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Executive function impairments in adolescents with post traumatic stress disorder: A comparative study of emotional and physical trauma

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Abstract

The aim of this study is to compare the executive functions of adolescents diagnosed with Post-Traumatic Stress Disorder (PTSD) following emotional and physical trauma with those of a healthy control group. The study included adolescents aged 12–18 years who presented to Child and Adolescent Psychiatry, Forensic Medicine, or Pediatric Surgery outpatient clinics and were diagnosed with PTSD following psychiatric evaluation. The study was conducted with 35 adolescents with a history of emotional trauma, 36 adolescents with a history of physical trauma, and 40 healthy controls. All participants underwent assessments of executive functions using the Wisconsin Card Sorting Test (WCST), Serial Digit Learning Test (SDLT), Rey Auditory Verbal Learning Test (RAVLT), and Stroop Color and Word Test (SCWT. Both trauma groups showed significantly lower scores compared to the control group on the SDLT, RAVLT subtests, WCST completed categories, WCST total errors, WCST percentage of perseverative errors, Stroop 2 time, Stroop 3 time, Stroop 4 time, Stroop 5 time, Stroop 2 corrections, and Stroop 5 errors subtests.

Keywords: Post-traumatic stress disorder, executive functions, adolescent, neurocognitive assessment

Introduction

Trauma is defined as stressor events that disrupt an individual's mental and emotional life and impair daily functioning [1]. Children and adolescents are frequently exposed to various traumatic events such as physical and sexual abuse, accidents, natural disasters, and chronic illnesses [2]. Post-Traumatic Stress Disorder (PTSD) emerges following exposure to such an event and is characterized by re-experiencing, avoidance, numbing, and hyperarousal symptoms. Symptoms lasting longer than one month constitute PTSD; shorter-duration symptoms accompanied by dissociative features are classified as Acute Stress Disorder. While the lifetime prevalence of PTSD in the general population ranges from 1% to 14%, it varies between 19% and 40% in children and adolescents, being particularly higher among girls [3].

PTSD has also been shown to adversely affect cognitive functions, particularly executive functions (EF) such as attention, memory, and higher-order processes [4]. EF encompasses inhibitory control, working memory, set-shifting, and verbal fluency, among others [5]. The development of these functions parallels the maturation of the prefrontal cortex and its white-matter connections with other brain regions [6]. Consequently, traumatic experiences during childhood and adolescence can disrupt these ongoing neurodevelopmental processes, leading to declines in academic performance, increased impulsivity, and social adaptation difficulties [7].

The present study aims to evaluate executive functions in adolescents who have experienced physical or emotional trauma and meet diagnostic criteria for PTSD, using neurocognitive assessments. We will administer the Stroop Color and Word Test (SCWT), Wisconsin Card Sorting Test (WCST), Serial Digit Learning Test (SDLT), and Rey Auditory Verbal Learning Test (RAVLT) to three groups: those exposed to physical trauma, those exposed to emotional trauma, and trauma-naïve healthy

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controls. This approach will allow us to determine whether and how different types of trauma differentially affect executive function performance.

Material and Methods

Study design and participants

The study was approved by Dokuz Eylül University Ethics Committee (Decision No: 2017/09-22; Date: 27/04/2017). This study was conducted in accordance with the Declaration of Helsinki, which outlines ethical principles for medical research involving human participants. The research adhered to all relevant ethical guidelines, ensuring that the rights, well-being, and privacy of the participants were protected throughout the study. Adolescents aged 12–18 years with a history of trauma (emotional or physical) who presented to the Child and Adolescent Psychiatry, Forensic Medicine, and Pediatric Surgery outpatient clinics were assessed psychiatrically for eligibility to participate in the study. Following the evaluation, executive function tests were administered to 71 adolescents diagnosed with PTSD who provided informed consent to participate, as well as to 40 individuals comprising the healthy control group (Figure 1). All participants underwent a semi-structured diagnostic interview (Kiddie Schedule for Affective Disorders and Schizophrenia Present and Lifetime Version- K-SADS-PL) conducted by a certified clinician to confirm PTSD diagnosis and rule out differential diagnoses. This single-center case–control study included 111 adolescents. Inclusion criteria comprised: (1) clinically normal intellectual functioning, and (2) written informed consent from both the adolescent and a parent or legal guardian. The emotional trauma group comprised 35 participants (30 females, 5 males; mean age: 15.11±1.62), the physical trauma group 36 participants (16 females, 20 males; mean age: 15.5±1.69), and the healthy control group 40 participants (31 females, 9 males; mean age: 15.2±1.71).

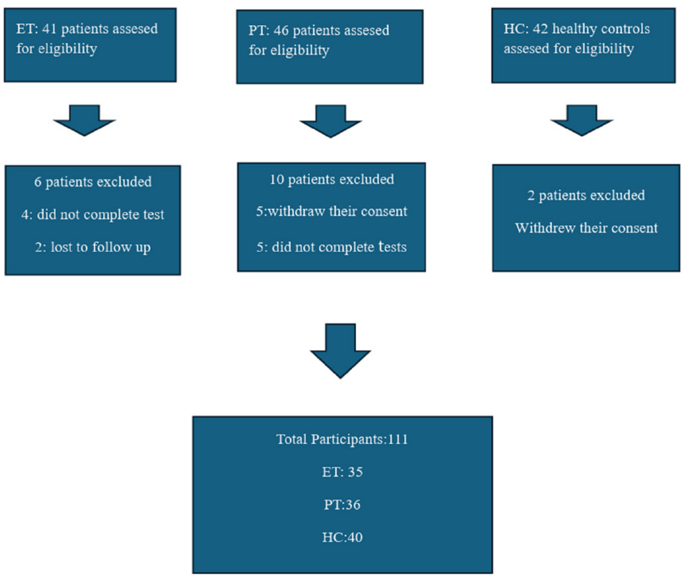

Figure 1. Participant flow diagram

Study Protocol and Data Collection

Adolescents who consented to participate and were deemed eligible based on psychiatric evaluations (71 patients and 40 healthy controls) were included in the study. A sociodemographic data form was administered to all participants and their families to collect information regarding demographic and clinical characteristics. To assess executive functions, four standardized neuropsychological tests were administered to all adolescents in the PTSD group and the healthy control group. These tests included the Wisconsin Card Sorting Test (WCST), the Serial Digit Learning Test (SDLT), the Rey Auditory Verbal Learning Test (RAVLT), and the Stroop Color-Word Test (SCWT). All assessments were conducted individually in a quiet, designated room within the Neuropsychology Unit of the clinic to minimize environmental distractions. The tests were administered between 09:00 and 15:00, in accordance with the availability of the neuropsychology room. Standardized administration procedures were strictly followed to ensure that all participants were evaluated under uniform testing conditions.

Statistical analysis

All statistical analyses were performed in IBM SPSS Statistics version 22.0. Prior to group comparisons, data were inspected for normality and homogeneity of variance using Kolmogorov–Smirnov tests and Levene's test, respectively. Categorical variables were analyzed with Pearson's chi-square test. Continuous variables meeting parametric assumptions were compared using one-way analysis of variance (ANOVA), followed by Bonferroni post hoc tests when indicated; independent-samples t-tests were employed for pairwise comparisons. A two-tailed p-value <0.05 was considered statistically significant.

Result

Neurocognitive test data were collected from all 111 adolescents—35 with emotional trauma, 36 with physical trauma, and 40 healthy controls—using the SDLT, RAVLT, WCST, and SCWT.

ANOVA revealed statistically significant group differences in learning and memory measures. Specifically, SDLT total scores differed across groups (p=0.001; Table 1).

RAVLT performance also varied significantly: Trial 1 (p=0.001), Trial 5 (p<0.001), total recall across five trials (p<0.001), delayed recall (Trial 7; p<0.001), and recognition (p<0.001) (Table 2).

Executive function measures from the WCST showed significant group effects for categories completed (p=0.032), total errors (p=0.023), and perseverative error percentage (p=0.010), while total correct responses did not differ (p=0.225) (Table 3).

In the SCWT, significant group differences were observed for:

- Condition 1 (word reading) time (p=0.042)
- Condition 2 (color naming) time (p=0.006) and errors corrected (p=0.019)

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- Condition 3 (incongruent trials) time (p<0.001)
- Condition 4 (shape trials) time (p=0.010)
- Condition 5 (mixed trials) time (p=0.001) and errors (p=0.031) (Table 4).

Overall, adolescents with emotional or physical trauma performed significantly worse than healthy controls across measures of attention, memory, cognitive flexibility, and inhibitory control, with the emotional trauma group most consistently showing the greatest deficits.

Table 1. Comparison of case and control groups in terms of SDLT scores

SDLT score	Emotional Trauma (n=35)	Physical Trauma (n=36)	Healthy Controls (n=40)	p
SDLT Score (Mean±SD)	10.48±6.48	11.41±6.27	15.52±5.03	**0.001**

A one-way ANOVA test was used, and a p-value of less than 0.05 was considered statistically significant. SDLT: Serial digit learning test

Table 2. Comparison of case and control groups in terms of RAVLT scores

RAVLT subscores	Emotional Trauma (n=35)	Physical Trauma (n=36)	Healthy Controls (n=40)	p
Immediate Recall (Trial 1)	6.37±1.57	5.83±1.44	7.15±1.33	**0.001**
Immediate Recall (Trial 2)	9.80±.2.05	10.58±1.71	12.22±1.87	**<0.001**
Total Immediate Recall (Trials 1–5)	42.65±8.43	43.77±6.57	51.67±6.48	**<0.001**
Delayed Recall (Trial 7)	8.80±2.69	8.52±2.14	10.95±2.15	**<0.001**
Recognition	11.51±2.36	10.80±2.57	13.12±1.92	**<0.001**

A one-way ANOVA test was used, and a p-value of less than 0.05 was considered statistically significant. RAVLT: Rey auditory verbal learning test

Table 3. Comparison of case and control groups in terms of WCST scores

WCST subscores	Emotional Trauma (n=35)	Physical Trauma (n=36)	Healthy Controls (n=40)	p
Number of Categories Completed	4.51±2.13	5.00±1.83	5.55±0.90	**0.032**
Total Correct Responses	70.60±14.97	74.88±15.59	75.75±9.60	0.225
Total Errors	38.02±27.55	33.86±23.05	24.32±13.92	**0.023**
Percentage of Perseverative Errors	17.71±15.38	13.22±6.72	10.80±3.94	**0.010**

A one-way ANOVA test was used, and a p-value of less than 0.05 was considered statistically significant. WCST: Wisconsin card sorting test

Table 4. Comparison of case and control groups in terms of SCWT Sub-Scores

SCWT subscores	Emotional Trauma (n=35)	Physical Trauma (n=36)	Healthy Controls (n=40)	p
Stroop 1 Time (sec)	11.28±2.93	11.44±2.43	10.06±2.37	**0.042**
Stroop 1 Corrections	0.11±0.47	0.11±0.66	0.02±0.15	0.644
Stroop 1 Errors	0.05±0.33	0±0	0±0	0.341
Stroop 2 Time (sec)	12.19±3.30	12.12±3.59	10.19±2.08	**0.006**
Stroop 2 Corrections	0.45±1.01	0.11±0.52	0.05±0.22	**0.019**
Stroop 2 Errors	0.14±0.60	0.02±0.16	0.02±0.15	0.295
Stroop 3 Time (sec)	16.01±4.24	16.09±3.95	12.77±2.50	**<0.001**
Stroop 3 Corrections	0.91±1.26	0.80±1.00	0.45±0.81	0.129
Stroop 3 Errors	0.40±1.16	0.19±0.52	0.02±0.15	0.088
Stroop 4 Time (sec)	20.91±8.29	20.10±5.35	16.80±4.31	**0.010**
Stroop 4 Corrections	0.94±1.41	0.83±1.27	0.50±0.96	0.261
Stroop 4 Errors	0.57±1.55	0.27±0.65	0.02±0.15	0.052
Stroop 5 Time (sec)	32.18±11.90	32.46±10.79	24.64±6.91	**0.001**
Stroop 5 Corrections	1.74±2.22	1.80±1.65	1.35±1.27	0.464
Stroop 5 Errors	1.65±2.61	1.86±1.64	0.77±1.22	**0.031**

A one-way ANOVA test was used, and a p-value of less than 0.05 was considered statistically significant. SCWT: Stroop color word interference test-TBAG form

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Discussion

This study utilized four neurocognitive assessments—the SDLT, RAVLT, SCWT, and WCST—to evaluate EF across participants. Results indicated that the emotional trauma group exhibited the poorest performance on the SDLT, which primarily measures short-term memory and learning ability. The physical trauma group performed better than the emotional trauma group but worse than healthy controls. Both trauma groups scored significantly lower than controls. Previous clinical studies have linked SDLT performance to medial prefrontal cortex (mPFC) and hippocampal function, highlighting its sensitivity to dysfunction in these regions [8-10]. These findings support the notion that SDLT requires not only learning but also attention, organization, and associative processes connected to frontal lobe functionality [11].

Excessive stress surpassing normal levels can cause deleterious effects on the hippocampus, leading to volumetric reductions [12-14]. Given the disruptive impact of trauma on mPFC function, the reduced SDLT performance observed in PTSD patients aligns with prior evidence [15]. Notably, the emotional trauma group's significantly lower SDLT scores compared to the physical trauma group may relate to higher trauma severity and greater comorbid psychiatric diagnoses in this group. Literature supports that trauma types such as sexual abuse are associated with increased cognitive impairment and more severe PTSD symptomatology, particularly when comorbid major depressive disorder (MDD) or anxiety disorders are present [16–19]. Studies suggest a correlation between PTSD symptom severity and EF performance deficits [20].

Regarding RAVLT outcomes, significant group differences were observed in immediate, delayed, and recognition memory subtests. Although no significant difference emerged between trauma groups, the physical trauma group demonstrated relatively better mean scores. Both trauma groups showed significantly poorer performance than controls in delayed and recognition recall. Similar findings are reported in adolescent samples exposed to various traumas, where PTSD-positive individuals exhibit markedly reduced verbal memory and learning abilities compared to both trauma-exposed PTSD-negative and healthy controls [20]. This aligns with Yasik et al. (2007), who observed that PTSD diagnosis corresponded with significant impairments in RAVLT performance relative to non-PTSD and control groups, emphasizing the impact of PTSD on auditory-verbal learning and memory [21].

The WCST, assessing frontal lobe functions such as complex attention, set-shifting, perseveration, working memory, conceptualization, and abstract reasoning, revealed significant deficits in both trauma groups compared to controls. Specifically, emotional and physical trauma groups performed worse on categories completed, total errors, and perseverative error percentage. The emotional trauma group showed numerically poorer results than the physical trauma group, though differences were not statistically significant. These findings mirror neuroimaging studies implicating prefrontal and anterior cingulate cortex dysfunction in PTSD, manifesting as impaired feedback utilization, selective attention, rule acquisition, and behavioral adaptation [22,23].

Adult studies corroborate these findings, demonstrating that individuals with trauma exposure, irrespective of PTSD diagnosis, exhibit EF impairments on the WCST compared to healthy controls [24]. Our data are consistent with Flaks et al. (2014), though their heterogeneous trauma sample differed in type and range [24]. Similarly, pediatric studies report that children with PTSD following familial maltreatment show diminished WCST performance relative to matched controls, particularly in categories completed and perseverative errors, paralleling our findings in emotional trauma [25].

Analysis of SCWT subtests indicated that both trauma groups required significantly longer completion times for Conditions 2 through 5 compared to controls. This suggests impaired information processing speed and diminished attentional capacity in trauma-exposed adolescents. While error and correction rates were generally similar, the significant Stroop 5 error differences indicate the presence of Stroop interference effect in trauma groups. The Stroop interference is associated with frontal lobe processes including selective attention and inhibitory control [26]. Our findings imply disrupted attentional functions in trauma-exposed adolescents.

Consistent with our results, prior research has documented significant differences in Stroop performance among PTSD-positive, trauma-exposed PTSD-negative, and control groups matched for demographic variables [27]. Moreover, studies of female adolescents with sexual abuse-related PTSD demonstrate prolonged Stroop response times and interference effects compared to both abused non-PTSD and healthy controls [28], lending clinical support to our observations of greater EF impairments in PTSD.

Overall, emotional trauma cases generally exhibited the lowest neurocognitive scores on SDLT, RAVLT (trials 2, total recall, delayed recall, recognition), WCST, and Stroop subtests, whereas physical trauma cases scored lowest on certain RAVLT and SCWT. This suggests a greater EF impairment severity in emotional trauma relative to physical trauma, though no prior studies have directly compared PTSD-related EF impairments by trauma type. Literature indicates sexual trauma carries a higher risk and severity for PTSD and chronicity compared to other trauma types [29-31]. Interpersonal violence, including sexual and physical abuse, has consistently been linked to PTSD symptomatology in both adolescents and adults [32-36]. Our findings, revealing worse EF performance in emotional trauma—dominated by sexual abuse—support this literature and suggest that trauma type influences EF impairment severity [20,37].

Several limitations warrant consideration. Although age matching was achieved, sex matching was not possible due to the predominance of females in the emotional trauma group and males in the physical trauma group, reflecting clinical presentation trends. While direct effects of sex on EF remain understudied, differential PTSD severity and cognitive impairment by trauma type may partly reflect sex differences in our sample. Additionally, IQ was assessed clinically rather than via standardized psychometric tests, limiting interpretability. Finally, comorbid psychiatric diagnoses and pharmacotherapy in trauma groups may confound EF outcomes, necessitating cautious interpretation.

Conclusion

This study demonstrates that adolescents with PTSD following physical or emotional trauma exhibit significant impairments in executive functions compared to healthy controls. Notably, emotional trauma, often involving interpersonal violence such as sexual abuse, is associated with greater deficits across multiple cognitive domains, including attention, memory, cognitive flexibility, and inhibitory control. These findings underscore the critical impact of trauma type and severity on neurocognitive outcomes in youth. Early identification and targeted interventions addressing executive dysfunction in traumatized adolescents are essential to mitigate long-term functional impairments. Future research should further explore the moderating roles of sex, comorbidities, and treatment effects on cognitive outcomes in this population.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study received ethical approval from the Dokuz Eylül University Ethics Committee (Decision No: 2017/09-22; Date: 27/04/2017).

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