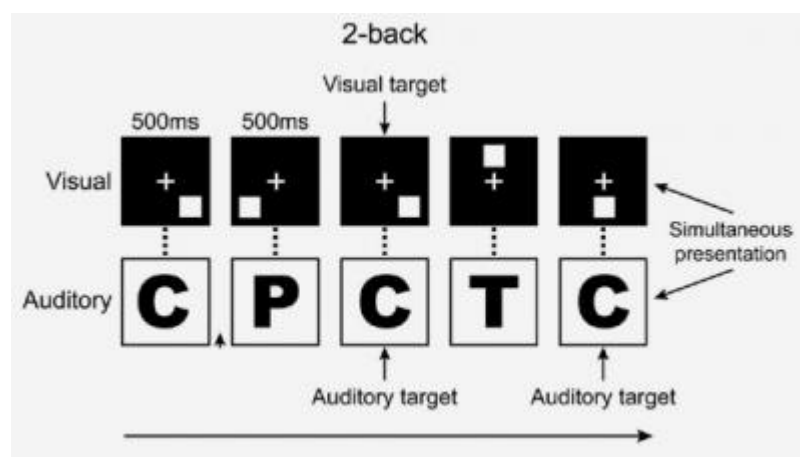
Known Benefits of Working Memory Training

Working memory training has clear long-term **neuroplasticity effects** in brain regions involved in attention, executive function and intelligence, such as changes in the density of cortical dopamine D1 receptors (1, 2, 3)
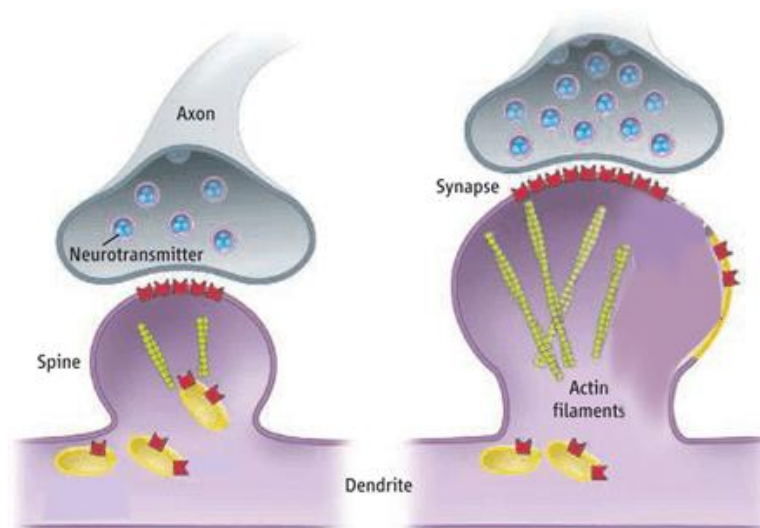
There are many scientific studies demonstrating that WM training results in improvements in a range of important cognitive skills as well as improved cognitive function in clinical populations with known WM deficiencies. (1)

> *"The results of individual studies encourage optimism regarding the value of WM training as a tool for general cognitive enhancement. ...Studies of core training show improvements in a variety of areas of cognition... Core WM training thus represents a favourable approach to achieve broad cognitive enhancement."* (Morrison & Chein, 2011, p. 34).

Working memory training has been shown in replicated studies and meta-reviews to result in the following brain benefits. Such benefits are often found for both younger and older benefits, indicating that neuroplasticity effects from training are not restricted to younger brains.

- Fluid intelligence (IQ) – i.e. abstract reasoning and problem-solving abilities (1)
- Improvements in both verbal and visuospatial working memory (1)
- Improvements in executive attention control such as multi-tasking in both younger and older adults (1, 2).

- Memory for personal experiences ([1],[2])
- Reduced symptoms of ADHD and learning disabilities, for children and adults ([1], [2])

Can Working Memory Training Increase IQ?

The potential effectiveness of the dual n-back for increasing IQ was brought into the spotlight by Dr. Susanne Jaeggi and her group at the University of Michigan in a seminal PNAS paper in 2008: *Improving Fluid Intelligence By Training On Working Memory*. Their results led prominent IQ researchers to the conclusion:

> *"Increasing intelligence is possible after all ...with more training leading to greater gains ...across the spectrum of abilities. ...Almost 40 years ago, Jensen claimed that, when all is said and done, there is not much one can do to raise people's IQs. Jaeggi and her colleagues have made an important contribution... by showing that intelligence is trainable to a significant and meaningful degree."*

> **Robert Sternberg,** Professor of Cognitive Psychology, Indiana University

Since the Jaeggi study, numerous studies investigating the effects of dual n-back training on cognitive performance have been published, and there has been a heated controversy among both cognitive scientists and the popular media surrounding the idea that cognitive training can increase IQ.

Some studies have failed to replicate the IQ-boosting training effect – such as this study by a team led by Todd Thompson at MIT.

But other studies have found a significant 'wide transfer' IQ increasing effect, such as this one by Sarah Rudebeck in Oxford University's Department of Experimental Psychology:

> *"we found that the trainers, compared to non-trainers, exhibited a significant improvement in fluid intelligence after 20 days.... Our findings demonstrate that practice on a ...working memory task can potentially improve aspects of both ....memory and fluid intelligence."* (2012)

So how are we to evaluate the conflicting evidence? Does dual n-back training work or not?

In answering this question, we can distinguish between different grades of evidence.

1. **'In house' research conference talks, papers 'under review' and other non-published material. (e.g.** *Lumos Labs* **unpublished papers.)**
2. **Single peer-reviewed journal articles that have not been replicated.**
3. **Several peer-reviewed journal articles from different labs with replications.**
4. **Meta-reviews of multiple peer-reviewed journal articles with replications.**

The higher the level the more reliable the evidence - whether for computerized cognitive training, or for other brain cross training methods such as exercise or fasting.

Meta-Review Studies

We find that the latest meta-reviews for dual n-back and working memory training conclude dual n-back training **is effective** in improving general cognitive performance and IQ test scores on average, but that it does so in a way that depends to a large extent on underlying variables such as motivation, and training regimes ([1])

[For example, this 2014 meta-review](#) by Jacky Au and colleagues at the University of California, concludes:

> *"Our work demonstrates the efficacy of several weeks of n-back training in improving performance on measures of Gf [fluid intelligence]. We urge that future studies move beyond attempts to answer the simple question of whether or not there is transfer and, instead, seek to explore the nature and extent of how these improved test scores may reflect "true" improvements in Gf that can translate into practical, real-world settings."*

Training Optimization

Jacky Au and colleagues argue in their meta-review that the average increase in IQ from training they found is an **under-estimate** due to the samples and testing criteria. Moreover, they believe that the effect size they reported could be increased by **optimizing** certain game parameters including:

- Program completion
- Increasing intrinsic motivation for program completion

For these reasons the authors argue:

> *"the results reported in this meta-analysis represent a low-end estimate of the true extent of improvement that n-back training can have on measures of [intelligence]".*

The name of the game is now is determining precisely what parameters of dual n-back training can optimize wide transfer to IQ and general cognitive performance. An analogy is growing tomatoes. If you know you can grow them, your next concern is to figure out how to make them bigger and better – by e.g. different watering schedules or adding fertilizer or varying the growing temperature!

Interference Control &
'Second Generation' N-Back Training

One strong candidate parameter for optimizing dual n-back training that I have been particularly interested in is **interference control**.

Interference is a technical term for ***distracting information*** that is similar to the information you need to perform well in a cognitive task. If you are playing the n-back game, and you are at a 3-back level, a matching stimulus for N=2 or N=4 would qualify as interference. This is shown in the diagram.
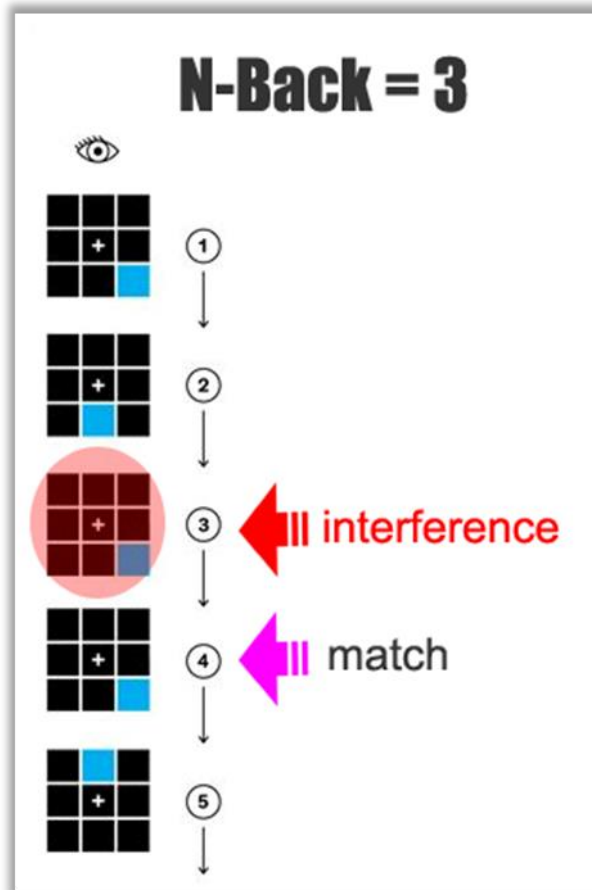
There is good scientific evidence that ***interference control*** – the ability to filter out distracting information of this sort – ***underlies the link between working memory and intelligence***.

- First, brain imaging studies reveal that [neural mechanisms of interference control underlie the relationship between fluid intelligence and working memory span](#).

- Second, Claudia von Bastiana and Klaus Oberauera at the Department of Psychology, University of Zurich, have found that a game based on ['supervision' working memory training alone resulted in IQ gains](#). Supervision is terminology for ***that aspect of working memory used for interference control*** - defined as "selective activation of relevant and inhibition of irrelevant information".

Based on the strong role of interference control in linking IQ with working memory capacity, interference training is now built into the [i3 Mindware app](#) as a default. Building interference control into the dual n-back game is something new, and for this reason we call it 'second generation' (2G) dual n-back training.

Computerized Cognitive Training Summary

Based on meta-review evidence we can conclude that working memory training is worth investing your time and effort into if you want to achieve gains in general cognitive performance. No equivalent cognitive gains result from other types of computerized cognitive training, or learning musical instruments, playing video games.

We can consider an analogy with sports performance. Substantial gains in sports performance are now possible – and achieving those gains relies on scientifically guided training programs. Likewise it is becoming apparent that cognitive performance gains are possible and these too rely on scientifically guided training programs. Evolved versions of the dual n-back and other forms of working memory training will be central over the next decade in achieving and maintaining the highest levels of IQ and cognitive performance.

[To find out more about the i3 Mindware cognitive training app for increasing IQ click here.](#)