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Cognitive Coping and Frontal Lobe Epilepsy: A Task Switching Study

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Abstract

The present study examines the role of cognitive coping in task switching abilities of patients with frontal lobe epilepsy (FLE). Participants (25 patients with FLE & 25 healthy controls) performed switching task and reported the use of cognitive coping strategies. Results showed that patients with FLE had sustained attention for emotion which lead to the unbalanced switch cost between tasks. This pattern of results did not appear in controls. Relative to controls, patients with FLE reported more frequent use of maladaptive cognitive coping strategies such as self-blame, other blame, rumination, and catastrophizing and less frequent use of putting into perspective, positive refocusing, positive reappraisal, acceptance and planning. Cognitive coping strategies were associated with switch costs. Greater use of maladaptive strategies was positively correlated with weaker task switching abilities. This study for the first time highlighted the role of cognitive coping in frontal lobe epilepsy during switching conditions. Implications of results were discussed.

Keywords: Frontal lobe epilepsy; Seizures; Emotion; Cognition; Task switching; Coping strategies; Rumination; Catstrophizing

Introduction

Frontal lobe epilepsy (FLE) is characterized by short-term, frequent seizures that arise in the frontal lobes of the brain [1]. Patients may experience abnormalities in body posturing, motor skills and sensorimotor tics. These symptoms are recurrent due to the over-activationwithinone central foci that moves to lateral brain regions [2]. Frontal lobe monitors a wide array of higher order cognitive functions [3,4] such as learning, inhibitory control, reward processing and working memory [5,6]. Patients following frontal lobe damage show disorganization, failure in accomplishment of goal-directed activities and response inhibition [7-10]. Patients with frontal lesions have more perseverative and set loss errors as compared to patients with non-frontal lesions [11]. Patients with frontal lesions in either hemisphere take longer time to learn the cognitive task and show more errors [12,13]. Frontal lobe lesions are associated with increased distractibility [14]. After excisions of the frontal lobe, patients show impairment in memory and learning specifically an inefficient use of a strategy which is required for successful performance [15-18]. Excisions from left or right frontal cortex results in severe learning impairments [19] because frontal cortex is critical for learning associative tasks and retrieval of the information from memory [20,21]. Patients demonstrate inability to plan, co-ordinate and organize the sequence of activities after damage to frontal lobe [22,23]. Lesions in frontal lobe causeinability to adopt new rules [13,24,25] and increased time cost during task switching [26]. Patients with frontal lobe lesions experience significant problems in response preparation and inhibition [27].

Frontal lobes have compound connections to cortical, subcortical and brain stem sites and control higher order cognitions such as inhibition, cognitive flexibility, problem solving, planning, and behavior. Thus, executive function is broad term which encapsulates diverse anatomical structures diffused in central nervous system [28]. Prefrontal cortex play a fundamental role in cognitive development such as lateral areas are involved in higher executive functions which are required to perform goal-directed actions whereas ventromedial areas control emotional and instinctual behaviors [29]. Prefrontal cortex monitors executive control, emotion processing, working memory, learning and temporal structure of the task relevant response. This brain region is responsible for coordination and transfer of information that is required for operation of multiple level cognitions [30]. Dorsolateral prefrontal cortex is associated with set-shifting, planning, problem solving and response inhibition [31]. Anterior cingulate cortex is involved in decision making, inhibition of task irrelevant response, and motivated behaviors [32]. Orbitofrontal cortex is involved in set maintenance, impulse control and evaluation of subjective experiences of emotions [33].

In an article "An integrative theory of prefrontal cortex function" written by Miller and Cohen et al. [34] it is argued that prefrontal cortex is the primary control center for cognitions. The control is implemented by the increased gain of either sensory or motor neurons that are engaged by elements of the task or goal. Prefrontal cortex has supervisory role for the active maintenance of and achievement of task goals affecting visual processes and sensory modalities for emotional evaluation, memory, retrieval and response execution. As a net result, neural activity along pathways is established for cognitive mapping that is required to perform a given task. This theory draws concepts from the early view of selective visual attention [35] which is based on the competition between stimulus attributes. Brain selects stimulus attributes and gains increased neural response to those stimulus dimensions. These neural outputs have more access to reach downstream processing stage and as a result guide behavior. According to Miller and Cohen, selective attention is in fact control of attention. Prefrontal cortex controls the sensory input and the resultant neural response, as well as the organizations of memory and emotions. Control of cognitions involves prefrontal reciprocal connectivity with the sensory and motor cortices, and the limbic system. Thus, in situations of the receipt of biased signals, cognitive control is required to override the selective attention, error monitoring, decision-making and memory inhibitionand to promote the task-relevant responding.

The "cascade of control model" by Banich (2009) assumes the sequential flow of brain regions involved in the maintenance of attentional sets to achieve a certain goal. These regions are dorsolateral

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and the mid- prefrontal cortex, and the anterior dorsalcingulate cortex. The posterior dorsolateral prefrontal cortex maintains the appropriate attentional set and rules out biased and irrelevant information. The mid-dorsolateral prefrontal cortex follows the task-relevant representation that is instrumental to achieve the goal. The posterior dorsal anterior cingulate cortex is responsible for task relevant response selection [36].

According to Miyake and Friedman's theory of executive functions, updating, inhibition and switching are three important inter-related aspects of executive functioning. Updating is the continuous monitoring and maintenance of the contents of working memory. Inhibition is the capacity to supersede a response which is not relevant in the given condition [37]. Switching is the cognitive flexibility to shift between different task-sets. Generally, switching experiments require participant to shift between two tasks, when each task is assigned a specific task-rule. For an efficient switching, the participants' attention must be in accordance with the task-rule [38,39]. A cost may arise due to the deferral in selection of the task-rule called as switch cost [40]. The switch cost is product of the activation of relevant task-rule in working memoryand inhibitory mechanisms to reduce theintrusion from competing task-set [41,42]. These functions are predominantly performed by areas in the prefrontal cortex [43]. Patients with FLE often report cognitive function deficits such as impaired attention, concentration and memory [44]. Patients with FLE show impaired set-shifting performance on visuomotor sequencing task [45]. In situations which require dual-task performance, patients with FLE show failure in cognitive switching [46].

Neuropsychological studies demonstrate that patients with FLE have impaired performance on cognitive functionssuch as attention, memory, response inhibition, memory span, anticipatory behavior and concept formation [47,48]. Cognitive deficits are displayed in executive dysfunctions in response initiation, selection and inhibition [49,50]. Patients with FLE show deficits in set shifting and inhibition on color-word interference test [51]. Focal damage of the frontal cortex leads to increased switch costs [26].

Patients with epilepsy experience emotional distress during seizures that are accompanied by vigilant attention toward emotion-related stimuli [52]. Patients with focal epileptic seizures display intense emotional agitation due to the decreased synchrony in signals recorded from neural network involved in emotional processing and a total loss of synchrony between amygdala and orbito-frontal cortex [53]. Cognitive coping is helpful to regulate emotions, thoughts and cognitions [54]. Failure in cognitive coping results in pathological behavior and psychiatric disorders [55]. Frequent use of coping strategies such as rumination, self-blame, catastrophizing results in emotional problems whereas positive reappraisal leads to less vulnerable behavior toward emotional turmoil [56-58]. Coping is defined as an individual's constant effort to manage demands of the internal and external environment which taxes resources of the person. It is a cognitive mechanism which helps to accomplish goal-directed and motivational behaviors [59]. Deficits in executive functions are associated with the activation of maladaptive coping strategies, whereas higher levels of executive functions are involved with the application of adaptive coping strategies and positive emotional as well as behavioral outcomes [60].

The present study

The present study aimed to examine the relationship between cognitive coping strategies and task switching in patients with FLE. To date, it is unclear how strategies for cognitive coping influence executive functions associated with frontal lobe epilepsy and whether patients with FLE employ any differential coping mechanism on cognitive level relative to healthy individuals. This study is the first investigation into coping strategies in patients with FLE in connection with their switching abilities.

Hypotheses

1. Contrary to controls, patients with FLE would show sustained attention for emotion rather than age task. This should result in larger switch cost for age task.

2. Patients with FLE would show higher use of maladaptive coping strategies than controls.

3. Switch costs would be related with coping strategies.

Method

Participants

Twenty five patients (*M*=27.36, SD=3.45, 23-35 years) with FLE took part in the study at Jinnah and Services Hospital, Lahore. Patients were diagnosed on the basis of EEG evidence and seizure semiology with onset in the frontal lobe. The average age at the onset of FLE was 17 years. All patients were on anticonvulsant medication and had dysfunction outside the frontal region as assessed by MRI. Patients had no history or current psychiatric disorder as assessed by clinical psychologist according to the guidelines of DSM-IV [61]. Twenty five healthy individuals (*M*= 25.80, SD=5.17, 23-35 years)were contacted from local community with an inclusion criteria of having no history or current symptoms of neurological or psychiatric disorder according to the guidelines of the DSM-IV [61] and no use ofanticonvulsant medication. Patients and controls were matched on demogrpahic variables: age, gender, education, economic status andintellectual function (as measured by Standard progressive matrices [62] (Table 1).

Materials

Task switching experiment:

Experimental stimuli: The experiment was designed with 48 facial photographs (24 faces of children with age range as 9-12 years and 24 faces of adults with age range as 18-24 years) which depicted happy and neutral expressions of emotions. Half of these faces portrayed female gender. Images were standardized on 288×288 pixels with white background. Prior to the final experimental testing, it was ensured that

Characteristics	Patients (n=25)	Control (n=25)
	N	***N***
Gender		
Female	10	11
Male	15	14
Economic Status		
Lower	02	03
Middle	15	13
Higher	08	09
Education		
Primary	-	-
Secondary	10	12
Higher	15	13
Intellectual Function	25	25
Psychiatric Comorbidity	None	None

Table 1: Demographic and Clinical Characteristics for Patients with FLE and Healthy Controls

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the emotional expression in the pictures were recognizable by patients and controls. Ratings were obtained on a 10-point scale describing the salience of emotions in the pictures (1=poor; 10=excellent).48 pictures were selected from a large pool on the mean ratings (happy M=8.00, SD= 0.50) of 20 subjects from each participant group with good inter-rater reliability (79).

Experimental design and display: The experiment was designed in E-prime software [63] with an alternating-run paradigm of task switching [39]. The tasks were emotion and age categorization to faces. Both tasks were counterbalanced across participants.The experiment was designed with 241 trials and was presented to the participants on laptop screen. The structure of trials was comprised of a fixation, blank screen followed by the presentation of facial image. The images were presented on coloured background screen which served as task cue. These images remained on the screen until response. Manual responses were recorded by pressing fixed keys on the keyboard, 1=child; 2= adult; happy=3; neutral=4. The faces were remained on the screen until the response was completed. The first trial in the task switching experiment had no task switch, therefore the analysiswere exclusive of the data on the first trial. Switch trial was defined as the trial with a changed task as it was on the previous trial whereas the repeat trial had the same task asthe previous trial. The analyses were performed on equal number of the switch and repeat trials (240=120 switch; 120 repeat) with a clear distinction of emotion and age task (120 switch trials=60 emotion, 60 age; 120 repeat trials=60 emotion, 60 age). The structure and display of the trials are shown in Figure 1.

Cognitive Emotion Regulation Questionnaire (CERQ): Cognitive coping was measured through CERQ. It is a 36 item self-report questionnaire, developed by Garnefskiand colleagues [64]. The questionnaire was used to examine strategiesthat a person employs in order to reduce the severity of negative life events. The CERQ has nine subscales which are conceptually different from each other: self-blame, other blame, rumination, catastrophizing, putting into perspective, positive refocusing, positive reappraisal, acceptance and planning. Each subscale has 4-items and refers to a cognitive strategy used to regulate emotions. Self-blaming refers to blame on one self for the negative experiences in life; other-blame refers to putting blame on environment or another person; rumination refers to thinking about negative events; catastrophizing indicates thoughts emphasizing negative experiences; putting into perspective refers minimizing the seriousness of the event relative to other events; positive refocusing refers thinking about joyful issues; positive reappraisal refers to thoughts of creating positive meaning to life; acceptance refers to approval of the past experiences; planning refers to thoughts of practical steps to handle negative events. Each strategy is scoredon a 5-point Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). Total score on each subscale ranges from 4 to 20. Subscales have good internal consistencies ranging from 0.68 to 0.86 [65,66].

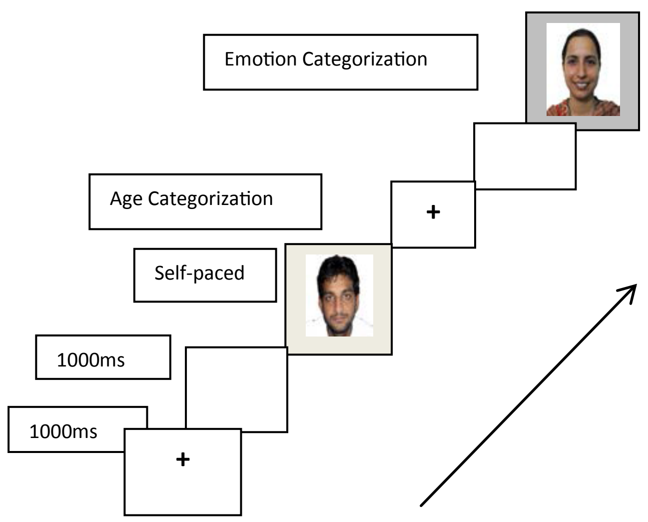

Figure 1: Example of the Stimuli and displays for the emotion and age task

Results

Task switching

Response times (reaction times: RTs) for the first trial (no switch trial) and those exceeding 2.5 standard deviations from each participants' mean were excluded. Switch costs for each task were calculated by subtracting mean RTs on repeat trials from mean RTs on switch trials). Mean RTs were submitted to a repeated measures analysis of variance with trial (*switch: task is changed as the previous trial* vs. *repeat: task is same as the previous trial*), task (*emotion* vs. *age*) as within subject factors and group (*patients with FLE vs. controls*) as between subject factors.

The main effect of trial was significant F (1, 48)=111.00, p<0.001, ηp2=.69, switch (M=1319.00ms); repeat (M=957.41ms). Main effects of task F (1, 48) =3.40, p=.07, ηp2=.06, (emotion M=1121.23; age M= 1155.16ms) and group F (1, 48) =5.48, p=.02, ηp2=.10, patients with FLE (M=1351.00); control (M = 925.42ms) were not significant. These was a significant interaction between trial x task F (1, 48) =13.10, p<0.001, ηp2=.21, switch (emotion M=1284.00; age M=1354.15 ms) repeat (emotion M=959.00; age M=956.16 ms). The interaction between trial x group was not significant F (1, 48) =.04, p=.84, ηp2=.00, patients with FLE (switch M=1535.20 ms; repeat M= 1167.00 ms); controls (switch M= 1103.00 ms; repeat M= 748.10 ms). The interaction between trial x task x group was significant F (1, 48) =26.35, p<0.001, ηp2=.35, Figure 2. This higher order interaction was analyzed through separate repeated measures analysis of variance for patients and controls. For patients, there was a significant main effect of trial F (1, 24) =51.51, p<0.001, ηp2=.68, switch (M= 1535.20 ms); repeat (M=1167.00 ms) and task F (1, 24) =6.67, p<0.01, ηp2=.21, emotion (M= 1308.60 ms); age (M=1393.33 ms). There was a significant interaction between trial x task F (1, 48) =50.52,p<0.001, ηp2=.67. Switch cost for the age task was larger than the emotion task t (24) = 7.10, p<0.001, emotion (M=280.38 ms); age (M=456.55 ms). For controls, there was a significant main effect of trial F (1, 24) =60.35, p<0.001, ηp2=.71, switch (M= 1103.00 ms); repeat (M=748.10 ms). The effect of task was not significant F (1, 24) =1.02, p=.32, ηp2=.04, emotion (M= 933.66 ms); repeat (M=917.00 ms). The interaction between trial x task was not significant F(1, 24) =0.92, p=.34 ηp2=.03. Errors are shown in Table 2.

Coping strategies and task switching

Pairwise comparison between scores on subscales for CERQ showed that patients with FLE and controls use different coping strategies. Pearson correlations were carried out to determine the relationship between switch costs and scores on coping strategies. Results showed significant correlations between scores on coping strategies and switch costs. Self-blaming (r=.43, p<0.001), other-blaming (r=.44, p<0.001), rumination (r=.46, p<0.001), and catastrophizing (r=.47, p<0.001) had a positive contribution towards switch costs. In contrast, planning (r=-.31, p<0.05) and acceptance (r= -.27, p<0.05) had negative association

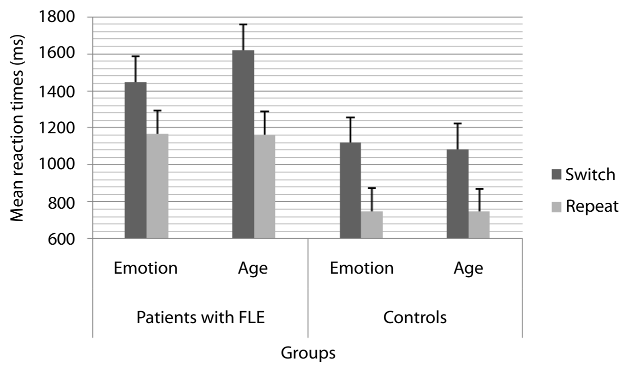

Figure 2: Mean reaction times (ms) for switch and repeat trials

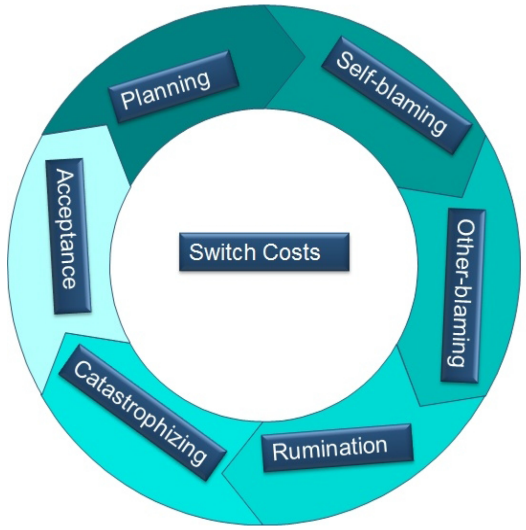

Figure 3: The schematic diagram for the coping mechanism is portrayed

	Patients	**Controls**	
	M **(SD)**	***M*** **(SD)**	
Self-blaming	14.12 (3.43)	5.72 (1.27)	*t* (24)=13.22, *p*<0.001
Other-blaming	13.60 (3.57)	5.56 (1.52)	*t* (24)=12.19, *p*<0.001
Rumination	14.16 (4.10)	6.24 (1.23)	*t* (24)=10.25, *p*<0.001
Catastrophizing	14.80 (4.71)	5.36 (1.38)	*t* (24)=10.40, *p*<0.001
Positive refocusing	7.48 (2.32)	16.20 (2.39)	*t* (24)=19.48, *p*<0.001
Positive reappraisal	8.00 (2.19)	16.24 (2.53)	*t* (24)=15.06, *p*<0.001
Acceptance	6.92 (1.91)	15.96 (2.74)	*t* (24)=13.71, *p*<0.001
Planning	6.56 (2.02)	15.60 (2.53)	*t* (24)=15.39, *p*<0.001
Putting into perspective	6.88 (1.96)	17.16 (2.39)	*t* (24)=16.10, *p*<0.001
Cognitive coping	93.08 (11.72)	104.04 (9.94)	*t* (24)=3.92, *p*<0.001

Table 2: Scores on Subscales of CERQ for Patients and Controls

with switch costs. Few strategies such as positive refocusing (*r*=-.23, p=.11), positive reappraisal (*r*=-.23, p=.11) and putting into picture (*r*=-.02, p=.86) had no significant relationship with switch costs.

Discussion

The present study was designed with to examine three main objectives (1) switch costs in patients with FLE and healthy individuals (2) cognitive coping strategies in patients with FLE (3) relationship between switch costs and coping strategies. Results supported first hypothesis of the study. Switch costs for the age task was larger than the emotion task. This effect was not evident in controls. This result is consistent with previous studies suggesting the role of frontal lobe in executive functions [22,23]. Damage in frontal lobe results in deficient goal-directed activities, response inhibition and organization [7-10,11-14]. Lesions in frontal lobe leads to impaired memory, learning [15-19] and retrieval from memory [20,21]. These abnormalities cause incapacity to adopt task-rule when the task switches [13,24-26]. The epileptic seizures in focal areas are associated with weak set-shifting ability [45]. Alongside, there are deficits in broad cognitive domains of attention, memory, and response selection [44,47-50] observed in interference tasks [51]. Patients with epilepsy experience heightened emotional behavior and attention to emotion-related stimuli [52] due to an abnormal synchrony predominant in amygdala and orbito-frontal cortex [53]. Our results showed that patients with FLE had sustained attention to emotion which delayed the performance of age task. On comparison, a larger switch cost was observed for age task. These patterns of results were in contradiction with the controls data. Healthy controls paid equal attention to both tasks, thus no asymmetric switch costs appeared for the tasks.

The second hypothesis of the study was supported by the finding that patients with FLE had weaker cognitive coping and maladaptive coping strategies relative to controls. Contrary to controls, patients with FLE reported a greater use of self-blame, other blame, rumination, and catastrophizing whereas a lesser use of strategies as putting into perspective, positive refocusing, positive reappraisal, acceptance and planning. The frequent use of rumination, self-blame, and catastrophizing play a positive role in emotional disorders. Positive reappraisal is associated with less frequent emotional chaos [56-58]. The switch costs were positively associated with self-blame, other-blame, rumination and catastrophizing. This result supported the third hypothesis of the study and depicted that higher use of self-blame, other-blame, rumination and catastrophizing were associated with task switching deficits. Cognitive coping strategies such as putting into perspective, positive refocusing, positive reappraisal, and acceptance and planning had an inverse relationship with switch costs. Higher use of these strategies was related with lesser switch costs. Notably, correlations werenot significant for positive refocusing, positive reappraisal and putting into perspective.This result showed that blaming oneself or others for negative life experiences occupies mind and slows down the flow of cognitions. Previous research depicted that blaming is associated with poor recovery from traumatic experiences [67], however, our results clarified the basic mechanism of reduced rehabilitation. The self or other blaming interrupts the cognitive stream, as a result cognitions get stagnant.Another contributing factor towards cognitive decline is rumination about negative life events. The present finding gained support from the previous finding that catastrophic thinking is associated with difficulty in disengaging attention from negative experiences.

In contrast to these maladaptive strategies, acceptance and planning play influential role in efficient cognitive functioning. Approval of the past experiences, no matter negative in valence and problem solving approach help in reducing switching deficits. Acceptance and commitment are new behavioral and cognitive approaches to desensitize the negative life experiences [68]. The schematic diagram for the coping mechanism is portrayed in Figure 3. Therapists should consider modification of the negative schema that is activated in patients with FLE that would be extremely beneficial for effective rehabilitation.

Limitations and Future Directions

This study for the first time demonstrated that cognitive coping is an important mechanism for task switching abilities in patients with FLE. Strategies for cognitive coping can serve as an indicator of the cognitive decline associated with frontal lobe epilepsy. These results are important for therapeutic interventions in frontal lobe epilepsy. It can help guide the cognitive therapists to focus on the structure of coping mechanism and adapt therapeutic process to modify maladaptive cognitive strategies. Such adaptations could aid the process of neuro-rehabilitation and provide support for patients with cognitive deficits. However, results of the present study are constrained due to the small sample size; therefore the study must be replicated with larger sample. Future research must also focus whether switching deficits associated with FLE can be improved with therapeutic interventions. It might be of practical value to examine neural correlates of coping strategies to prevent relapse in patients with epileptic seizures.

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