



The therapeutic potential of working memory training for treating mental disorders

Sharaf Ansari*

Samsung R&D Institute, Bangalore, India

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Working memory (WM) is a measure of the number of items that can be held in short-term memory at once (Baddeley, 1992). Working memory is hypothesized to be a core component underlying fluid intelligence (Engle et al., 1999), and is the base ability tapped by a battery of complex task such as visuospatial reasoning and reading comprehension (Baddeley, 2003). It was once believed to be static in an individual and to have a strong heritable component (Sternberg, 2008). Recent studies such as Jaeggi et al. (2008), however, have challenged this view.

There has been a recent furor over the possibility that working memory training, of the order of a few weeks, could lead to significant increases in fluid intelligence. Several studies (Jaeggi et al., 2008) have reported transfer effects, yet others (Redick et al., 2013; Thompson et al., 2013) have not shown similar increases, even with highly similar experimental methodology. The factors mediating transfer effects are still unclear. Recently, though it has been suggested (Jaeggi et al., 2014; Au et al., 2015) that individual differences such as intrinsic motivation and self-perceived cognitive deficits of the participants may play a role. The same factors could plausibly mediate the therapeutic benefits of working memory training in patients suffering from mental disorders.

The effects of training working memory are still being hotly debated. The evidence for transfer effects is still preliminary. There are several recent reviews of the literature such as Shipstead et al. (2012) and Melby-Lervåg and Hulme (2013) which offer detailed criticisms of reported transfer. Existing studies may suffer from a variety of flaws like an inadequate conceptualization of working memory, use of no-contact control groups, and failing to account for improvements in non-WM cognitive function. For a meta-analysis of the effects of working memory training which tries to address some of these concerns, see Au et al. (2015). For critical replies to this review, see Melby-Lervåg and Hulme (2015) and Bogg and Lasecki (2014). For the purposes of this paper, I take the position that some initial evidence of the effectiveness of working memory training exists.

There has been an interest in the value of working memory training for purposes other than directly inducing an increase in fluid intelligence, such as its potential to treat rumination in depression (Wanmaker et al., 2015), treating attention deficit hyperactivity disorder (Klingberg et al., 2002), and even improving deductive reasoning (Beatty and Vartanian, 2015). Also, there has been a growing interest and excitement about cognitive training for treating psychiatric disorders, for example Subramaniam and Vinogradov (2013).

With regards to the brain, working memory has been hypothesized to have a substrate in regions of the brain like the pre-frontal cortex, the most evolutionarily recent part of our brain. (D'Esposito et al., 1995) Its dysfunction is also suspected to be involved in the occurrence of several mental disorders such as depression, attention deficit hyperactivity disorder (ADHD) and schizophrenia.

Though not much research has been done on the brain changes caused by attempts to train working memory (and the research done varies wildly in methodology), preliminary research seems very encouraging. A review by Buschkuhl et al. (2012) found that structural and functional changes take place in the brain after working memory training and that improvements in working memory may be due to changes in activation in the prefrontal and parietal brain areas. So, working

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Srikantan S. Nagarajan,
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USA

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Laura Anne Libby,
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*Correspondence:

Sharaf Ansari,
sharaf484@gmail.com

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memory training may induce changes in brain regions believed to be dysfunctional in certain mental disorders.

Attention deficit hyperactivity disorder is a disorder characterized by impulsivity, inattention and inappropriate motor control (Klingberg et al., 2002; Polanczyk et al., 2007). It is one of the most common causes of learning disability in the world, affecting between 1 and 20% of all school children (Polanczyk et al., 2007).

Working memory is believed to be compromised in ADHD, possibly due to impairment in the frontal lobe (Schweitzer et al., 2000). Klingberg et al. (2002) found that working memory significantly increased performance on both trained and untrained WM tasks, in children suffering from ADHD. More recently, Beck et al. (2010) found that 5 weeks of working memory training in children and adolescents decreased measures of inattention, decreased number of ADHD symptoms, and improved working memory. This strongly suggests potential for working memory training to alleviate symptoms of ADHD. However the evidence for treating ADHD with working memory training is still severely lacking. Recent meta-analysis such as Cortese et al. (2015) and Sonuga-Barke et al. (2013) have not found reduction in ADHD symptoms, which implies that existing working memory training techniques may be of limited use in treating ADHD. A preliminary study on adolescents by Stevens et al. (2015) reported a normalization of deficits in frontoparietal brain region activation in ADHD patients and explores the possibility that cognitive training specifically tailored for treating ADHD might be more effective than the commonly used CogMed™ approach.

As an extremely common mood disorder, depression is a global phenomenon. It can be crippling in nature and has very high present and projected costs for society (Sobocki et al., 2006). Depression is also associated with impairments in working memory (Rose and Ebmeier, 2006), possibly due to constant inference to normal functioning from negative material (Joormann and Gotlib, 2008).

In a study to observe the effects of working memory training on rumination (a common symptom of depression), Onraedt and Koster (2014) found that 6 days of working memory training

did not have a measurable effect on measures of depression. In another recent study Wanmaker et al. (2015) did not find any positive effect of working memory training on measures of depression, anxiety and rumination.

Even though these two studies did not show any alleviation of disease symptoms, it may be premature to assume the inefficacy of working memory training to treat depressed individuals. If intrinsic motivation plays a mediating role in guiding the efficacy of working memory training, it is plausible to suggest that the lack of positive effect in depressed patients could be due to a lack of motivation, a lack of interest being a key part of depression. Working memory training, combined with other non-pharmacological therapies such as an exercise regime, may still hold promise.

Schizophrenia is often associated with cognitive impairments, with a majority of patients having some sort of impairment (O'Carroll, 2000). There is evidence for disturbed frontotemporal disruptions during working memory tasks in patients suffering from schizophrenia (Meyer-Lindenberg et al., 2001).

A study by Hubacher et al. (2013) found that 4 weeks of working memory training improved visual and verbal memory in patients with chronic schizophrenia. Another study by Subramaniam et al. (2014) found increased working memory 6 months after a 16 week working memory training regime. A recent meta-analysis by Li et al. (2015) found WM training activation changes in the brain of schizophrenics. These results are exciting due to the extensive cognitive impairments generally faced by schizophrenia patients and the resulting occupational and social costs.

In summary, it appears that working memory training shows promise (possibly used in a supplementary fashion to more traditional treatment options). It is possible that the effects of working memory training in treating mental disorders are mediated by factors such as intrinsic motivation, which may in turn limit effectiveness in disorders characterized by a lack of motivation, such as depression. In conclusion, much research remains to be done, but, at present, working memory training seems to have great therapeutic potential.

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