



BSc in Psychology

Cognitive function in Post-Traumatic Stress Disorder: Are deficits in memory or working memory among people with PTSD symptoms?

May, 2018

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Foreword

Submitted in partial fulfillment of the requirements of the BSc Psychology degree, Reykjavik University, this thesis is presented in the style of an article for submission to a peer-reviewed journal.

Abstract

Post-traumatic stress disorder (PTSD) is a psychiatric disorder triggered by a traumatic event involving death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence. Symptoms of PTSD include concentration disturbances in memory along with abnormalities in underlying working memory (WM). The PTSD Checklist from DSM-5 (PCL-5) was completed by 50 students during their second year of BSc study at the Department of Psychology in Reykjavík University, Iceland. There were 13 students who reached the diagnostic criteria for PTSD according to the checklist and 35 who did not. This allowed researchers to compare the two groups on WM and memory tasks. Three tasks were used, Digit Span Subtest of the Wechsler Adult Intelligence Scale (WAIS-IV) and Operation Span were used to assess WM, and Logical Memory subtest of Wechsler Memory Scale as a measure of immediate and delayed memory. Results showed no significant differences between the two groups on the WM tasks. On the other hand, a significant difference was found between the groups on the Logical Memory task. These results indicate that memory is impaired in people with PTSD while WM is intact. These findings are in concordance with studies showing memory impairments in individuals with PTSD. However, they do not support evidence for WM impairments in PTSD patients.

Keywords: PTSD, Memory, Working memory, Digit Span, Wechsler Scales, Operation span, Logical Memory, Wechsler Memory Scale

Útdráttur

Áfallastreituröskun er skilgreind sem viðbrögð í kjölfar erfiðrar lífsreynslu, til dæmis í kjölfar líkamsárásar, nauðgunar eða dauðsfalls. Einkenni felast meðal annars í því að endurupplifa atburðinn á einhvern hátt, auk þess að upplifa svefntruflanir, einbeitingaerfiðleika og að vera ofurviðbrigðin. Til þess að vera greindur með áfallastreituröskun þarf einstaklingur að sýna einkenni áfallastreituröskunar í meira en einn mánuð. Í þessari rannsókn voru 50 nemendur á öðru ári í Sálfræðideild Háskólans í Reykjavík sem svöruðu spurningalista sem metur einkenni áfallastreituröskunar (PTSD Checklist for DSM-5, PCL-5). Það voru 13 nemendur sem uppfylltu greiningarskilmerki áfallastreituröskunar samkvæmt þessum spurningalista og 35 sem gerðu það ekki. Þrjú próf voru notuð til þess að bera þessa tvo hópa saman á bæði minnis- og vinnsluminnisprófum. Þar af mældu tvö vinnsluminni, Digit Span undirpróf Wechsler Adult Intelligence Scale (WAIS-IV) og Operation Span. Þriðja prófið mat skammtíma minni og seinkað minni, Logical Memory II undirpróf Wechsler Memory Scale (WMS-III). Niðurstöður sýndu að vinnsluminni þeirra einstaklinga með áfallastreituröskun er ekki marktækt verri miðað við samanburðarhóp, sem er í ósamræmi við fyrri rannsóknir. Hinsvegar sást marktækur munur milli hópana á Logical Memory II. Það bendir til þess að minni sé skert hjá einstaklingum með áfallastreituröskun eins sem styður fyrri rannsóknir.

Are deficits in memory or working memory among people with PTSD symptoms?

Post-Traumatic Stress Disorder (PTSD) is a psychiatric disorder triggered by a traumatic event involving death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence (APA, 2013). Characteristic symptoms include re-experiencing the traumatic event, avoiding trauma-related stimuli, negative thoughts and feelings and hyperarousal. The symptoms create distress or functional impairment which are not due to medication, substance use or other illness and last for more than one month (APA, 2013). Trauma is labeled as a normal reaction to an abnormal event. In contrast, PTSD is characterized as an abnormal reaction to an abnormal event (Van der Kolk et al., 2014). Approximately 8 out of 100 people will have PTSD at some point in their lives (Kessler et al., 1995) with higher prevalence in certain subgroups, such as veterans exposed to combat (Hoge et al., 2006; Seal et al., 2007). Foremost, PTSD is associated with an enhanced recall of trauma-related information such as re-experiencing the event. Recall of information can be in many forms such as; images, thoughts, nightmares, and smells. Symptoms may also include exaggerated reactions to surprises, emotional numbness, irritability, hyperarousal, and avoiding situations which remind the individual of the traumatic event experienced (Ehlers et al., 2004). Van der Kolk et al (2014) describe these symptoms as memory imprints following a traumatic event where the past intrudes upon the present and the event negatively changes how one feels and thinks. The focus becomes on the dysfunction and distress one experiences rather than the details of the event. Crucial symptoms of the condition are distractions in memory, concentration, and cognitive speed, in other words, the speed in which a person can understand and react to visual-, auditory information or movement (Clark et al, 2003; Twamley et al., 2009). A recent meta-analysis of over 60 studies examining PTSD and its association with cognitive deficits found reliable evidence for impairment in verbal learning (i.e., immediate memory), delayed memory, attention, working memory, and

processing speed in PTSD patients (Scott et al., 2015). Interestingly, greater effects were seen on verbal learning and memory than visual learning and memory. Smaller deficits were seen in executive functions, language, visual learning and memory, and visuospatial abilities.

WM reflects our everyday functions and difficulties and has relations with important academic and functional outcomes predicting high mental abilities (Dalgelish, 2004). WM is a limited capacity system and temporarily stores information required to carry out simple and complex cognitive tasks such as problem solving, learning, comprehension and the process of thinking, for example, when reading and recalling a phone number while you dial requires working memory (Dalgelish, 2004; Engle, 2002; Baddeley, 1986). WM is typically measured using complex span tasks which include cognitive operations and short-term memory tests (Conway et al., 2005). WM span tasks, such as Digit Span subtest of the WAIS-IV and Operation Span are common measures of WM capacity and have shown to be reliable (Conway et al., 2005). Jenkins et al., (2010) reported that a PTSD group repeated fewer total digits on Digit Span backward compared to a control group who had experienced trauma but not developed PTSD. Vasterling et al., (2002) studied 26 PTSD diagnosed Vietnam veterans and 21 psychopathology-free male Vietnam veterans and explored the relationship between WM amongst the two groups. The veterans diagnosed with PTSD performed less proficiently on the Digit Span subtest. Their results also showed that PTSD veterans without mental disorders performed more proficiently than PTSD veterans with a mental disorder, indicating that mental disorders increase deficits in cognitive function among PTSD veterans.

Another cognitive factor that has been associated with PTSD is memory. A meta-analysis of nine studies from 1995 – 2003 all identified severe effects on the hippocampus in PTSD patients, a brain area critical for learning, memory and emotional memory (Kitayama et al., 2005; Bremner et al., 1995). More activations in the area have been associated with better immediate recognition memory and recollection of emotional stimuli (Machiewicz et

al., 2006). All studies showed a smaller volume on both the left and right side of the hippocampus in adult subjects with chronic PTSD (Kitayama et al., 2005). Further studies on PTSD patients have demonstrated deficits in both delayed and immediate auditory memory which were associated with a lower hippocampal volume (Bremner et al., 1997). A meta-analysis including 28 studies, with a total of 1,489 PTSD subjects, showed significantly impaired verbal memory among participants with PTSD who complained of memory impairment (Johnsen & Asbjornsen, 2008). All studies demonstrated highly significant values for the difference in memory between PTSD patients and comparison groups. The Wechsler Memory Scale, Logical verbal memory, and Auditory Verbal Learning Test (AVLT) were frequently used tests among the 28 studies to assess memory and WM where PTSD subjects scored significantly lower than comparison groups. The studies also suggested that the memory impairments in PTSD subjects are related to trauma type where greater impairment was found in traumatized war veteran groups compared to sexual/physical abuse. The author's explanation for this difference was that the PTSD condition in veterans had lasted for several years, suggesting that memory impairment may be related to illness duration (Johnsen & Asbjornsen, 2008). A study performed on PTSD combat veterans administered Digit Span and Logical Memory to examine if their working memory and memory was impaired. The veterans did show impaired memory on the Logical Memory where non-PTSD combat veterans scored significantly higher than PTSD combat veterans. However, they did not score lower on the Digit Span subtest compared to the control group suggesting comparable working memory (Burriss et al., 2007).

Studies have reported that the pre-existing learning and memory deficits, including hippocampus dysfunction, increases one's vulnerability developing PTSD after experiencing a traumatic event (Gilbertson et al., 2006). A study performed on twins suffering from PTSD supports this idea where a smaller hippocampus and memory impairments were a pre-

existing risk factor for developing the disorder. PTSD twin pairs also showed a significantly smaller hippocampus than non-PTSD twin pairs (Gilbertson et al., 2002). Nevertheless, further research is needed that includes dizygotic twins to tease apart the influence of genetics and similar environment on smaller hippocampal volume in PTSD.

Cognitive deficits, such as WM memory and logical memory, have clearly been identified in Post-Traumatic Stress Disorder (Bremner et al., 1995; Bremner et al., 1997; Johnsen & Asbjornsen, 2008; Kitayama et al., 2005). However, incongruity among studies indicates that further research is needed to investigate the nature and to determine the accuracy and consistency of impairment in WM and memory amongst PTSD patients. The aim of the present study was to evaluate WM and memory performance in students who fit the criteria for PTSD and students who did not fit the criteria. The aim was to test differences between the two groups where it was hypothesized that the PTSD group would perform poorer on memory and WM tests.

Method

Participants

The sample consisted of second-year psychology students at Reykjavík University. Mean age of participants was 23.2 years (range 20 – 34y, $SD = 3.7$). The total number of participants was 50, 39 female and 11 male. They were recruited through a class named Cognitive and Perceptual Psychology and were offered 4% of their final grade in exchange for a participation in the research.

Measurement

Working memory was assessed using two span tasks. The first was the Digit Span subtest from Wechsler Adult Intelligence Scale (WAIS-IV) and consisted of Digit Span forward and Digit Span backward (Wechsler, 1954). Both included 16 orally presented number sequences where participants were asked to either recall digits in serial order (2 trials

each at list lengths 2-9) or in reverse serial order (2 trials at list length 2-8). The Internal consistency for Digit Span has been good in previous studies ($\alpha = .87$) (Colom et al., 2008). The second working memory task was Operation Span task (OSPAN) which is a computerized task (Turner & Engle, 1989). A fixation cross appears at the center of the screen where a completed math problem appears. Half of the equations are correct and half are incorrect. Subjects were asked to read and verify the math equation and determine whether the solution is correct or not by clicking on “O” (incorrect) or “S” (correct) on the keyboard. Following a certain amount of math equations, a word is presented. For example, a four-item set might be:

is $(10/2) - 1 = 1$? DOG
is $(7 * 1) + 1 = 8$? BEAR
is $(10 * 2) - 5 = 15$? HOUSE
is $(30 / 2) + 1 = 17$? GARDEN
???

Following each complete set, a question mark appeared which cued participants to write down the words in the correct order. The performance was measured with one overall score. The Operation Span task had been translated into Icelandic by Eydís Arnardóttir (2017). Logical Memory II, a subtest from Wechsler Memory Scale-III (WMS-III) was used to measure recall of story passages both immediately after hearing a short story and again approximately after a 30-minute delay. The internal consistency for Logical Memory was found acceptable in a previous study ($\alpha = .79$) (Wechsler, 1997). In this study, the Cronbach’s alpha for Logical Memory II showed strong internal consistency ($\alpha = .95$).

Trauma exposure was assessed with the Life Event Checklist for PTSD (LEC-5) which screens for potentially traumatic events in a patient’s lifetime (Weathers et al., 2013). The checklist includes 17 categories of traumatic events which may result in PTSD or

distress such as “*Sexual assault*”, “*Sudden violent death*” and “*Fire or explosion*”. The Subjects had six answer options and were asked to check one of the following for each item: “*Happened to me*”, “*Witnessed it*”, “*Learned about it*”, “*Part of my job*”, “*Not sure*” or “*Doesn't apply*”. The Cronbach’s alpha for LEC-5 in this research showed good internal consistency ($\alpha = .82$).

Finally, the subjects answered the Post-Traumatic Stress Disorder Checklist for DSM-5, (PCL-5) (Weathers et al., 2013). The PCL-5 is a 20-item self-report measure and includes measurements of intrusion, avoidance, and negative alternations in cognitions/mood referencing the past month. An example of a question is “*Repeated, disturbing, and unwanted memories of the stressful experience*” where answer options were on a four-digit ordinal scale: (0) *not at all*, (1) *a little bit*, (2) *moderately*, (3) *quite a bit*, and (4) *extremely*. A symptom score can lie between 0 and 80 where a cut score of 33 can be determined as probable PTSD (Weathers et al., 2013). Internal consistency for PCL-5 has shown to be strong in a previous study ($\alpha = .94$) (Bleviss et al., 2015). The Cronbach’s alpha for PCL-5 in this research was high ($\alpha = .94$) suggesting the questionnaire had strong internal consistency. The PCL-5 and LEC-5 were translated into Icelandic by the psychologist Berglind Guðmundsdóttir et al. (2015). Along with the above-mentioned span tasks and questionnaires, subjects were asked the following question; “*Do you have any psychiatric diagnosis, if yes, then what?*” to reveal if they had any diagnosis from a doctor such as ADHD or depression which could potentially affect their PCL-5 scores. This would allow researchers to see if correlation would be seen between different diagnostics and PTSD symptoms.

Procedure

The research took place at Reykjavík University in a closed examination room. The examination took approximately 30-60 minutes and one researcher was present during the

experiment. First, the subjects were handed an informed consent and introduction letter where the purpose of the research was described. The first and last test of the experiment was Logical Memory task II subtest of the Wechsler Memory Scale. A short story was read to the subjects, and the subjects were asked to recall all events from the story. Two working memory tasks were then completed, the Digit Span and the Operation Span. The researcher explained carefully how both tasks would be performed. After completing the Digit span, a computer was handed to the subjects where the Operation Span task was completed. Subjects were informed that they had to read out loud every math problem that would appear on the computer, including words. They were also informed to keep in mind that they were going to be asked to recall words presented to them and that they had to write the words down in chronological order. They were simply asked to write down “X” if they did not remember the location of a word. This was to see if the subject was aware of the order in which the stimuli were presented. Next, the Logical Memory II was implemented again to measure delayed memory where subjects were asked to recall the same story they heard in the beginning. Finally, all subjects were handed an iPad where they answered the Life Event checklist for PTSD (LEC-5) and the checklist for Post-Traumatic Stress Disorder (PCL-5) along with the question “*Do you have any psychiatric diagnosis, if yes, then what?*”.

Data collection and analysis

This is a quantitative research design study. Repeated Measures ANOVA was used to compare immediate and delayed memory in the Logical Memory II scale where the participants were the same in each group. One-way ANOVA was used to evaluate the difference between the PTSD and control group in relation to Operation Span. Regression analysis was used to compare Digit Span backward and Digit Span forward with scores on the PCL-5 questionnaire measuring PTSD symptoms.

Results

Descriptive Statistics

Figure 1 presents the distribution of PTSD scores from the PCL-5 questionnaire. 13 students reached the criteria for PTSD while 35 did not. The mean score for the whole sample was 22.02 ($SD = 15.40$) where the cut off score for probable PTSD was 33.

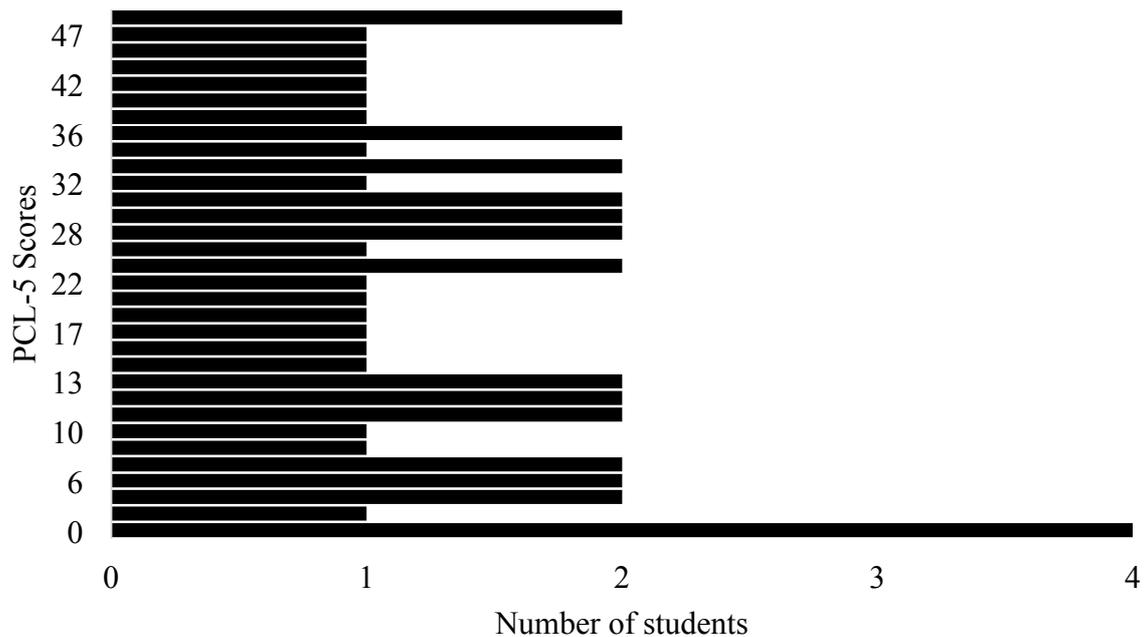


Figure 1. Distribution of PCL-5 scores for the whole sample.

The total mean score for Digit Span forward was 6.16 ($SD = 1.14$) and Digit Span backward 4.29 ($SD = 0.97$). The total mean score for Logical Memory II Scale measuring immediate memory was 9.36 ($SD = 2.96$) and delayed memory 8.77 ($SD = 3.09$). The total mean score for Operation Span was 22.98 ($SD = 8.63$).

Effects of Post-Traumatic Stress Disorder on Working Memory

Using one-way ANOVA, a significant difference was not seen between the two groups and their scoring on Operation Span task, $F(1, 44) = 0.09$ $p = .762$). The mean score in Operation Span for the PTSD group was 22.08 ($SD = 7.51$) and the control group 22.97 ($SD = 9.01$).

The difference of means in Digit Span forward and Digit Span backward between the PTSD group and the control group was analyzed using mixed ANOVA. The main effect between Digit forward and Digit backward was significant ($F(1, 1) = 104.98, p < .01$), both groups scored significantly lower on Digit Span backward. The main effect between the PTSD and control groups was not significant ($F(1, 1) = 0.00, p = .978$) which shows that the two groups did not score different overall. The interaction effect between the groups was significant ($F(1, 1) = 4.63, p = .037$) as shown in figure 2.

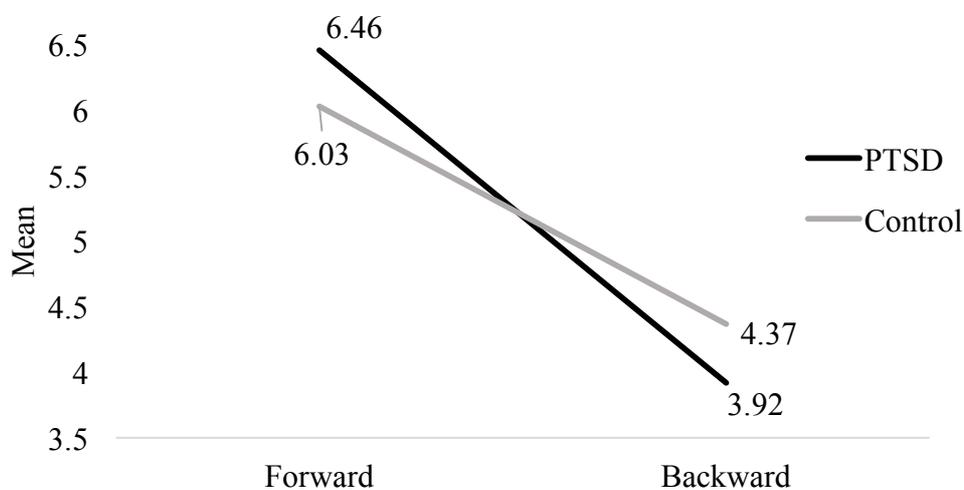


Figure 2. The interaction effect between PTSD and control group and Digit span forward and backward.

Effects of Post-Traumatic Stress Disorder on Memory

Next, the difference of means in Logical Memory II between the PTSD group and the control group was analyzed using mixed ANOVA. The main effect between immediate and delayed memory was significant ($F(1, 1) = 10.01, p < .01$) which shows that both groups scored significantly lower on delayed memory. The main effect between PTSD and control group was very close to being significant ($F(1, 1) = 3.13, p = .085$) which would tell us that the PTSD group scored significantly lower than the control group. Figure 2 shows that the interaction effect between the two groups was not significant ($F(1, 1) = 1.48, p = .232$).

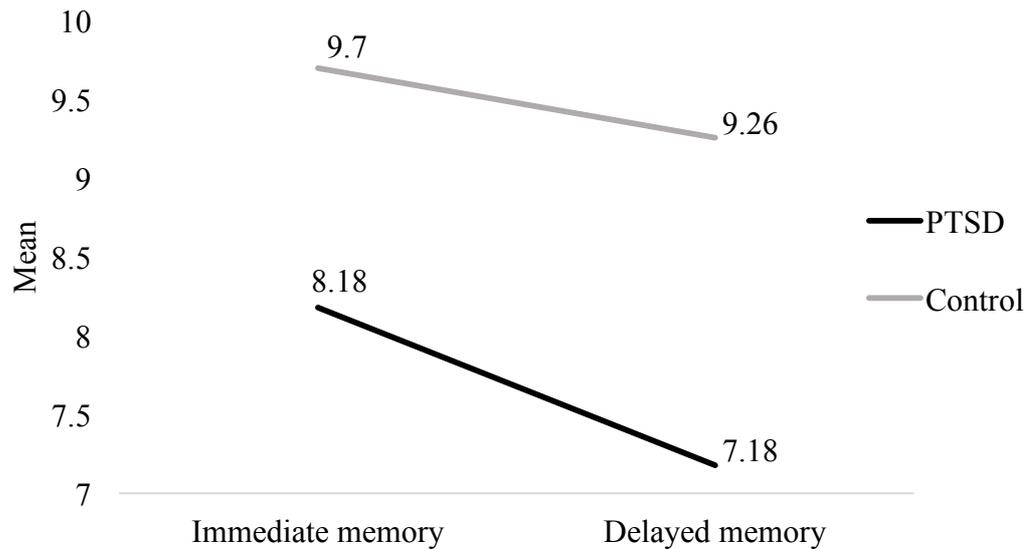


Figure 3. Mean scores for the PTSD group and the control group on Logical Memory II.

Psychiatric diagnostics and Post-Traumatic Stress Disorder

The relation between anxiety, depression, and ADHD and scores on the PCL-5 scale was analyzed where the psychiatric diagnostics were viewed as independent variables and the two groups according to PCL-5 as dependent variables. There were five subjects who revealed they had ADHD, eight with depression and 14 with anxiety. Table 2 shows the correlation between the psychiatric diagnostics and the two groups, PTSD and control group.

Table 2

Correlation between the independent and dependent variables

Disorders	Correlation	
	PTSD	Control
Anxiety	.38	.13
Depression	-.03	.24
ADHD	.30	.02

Note. * $p < .01$.

The highest correlation was a moderate correlation between anxiety and the PTSD group where ADHD also showed moderate correlation with the PTSD group, but neither were significant. Depression had almost no correlation with the PTSD group and showed weak correlation with the control group and were also not significant.

Life Event Checklist and PTSD

Correlation between events in the Life Event Checklist for PTSD (LEC-5) and scores on the PCL-5 scale was analyzed. Table 3 shows that four events had a particularly strong correlation with the PTSD group; natural disaster, fire or explosion, transportation accident, and life-threatening illness or injury. However, none were significant ($p > .01$). These four events had a weak correlation with the control group except for life-threatening illness or injury which had a moderate correlation with the control group where none were significant ($p > .01$).

Table 3

Correlation between Life Event Checklist (LEC-5) and scores on the PCL-5 scale

Life events	Correlation	
	PTSD	Control
Natural disaster	.91	.31
Sexual assault	.50	.29
Fire or explosion	.97	.27
Transportation accident	.92	.25
Assault with weapon	.50	.12
Captivity	.50	.11
Life-threatening illness or injury	.97	.44

Note. * $p < .01$

Three other events had a moderate correlation with the PTSD group; sexual assault, assault with weapon, and captivity. All of which had a weak correlation with the control group.

However, all were not significant ($p > .01$).

Discussion

The results in this research on Digit Span are not in concordance with Jenkins et al (2010) where PTSD subjects scored significantly lower on Digit Span forward and backward compared to subjects not with PTSD. In this study, the PTSD group scored higher on Digit Span forward and lower on Digit Span backward compared to the control group. However,

there was not a significant difference. The reason for this might be because the PTSD group was much smaller than the control group. Also, the PTSD subjects in Jenkins et al (2010) research had most likely worse symptoms since they were seeking help because of their PTSD symptoms, whereas the subjects in this research were college students who were not seeking help because of PTSD symptoms of which we know of. These results on Digit Span are also not in concordance with Vasterling et al (2002) who showed that Vietnam veterans scored significantly lower on Digit Span compared to their control group. It is appropriate to mention that their PTSD subjects were veterans and therefore are most likely dealing with worse PTSD than the students who fit the diagnostic criteria in this research. Their results also showed that veterans with other psychiatric diagnostics along with PTSD performed worse than veterans only with PTSD. In this study, there was no significant correlation between the PTSD group and anxiety, ADHD and depression. This might be because the sample group was very small where in further research the sample needs to be larger. These results do not support the outcome of Jenkins et al (2010) and Vasterling et al (2002) studies which confirm that PTSD subjects perform worse on WM tests.

On the other hand, the results on Logical Memory Scale II were in concordance with Bremner et al (1997) where PTSD subjects scored significantly lower on delayed and immediate memory tests. Even though the difference between scores on Logical Memory II between the two groups in this research was not significant, it was that close to being significant that it was interpreted significant considering the few subjects in the PTSD group compared to the control group. Johnsons & Asbjornsens meta-analysis (2008) show the same results where it was seen that PTSD subjects performed significantly worse on Logical Memory.

Burris et al (2007) results were the same as in this research regarding both memory and WM. PTSD subjects scored significantly lower on Logical Memory Scale but did not

score significantly lower on Digit Span. The mean score for Logical Memory in Burriss et al (2007) for PTSD patients was approximately 6 and the control group was approximately 8. In this research, the mean score for PTSD subjects was around 8 and the control group around 10. The fact that the participants scored higher in this research might be because they were second-year colleague students whereas the subjects in Burriss et al (2007) were veterans.

The fact that no correlation was significant between both the psychiatric diagnostics and PTSD and the life events from LEC-5 and PTSD might be explained by the small groups in this study. Further research is needed to review the effectiveness of PTSD and other psychiatric diagnostics with a bigger sample.

The advantages of this research were the neuropsychological tests used to assess memory and WM. They are frequently used tests and have shown to be reliable in previous studies. These findings are consistent with previous studies which show that memory dysfunctions are associated with PTSD (Bremner et al, 1997; Johnson & Asbjornsen, 2008; Jenkins et al., 2010; Vasterling et al., 2002). As mentioned above, a disadvantage of this research was the size of the sample groups. The PTSD group was very small compared to the control group. The sample was also very specific since it contained only psychology students. In further studies, it would be appropriate to ask the subjects for permission to contact them again if they scored a specific number of scores on the PCL-5 suggesting they have PTSD and interviewed them to get clearer information regarding their psychiatric background. It would be better to perform a study with a more diverse and larger subject group including patients who have a PTSD psychiatric diagnostic from a psychiatrist.

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