

The Impact of Working Memory Training & Medication Treatment on Working Memory in Children with ADHD

Working memory (WM) is the cognitive system responsible for the temporary storage and manipulation of information and plays an important role in both learning and focusing attention. Considerable research has documented that many children and adults with ADHD have WM deficits and that this contributes to difficulties associated with the disorder.

A simple example illustrates the importance of WM for particular academic tasks. Try adding 3 and 9 in your head. That was probably easy for you. Now trying adding 33 and 99. That was probably more difficult. Finally, try adding 333 and 999. This is quite challenging for most adults even though each calculation required is trivially easy. The challenge occurred because you need to store information - the sum of 3+9 in the one's column and then ten's column - as you process the remaining part of the problem, i.e., 3+9 in the hundred's column, and this taxed your WM. If your WM capacity was exceeded, you could not complete the problem successfully.

This simple problem also illustrates the difference between short-term memory (STM) and WM. Short-term memory simply involves retaining information in mind for short periods of time, e.g., remembering that the problem you need to solve is 333+999. Working memory, in contrast, involves mentally manipulating - or 'working' with - retained information and comes into play in a wide range of learning activities. For example, to answer questions about a science chapter, a child not only has to correctly retain factual information but must mentally work with that information to answer questions about it. Thus, when a child's WM capacity is low relative to peers, academic performance is likely to be compromised in multiple areas.

Because WM deficits play an important role in the struggles experienced by many individuals with ADHD, it is important to consider how different interventions address this aspect of the disorder. In this study, the authors were interested in comparing the impact of Working Memory Training and stimulant medication treatment on the WM performance of children diagnosed with ADHD.

Participants were 25 8-11 year-old children with ADHD (21 boy and 4 girls) who were being treated with stimulant medication. Children's memory performance was assessed on 4 occasions using the Automated Working Memory Assessment (AWMA), a computerized test that measures verbal short-term memory, verbal working memory, visuo-spatial short-term memory, and visuo-spatial working memory.

At time 1, the assessment was conducted when children had been off medication for at least 24 hours. The second assessment occurred an average of 5 months later and when children were on medication. The third assessment occurred after children had completed 5 weeks of cognitive working memory

Training using the standard training protocol (see below). The final assessment occurred approximately 6 months after training had ended. This design enabled the researchers to make the following comparisons:

- WM performance on medication vs. off medication (T1 vs T2)
- WM performance on medication vs. after training (T2 vs. T3)
- WM performance immediately after training ended vs. 6 months following training (T3 vs. T4)

This final comparison provided information on whether any benefits provided by the training had endured.

In addition to measuring STM and WM at each time point, measures of IQ were collected at times 1, 2, and 3.

- Working Memory Training -

WM training was conducted using the standard cognitive training protocol with each child completing 20-25 training sessions within a 25 day period. The training requires the storage and manipulation of sequences of verbal, e.g., repeating back a sequence of digits in reverse order, and/or visuo-spatial information, e.g., recalling the location of objects on different portions of the computer screen.

Difficulty level is calibrated on a trial by trial basis so the child is always working at a level that closely matches their performance. For example, if a child successfully recalled three digits in reverse order, on the next trial he had to recall four. When a trial was failed, the next trial was made easier by reducing the number of items to be recalled. This method of 'adaptive training' is thought to be a key element because it requires the child to 'stretch' their WM capacity to move through the program.

- Results -

- Impact of Short-Term Memory and Working Memory -

Medication vs. no medication - When tested on medication, children showed better visuo-spatial WM relative to when they were tested off medication. However, no improvement was found for verbal STM, verbal WM, or visuo-spatial STM.

Performance on medication vs. performance after WM training - cognitive training led to significant gains in all four memory scores. Thus, there was evidence that WM training led to greater gains in WM than medication treatment alone. On all areas of memory assessed, the average score of participants had moved from below average to within the average range.

Performance 6 months after training ended - Training gains in 3 of the 4 memory components - all but visuo-spatial STM - remained significant 6 months after training had ended and there was little indication of any decline in children's performance. Thus, the benefits evident immediately following training had largely persisted.

- Impact on IQ -

IQ results on and off medication was equivalent. Likewise, there was no indication that WM training was associated with any increase in children's IQ results. Thus, the benefits of training were restricted to children's performance on the memory tasks.

- Summary and Implications -

Results from this study indicate that WM training yields greater benefits in WM for children with ADHD than are provided by stimulant medication treatment. Furthermore, memory gains following training persist for a significant period. Because adequate WM functioning is critically important for children's academic success, these are encouraging findings as they suggest that intensive training can ameliorate deficits in this important executive function. The absence of training benefits on IQ suggests that the benefits of training may be limited to WM specifically, although it should be noted that other WM training studies have reported benefits on particular aspects of intelligence. Thus, the impact of WM training on IQ requires further study.

However, it is important not to over interpret the results from this study. While it is tempting to regard this as a comparison of medication treatment and WM training for ADHD, and to view the results as indicating the superiority of the latter, this would be an erroneous interpretation. The constellation of difficulties that comprise ADHD for many children extend significantly beyond WM deficits, and this study did not examine a number of other important outcomes.

For example, it provides no information on the relative benefits of medication and WM training on children's attention, hyperactivity, other behavior problems, and academic performance. Even though other studies of WM training have found benefits in several of these areas, adding assessments of these critical outcomes to the current study would have strengthened it. This criticism is not intended to discount the important results obtained, but to instead provide an appropriate context for evaluating these interesting findings and it would not be surprising if medication treatment were to have greater impact in other important areas.

It is also the case that the study was limited by restricting the assessment of WM to computerized measures of this capacity, even though validated parent and teacher rating scale measures of WM are available. Incorporating such measures into the study would have provided a more comprehensive of children's memory functioning at each assessment point.

Although these represent important study limitations, the results provide additional evidence that intensive WM training can yield enduring benefits in this key executive function. Because the benefits provided by training enhance those provided by medication, it also suggests that WM training may be a useful complement to existing evidence-based interventions for ADHD, particularly for children whose WM functioning is limited to begin with.