

POST-TRAUMATIC STRESS DISORDER: AN OVERLOOKED LEARNING IMPAIRMENT?

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ABSTRACT

Recent research indicates that Post-Traumatic Stress Disorder (PTSD) alters the way a person perceives information, learns from it, and uses it in future situations. The following literature review investigates learning-related impairments recently found in PTSD individuals. The reviewed studies indicate that a learning impairment is indeed present, in the form of information encoding and acquisition problems, prospective memory impairments, and inefficient working memory. These findings are considered in relation to the first-line treatment for PTSD, as well as the occupational and social functioning of the individuals. This review highlights the importance of recognising the discovered difficulties, with hope that it will promote a better understanding of the struggles experienced by PTSD patients. Implications for future research are discussed.

INTRODUCTION

PTSD and the Diagnostic Criteria

Post-traumatic Stress Disorder (PTSD) is a psychiatric disorder that may develop after experiencing a traumatic event involving death, a life-threatening situation or a serious injury (American Psychological Association, 2013). Such events include combat, assault, natural disaster and incidents in which the person was threatened, or witnessed someone else under extreme stress. The reported lifetime prevalence of PTSD varies worldwide, from 0.3% in China to 6.8% in the United States (Kessler & Ustun, 2008). In the United Kingdom, a recent meta-analysis of war veterans estimated PTSD prevalence to be 4.8% (Iversen et al., 2009). By and large, higher PTSD prevalence has been reported in countries with higher risk for trauma (e.g., tsunami in Sri Lanka, see Dorrington et al., 2014) and in war veterans (Scott et al., 2015).

PTSD has been a classified disorder in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) since 1980, which is widely used by Psychologists and Psychiatrists to establish a clinical diagnosis. The current DSM-5 (APA, 2013) contains eight criteria for PTSD, which must be present for at least one month. These include re-experiencing the traumatic events (e.g., via intrusive thoughts, nightmares), avoidance of trauma-related stimuli, extreme negative thoughts or feelings after the trauma, and extreme trauma-related arousal and reactivity (Palmary, 2016). While many people exposed to trauma are likely to experience such symptoms for a few days after the event, people suffering from PTSD maintain these symptoms for months, even years after the incident (Scott et al., 2015). Experienced symptoms have a significant impact on a person's life, and often negatively affect their social or occupational functioning.

Treatments for PTSD

The first-line treatment for PTSD is Cognitive Behavioural Therapy (CBT) (National Institute of Care and Excellence, 2016 in Clark et al., 2011). The therapist using CBT would commonly investigate the negative automatic thoughts that form one's understanding about oneself, the world and the future, and help each client construct a more positive life approach (Hinton et al., 2015). In this way, CBT primarily allows the individual to form more rational responses to negative thoughts (Shnaider et al., 2012). This is usually achieved through weekly meetings and homework. This intervention is very popular due to its straightforward approach, clear structure and short duration; however, some practitioners are recently becoming more sceptical of its effectiveness (Clark et al., 2011). Other interventions, such as eye movement desensitisation and reprocessing, that help to alleviate the distress by accessing and processing the traumatic memories, have also been successful (Andrewes, 2017); nevertheless, CBT remains the primary treatment to date.

Brief Aetiology of PTSD

There are many theories that attempt to understand the aetiology of PTSD on a neurological level. One of the most researched theories proposes that PTSD develops as a result of a decrease in brain volume in the part of the brain called the hippocampus, which is responsible for the formation, organisation and storage of memories along with the sensations and emotions linked to them (Van Rooij et al., 2015). This theory is termed the glucocorticoid-stress model (GSM), and suggests that exposure to traumatic events elevates the levels of the stress hormone glucocorticoid, which is toxic to the hippocampus (Sapolsky, 2000). It is suggested that as the neural circuit between the brain and the hippocampus becomes impaired, it creates various problems, such as the appearance of intrusive negative thoughts and flashbacks. This theory remains strong, as the impairments

that PTSD individuals experience because of their disorder, such as memory problems and faulty thought-control, are closely related to hippocampal malfunction (Kaouane et al., 2012). However, it remains unknown whether a small hippocampus is a pre-existing risk factor or a post-trauma alteration, which complicates scientists' understanding of the disorder and possible treatments (Sapolsky, 2000). Other theories have also proposed that impaired attention control and hypervigilance could be potential causes and maintenance factors of PTSD (Blair et al., 2013; Niam et al., 2015). Thus, the existence of various theories makes PTSD a puzzling psychological disorder (Mikics et al., 2008).

PTSD AND LEARNING DIFFICULTIES

Although many studies have identified various memory and learning related difficulties that follow PTSD, research has surprisingly neglected to investigate a direct link between the impairments and a learning disorder as a result of PTSD. This poses a problem because many up-to-date interventions and occupational settings directly rely on learning, which, if impaired in PTSD individuals, leads to ineffective treatments and unsuitable conditions for them. Unfortunately, to date, this has failed to be addressed by researchers and practitioners.

The first and only study that drew a parallel between PTSD and learning emphasised that memory impairments documented in PTSD resemble a learning disability (Levy-Gigi et al., 2012). The authors argued that PTSD patients' inability to correctly use their knowledge when the situation requires it, is the main contributor to the learning impairment. Levy-Gigi and colleagues' (2012) study was the first piece of research to highlight the need to further investigate learning difficulties in PTSD, as they appear to be overlooked in clinical, occupational and social settings and also significantly diminish the effectiveness of existing interventions. For example, the guidelines for clinical practitioners of the United Kingdom, such as from the Scottish Intercollegiate Guideline Network (SIGN) and National Institute for Health and Care Excellence (NICE), fail to consider the various learning impairments and encoding deficits related to PTSD when recommending treatments (Clark et al., 2011). As such, many practitioners might be unaware of their patients' difficulties and might thus fail to tailor their treatment accordingly. A similar lack of understanding is also present in occupational settings, such as jobs and universities, which can have a significantly negative impact on PTSD individuals' performance, self-esteem, motivation and social functioning. The lack of appropriate help could be one of the reasons PTSD individuals develop maladaptive behaviours and ways of dealing with their symptoms; therefore, it is crucial to promote a better understanding of the disorder's characteristics in the clinical and occupational settings.

In line with this, the current literature review is set out to investigate the extent to which recent studies support learning impairments in PTSD. The review will specifically examine three important aspects of successful learning: encoding and acquisition of information, prospective memory performance, and working memory capacity. Moreover, this review will

highlight the importance of recognising the discovered difficulties in clinical, occupational and social settings. There is hope that this review will promote a better understanding of learning and memory related difficulties in PTSD, and that it will bring more attention to the matter and highlight its potential as a promising research topic.

METHODOLOGY

A computer-based search was performed on Google Scholar, Web of Knowledge and PSYCinfo. A total of six studies published between 2010 and 2016 were identified for the current review. See *Appendix 1* for exclusion criteria and a summary of the selected studies.

WHAT DOES RECENT LITERATURE REVEAL ABOUT PTSD AND LEARNING?

PTSD Individuals are Unable to Control What They Learn

Something as simple as remembering or forgetting appears to be a difficult task for PTSD individuals. Such a lack of control over information has been linked to a learning impairment, as the inability to selectively control the encoding of information has been repeatedly identified in PTSD patients (Cottencin et al., 2006). The said individuals appear to be unable to differentiate between automatic or intentional learning and often forget what they are supposed to remember, and remember what they are supposed to forget. Previous studies that investigated the forgetting of items in PTSD patients have shown that they have trouble with intentional memory (Cottencin et al., 2006), and with the recall of positive and neutral items (McNally et al., 1998). Studies have suggested that this relates directly to unwanted intrusions and flashbacks, which characterise the disorder and inhibit successful encoding (Nemeroff et al., 2006; APA, 2013). However, recently these symptoms have been brought up as evidence for inefficient learning and an information processing impairment in PTSD (*see* for review Acheson, Gresack, & Risbrough, 2011; Brewin, 2010).

One such recent study investigated PTSD individuals' ability to intentionally forget certain stimuli (Zwissler et al., 2012). The participants were firstly presented with a direct forgetting paradigm (Basden & Basden, 1998), which contained various photos and instructions to either remember or instantly forget the presented photo. Upon finishing this paradigm, the participants were presented with a recognition test that included previously introduced photos and others which were thematically similar. The results indicated higher recognition of 'forget' items, than 'remember' items, and false recognition of thematically similar photos. The authors suggest that PTSD individuals' inability to segregate 'forget' and 'remember' photos might have occurred as a result of faulty initial encoding which contributed to impaired rehearsal of the stimuli. Thus, Zwissler and colleagues' (2012) study highlights PTSD individuals' impaired ability to remember and effectively learn new information intentionally, as the individuals lacked appropriate control over their learning.

Interestingly, the results also provided evidence for a strong influence of emotions on 'forget' or 'remember' items. The participants who provided higher arousal ratings from the photos made more errors on the recognition task. A possible explanation for this is an accidental emotional encoding occurring at the initial presentation of the stimuli, prior to the induction of 'forget' or 'remember' cues, which was shown to occur for the PTSD but not for healthy subjects (Zwissler et al., 2012). The authors suggested that this is compatible with the notion of 'thought intrusions', often involved in the aetiology of PTSD. Specifically, the incidental encoding might appear as a result of 'intrusive' thought processing during the pre-cue interval. The idea of enhanced encoding of arousing information has also been supported by other studies investigating aversive stimuli perception in PTSD (Bryant et al., 2008; Vythilingam et al., 2007). In other words, PTSD individuals appear to experience an involuntary bias towards certain stimuli that are arousing, and hence lack appropriate control over the acquisition of the material intended to be learned. It is therefore possible that certain interventions, such as CBT, which rely on learning, need to be revised for PTSD individuals to achieve greater effectiveness.

A Struggle to Apply Newly Learned Information to Future Situations

Recent research also suggests that the ability to apply previous knowledge to new situations might be impaired in PTSD individuals (Levy-Gigi et al., 2012). Specifically, they may fail to appropriately encode the context in which the information was learned. Such a deficit in the so-called contextual encoding might lead to problems with later memory retrieval, in the form of inappropriate generalisations of past learning to novel events. Levy-Gigi and colleagues (2012) investigated this in their recent study through the use of a computer-based task where PTSD individuals were asked to generalise previously learned outcomes to new situations.

In the first phase of the task the participants acquired new information, where they simultaneously viewed three sets of stimuli (a face and two coloured fish) and learned by trial-and-error, which fish belonged to which face. In the second phase, the participants were tested on all previous fish-face association and new fish-face trials without feedback, to trace how well they were able to generalise their knowledge from phase one. The results showed that PTSD participants had a higher amount of generalisation errors than controls, indicating a poor learning performance. However, culture, gender and IQ could not better explain the results of the study. Thus, the authors suggested that the underlying problem of impaired generalisation learning showed by the PTSD subjects was a hippocampal deficit (Levy-Gigi et al., 2012).

Although the study did not directly investigate the hippocampal networks, the Acquired Equivalence Task used in this study was established as a reliable tool for measuring hippocampal activity (Myers et al., 2003). As such, Levy-Gigi et al., (2012) managed to connect the GSM model to the learning deficit, and revealed that PTSD individuals experience an underlying learning impairment due to a malfunctioning hippocampus. The deficit was shown to inhibit

them from fully integrating learned information and from successfully applying it in future situations. These findings are crucial for the development of better interventions and rehabilitation techniques for PTSD individuals, and need to be considered by the clinical sector.

Impaired Working Memory

PTSD individuals also appear to suffer from impaired working memory (Shaw et al., 2009), which is an essential cognitive process that underlies most learning and is crucial to PTSD individuals' daily functioning. Working memory is responsible for the encoding, maintenance and retrieval of temporary information (Baddeley, 2003). Honzel, Justus and Swick (2014) investigated working memory in PTSD individuals under single and dual-task conditions. Of particular interest to this review was PTSD individuals' performance on the dual-task condition. That is, because the nature of the tasks is considered to relate to peoples' daily duties at work and at universities, where some information must be mentally maintained, while another task is performed (Allen et al., 2009; Sebastian et al., 2013). The results of the study showed that there was a significant decrease in retrieval accuracy in the PTSD group when the dual-task conditions were performed, but not during the single task. More specifically, a multitasking deficit was observed as the second task was introduced. The authors suggested that the PTSD patients struggled to maintain information when asked to divide their limited executive resources between the two tasks, which caused multitasking problems and subsequent working memory failure.

Interestingly, when the activity of the brain was measured using electroencephalography (EEG), data from the study indicated that the working memory deficit was attributed to inefficient frontal and parietal brain networks (Honzel et al., 2014). This notion is in line with other studies showing impaired working memory in individuals with damage to these very areas (Thompson-Schill et al., 2002). Therefore, the overall brain functioning of PTSD individuals appears to be impaired to a similar degree as in patients with brain injuries. This highlights the importance of investigating PTSD related memory deficits, as they appear to be caused by brain-related malfunctioning, beyond the psychological trauma. Moreover, the study suggests that PTSD individuals' daily performance, whether in a social or occupational setting, may be negatively affected due to an impaired ability to store information in working memory (Miyake & Friedman, 2012). Therefore, the current findings are crucial for a better understanding of impairments that PTSD individuals experience every day.

In another study, Zhang et al., (2013) investigated the role of emotions on the working memory of PTSD individuals, since emotional negativity is considered to be a significant part of the disorder. The researchers concluded that working memory was impaired in PTSD patients due to the presence of negative emotions, which served as distractors. In the study, the participants were asked to perform a three-step working memory task involving memorisation, distraction (negative or neutral images) and retrieval. The task was performed under a functional magnetic resonance imaging (fMRI), and the neural

activity was recorded. The results indicated that PTSD individuals were significantly more distracted by the negative images, which showed to negatively affect their working memory performance. The findings were supported by a higher activation of emotion-processing brain areas in the PTSD group, such as the fusiform gyrus and the amygdala. Additionally, it was noted that unlike healthy individuals, the PTSD patients failed to invoke compensatory mechanisms that could regulate their brain activity in the presence of negative stimuli, contributing to poorer performance. Moreover, the authors highlighted that PTSD individuals were unable to inhibit emotional distraction, unlike controls, which indicated further problems with working memory encoding. This study helps to understand that working memory is a significant cognitive process related to information acquisition that appears to be impaired in PTSD and can cause serious learning problems in their daily life.

Moreover, other recent research by Schweizer & Dalglish (2011) showed that PTSD individuals struggle to employ working memory in emotion-related contexts. In their study, the participants were required to remember a small amount of neutral words, while simultaneously processing sentences containing either trauma-related or neutral thoughts. As hypothesised, the PTSD group showed impaired working memory when faced with trauma-related sentences, but not while coming across neutral sentences. The authors argued that the noted impairments reflect everyday difficulties for PTSD individuals in carrying out tasks when encountering emotional distractions. While it was not entirely clear whether the negativity of the information, its arousal-inducing content or its self-relevance was critical to the impairment of working memory in this study, the findings nonetheless provided evidence for impaired encoding in the presence of emotional distractors among PTSD patients. These findings need to be seriously considered by occupational therapists, to ensure that PTSD individuals receive appropriate help in their social and occupational undertakings.

Impaired Prospective Memory

The struggle that PTSD individuals' encounter remembering to complete certain daily tasks reveals problems with prospective memory, which is crucial for successful everyday functioning and learning. Recent research has been extended to investigate prospective memory (PM) encoding in PTSD (McFarland et al., 2016). PM is the ability to remember to complete an action in the future (Vedhara et al., 2004), that could involve remembering a deadline, preparing for a meeting, or running an errand (Smiths, Deeg, & Jinker, 1997). There are several reasons to believe that PM may be impaired in PTSD patients. Firstly, PM is processed in the hippocampus and the medial prefrontal cortex, and the former has consistently been involved in the aetiology of PTSD (Adda, Castro, Alem-Mar e Silca, de Manreza, & Kashiar, 2008). Decreased activity in the hippocampus could therefore impair PM in PTSD individuals (Rauch et al., 2006). Secondly, PTSD has been associated with impaired retrospective memory and inhibitory processing (Johnsen & Asbjornen, 2008; Diener et

al., 2010), which are both critical for PM since they constitute one's memory (Schnitzpahn et al., 2013). The impairment of PM in PTSD could have very serious effects on the everyday functioning of individuals, and their ability to remember important information (Moradi et al., 1999). Additionally, remembering and retrieving the correct information is especially important for the future use of acquired information; therefore, PM is inevitably linked to learning.

The first and only study to date that has investigated PM deficit in PTSD individuals, found that PTSD patients had difficulties completing tasks that required PM (McFarland et al., 2016). The researchers used a PM paradigm in order to simulate everyday tasks in which participants would be required to interrupt an ongoing task, in place of another (e.g., remembering to take medication while doing laundry). The task was computerised and consisted of event-based and time-based trials, where the participants engaged in an ongoing distractor task that required periodic interruption to trigger the PM (Kelemen et al., 2006). The results of the study indicated a negative correlation between PTSD symptoms and PM performance. In particular, the PTSD symptom clusters (hyperarousal, re-experiencing and avoidance) contributed to the PM impairment, while attention and age did not significantly relate to the PM performance.

The authors suggested that the reduced PM performance in the PTSD group might have occurred as a result of reduced inhibition that caused difficulties to disengage from the ongoing task (McFarland et al., 2016). The authors also revealed that impaired working memory may have contributed to difficulties in monitoring the situation for a PM cue and therefore impaired PM execution. Indeed, previous research has indicated that inhibition and working memory appear impaired in PTSD, and these findings may suggest a complex relationship between those deficits, leading to a PM impairment (Floyd, Rice & Black, 2002). Thus, overall, the noted impairment of successful PM performance in PTSD individuals may be associated with problems engaging in efficient learning due to an impaired ability to maintain PM intentions (Cook et al., 2007). PTSD individuals may be particularly sensitive to such impairment in a learning environment, where learning constantly involves PM performance for deadlines and meetings (e.g. university, new jobs or projects) (McFarland et al., 2016). Therefore, although the current study is the first to investigate PM in association with PTSD, it provides critical implications for understanding underlying learning difficulties in PTSD individuals. More research is needed in this field, in order to explore the extent of PM influence on learning and work-related performance.

LEARNING IMPAIRMENTS IN PTSD: INFLUENCE ON TREATMENT, OCCUPATIONAL AND SOCIAL FUNCTIONING

The second part of the review is aimed at briefly investigating how the above-mentioned findings create functional problems for the individuals with PTSD. Most importantly, this section will outline how the discussed learning impairments of

acquisition, encoding, prospective and working memory, influence the effectiveness of treatment for PTSD. Additionally, the ways which the occupational and social lives of PTSD individuals might be affected due to the outlined impairments will be discussed.

Decrease in the Effectiveness of CBT

The decreased efficacy of cognitive behavioural therapy (CBT) for PTSD (Buhmann et al., 2016; Corrigan et al., 2015) might be a product of the learning impairments associated with the disorder. For example, Levy-Gigi et al., (2012) highlighted that the inappropriate generalisation of past learning to new situations might interfere with the effectiveness of cognitive therapy, particularly since CBT relies on changes in thought processes. Moreover, since CBT specifically relies on the application of learned techniques to new contexts, the therapy is likely to be ineffective for PTSD individuals due to their inability to apply learning acquired in therapy to contexts in daily life (Levy-Gigi et al., 2012). Furthermore, the observed biases towards negative stimuli in PTSD individuals might explain the individual differences in the effectiveness of CBT (Levy-Gigi et al., 2015). As such, therapies that focus on learning skills and help to re-structure negative processing may perhaps be more successful for PTSD individuals. Overall, these studies have highlighted several problems with learning and information processing in individuals with PTSD that need to be taken into consideration when recommending and choosing a treatment for a patient with this condition.

Furthermore, CBT falls out of favour when considering recent evidence for problems with prospective memory (McFarland et al., 2016). Since weekly homework is a large part of the therapy, it is crucial that the person receiving the therapy must have a good prospective memory, to fully benefit from the intervention. However, as recent findings demonstrate, PTSD individuals experience troubles with prospective memory performance (McFarland et al., 2016), and might therefore not benefit from the structure of CBT. This could be an important factor to consider when recommending or implementing CBT as a first-line treatment for PTSD, however, recent NICE guidelines for PTSD treatment do not report this information (Clark et al., 2011). Therefore, it is important to emphasise the demand for novel approaches towards the treatment of PTSD as well as the inclusion of recent research finding in NICE and SIGN clinical practitioner guidelines.

Other deficits in learning, such as difficulties with multitasking in the presence of negative stimuli, the inability to fully utilise working memory and to successfully store information long term, can all be relevant for various aspects of psychotherapy. For example, a recent study has shown that interventions such as memory training and transcranial direct current stimulation (tDCS), which has been used as a tool for cognitive enhancement, improved cognitive and emotional abilities in PTSD (Saunders et al., 2016). Subsequently, improved learning, hypervigilance, and concentration were also observed as a result of the interventions. Most importantly, the study highlighted that the expertise required to find and implement the right treatment lies in the ability to firstly understand various impairments in PTSD. Thus,

possessing the knowledge about the learning difficulties in PTSD is crucial for an improvement in relevant psychological interventions. As such, it remains surprising that, to date, limited attention has been brought to these learning impairments in PTSD.

Recent research has indicated that learning impairments in PTSD cannot be neglected and that they are not just a by-product of the disorder. By bringing more attention to these impairments, researchers could provide ways to improve current treatments and guidelines for PTSD. This could help to achieve more efficient interventions, and save significant resources. For example, testing for learning impairments in PTSD could help clinicians to better detect and understand individuals who might not respond to traditional treatments. As a result, hospitals could avoid unnecessary loss of resources. Therapy effectiveness could, for example, be investigated through an analysis of generalisation patterns in patients, which could help to investigate PTSD severity, as suggested by Levy-Gigi and colleagues (2012) in their study, and hence help to provide more targeted treatment. In fact, recent studies investigating impairments in PTSD are not short of suggestions for improvement that could benefit PTSD individuals and the society. Hopefully, future studies will place more importance on meaningful implications of these research findings and attempt to apply them in clinical settings.

Occupational and Social Functioning Problems

The noted problems with generalisation of past information to new contexts are especially troublesome in occupational and social settings for post-trauma individuals (Levy-Gigi et al., 2012). That is because PTSD individuals may generalise their past learning to wrong contexts, times or places in the future, as evident by Levy-Gigi and colleagues' (2012) research. Such impairment could not only contribute to the maintenance of PTSD and learning impairments, but also to functional difficulties. This could be particularly troublesome in a working environment, where retrieval and correct application of learned information is crucial. In addition, the noted impairment could make education particularly difficult for individuals with PTSD. This is in line with recent reports indicating a high drop-out rates of young veterans at universities (Marcus, 2017). Thus, learning impairments in PTSD should be emphasised in order to create a more inclusive working and learning environment for individuals who suffer from the noted difficulties.

Moreover, impaired social and occupational functioning is highly likely to appear in PTSD patients due to their observed deficits in various memory-related domains. Since inefficient memory encoding might take place in the everyday life of PTSD individuals, it can create problems in meeting deadlines, remembering meetings at work or getting together with friends and family (McFarland et al., 2016). The inability to perform well on such tasks, might contribute to negative thoughts about oneself. Research shows that negative changes related to the perception of oneself, contribute to a greater risk of maintenance and enhanced symptoms of PTSD, even after initial symptoms are controlled for (Woodward et al., 2015). It is, therefore, important to identify problems that occur as a

side effect of impaired encoding and acquisition in post-trauma patients. Additionally, ways to deal with the impairments need to be established in order to protect PTSD individuals from falling into a vicious cycle that can worsen their condition.

CONCLUSION

Recent studies reveal that PTSD possesses characteristics that are similar to a learning impairment. Specifically, research indicates that PTSD alters the way a person processes information, learns from it, and functions in an environment that presents it. In the current review, the investigated impairments in information encoding, in its acquisition, as well as in prospective and working memory, undoubtedly link PTSD to a learning disorder. This appears to be overlooked in

the clinical world, as well as in research. The only research to date that clearly puts forward PTSD as a learning disorder has been outlined in this review, alongside other relevant studies pointing in that direction. However, more empirical evidence is needed in order to identify the extent of the learning impairments presented in individuals with PTSD. Moreover, the current review suggests that the altered information processing in PTSD influences individuals' daily functioning and may be a significant factor contributing to the reportedly decreased effectiveness of CBT, and problems in occupational and social settings. Therefore, increased awareness of the learning impairments in PTSD could help to improve current interventions, decrease treatment costs, and help post-trauma patients lead a better life.

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Appendix 1: Summary Table of the Selected Studies and Study Selection Criteria

Study	Aim	Method	Results	Implications
McFarland et al., (2016)	Investigated the relationship between PTSD symptom severity and event-based prospective memory (PM).	Participants: 40 military veterans, 24-60 years old. Measures: 42 minutes PM task, and 192 multiple-choice trivia questions with embedded PM cues. PTSD: Clinical diagnosis and PTSD Checklist, Civilian Version (PCL-C)	PTSD symptoms were associated with poor PM performance. PTSD cluster C (avoidance and numbing symptoms) and D (hyperarousal symptoms) were each negatively correlated with PM performance.	Poor PM suggests problems with: <ul style="list-style-type: none"> • Working memory, inhibition and learning • Functional impairment i.e. forgetting to remember • Certain aspects of psychopharmacological and psychosocial interventions.
Zwissler et al., (2012)	Investigated direct forgetting for neutral material in severely traumatized, unmedicated people with and without PTSD.	Participants: 26 PTSD, 25 severe traumatic stress, 16-30 years old. Measures: Direct Forgetting Paradigm (photographs), followed by a recognition test. PTSD: Clinically diagnosed	Higher false-alarm rate in response to the 'remember' lures, and significantly lower recognition accuracy for remember-pictures in the PTSD group and not in the severely traumatised patient group.	High false alarm rated in PTSD suggests faulty source-monitoring, reduced inhibitory functioning. Low recognition accuracy demonstrates inefficient learning, due to encoding problems.
Zhang et al., (2013)	Investigated the impact of negative emotional distraction on working memory in patients with PTSD using fMRI.	Participants: 20 PTSD, 20 healthy controls, 18-40 years old. Measures: Three-step working memory task (memorisation, negative/neutral distraction, retrieval) under fMRI. PTSD: Clinically Diagnosed	Performance during retrieval phase was poor when it followed negative distractor. PTSD group showed higher activation in emotion processing regions.	The findings suggest that PTSD patients are somewhat unable to involve compensatory mechanism when presented with negative information. They are also unable to regulate their brain activity and perform on-going cognitive tasks in the presence of negative distractors.
Levy-Gigi et al., (2012)	Investigated the ability of individuals with PTSD from two different countries to generalize previous learning to novel situations.	Participants: Israel: 19 PTSD, 22 trauma patients. Hungary: 22 PTSD, 25 trauma patients, 5 healthy controls. Measures: Acquired Equivalence Task PTSD: Mini-International Neuropsychiatric Interview (M.I.N.I.) by clinical psychologist.	PTSD groups had a significantly higher percentage of generalization errors compared to the non-PTSD groups.	The study concludes that PTSD is not only a stress disorder but also a learning disorder. Deficits in the ability to generalise might decrease the efficacy of behavioural and cognitive therapies.
Honzel, Justus and Swick (2014)	Investigated whether working memory impairments are related to limitations in executive control.	Participants: 18 PTSD, 16 controls. Measures: Sternberg Memory Task and Arrow Flanker Task PTSD: Clinically assessed	When combining both tasks, PTSD individuals showed declines in both recognition accuracy and the event-related potential.	PTSD individuals appeared less efficient at storing the stimuli long-term, and the second task reduced their ability to successfully rehearse the encoded information. This encoding inefficiency provides deficit in learning. Working memory problems and multi-tasking problems were also present.
Schweizer and Dalgleish (2011)	Investigated whether PTSD individuals would show impaired emotional working memory capacity on novel emotional reading span task when the operation component (the sentences) was PTSD-related.	Participants: 25 lifetime PTSD, 14 current PTSD, 21 trauma. Age 17-65. Measures: Posttraumatic Cognitions Inventory, emotional working memory capacity (eWMC) task PTSD: Clinically assessed	The PTSD group showed impaired eWMC in the context of trauma-related sentences.	The study highlights everyday difficulties in carrying out routine cognitive operations due to emotionally laden thoughts, feelings and images that PTSD individuals might encounter and find distracting. Suggest that interventions for PTSD patients that can specifically tackle eWMC may be beneficial.

EXCLUDING CRITERIA

Key words such as ["PTSD" and "learning impairment"], ["PTSD" and "learning disability"] and ["PTSD" and "learning deficit"] were used to find relevant studies. The identified journals were downloaded and screened using the following excluding criteria:

- The study has been published in the past five years (2010 – 2016).
- The study is not a review or a meta-analysis.
- The study is on PTSD in adults only, with a diagnosis established for at least one full year.
- The study has been set out to specifically investigate PTSD.
- There are fairly balanced gender groups, appropriately controlled for comorbidity of other mental disorders and other confounding factors such as age and IQ present in the study.
- Studies contain a clinical assessment of PTSD.
- The study is not a computerised model or an animal study.
- The study investigates encoding or acquisition of information, working memory or prospective memory specifically in PTSD individuals.

Out of 27 initially identified studies, 6 met the above-mentioned criteria. All of them used experimental designs.