
Executive Functions in an Egyptian Sample of Adults with Generalized Epilepsy

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Abstract: Epilepsy affects 65 million patients worldwide, Furthermore, Impacts of epilepsy are experienced across many aspects of an individual's life, including mental and physical wellness, cognitive abilities, instructional performance, occupational roles, and social networks, Cognitive function is critical to the quality of life of patients with epilepsy, so this study considered executive functions in epilepsy patients. Epilepsy syndromes are divided into focal and generalized types, which is dependent on whether seizures emerge from a localized brain area or display a widespread involvement of both hemispheres from the outset. *Objective:* The present study aimed to investigate the executive functions (EFs) (planning, cognitive flexibility, and working memory) in adults with generalized epilepsy. *Materials and methods:* A total of 25 adults aged 18 to 44 years with generalized epilepsy were recruited from the Epilepsy outpatient clinic of the Department of Neurology, Kasr Al-Ainy Hospital in Cairo. A similar amount of age- and sex-matched healthy volunteer's controls (numbered 32) were included as a control group. The participants completed subtests from the Arabic version of the Wechsler Intelligence Scale for Adults (Fourth Edition) including Digit Span, Arithmetic, Letter-Number Sequencing, and Block Design, as well as the Stroop Color-Word Test as a neuropsychological test. *Results:* Compared to the Control group Adults with generalized epilepsy exhibited poor performance in EFs - planning, cognitive flexibility, and working memory. *Conclusion:* Adults with generalized epilepsy had impairment in planning, cognitive flexibility, and working memory which may affect their Quality of life.

Keywords: Epilepsy, Generalized Epilepsy, Executive Functions, Egypt

1. Introduction

Epilepsy is a neurological disorder characterized by recurrent seizures and associated with negative neurobiological, cognitive, and psychosocial outcomes [29, 5, 13, 27]. Also, the impacts of epilepsy are experienced across many aspects of an individual's life, including mental and physical wellness, cognitive abilities, instructional performance, occupational roles, and social networks [24].

The word "epilepsy" is derived from the Greek *Epilepsia*, which means seized or attacked. Epilepsy syndromes are divided into focal and generalized types, which is dependent on whether seizures emerge from a localized brain area or

display a widespread involvement of both hemispheres from the outset [7]. Moreover, the condition can last for a few years, whereas it tends to be a life-long tendency for other cases [14]. As a chronic illness, epilepsy has a high prevalence rate and is more common in developing than developed countries [14, 26]. Furthermore, epilepsy affects 65 million patients worldwide, including Egypt, with a crude lifetime diffusion rate of 12.67/1,000 [26]. Consistent with the most recent estimation of epilepsy, it affects about 50 - 70 million people worldwide [19]. According to the World Health Organization (2016), the annual prevalence rate of epilepsy can reach 2.4 million.

Epilepsy can begin during childhood. Thus, seizure onset generally occurs at a vital phase to the growing of basic

intellectual, behavioral, and social skills which are fundamental for educational, occupational, and interpersonal development [34, 36, 29]. Consequently, an understanding of cognitive disabilities associated with epilepsy is essential [36].

Previous studies revealed that people with epilepsy and their families recognize cognitive deficits as significant comorbidity. For example, Arunkumar, Wyllie, Kotagal, Ong & Gilliam conducted a study on five parents of 80 children and adolescents with epilepsy. The respondents were tasked to make a list of their concerns about living with or caring for their children with epilepsy. The concerns were cited in order of importance. Meanwhile, the older children in the sample were asked to state (independent of their parents) their concerns about having epilepsy. For parents and children, the cognitive effects of epilepsy were the second most common concern, including learning disabilities, academic difficulties, weak concentration, and poor memory. Additionally, these effects are not specific to children. In a survey by the International Bureau of Epilepsy 44% of patients with epilepsy display difficulties in learning, whereas 45% are suffering from thinking slowness [6].

Previous studies argued that cognitive functions are a significant predictor of self-evaluation of quality of life among adults with epilepsy [32, 36]. Besides and apart from their condition, patients with epilepsy are highly vulnerable to other risk factors, such as cardiovascular and inflammatory diseases, which increase the possibility of cognitive decline [21]. In this regard, the current study sheds light on certain cognitive functions affected by epilepsy.

2. Literature Review

2.1. Executive Functions (EFs)

EFs are a set of cognitive, mental, and behavioral skills associated with goal-directed action and adaptive behaviors [9, 18, 11]. EFs are deemed to play an important role in learning and educational achievement, occupational performance, and social relationships [35, 9]. Besides, EFs are considered processes that regulate an individual's thoughts and behaviors. EFs include planning, organization, cognitive flexibility (CF), decision making, purposive action, concept formation, and abilities to monitor, self-correct, and self-regulate [15, 17, 29]. EFs develop from childhood to adulthood, where an earlier developmental period occurs between birth and 3 years of age. Inability to accomplish daily living activities or to adapt socially may be due to deficits in EFs [29].

According to Ahmed & Miller, EFs are "higher-order cognitive processes involved in goal-oriented behavior, such as planning and sequencing" [1]. The core EFs are inhibition (self-control: resisting temptations and resisting impulsive actions), interference control (selective attention and cognitive inhibition), working memory (WM), and CF (i.e., creative thinking, ability to view from various perspectives, quick and flexible adaptation to changing situations). EFs are

trainable and can be enhanced with practice [17]. A variety of psychological structures belong under this category.

Despite the importance and prevalence of EFs in patients with epilepsy, studies on epilepsy in the Egyptian context are very few. To address this concern, the study examined EFs in patients with generalized epilepsy. Specifically, the study targets the three core EFs, namely, WM, planning, and CF.

2.1.1. Working Memory

WM is described as temporarily storing and manipulating data while engaging in problem-solving processes [37, 16, 8], which includes retaining and processing information. WM is essential for making sense of concepts that become clear over time, require mental recall, and relate to future concepts. Consequently, WM is necessary for understanding written or spoken language. A few examples of WM are solving arithmetic operations, recalling (i.e., reordering a to-buy list), translating instructions into actions, incorporating new information (updating), considering alternatives, and relating information to derive a general principle or to identify relationships between items or ideas. WM is a skill necessary for perceiving connections between apparently unrelated concepts and breaking apart elements from an integrated whole, thus leading to creativity, which involves disassembling and synchronizing elements in a new manner. Additionally, WM enables individuals to utilize not only conceptual knowledge but also perceptual input to influence and to consider previous and future ideas in decision making [17]. WM is considered an integral part of EFs because it is used in combination with inhibitory control and CF, which are related to the development of EFs [39, 41].

2.1.2. Cognitive Flexibility

CF or mental shifting denotes the ability to change viewpoints (e.g., "What would an object look like if I see it from a different way?" Or "Let me see if I can realize this topic from your perspective."). Additionally, CF includes changing the manner of thinking. For example, when faced with difficulty in solving a problem, new and original solutions may be conceptualized [17]. Conversely, CF involves sufficient flexibility in adapting to the way of thinking or priorities of others, acknowledging errors, and taking advantage of unforeseen opportunities. [16, 17]. CF is defined as the ability to shift standpoints, refocus attention [16], or change tactics during ineffective problem-solving. CF is involved in the development of EFS as well as skills for academic achievement [40, 41].

2.1.3. Planning

Planning is a goal-directed action and is described as a localized higher-order skill under EFs. Besides, planning is observable, means-end behavior [43]. EFs are essential to success in daily life functioning. However, planning plays a more important function in adaptive and goal-directed action. Once a plan for tackling a problem is established, the person is required to commit the plan to memory to execute the steps (WM). Furthermore, important steps should be followed despite the constant demand for attention from environmental

stimuli. The process requires continued attention to remain focused on the task, inhibition of any contending reactions, and a potential shift to another plan to succeed in the task [43, 16]. Additionally, when the plan is implemented, the solution must be estimated as successful, and any mistakes must be observed and fixed to ensure success [41].

2.2. Executive Functions in Epilepsy

Cognitive function is critical to the quality of life of patients with epilepsy [32]. Furthermore, cognitive deficiencies in this group lead to long-term issues. For example, during childhood, cognitive deficiencies are evidenced by learning disabilities that hinder educational achievement and social skills [13]. Accordingly, executive dysfunction in patients with epilepsy leads to a negative vulnerability in their quality of life, such that executive dysfunction should be a target of diagnosis and therapy [31, 15, 28, 17]. Cognitive disturbances are prevalent in patients with all forms of epilepsy [3]. Executive dysfunction may be due to the interaction between etiological factors, such as biological, medical, and psychosocial ones. The effect of brain disorders on specific cognitive abilities can cause certain actions that are symptomatic of difficulties that accompany EFs. Youth with epilepsy reveal a deficiency in skills required for goal-directed behavior (e.g., CF, planning, and WM) [22; 25]. In this regard, Modi, Vannest, Combs, Turnier & Wade reported that 30%, 17%, and 18% of adolescents with epilepsy exhibited deficits in WM, CF/shifting, and planning/organization, respectively [30].

According to this, Desoky & Gabra observed poor performance of patients with epilepsy on most EFs. Specifically, long-term epilepsy and high rates of seizure were identified as the most two common factors that pointed to a positive correlation with executive dysfunction [15]. Liik, Vahter, Gross-Paju & Haldre found that patients with epilepsy performed significantly worse on verbal memory and verbal fluency. Furthermore, patients with focal epilepsy scored significantly less than those with generalized epilepsy [28].

Hessen, Alfstad, Torgersen & Losses conducted a study on 97 patients with focal or generalized epilepsy. They found a significant relationship between parent-reported cognitive dysfunction and assessed executive dysfunction [23]. Moreover, Borai, Aly & Ibrahim stated that even adults with epilepsy displayed executive dysfunction. Furthermore, no difference was noted between the generalized and focal forms of epilepsy, whereas a high frequency of seizure is associated with a deficiency in planning/problem solving and WM (verbal and visuospatial) [12]. So, the current study investigates whether patients with generalized epilepsy will display poor performance than control in EFs (Specifically, WM, CF, and planning).

3. Methodology

This study is an observational cross-sectional study whereas aimed to examine the difference between generalized epileptic patients and the control group in

executive functions.

3.1. Sample

The target population is adult patients with a diagnosis of generalized epilepsy. A quota sampling procedure was used to recruit 25 patients from epilepsy outpatient clinics of the Department of Neurology, Kasr Al-Ainy Hospital in Cairo. The age of the participants ranged from 18 to 44 years with an average of 30.52 years ($SD \pm 6.27$). Generalized Epilepsy was diagnosed based on clinical data supported by Normal brain imaging [a magnetic resonance imaging (MRI) or computerized tomography scan (CTS) and electroencephalography (EEG)] were normal or showed Generalized Interictal epileptiform discharge. Males represented 62.5%, whereas females 37.5% of the sample. All patients should have been seizure-free in the past (48 h) before neuropsychological assessment.

The exclusion criteria are as follows: an estimated intelligence quotient (IQ) below 80, any medical condition leading to cognitive impairment, diagnosis of a psychiatric disorder, alcohol, or drug abuse, or any brain-related surgical intervention. The IQ of each subject was estimated using the vocabulary subtest of the Arabic translation of the Wechsler Intelligence Scale for adults.

For the control group, 32 healthy individuals aged 18 to 44 years (30.13 ± 7.51). Males represented 50% of the sample. Table 1 outlines the characteristics of the sample, In addition to the basic clinical data of the patients' group represented in table 2.

Table 1. Characteristics of the Participants.

Characteristic	Patients (N= 25)	Control (N= 32)
Age	M= 30.52 years SD \pm 6.27 years	M= 30.13 years SD \pm 7.51years
Handedness		
Right- left	21-4	27-5
Gender		
Male	62.5%	50%
Female	37.5%	50%

Table 2. Characteristics of the epileptic patients group.

Characteristic	Patients (N= 25)
Mean duration of illness [range].	8.07 [3-25]
Mean frequency of seizure per month [range].	5.7 [3-16]
Numbers of anti-seizure medication [range].	[2-4]

3.2. Tools

The study uses five tests to assess the components of EF (i.e., WM, CF, and planning). *Working memory* was measured by the Arithmetic, Digit Span (forward and backward), and Letter-Number Sequencing Tests from the Arabic version of the Wechsler Intelligence Scale for Adults [2]. *Cognitive flexibility* was valued using the Stroop Color-Word Test [38]. *Planning* was estimated by using the block design test from the Wechsler Intelligence Scale for Adults, Arabic version [2]. Table 3 provides the reliability

coefficients of the above-mentioned measures.

Table 3. Reliability of tests.

Variable	Test-retest reliability (Pearson's <i>r</i>) N=20
Block design	.87
Stroop test (accuracy)	.85
Stroop test (speed)	.79
Digit span	.80
Arithmetic	.82
Sequence of letters and numbers	.91
Working memory	.94

Table 3 indicates that all reliability coefficients were reasonably high.

Table 4. The difference in Executive Functions between epileptic patients and controls.

Variable	Control N=32		Patients N=25		T-Value
	M	SD	M	SD	
Planning					
Block design	30.34	5.64	24.33	5.75	3.76**
Cognitive flexibility					
Stroop test (accuracy)	7.72	4.91	14.24	1.63	3.79**
Stroop test (speed)	249.38	72.78	301.67	77.27	2.49*
Working memory	52.75	6.85	48.09	8.33	2.22*
Digit span	21.22	3.89	19.76	4.01	1.32
Arithmetic	12.56	2.06	11.67	2.71	1.37
Sequence of letters and numbers	18.97	2.83	16.67	3.17	2.76**

* $P < .05$; ** $P < .01$

Table 4 revealed that adults with Generalized Epilepsy had significant impairment in planning, CF, and WM. However, no significant difference was observed in terms of performance on digit span and arithmetic compared to the healthy controls. This means that epileptic patients perform worse than normals in various executive functions.

This result confirms previous findings showing that executive dysfunction is prevalent in patients with different forms of epilepsy [3, 13, 32]. Furthermore, patients with epilepsy exhibited disturbances in the skills required for goal-directed actions (CF, planning, and WM; e.g., as presented by; 21, 25]. Also, Liik et al. stated that patients with epilepsy displayed poor performance on verbal memory and verbal fluency compared with patients without epilepsy [28].

Along this line, Modi, Vannest, Combs, Turnier & Wade found that 30%, 17%, and 18% of adolescents with epilepsy experienced impairments in WM, CF/shifting, and planning/organization, respectively [30]. As well as Hessen, Alfstad, Torgersen & Losses demonstrated a significant association between parent-reported cognitive dysfunction and assessed executive dysfunction in patients with generalized epilepsy [23]. Borai et al. found that a high frequency of seizure is associated with a deficiency in planning/problem solving and WM (verbal and visuospatial) in patients with generalized epilepsy [12].

5. Conclusion

Epilepsy is a prevalent neurological disorder in Egypt

3.3. Data Collection

Beforehand, the participants reviewed the consent form and were informed that participation was strictly voluntary. Furthermore, they were assured of anonymity and that their responses will remain confidential. They were not asked to state their names on the forms. The tests were completed in single sessions. The data was gathered from October 2019 to March 2020.

4. Results and Discussion

To verify the hypothesis, a t-test was calculated. Table 4 presents the results.

and is considered serious. It is triggered by a predisposition to epileptic seizures and associated with negative neurobiological, cognitive, and psychosocial outcomes. It affects several aspects of daily life, such as physical and mental wellness, cognitive abilities, academic performance, occupational roles, and social networks. The findings demonstrate that epilepsy affects planning, CF, and WM in patients with generalized epilepsy. Furthermore, executive dysfunction may negatively contribute to the quality of life. As such, the study suggests patients with epilepsy should be a target of diagnosis and therapy. Also, programs that aim to enhance EFs among this group should be developed. The literature confirms that EFs are trainable and can be enhanced with practice, hence, improving quality of life.

6. Limitations and Future Research

Although the current paper contributes to the extant literature on EFs in patients with epilepsy in the Egyptian context, it has three limitations. First, the design (quota sample) limits the generalization of results. In other words, the findings may not apply to other Egyptian patients with generalized epilepsy. Second, various factors (e.g., level of education, sex, duration of illness, and medical history) were overlooked, which may influence the results. Third, the sample size is a typical concern of many studies on patients with epilepsy. Different results may be obtained from a large or diverse sample.

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