

Working Memory Training as a Treatment of Post-Traumatic Stress Disorder

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ABSTRACT

People affected by Post-Traumatic Stress Disorder (PTSD) often suffer from emotionally-intrusive thoughts that marginalize working memory capacity and limit attention. Working memory training emphasizes developing attentional control skills to reduce these negative symptoms. Increased attentional control is, therefore, reflected in the ability to filter extraneous information and improve cognitive functioning. When used as a treatment for PTSD, participants may develop the ability to ignore irrelevant threat-stimuli and become more effective at goal-oriented activities. Further, participants are better able to hold information in working memory and manipulate it to reach a specified goal. Developing better attentional control increases the availability of cognitive resources, ultimately reducing the intrusive thoughts that often plague people with PTSD.

Keywords: Working Memory Training (WMT); Post-Traumatic Stress Disorder (PTSD); Attention control; Cognitive control; Emotional memory; Anxiety

INTRODUCTION

Post-Traumatic Stress Disorder (PTSD) is characterized by re-experiencing aspects of a traumatic event [1]. The emotionally-intrusive thoughts associated with PTSD often marginalize working memory capacity and limit attention [2]. Therefore, working memory training focuses on increasing attentional control by improving the ability to filter irrelevant information and disengage from failed hypotheses when problem-solving [3].

In general, those with high working memory capacities demonstrate better attention control, which is reflected in the ability to filter information and selectively engage in task-relevant information [3]. Applied to PTSD, research is beginning to demonstrate that improved attention control increases the ability to filter intrusive thoughts and disengage from emotionally traumatic information [4]. The result is often reduced symptoms and improved cognitive functioning [5].

The following paper will discuss working memory training and attention control. Further, standard methods of training working memory will be examined. Additionally, this paper will consider the current research related to PTSD and the implications from the research for related disorders, which is currently more abundant. Finally, the implications for use

specifically in veteran populations will be examined as a potential prophylactic measure to reduce the onset of PTSD or as a complementary treatment option for current PTSD therapies.

LITERATURE REVIEW

Post-traumatic stress disorder

PTSD affects between seven and eight percent of Americans adults, according to the National Center for Post-Traumatic Stress Disorder (PTSD: National Center for PTSD, 2019; Larson et al., 2019). In combat veteran populations, this number is even higher, as many as 20% (PTSD: National Center for PTSD, 2019). PTSD is recognized as clusters of symptoms with prominent features overlapping with anxiety and depression [1].

Additionally, the occurrence of intrusive thoughts is often reported as one of the most distressing aspects of PTSD. Like anxiety, people experiencing PTSD symptoms are more likely to focus attention towards threatening stimuli [6,7]. Further, people with PTSD are more likely to perceive a threat disproportionately. The interference often results in impaired occupational functioning [6].

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In the Veterans Health Administration, behavioral treatments are the primary method of treatment for PTSD (PTSD: National Center for PTSD, 2019). However, given the level of stigma surrounding mental health care in military populations and the reported barriers to care experienced by veterans warrant examination of alternative treatment modalities [1,8]. Additionally, emerging research has demonstrated a link between working memory training and attentional control. The relationship between these factors supports a developing alternate pathway to treatment [2,9]. Therefore, it is vital to continue the empirical examination of new treatment methods that can better serve the veteran community.

Neurocognitive effects of PTSD

Neurocognitive impairment has been widely recognized across multiple domains as associated with PTSD. Moreover, impairments in verbal memory and executive functioning are increasingly associated with PTSD [10]. Such deficits have been attributed to hyperactive amygdala functioning combined with decreased functioning of the medial prefrontal cortex in trauma-exposed people with PTSD [10].

Several recent studies have begun examining the relationship between executive functioning and psychosocial and occupational functioning. Disruptions of working memory and attention control have become a particularly important area of study for PTSD due to the relationship between attention control and intrusive cognitions [2,9]. Furthermore, deficiencies in working memory are significantly related to poorer functioning and lower global intelligence levels, which can be disruptive at the community level [7].

Attentional control theory

Attentional control theory offers that anxiety influences cognitive functioning by impairing attentional control. Attentional control is comprised of top-down and bottom-up information processing. When attentional control is intact, goal-oriented information is selectively prioritized and maintained in working memory, while, extraneous information is ignored [4,11].

Anxiety impairs the attentional control system by reducing top-down processing, resulting in increased bottom-up biased attention. In other words, bottom-up processing is reflexive and threat oriented and becomes overly present when top-down processing is inhibited. Therefore, biased attention is given to threat-provoking stimuli, leaving the experiencing person less able to filter extraneous information [4,11]. Consequently, anxiety heightens the perception of threat and shifts attention away from task-relevant information.

Additionally, attentional control theory offers that inability to filter irrelevant information reduces working memory ability and increases vulnerability to cognitive impairment. Moreover, some researchers posit that the relationship between working memory deficiencies and anxiety disorders are cyclic [11]. Thereby, impaired working memory capacity reduces the ability to filter threat-provoking stimuli, leading to increased anxiety.

Alternately, anxiety produces attentional bias to threat-provoking stimuli that strain the cognitive resources needed to maintain homeostasis between top-down and bottom-down processing. Thus, leading to a reduction in working memory function. Therefore, the interplay between anxiety, working memory, and attentional control entraps people into a cycle of cognitive impairment that biases negative thinking [4,11].

Working memory

Working memory is defined as the area of cognitive functioning that allows for temporarily storing and manipulating information while performing cognitive tasks [3,12]. While some researches consider working memory in terms of short-term memory, others view working memory as an independent system [12]. Despite this disagreement, researchers agree that working memory is designed to process task-critical information [12].

Further, working memory capacity is considered limited to between seven and nine pieces or "chunks" of information in typically functioning adults [3]. When information cannot be filtered and subsequently disengaged from, task-completion is hindered [5]. Therefore, a failure to disengage or filter intrusive stimuli reflects the deficit in attentional control.

Working memory training

To combat the limits of working memory, working memory training consists of tasks designed to increase a person's working memory [13]. As a central aspect of intellectual ability and general functioning, impairments in working memory have significant consequences on the experiencing individual. [4,13]. Ongoing research is increasingly examining the effects of working memory training for several interest areas.

Currently, the most prevalent areas of research on this topic concern the influence of working memory training on fluid intelligence, and attentional control [14]. Further, increased interest has led to several promising findings for symptom reduction in anxiety disorders [6,15]. Most frequently, training is administered through computer-based software, making training affordable and accessible in a variety of settings [4,13]. To address weaknesses in working memory, researchers have focused on three primary types of training.

n-back training

n-back training is characterized as a neurocognitive performance task [4,13]. The n signifies the number of items back that need to be recalled after being presented with an informational sequence during each trial [4]. During a 2-back task, the participant would be asked to recall the item presented two positions prior [12]. In working memory training, the n-back task is often administered in rounds, with difficulty increasing as the training advances [13].

Dual n-back training

More common in working memory training for attention control is a variation of the n-back task termed the dual n-back [1]. A dual n-back includes the presentation of two stimuli, one

task for completion and another set of irrelevant information to be ignored. In this instance, the stimuli may be auditory, visual, or a combination of the two [11]. In working memory training geared toward developing attention control, participants are presented with sequential information while simultaneously being presented a neutral-balanced image. Participants are then prompted to recall specific items.

Furthermore, working memory training for anxiety, PTSD, and other disorders have altered the standard dual n-back procedures to include emotionally evocative images, dubbed affective working memory training [13]. For example, participants are asked to recall previously learned information while being exposed to negative stimuli. By introducing an emotionally charged image, researchers are better able to understand the specific characteristics of threat information processing.

Attentional control theory and n-back training

Building on Attentional Control Theory, people with higher state anxiety levels dedicate more cognitive resources to processing threat information [3,11]. Therefore, impaired attention control results in the inability to filter irrelevant threat information inhibiting the person from completing the presented task [11]. The impairment subsequently results in impaired occupational and social functioning. Accordingly, the goal of n-back and dual n-back training is to increase the ability to filter information entering working memory to allow for more effective task processing.

Attention control treatment

Attention control treatments are designed to teach participants to ignore threatening stimuli and attend to the current task being completed [2]. Similar to n-back training, attention control treatments are delivered through computer-based programs. Further, in attention control treatment, participants are presented with pairs of faces demonstrating different emotional expressions, while being asked to identify a target probe appearing on the screen. To complete the task successfully, the participant must ignore the images and attend to the target probe [2].

Attentional bias modification treatment

Attentional bias modification treatments closely mirror attention control treatments. However, when the probe is presented, it is in the location of the neutral-valanced image [2]. By presenting the probe in this location, the participant is training to focus attention away from the threatening stimuli [2].

Whereas, in attentional control training, the probe is presented equally between neutral and emotional stimuli [2]. Additionally, attention control training requires active engagement with the stimuli and cognitive discrimination from the participant, to identify a feature of the probe [2]. Conversely, attentional bias modification treatment elicits total disregard of the emotion-provoking stimuli. Once control of attentional bias can be exerted, attentional control skills can be applied to other cognitive tasks.

Working memory training skills transfer

Learning transfer is generally understood in two ways, near and far [3]. Near transfer is the idea that learned skills and knowledge are applied equally between the training task similar activities, every time the learned skill is used [3]. However, in working memory training, learning transfer remains poorly understood. Furthermore, research on executive functioning and fluid intelligence has resulted in mixed findings on the occurrence of near transfer [3].

Nevertheless, near transfer effects for working memory training have been detected in several populations and indicate promising outcomes to increase attentional control [4]. Still, like the research on fluid intelligence, other researchers have found little to no transfer effect, suggesting that the skills are limited to the training activity. Consequently, the presence of improved task-specific training performance in the absence of near transfer to other tasks denotes a potential lack of utility for working memory training.

It appears that these mixed results may be related to the population of participants. Covey and colleagues suggest that outcomes of working memory training in typically developed populations indicate a lack of effect. Further, other researchers have conveyed similar findings that transfer effects are significant in atypical functioning people, namely, those with anxiety or worry related symptoms (PTSD: National Center for PTSD, 2019). Clearly, the mechanisms of change remain poorly understood.

Alternately, far transfer is the application of skills and knowledge to reasoning and cognitive tasks that differ substantially from the training activity. In research assessing the effects of working memory training on fluid intelligence, researchers have found little evidence of far transfer. Although some studies have indicated that working memory training does carry implications for skills transfer to more complex reasoning tasks. The connection is believed to be linked to the relationship between working memory capacity and fluid intelligence [14].

Furthermore, far transfer has not been widely observed in working memory research focused on symptom reduction for PTSD and anxiety disorders [14]. However, this area research is still in its infancy, and the potential effects of working memory training on complex reasoning ability are poorly understood. Continued research on far transfer after working memory training remains vital to understanding the change mechanisms associated with learning transfer effects.

Reduction of PTSD symptoms

The goal of working memory training is the reduction of distressing symptoms. Most notably, has been the reduction of intrusive thoughts as measured by self-report questionnaires [2, 3,13]. As a result, researchers have begun to increase focus on understanding the cognitive mechanisms behind recurrent intrusive thoughts in anxiety-related disorders. While research is still limited for PTSD, research on anxiety extended easily to the overlapping symptoms shared with PTSD.

Often, the most distressing symptom of PTSD is intrusive thoughts (PTSD: National Center for PTSD, 2019). Working memory training targets these thoughts passively through building working memory capacity. It has been suggested that the results of training extend to attentional control through practice and repetition. Over time, the participant becomes more efficient at filtering out extraneous information that evokes negative or fearful emotions, though, the transfer process remains unclear.

Intrusive thought reduction

To date, much of the extant research has been focused on anxiety disorders. However, due to the similarity in symptomology shared between generalized anxiety and PTSD, these outcomes are highly relevant in understanding the utility of working memory training [1,9]. For instance, a recent study conducted with participants exhibited high-levels of worry found that working memory training using the dual n-back paradigm results in the reduction of worry related symptoms.

Additionally, a recent meta-analysis concluded that these results are likely attributable to the link between anxiety and impaired working memory capacity [15]. Further, working memory training is positively associated with increased attentional control ability. Thereby, attentional control growth frees up cognitive resources to filter information and complete goal-driven tasks, thus, reducing distressing symptoms [4,16].

PTSD specific research

A review of the recent literature on working memory training for the reduction of PTSD symptoms revealed mixed findings. Several studies reported positive outcomes for working memory training in PTSD populations. Most often, PTSD symptoms were measured by self-report questionnaire, pre and post-treatment. Working memory training consisted primary of affective dual n-back tasks, administered over 15-20 sessions.

Overall it appeared that post-treatment symptom reduction had occurred. Dual n-back participants reported greater overall gains and higher levels of symptoms reduction. However, significant results were often noted in the PTSD control group when included. Interestingly, several researchers illustrated that when a PTSD control group was included and administered 1-back training program, participants showed similar improvement. Therefore, it is challenging to ascertain a full understanding of change mechanisms in question.

Finally, while the vast majority of the research appears promising, a few studies have found no change or levels of change below significance in working memory capacity and symptom reduction. Moreover, continued investigation into the skills transfer process is warranted to disambiguate the mixed findings. Therefore, it follows that any working memory training may be influential in working memory capacity and attention control. Conversely, the same outcome was not reported when healthy-trauma exposed controls were used.

Clinical implications

There has been some indication that lowers working memory pre-trauma exposure may represent vulnerability for the development of certain psychological disorders, namely, PTSD and anxiety [17]. Deficits in cognitive control are well documented in PTSD research. Likewise, chronic re-experiencing of symptoms is a defining feature of PTSD and is associated with proactive interference information recall due to the intrusion of distressing thoughts [17].

Further, research supports the positive relationship between attention control, the ability to suppress intrusive thoughts, and working memory performance in healthy controls [13]. It extends that working memory training mediates the suppression of intrusive thoughts by developing attentional control abilities. Therefore, it may be possible to use working memory training as a preventative measure to reduce the development of anxiety and PTSD.

Combat veterans have the highest rates of PTSD in the US (PTSD: National Center for PTSD, 2019). Military members are regularly exposed to combat trauma when deployed and often return with severe mental health concerns. Pre-deployment screenings have been useful for tracking the progress and development of traumatic brain injury, but to date, there are no measures in place to prevent the development of PTSD (PTSD: National Center for PTSD; Larsen et al., 2019).

Future research should consider the implications of pre-screening military members for vulnerability for developing PTSD. Given the connection between working memory capacity and attentional control, assessing cognitive functioning offers one step towards identifying risk factors. Further, once risk factors are identified, implementation of training designed to develop cognitive processing skills may offer increased resiliency and reduced rates of mental disorders affecting military personnel.

Another area of interest involves using working memory training as a complementary training program in addition to traditional treatment protocols. Returning to the previous example, veteran populations report significant barriers to care and may not be well served by the current mental health care system. Further, transient populations, such as military members, would likely benefit from the accessibility of computer-based training.

In addition to military and veterans, several other vulnerable populations may benefit from working memory training [4]. Rural populations, for instance, are routinely underserved but no less affected by trauma and anxiety. Understanding the potential mediating factors of working memory training on executive functioning and symptom reduction in underserved populations offers an interesting avenue for future research.

Currently, research is limited, discussing the comparison of working memory training to augment traditional treatment approaches. McDermott and colleagues (2016) posited that the reduction of intrusive thoughts associated with PTSD after participating in working memory training is highly supportive for further empirical study. Research should continue to explore

the various applications of working memory training as a preventative measure.

DISCUSSION AND CONCLUSION

In sum, the extant research is supportive of working memory training as a treatment option for PTSD. Although working memory training remains an emerging area of research, the potential to positively impact many populations and increase the efficacy of current treatment protocols for PTSD and related disorders is clear. Regarding combat exposure, the idea that a prophylactic measure could be established to help reduce the onset of PTSD is exciting. Eighteen years of war has left an entire generation scared by combat-related trauma. Ongoing conflict will continue to scar the next generation of veterans and increase the need for preventative action to minimize the aftermath of war. Continued research into new screening strategies and protective measures may offer the best solution to a population in crisis.

DISCLOSURE OF INTERESTS

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