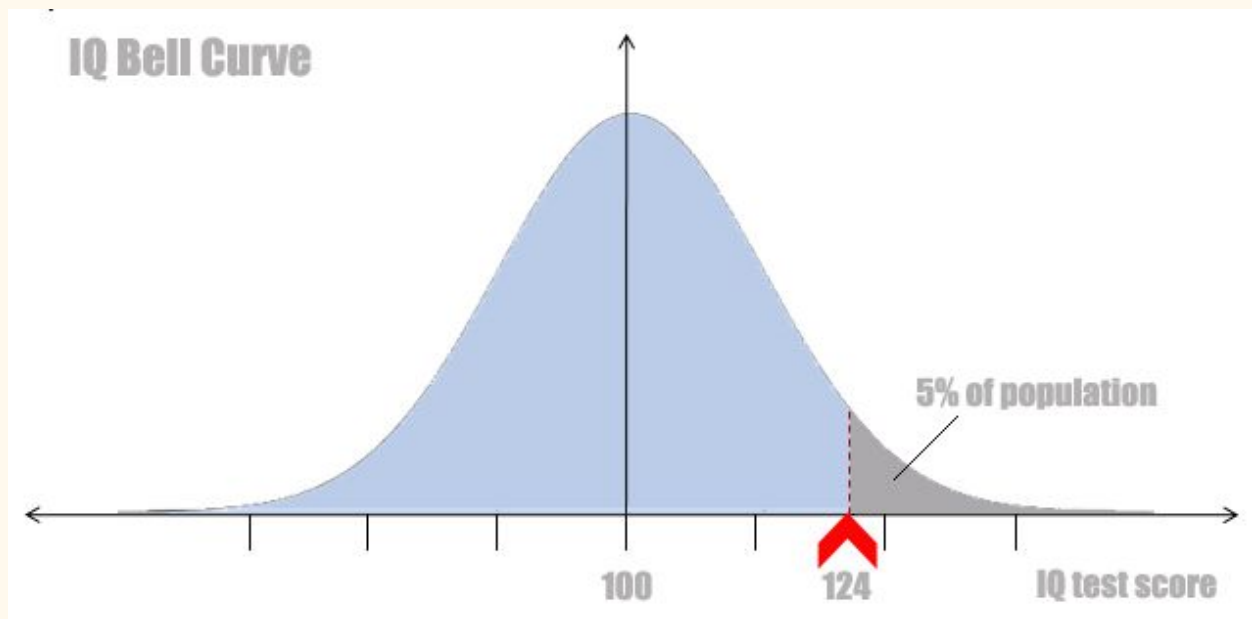


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# PSYCHOMETRIC IQ AUGMENTATION 6



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# Evidence Based IQ Augmentation Apps

Your general intelligence (**g**) as measured by psychometric IQ tests and other aspects of cognitive performance can be improved by a number of neuroplasticity interventions, including brain training apps, nootropics (phytochemicals, supplements and smart drugs), exercise, intermittent fasting, meditation, neurofeedback, and transcranial direct current stimulation (tDCS).

In this eBook I review evidence-based IQ augmentation apps.

## Central Hub of Intelligence

We saw in *Psychometric IQ Augmentation 2 and 5* how we can hone in on an **attention control - working memory- fluid reasoning central hub** - the work of the Fronto-Parietal Network - to pinpoint the core of general intelligence ([review](#)). This is the Central Hub of Intelligence.

The brain training apps reviewed below all target this Central Hub of Intelligence.

## IQ Augmentation Brain Training: A Review

We know from a largely skeptical scientific press that many brain training apps claimed to improve cognition do not work beyond practice effects. The popular scientific press has often taken an anti-brain training stance, largely because of the aversion to commercially successful companies that offer little in the way of cognitive benefits in practice.

But it has become clear from an ever-growing volume of peer-reviewed research that some types of brain training **are** effective for increasing cognitive ability and IQ.

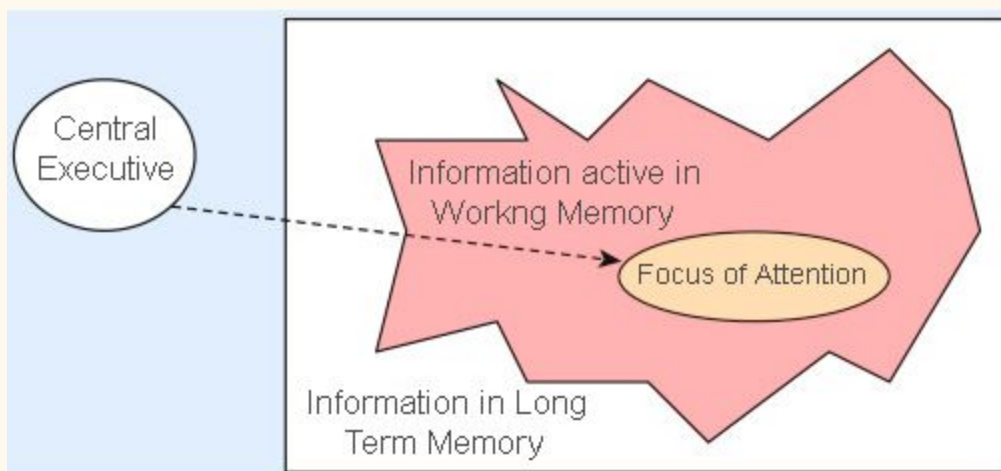
We need to filter out the **placebo** results and hone in on those which show effectiveness under the exacting standards of placebo-controlled, double blind, laboratory studies - those that meet the exacting standards of **peer-reviewed scientific journals**.

It is apparent that the brain training apps that work most effectively target Central Hub Intelligence neuroplasticity.

## Working Memory Brain Training

*“The results of individual studies encourage optimism regarding the value of working memory training as a tool for general cognitive enhancement.”* [Morrison & Chein review.](#)

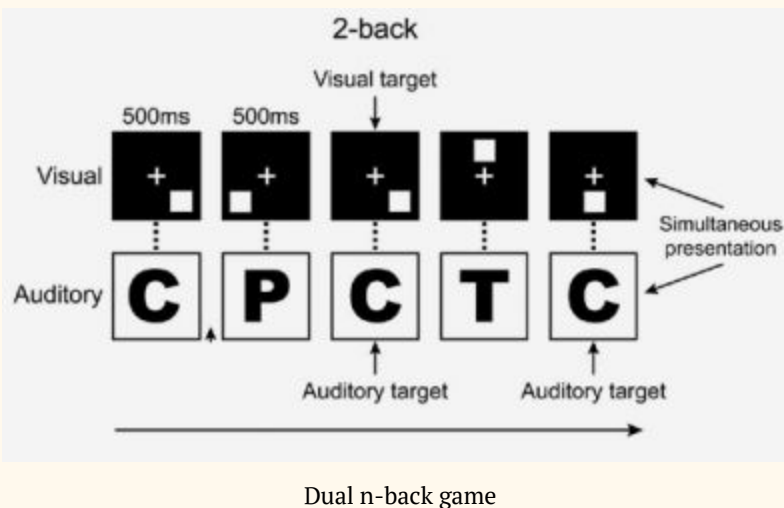
**Working memory (Gwm)** is one of the broad abilities of general intelligence. It is your ‘mental workspace’ – the limited amount of content (verbal, spatial, images) you can process ‘online’ and focus on for problem solving, reasoning, planning, comprehending & decision-making. Working memory is **limited capacity** - you can only activate **some** information from all the knowledge and memories held in your long term memory at any given time.



Cowan's model of working memory (1988) ([ref](#))

### Dual N-Back

One of the most well-known working memory training methods is the **dual n-back**. This is a game that involves keeping track of continuously changing audio letters and shape locations, and responding when there is a match ‘n’ times back in the sequence - as shown here.



This figure shows a 2-back game. The game is *adaptive* so that if you get good at this, you go up to a 3-back, 4-back, 5-back and so on.

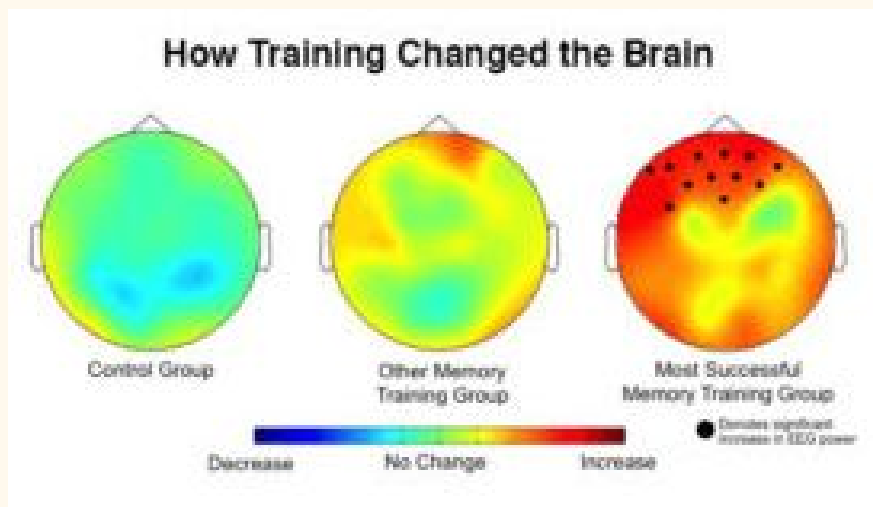
Have a look at [this October 17th 2017 Johns Hopkins University press release](#) about a study published that week on dual n-back training. The study was published in the [Journal of Cognitive Enhancement](#) and can be found [here](#) Johns Hopkins researchers suspected the problem wasn't the idea of effective brain training, but the type of training exercise researchers chose to use.

The training exercises Johns Hopkins compared are not the commercial products typically available and sold to consumers, but a lab-designed dual n-back.

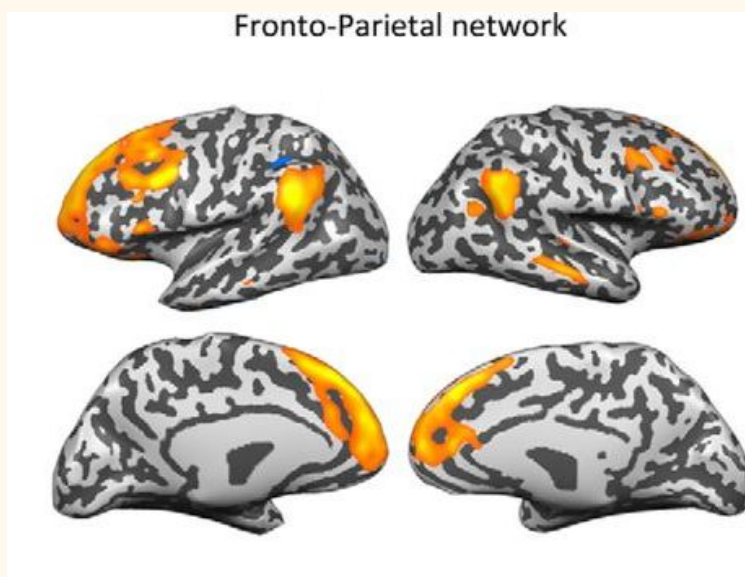
There were three groups in the study: One group trained with the **dual n-back**, another group trained with another working memory exercise called the **symmetry span task**, and a third (control) group trained with a challenging **verbal logic task** that did not involve working memory. Everyone took a round of cognitive tests, trained five days a week for 30 minutes, then returned to the lab for another round of tests - including brain EEG recordings - to see if anything about their brain or cognitive abilities had changed.

The researchers found that the group that practiced the dual n-back exercise showed a **30% improvement in their working memory** - a core component of Central Hub Intelligence. That was nearly double the gains made by the group working with the other working memory exercise.

The dual n-back group also showed significant changes in brain activity in the **prefrontal cortex**, the critical region responsible for general intelligence.



This Johns Hopkins' study adds to the message of the multiple brain imaging studies ([ref 1](#), [ref 2](#), [ref 3](#)) showing **neuroplasticity change** in the the **Fronto-Parietal Network (FPN)** as a result of dual n-back training. As we reviewed in *Psychometric IQ Augmentation 2*, the FPN is the brain's 'control hub' underlying Central Hub Intelligence. This neural network sends out top down signals for current task goals and exerts control by flexibly biasing information flow across multiple large-scale functional networks. The FPN is a key network underlying intelligent, goal directed action and learning.



(Views from outside and inside of both hemispheres)

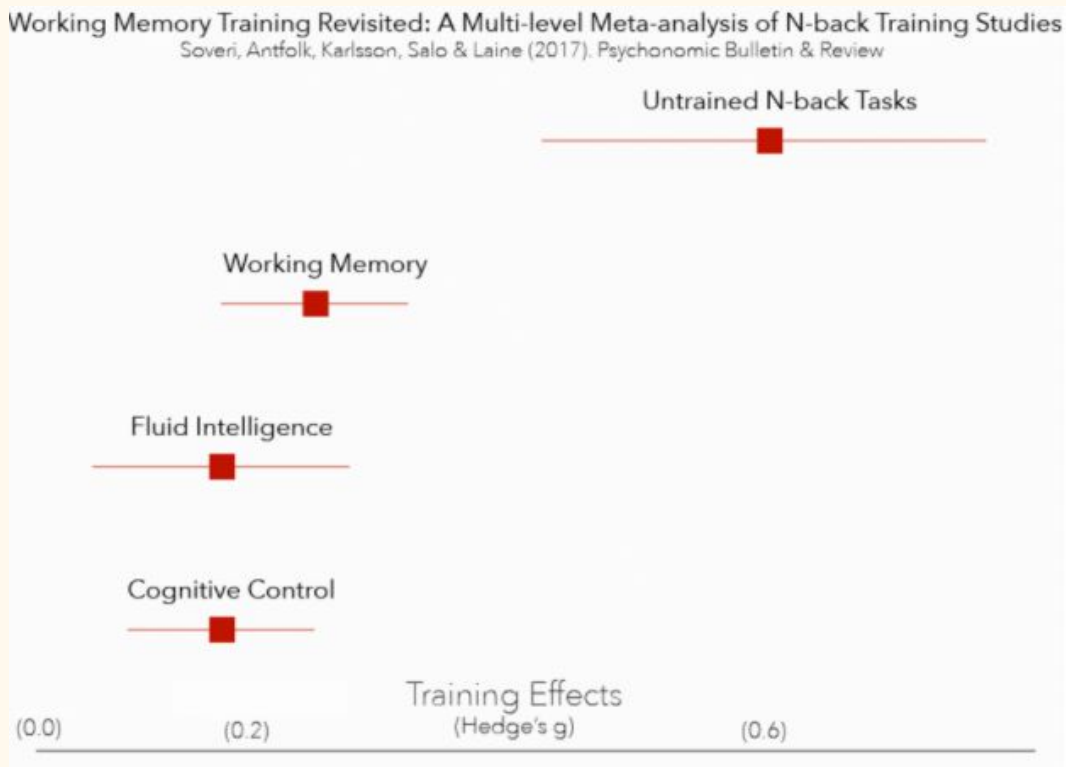
Cognitive neuroscience and neuroimaging research has demonstrated the following as a result of dual n-back training:

1. **Functional connectivity** within the Fronto-Parietal Network increases following training, and the magnitude of increased connectivity is tied to improvements in task performance ([ref](#)).
2. Working memory training **increases grey matter volume** in the Fronto-Parietal Network ([ref](#)).
3. Working memory training results in **neuroplasticity change in dopamine receptors** in the Fronto-Parietal Network. The neurotransmitter dopamine is very important for working memory and working memory performance is affected by dopamine levels in the prefrontal cortex, with dopamine release observed during the performance of working memory tasks ([ref1](#), [ref2](#)).

This Johns Hopkins study also adds to the **dual n-back behavioral studies** that have been analyzed in recent 'meta-reviews'. The conclusion of these reviews is that there are real IQ augmenting training effects of DNB brain training beyond placebo effects and just getting good at the n-back game itself through practice ([review 1](#), [review 2](#)).

The very latest 2017 meta-review of 33 published, randomized, controlled DNB trials from independent labs all around the world ([review](#)) finds there are real (non-placebo) training effects of DNB brain training on:

- Other n-back games - the biggest effect
- Working memory (*Gwm*)
- Fluid reasoning / Fluid intelligence (*Gf*)
- Attention Control



Training effect sizes of the dual n-back game

How can we interpret these 'training effects'? The effect size for working memory capacity (**Gwm**) is 0.24. Let's take another kind of intervention to compare. 0.24 is the same effect size of antidepressants such as Fluoxetine in treating depression ([ref](#)). Certainly a lot is invested into developing anti-depressants. So we should take notice of this kind of effect size when it comes to augmenting IQ.

While dual n-back benefits for working memory (**Gwm**) have been consistently demonstrated, there has been controversy concerning dual n-back training benefits for **Fluid reasoning** ability (also called 'fluid intelligence'), but the weight of the evidence indicates otherwise as you can see. The effect is small but real. Dr Au and colleagues' earlier 2015 meta-analysis also found the same effect size of dual n-back brain training on fluid reasoning ([ref](#)), and they 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 fluid intelligence.”*



So we have two independent groups, reviewing all the available evidence on DNB training, coming to the same conclusion about training benefits for Fluid reasoning (*Gf*), as measured by matrices IQ tests.

In conclusion, dual n-back training works. It improves IQ through neuroplasticity change, and it does so to a useful extent.

There are multiple n-back apps available online ([i3 Mindware](#) is one). Ensure that you choose one that implements a lab-tested program and that you commit to program completion.

## Cognitive Control Training (CCT)

The standard dual n-back is a **working memory** (*Gwm*) training intervention; it trains working memory **updating**. The dual n-back is not designed to train **executive attention control functions**.

There is another class of brain training interventions called **executive control training** or **cognitive control training (CCT)**, specifically designed to activate areas of the brain that allow us to control and direct our attention and adjust our thoughts and actions when confronted with conflict during information processing. Due to central role of attention control in the Central Hub of Intelligence, this training strategy makes a lot of sense for IQ augmentation.

### Dual N-Back with Interference Control Training

The Central Hub of Intelligence can be thought of as the seat of flexible problem solving and adaptation to new task-demands in the face of interference or information conflict.

**Interference control** is the ability to filter out distracting information that attracts attention and resolve information-conflict. Interference control is of particular value in our Attention Economy, where all-pervasive information continually consumes the scarce resource of our attention, and where there is a need to filter out distractions and resolve information conflicts as we pursue our goals and projects.

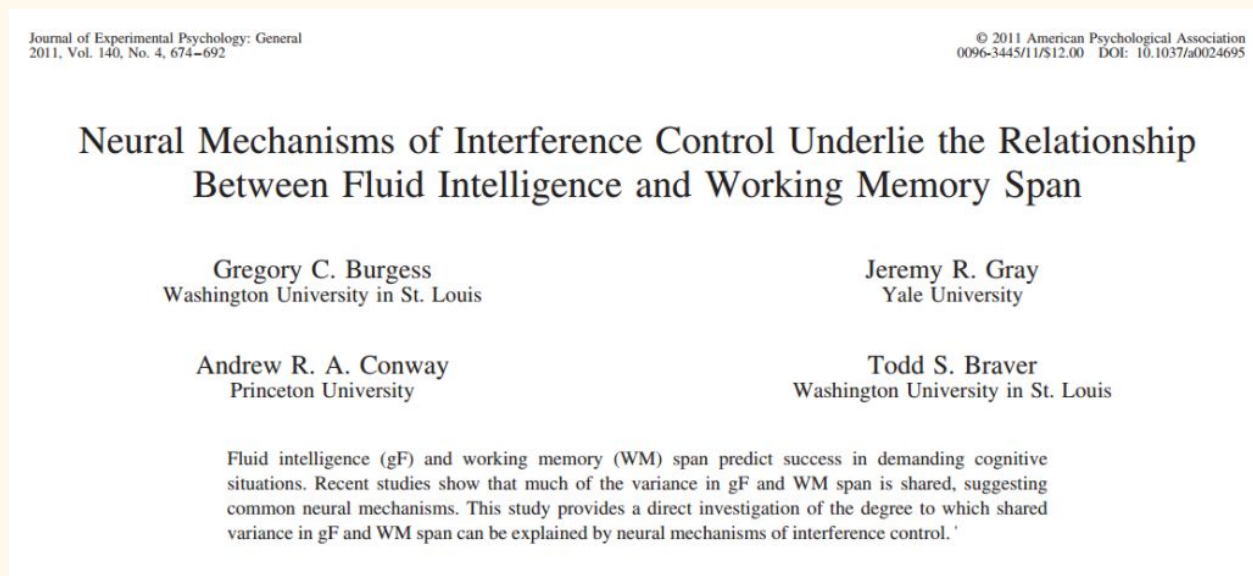
The first study that looked at the dual n-back with built-in interference control training found that compared to the standard dual n-back interference training resulted in improved attention control ([ref](#)). It also resulted in increased electrical signalling in the parietal cortex (part of the Fronto-Parietal Network). This, they concluded:

*“may be related to improvements in processing speed, attentional control, or both”*

In a recent 2017 study, dual n-back **and** interference control training - compared to standard dual n-back training - resulted in improvements in both memory and language ([ref](#)). The researchers conclude:

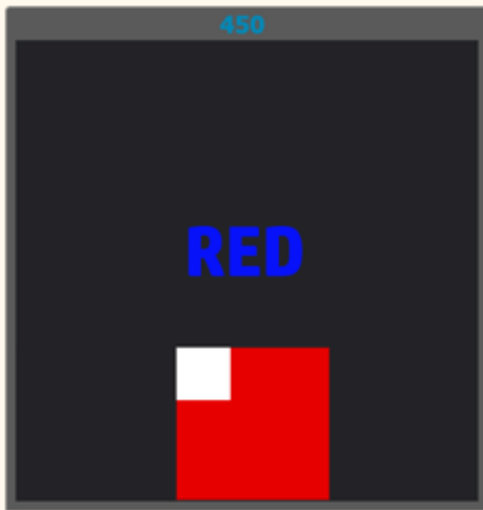
***“domain-general cognitive control mechanisms are plastic...and may play a causal role in linguistic and nonlinguistic performance”***

Neuroimaging research shows that interference control underlies the link between fluid reasoning/intelligence (**Gf**) and working memory (**Gwm**) ([ref 1](#), [ref 2](#)).

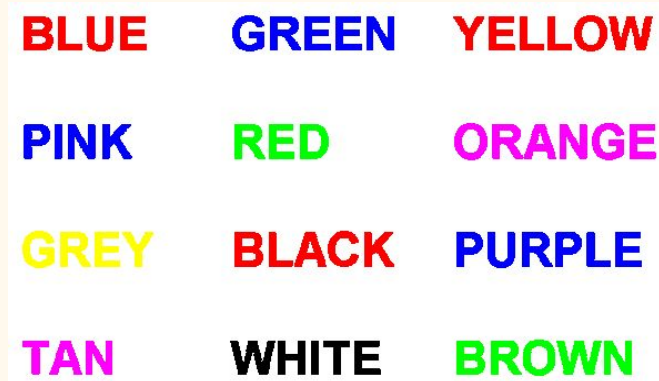


Note that 'fluid intelligence' is fluid reasoning ability

Interference control training is built into some dual n-back game apps (e.g. [i3 Mindware](#), [Dual N-Back Pro](#) & Brain Workshop) through carefully designed sequencing of the stimuli to create information conflict. What has been a target for a while suddenly switches to becoming a distraction in the game, requiring that you exert attention control to stop responding to it. This makes the dual n-back more challenging, and provides more effective training.



[i3 Mindware](#) and [HighIOPro](#) games also include the ‘Stroop’ n-back’ based on the Stroop Task) - a variation of the dual n-back in which you need to ignore the *meaning* of words (red in the example here), and just respond to matches of the words’ colour (blue). To get a feeling for the interference control needed for this n-back task, try quickly saying the ink colours, ignoring the color names, in this set of words. This is the Stroop Task.



### Task Switching & Selective Attention Training

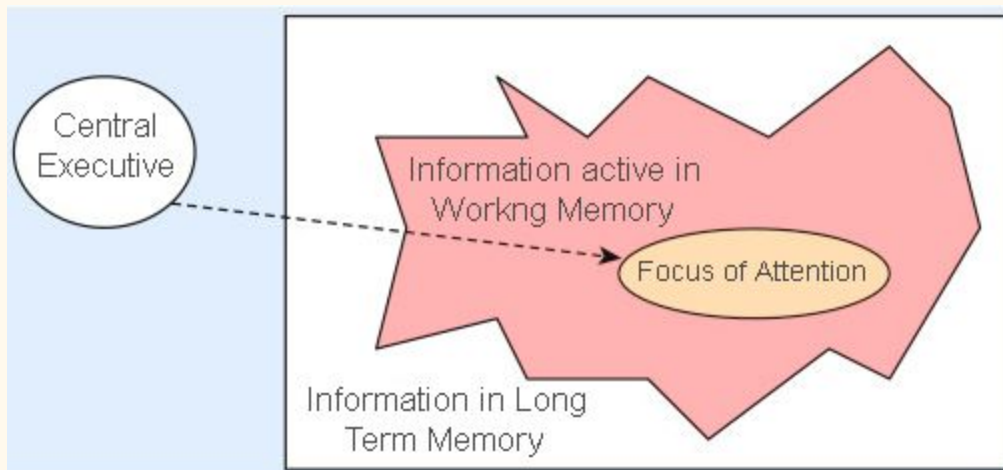
Another cognitive control task developed for improving attention control and broader measures of intelligence is **task switching** ([review](#)).

Task switching training involves having to selectively attend to only *some* features of the information available to your senses (ignoring others) to perform a task, and then flexibly changing the features you attend to based on an updated rule set. The rules of the game change unpredictably based on some cue. Three studies looking at the benefits of task switching training compared the effects of training children (8–10), young adults (18–26) and older adults (62–76), and found training benefits for untrained executive control tasks and fluid intelligence (*Gf*) across all age groups ([review](#)).

Executive control selective attention and task-switching training is implemented in the [i3 Mindware](#) and [HighIQPro](#) brain training apps in their ‘gated’ dual n-back games. **Input gating**, for example, requires the flexible switching between four streams of information rather than the standard two (audio and visual) in the dual n-back.

### Output Gating Training

Not all information that you are keeping ‘online’ in the mental workspace of working memory may be useful for what you are currently trying to do. For instance, you need to apply the instructions you’re holding in working memory, just one step at a time. In Cohen’s model of working memory shown below, you can see that the focus of attention at any given moment selects from all the information that is active in working memory



This kind of selection from workspace information depends on another executive control function called working memory **output gating**. Studies have shown that output gating, like selective attention and task switching, depends on the Fronto-Parietal Network (as well as corticobasal ganglia circuits)([ref](#), [review](#)).

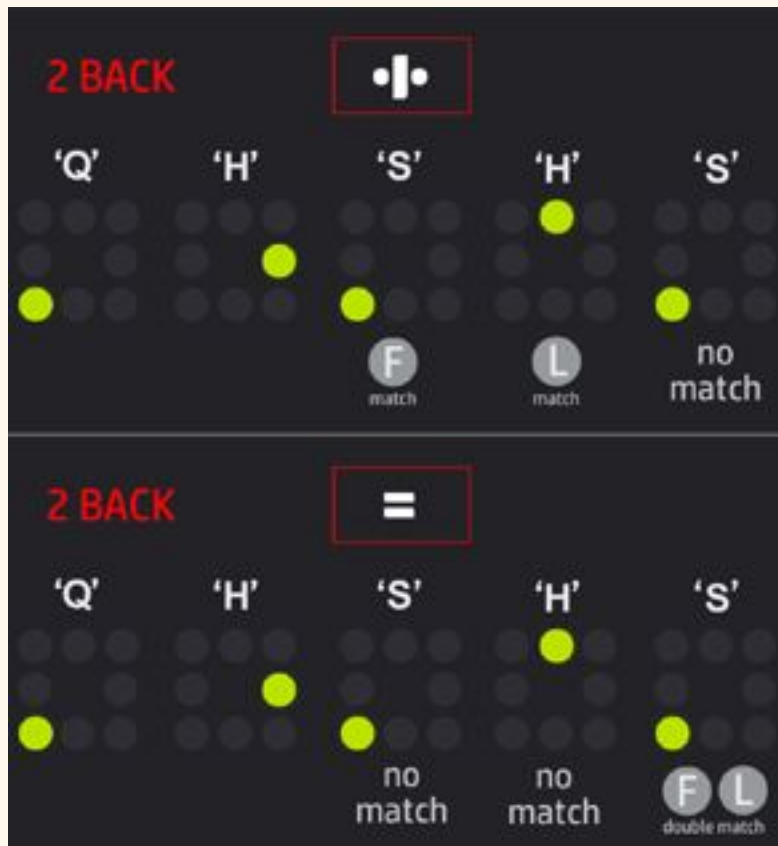
Output gating is particularly important for the application and learning of abstract, higher order rules - precisely what is needed for psychometric IQ. It is needed for all these IQ-related abilities ([ref1](#), [ref2](#), [ref3](#)):

- Applying complex rules
- Generalization and learning from single cases

- Complex reasoning
- Complex decision making
- Complex planning

[i3 Mindware](#) and [HighIQPro](#) are the only apps on the market incorporating output gating brain training.

For those already familiar with the dual n-back training, the output gating is shown below. In the top panel sequence the 'division' cue tells you to only respond for a 2-back match when either the location or the letter match on their own but not when they both match at the same time. In the bottom panel the 'equals' cue tells you to only respond for the 2-back match when there is a location and letter match at the same time, but not when either of them matches on its own.

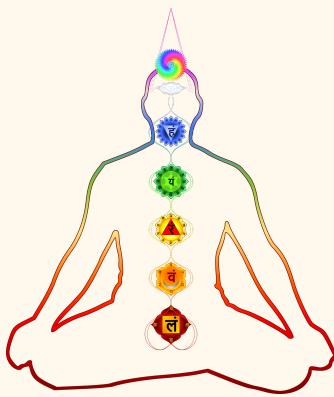


Example sequences for output gating in the dual n-back

## Sustained Attention Training

Sustained attention training involves:

- sustained attention to a target
- disengaging from a distracting object (attention switching)
- redirecting focus to the target (selective attention)



In **focused attention mindfulness meditation**, the ‘target’ can be awareness of breathing ([ref](#)). This sustained attention mindfulness practice has been shown to result in improvements in diverse attention functions, as well as the Stroop task and working memory (*Gwm*) performance. Cognitive neuroscience studies have found changes in activity of the cingulate cortex and other frontal areas, known to be involved in interference control and resolving information conflict - part of the Fronto-Parietal Network and Central Hub of Intelligence ([review](#)).

A sustained attention computer game with neurofeedback that adapts in difficulty like the dual n-back has also been shown to improve sustained attention and vigilance, with fewer attention lapses ([ref](#), [ref](#)).

## Useful Field of View / Processing Speed Training

**Useful Field of View** (UFV) training is a game that exercises central executive attention control but also speed of processing and sensory discrimination. The game involves quickly discriminating between stimuli in the center of your attentional focus, while also scanning for targets in the periphery of your vision among distractors. You can imagine a real world equivalent of this task when driving - having to divide your attention between what you are currently focusing on (e.g. an exit sign) while also keeping situationally aware of the traffic around you.

The UFV exercise has been studied for thirty years ([review](#)). Most of these studies have been conducted on older people (60 years plus). But also middle aged ([ref](#)) and younger adult ([ref](#)) population studies have been conducted too. The conclusions of a comprehensive 2017 meta-review of all these UFOV studies ([review](#)) concludes:

- Useful Field of View training improves neural outcomes, speed of processing, and attention.
- Useful Field of View training improves older adults' everyday function.
- Improvements from Useful Field of View training endure across ten years.

Useful Field of View training is currently available in the 'Double Decision' game of the company *BrainHQ*.

## Summary

In summary, I have reviewed a number of evidence-based brain training games and apps, focusing on interventions that result in neuroplasticity change in the Fronto-Parietal Network and the Central Hub of Intelligence. These include games implementing the dual n-back, interference control, as well as a number of other cognitive control games that target attention control and resolving information conflict. I also reviewed sustained attention and Useful Field of View brain training interventions.

Training with these apps can improve your baseline psychometric IQ and Executive Control functions such as attention focus and flexibility.