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Neuropsychological profile of memory and attention in individuals with temporal lobe epilepsy and its comparison with healthy people

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ABSTRACT

Background: Epilepsy is associated with multiple neuropsychological deficits, and various studies have reported impairments in memory, language, executive functions, and attention. This condition can significantly affect social interactions and communication, leading to challenges in daily life.

Aims: The present study aimed to investigate the neuropsychological profile of attention and associative memory in individuals with temporal lobe epilepsy (TLE) and compare it with healthy individuals.

Methods: The research employed a descriptive, causal-comparative design. Sixty individuals with temporal lobe epilepsy and 60 healthy individuals (N= 120) comprised the sample. The Wechsler Memory Scale(Wechsler, 1945) for Adults and the Integrated Visual and Auditory Continuous Performance Test(Berginström et al., 2015) were used to measure variables. Data analysis was conducted using an independent t-test and its non-parametric equivalent, the Mann-Whitney U test.

Results: The results indicated a significant difference in associative memory between individuals with epilepsy and healthy individuals ($Z= 8.90$, $p< 0.01$). Moreover, a significant difference was found in auditory attention between the two groups ($Z= 8.18$, $p< 0.01$). Finally, there was a significant difference in visual attention between individuals with epilepsy and healthy individuals ($Z= 9.90$, $p< 0.01$).

Conclusion: The study's findings suggest that individuals with temporal lobe epilepsy exhibit significant deficits in memory and attention compared to their healthy counterparts. These findings highlight the importance of the temporal lobe in cognitive processes and emphasize the necessity of neuropsychological assessments in treatment programs to improve the quality of life for these patients.

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Extended Abstract

Introduction

Temporal lobe epilepsy (TLE) accounts for 70% of focal epilepsies and is considered a network disorder that affects various cognitive domains (Cairós-González et al., 2024). Epilepsy is associated with multiple neuropsychological deficits, with studies reporting impairments in memory, language, executive functions, and attention. This condition can significantly impact social interactions and communication, leading to challenges in daily life (Tani & Adali, 2024). One of the most influential and significant aspects of epilepsy is cognitive deficits, which manifest in areas such as problem-solving, attention, judgment, and executive functions (Tuchscherer et al., 2010). Cognitive impairment varies from mild to severe; individuals with mild impairment may notice changes in their cognitive performance while still being able to carry out daily activities. However, severe impairment can lead to a loss of internal control, anxiety, speech and writing difficulties, and, ultimately, an inability to live independently (Hoxhaj et al., 2023).

Memory is one of the most crucial cognitive abilities, as it forms the foundation of human learning. Memory allows us to utilize past experiences in the present (Naeeniyan, 2004). Verbal associative memory, sometimes called verbal, relational memory, is a subset of episodic verbal memory. This type of memory refers to our ability to remember associations between spoken words and words presented as related during initial learning. Associative memory refers to learning and recalling relationships between unrelated items (Suzuki, 2005). Among the primary concerns for individuals with epilepsy are cognitive impairments and the functioning of memory and attention. Notably, memory problems are estimated to affect approximately 50% of epilepsy patients (Keary et al., 2007). A study conducted by Miller et al(Miller et al., 2016). demonstrated that cognitive impairment is common in epilepsy patients, even in the absence of brain lesions. The number of anti-epileptic drugs (AEDs) taken may contribute to language deficits, visuospatial difficulties, and visual memory impairment, particularly in cases of heightened anxiety. Similarly, Hajjaj et al. (Hoxhaj et al., 2023) found that epilepsy can impact cognitive functions such as attention and memory, with these effects worsening as patients age.

Several studies have examined the neuropsychological profile of memory and attention in individuals with TLE and compared them with healthy counterparts. Englot et al. (Wills et al., 2021) investigated memory impairments in patients with drug-resistant TLE. The results indicated that individuals with TLE, particularly in verbal memory performance, perform worse than healthy individuals (Tuchscherer et al., 2010). These findings highlight significant memory impairments in this patient group, which can negatively impact their quality of life. Likewise, another study by Thompson et al. (Thompson et al., 2024) explored differences in episodic and semantic memory between individuals with TLE and healthy individuals. This research revealed that TLE patients exhibit poorer episodic and semantic memory performance compared to their healthy counterparts, with these impairments being linked to damage in the hippocampus and other memory-related brain regions.

Attention is another cognitive variable affected by epilepsy. As the primary component of cognition, attention is a mechanism through which a limited amount of information is actively processed, extracted from the vast sensory input available from stored memory and other cognitive processes (Kishi & Azizi, 2025; Sternberg, 2013). Attention requires an individual to respond to a specific stimulus while ignoring distracting stimuli (Wang et al., 2024). The initial stage of any learning process begins with attention, and insufficient attention can disrupt an individual’s learning ability (Hartmann, 2002). Attention is critical in regulating and prioritizing processed stimuli via the central nervous system. It is essential for cognitive performance, mental function, and behavior, as even minor lapses in attention can negatively impact learning (Azizi & Afrooz, 2025; Eskandari et al., 2024; Yazdanbakhsh & Azarnia, 2023). Furthermore, attention is a key cognitive ability that contributes to problem-solving and higher-order mental activities.

Helmstädter et al (Helmstaedter et al., 2024). have examined the effects of cognitive impairments related to attention and memory. Their research emphasized deficits in working memory and attention abilities in individuals with TLE. The findings indicated that TLE patients struggle with maintaining information in short-term memory and focusing on specific tasks, negatively impacting their daily functioning. Additionally, Tedrus et al (Tedrus et al., 2021). used functional magnetic resonance imaging (fMRI) to identify brain damage in TLE patients. This research demonstrated that brain damage in these individuals is particularly evident in areas related to memory and attention. The use of advanced imaging technologies can provide a better understanding of cognitive impairment patterns in epilepsy patients. Lastly, a study by Thompson and Strutton (2024) investigated the effects of memory and attention deficits in TLE patients compared to healthy control groups. Their research concluded that attentional deficits in TLE patients have negative implications for their daily and social activities(Thompson et al., 2024).

Although there is research on the neuropsychological profile of memory and attention in individuals with TLE, significant gaps remain in this field. One of the key inconsistencies in the literature is the varying reports on the impact of epilepsy on different types of memory, including short-term and semantic memory. Some studies suggest that memory impairments are particularly pronounced in verbal and episodic memory, whereas others have not explored these areas in depth or reported conflicting results. Furthermore, most of the research in this domain has been conducted outside Iran, with limited studies specifically examining the effects of epilepsy on memory and attention within the Iranian population. Consequently, the lack of extensive and comprehensive research on these cognitive impairments in Iran—especially considering cultural and clinical differences—highlights a major gap in the country's scientific literature. This underscores the need for further studies and targeted therapeutic interventions in this field.

Method

(A).Participants

The current research is fundamental in terms of its goal and descriptive in terms of its data collection method. Given the subject, which is the comparison of neuropsychological characteristics in patients with temporal lobe epilepsy and their healthy counterparts, the study is of a descriptive and causal-comparative type, cross-sectional in nature. The sample size was determined based on the recommendation for causal-comparative studies (15 participants per group), and considering two dependent variables in the study, 60 participants per group were chosen.Due to the large population and challenges in data collection, a convenience sampling method was used.

The statistical population of this study included all patients with epilepsy who visited neurologists in Tabriz and a control group consisting of healthy individuals matched with the patient group in Tabriz in 2023. The study's sample consisted of 60 individuals with epilepsy and a comparison group of 60 healthy individuals matched based on age, gender, and education level. The inclusion criteria for the study were: having temporal lobe epilepsy, being aged between 18 and 65 years, having at least primary school education, being capable of responding to questions, and providing consent to participate in the study. The exclusion criteria included: having psychotic disorders, substance abuse or addiction, personality disorders, other neurological disorders, and chronic physical illnesses.

(B). Procedure

For the study, visits were made to neurology clinics and doctors' private practices. Selection criteria were based on the study's inclusion and exclusion criteria, which were aligned with the research objectives. Before administering the questionnaires, a semi-structured interview was conducted separately with each patient. Patients who did not meet the inclusion and exclusion criteria based on this interview were excluded from the study.The researcher read the written consent form, which was placed at the beginning of the questionnaire, to the selected patients and obtained their written and verbal consent. After explaining the research objectives and ensuring their cooperation, the following tests were administered to the patients: Wechsler Memory Scale (WMS) and Integrated Visual and Auditory Continuous Performance Test (IVA-CPT-2).Patients were asked to respond carefully and thoughtfully, and they were encouraged to answer all questions as thoroughly as possible.

(C). Measures

Wechsler Memory Scale (WMS): The Wechsler Memory Scale (WMS) was developed by David Wechsler in 1945. This test results from ten years of research on memory functions, providing information to distinguish organic and functional memory disorders (Ryan, 1981). Advantages of the WMS include: Quick administration (approximately 15 minutes), Standardized scoring, Consideration of memory differences across various age groups. The WMS consists of seven subtests: Personal awareness of daily and personal matters (Information) – 6 questions (score range: 1 to 6), Awareness of time and place (Orientation) – 5 questions (score range: 1 to 5), Mental control – 3 tasks (score range: 1 to 9), Logical memory – 2 stories (score range: 1 to 23), Digit span (forward and backward recall) – 20 questions (score range: 1 to 7), Visual memory – 3 designs (score range: 1 to 14), Associative learning – 10 word pairs (score range: 1 to 21). The total memory score is obtained by summing the scores of all subtests, and it can be converted into a memory quotient using standardized age-based norms. The test-retest reliability for the overall scale is 0.89, Subtest reliability coefficients range from 0.62 to 0.80. The correlation coefficients between subtests and the total memory score range from 0.68 to 0.90, demonstrating satisfactory validity (karimi Lichahi et al., 2021). This study measured verbal working memory using a combination of the Logical Memory and Associative Learning subtests, while visual working memory was assessed separately. The Cronbach's alpha for verbal working memory was 0.89, and for visual working memory, it was 0.91.

Integrated Visual and Auditory Continuous Performance Test (IVA-CPT-2): The second edition of the IVA-CPT was designed based on the DSM-5 criteria to assess response control and five types of attention, following the Solberg et al (Berginström et al., 2015). model It evaluates attention performance in visual and auditory modalities across five categories: Focused attention, Sustained attention, Selective attention, Attention shifting, and Divided attention. This test classifies attention performance into severe, moderate, mild, normal, and above-normal levels. Participants are presented with a sequence of numbers (1 and 2) in a pseudo-randomized order as visual and auditory stimuli. When the number "1" appears (visually or auditorily), the participant must right-click the mouse. When the number "2" appears, they must not click. BrainTrain Inc. developed the IVA-CPT and is a type of continuous performance test (CPT). In collaboration with Nova University, Stanford University researchers demonstrated its high validity and reliability. Sensitivity: 92%, Correct piredictive power: 89% for diagnosing Attention-Deficit/Hyperactivity Disorder (ADHD).

(D). Statistical analysis

For analyzing the data collected from the statistical tests, descriptive statistics including the mean and standard deviation were used. To test the research hypotheses, an independent t-test or its non-parametric equivalent (Mann-Whitney U test) was employed. To examine the hypotheses regarding differences between two groups—individuals with temporal lobe epilepsy and healthy individuals—in associative memory and auditory and visual attention, the necessary assumptions for using parametric tests were first examined.

For this purpose, the Kolmogorov-Smirnov one-sample test and Levene's test were applied. Based on the results of these tests, the assumptions of normality of the distribution of dependent variables and homogeneity of variance of the dependent variables across the study groups were not met. Therefore, for testing both hypotheses between the groups, the non-parametric Mann-Whitney U test was used.

Results

Scale of Measurement: The interval nature of variables was confirmed, as the measurement tools had a zero point and assumed equal score intervals. Normality of Data Distribution: Tested using Kolmogorov-Smirnov's one-sample test. Results indicated that data were not normally distributed (Z-values were significant at $p \leq 0.05$). Homogeneity of

Error Variance: Tested using Levene's test. Results indicated non-homogeneous error variances (F-values were significant at p≤ 0.05).

Since the normality and homogeneity assumptions were violated, the Mann-Whitney U test (a non-parametric alternative) was used for hypothesis testing.

Table 1. Descriptive Statistics of Sample Demographics (n= 120)

Variables		F		%	
		Epileptic	Normal	Epileptic	Normal
Gender	Male	30	30	25	25
	Female	30	30	25	25
Education	Diploma	17	21	0.14	0.17
	Bachelor	27	26	0.22	0.21
	Master	16	13	0.13	0.10
Age	Epileptic	31.53(7.59)			
	Normal	31.82(7.97)			

According to Table 1, the mean and standard deviation of the age of the study sample in the epilepsy group was (31.53±7.59) and in the healthy group was (31.82+7.97). Also, out of a total of 120 people who met the inclusion criteria for the study, 60 were female (30 per group), and 60 were male (30 per group). On the other hand, most of the sample in both groups (27 in the epilepsy group and 26 in the healthy group) had a bachelor's degree, and people with a master's degree (16 in the epilepsy group and 13 in the healthy group) had the lowest frequency among the participants in the study.

Table 2. Descriptive Statistics of Variables in the Studied Groups

Variable		Component Epilepsy Group		Healthy Group		Skewness	Kurtosis
		Mean	SD	Mean	SD		
Associative Memory	Total associative memory score	0.20	2.98	19.33	2.31	0.14	0.30
Attention	Auditory (Words)	116.42	8.99	144.97	6.03	0.13	0.20
	Visual (Images)	119.68	9.77	143.33	5.80	0.09	0.14

As shown in Table 2, the mean scores for associative memory and attention (visual and auditory) are higher in the healthy group than in patients with epilepsy. Inferential statistical methods were applied to further analyze these differences.

Table 3. Mann-Whitney U Test Results for Associative Memory and Attention

Variable	Component	Mann-Whitney U	Z	p-value
Associative Memory	Total Associative Memory Score	121.50	-8.90	<0.001
Attention	Auditory (Words)	53.00	-8.18	<0.001
	Visual (Images)	67.50	-9.10	<0.001

The findings in Table 3 show a difference in associative memory between the two groups of people with epilepsy and healthy people (Z= -8.90, p< 0.01). Also, according to the results in Table 2, the average associative memory in people with epilepsy (0.20) is lower than that of healthy people (19.33). There is a difference in auditory attention between the two groups of people with epilepsy and healthy people (Z= -8.18, p< 0.01). Also, according to the results in Table 2, the average auditory attention in people with epilepsy (116.42) is lower than that of healthy people (144.97). Regarding visual attention, there is a difference between the two groups of people with epilepsy and healthy people (Z= -9.90, p< 0.01). Also, according to the results in Table 2, the average visual attention in people with epilepsy (119.68) is lower than that of healthy people (143.33).

inally, to obtain a clearer picture of the status of the two groups, the neuropsychological profile of these groups was drawn based on the average scores of associative memory, auditory attention and visual attention, the results of which are presented in Figure 1 As depicted in Figure 1, the healthy group consistently outperformed epilepsy patients in all cognitive measures. This suggests that epilepsy negatively affects neuropsychological functions, particularly associative memory and attention.

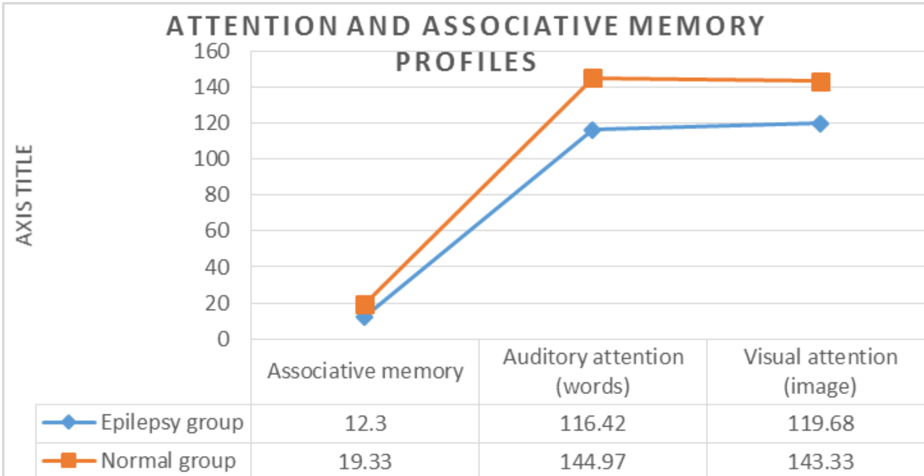

Figure 1. Neuropsychological Profile of Epilepsy and Healthy Groups

Conclusion

The present study compared verbal associative memory and attention between individuals with epilepsy and healthy individuals. The results indicated a significant difference in the mean scores of verbal associative memory between individuals with temporal lobe epilepsy and their healthy counterparts. Specifically, individuals with temporal lobe epilepsy had lower memory scores than the control group.

This finding aligns with the study by Rees et al. (Reyes et al., 2018) which examined memory function in patients with temporal lobe epilepsy and found that these individuals performed worse on memory-related tasks. Similarly, Kokkinos and Siminis. (Kokkinos & Seimenis, 2024) conducted a study on verbal memory in patients diagnosed with epilepsy, revealing that epileptic patients performed worse than the control group. Additionally, Menlove. (Menlove & Reilly, 2015)investigated verbal memory in individuals with epilepsy and concluded that due to frequent and severe seizures, these individuals experience significant verbal memory impairment.

To explain these findings, it can be stated that memory is a higher-order psychological process distributed across complex neural networks throughout the brain. One of the primary concerns for individuals with epilepsy is memory impairment (Thompson et al., 2024). Neuropsychological studies have identified several cognitive impairments associated with temporal lobe epilepsy. Both short-term and long-term memory can be significantly affected by the condition. Specifically, deficits in working memory disrupt visual, spatial, and verbal abilities (Helmstaedter et al., 2024).

Since temporal lobe epilepsy (TLE) is the most common type of epilepsy, most neuropsychological research on epilepsy has focused on memory (Helmstaedter et al., 2024). In cases of frequent seizures, particularly within a short period, memory may be disrupted longer because the brain does not have sufficient time to fully recover between seizure episodes (Stafstrom & Carmant, 2015). Temporal or frontal lobe abnormalities are the most common causes of memory issues in individuals with epilepsy; however, memory problems can occur in all types of epilepsy (Condret-Santi et al., 2014). The type of memory impairment depends on the cause of the seizures and the affected brain region (Zhao et al., 2014). Neuroanatomical perspectives also confirm the role of lesions in the lateral neocortex and medial temporal lobe structures, including the hippocampus, in memory impairment among epilepsy patients (Thompson et al., 2024).

Fleury et al. (Fleury et al., 2022) proposed that the relationship between memory and temporal lobe epilepsy may be linked to deep and medial temporal structures, where memory processes—specifically encoding and retrieval of new information—occur. Notably, epileptic seizures often originate from these same regions. Therefore, memory impairment in TLE may reflect significant damage to the hippocampus and surrounding structures.

The findings of this study also showed a significant difference in the mean scores of visual and auditory attention between individuals with epilepsy and their healthy counterparts. Consistent with these results, Taney and Edali. (Tani & Adali, 2024) examined cognitive functions in epilepsy patients and found that 70% of individuals with epilepsy performed worse than the control group in attention and concentration tasks. Similarly, the study by Falah et al. (Falah & Winston, 2024)assessing the neuropsychological profiles of epilepsy patients revealed that they performed worse than controls in attention and processing speed tasks.

Even when seizures are well-controlled, functional MRI studies of epilepsy patients indicate an underlying predisposition to attention deficits, demonstrated by reduced activity in the anterior insula, middle prefrontal cortex, and frontal operculum (Kwan et al., 2022). The symptomatology of epileptic seizures includes transient loss of awareness, which can contribute to attention deficits. Additionally, the cognitive side effects of antiepileptic drugs may further exacerbate attention impairments.

Findings from the Attention Network Test and eye-tracking studies further indicate that the orienting and executive control networks are often abnormal in epilepsy patients (Yang et al., 2024). Individuals with epilepsy struggle to sustain attention for extended periods and are easily distracted (Cano-López et al., 2024). This difficulty in maintaining focus can lead to inadequate attention to relevant environmental stimuli, resulting in socially inappropriate behaviors. Furthermore, it may cause insufficient attention to critical information presented in therapy sessions (Walker et al., 2019).

Most cognitive impairments in individuals with epilepsy stem from the underlying nature of the condition. These impairments may result from acquired causes (such as trauma, hypoxia, or ischemia) or from prolonged, recurrent seizures that can lead to cognitive decline. Additionally, high-dose medication intake and lower educational levels are factors that can further exacerbate cognitive dysfunction and negatively impact patients' quality of life. Due to the unpredictable nature of epilepsy, most patients experience varying degrees of anxiety and depression, imposing a significant psychological burden on them. Therefore, effective management of temporal lobe epilepsy (TLE) remains a critical challenge that requires attention.

The presence of attention deficits in adults with epilepsy is associated with greater psychosocial comorbidities and lower quality of life(Aydemir et al., 2011). These individuals demonstrate greater difficulty in performing daily tasks and work-related responsibilities(Lin et al., 2012). Moreover, patients with severe attention deficits are nine times more likely to experience depression and eight times more likely to develop anxiety compared to their counterparts without severe attention issues(Weiping & Lixiao, 2015). Given the heightened risk of reduced quality of life, emotional distress, and functional impairments in adults with epilepsy, attention deficits in these individuals require efficient identification and appropriate treatment. Addressing attention deficits may improve seizure management by enhancing medication adherence and minimizing seizure-exacerbating stressors.

This study faced several limitations that may impact the accuracy and generalizability of its findings. These limitations include the small sample size, which reduces the ability to generalize the results to broader populations; individual and clinical differences among patients, such as disease severity, duration of epilepsy, and types of medications used, which complicate data interpretation; limitations of cognitive assessment tools, which may have been designed for specific languages and cultures and may lack accuracy in other populations; insufficient control over environmental and psychological factors, such as stress and anxiety, which can influence memory and attention performance; and the absence of longitudinal studies to assess cognitive changes over time, restricting the understanding of cognitive dynamics in epilepsy.

Given these limitations, future research should aim to increase the sample size and population diversity to enhance the generalizability of findings. Longitudinal studies are also recommended to examine cognitive changes over time and track the progression or improvement of memory and attention. Utilizing advanced assessment tools and combining cognitive testing with neuroimaging techniques such as fMRI and EEG may provide more precise insights. Additionally, rigorous control of comorbid factors, such as depression and anxiety, as well as the effects of medications on cognitive performance, is necessary. Localizing and adapting cognitive assessment tools to match cultural and linguistic contexts can improve data accuracy and reliability. Finally, future studies should explore the effectiveness of various therapeutic interventions, including cognitive rehabilitation techniques and novel pharmacological treatments, on memory and attention performance.

Ethical Considerations

Compliance with ethical guidelines: This article is taken from the master's dissertation of the second author in the field of clinical psychology in the Faculty of Psychology, University of Tabriz. This study has been approved by the Ethics Committee University of Tabriz (Code: IR.TABRIZU.REC.143.152). In order to maintain the observance of ethical principles in this study, an attempt was made to collect information after obtaining the consent of the participants. Participants were also reassured about the confidentiality of the protection of personal information and the presentation of results without mentioning the names and details of the identity of individuals

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Conflict of interest: the authors declare no conflict of interest for this study.

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