

Thought suppression predicts task switching deficits in patients with frontal lobe epilepsy

Amara Gul, MPhil, PhD, Hira Ahmad, BS, MS.

ABSTRACT

الأهداف: دراسة العلاقة بين تحويل الأعمال والقمع الفكري لدى المرضى المصابين بالصرع الجبهي الأمامي.

الطريقة: أُجريت هذه التجربة في مستشفى جيناه، لاهور، باكستان وذلك خلال الفترة من فبراير إلى نوفمبر 2013م. شملت الدراسة 30 من المرضى الذين يعانون من الصرع الجبهي الأمامي، بالإضافة إلى 30 من الأفراد الأصحاء من المجتمع المحلي. أجرى المشاركون مهمة تحويل الأعمال حيث أنهم قاموا بمهمة تحويل الأعمال بناءً على التصنيفات العاطفية والعمرية بين الوجوه. ولقد قام المشاركون بتعبئة الاستبيان الخاص بقمع الأفكار.

النتائج: أظهرت الدراسة ثلاث نتائج مهمة: (أ) أن المرضى الذين يعانون من مرضى الصرع الجبهي الأمامي أضعف في قدرتهم على تحويل المهمة مقارنة بالأفراد الأصحاء. وتعود هذه النتيجة إلى وجود الاختلالات التنفيذية لدى المرضى الذين يعانون من الصرع الجبهي الأمامي. (ب) وبخلاف مجموعة الشاهد، فقد أظهر المرضى الذين يعانون من الصرع الجبهي الأمامي تكلفة أكبر في تحويل الأعمال بالنسبة للتصنيفات العمرية مقارنة بالعاطفية. ويمكن رؤية هذه النتيجة في سياق عجز الإدراك الاجتماعي وضعف السيطرة لدى المرضى الذين يعانون من الصرع الجبهي الأمامي. وبالإضافة إلى ذلك، فقد عكست المعدلات الأكبر من تحويل الأعمال تأثيراً على العواطف الوجهية مقارنة بالعمرية. وقد يمثل الاندماج العواطف كميّار وجهي يمكن أن يتعارض مع أداء تحويل الأعمال. ولقد كان لدى المرضى الذين يعانون من الصرع الجبهي الأمامي معدلات (أقل أو أكثر من) من القمع الفكري المتكرر وذلك بالمقارنة مع مجموعة الشاهد. وكان قمع الأفكار من المؤشرات المرتبطة بصورة واضحة من الناحية الإحصائية بتكلفة تحويل الأعمال. وكانت الدرجات العالية من قمع الأفكار مرتبطة بعيوب تحويل الأعمال.

الخاتمة: تشير نتائج الدراسة بأن القمع الفكري قد يكون سبباً مؤدياً إلى انخفاض الفكر المعرفي وذلك بصورة واضحة من الناحية الإحصائية.

Objective: To examine the relationship between task switching and thought suppression in connection with frontal lobe epilepsy (FLE).

Methods: This experimental study included 30 patients with FLE admitted to the Services and Jinnah Hospital, Lahore, Pakistan between February and November 2013, and 30 healthy individuals from the local community. Participants performed a task switching experiment where they switched between emotion and age categorizations among faces. In addition, they completed a thought suppression questionnaire.

Results: There were 3 important results: (i) Patients with FLE showed weaker task switching abilities than healthy individuals. This result is attributed toward executive dysfunctions in patients with FLE. (ii) Contrary to the control group, patients with FLE showed larger switch cost for the age than the emotion categorization. This result can be seen in the context of social cognition deficits and poor inhibitory control in patients with FLE. In addition, larger switch costs reflected a binding effect with facial emotion as compared to age. The integration might represent emotion as an intrusive facial dimension that interrupted task switching performance. (iii) Patients with FLE had more recurrent suppression of thoughts than controls. Thought suppression was a significant predictor for switch costs. High scores on thought suppression were correlated with task switching deficits.

Conclusion: The results suggest that thought suppression causes significant cognitive decline.

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From the Department of Applied Psychology, The Islamia University of Bahawalpur, Bahawalpur, Punjab, Pakistan.

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Address correspondence and reprint request to: Prof. Amara Gul, Assistant Professor, Department of Applied Psychology, The Islamia University of Bahawalpur, Bahawalpur 63100, Punjab, Pakistan. E-mail: amara_psychology@hotmail.com

Frontal lobe epilepsy (FLE) is the second most common type of epilepsy characterized by periodic seizures that arise in the frontal lobes of the brain.¹ Symptoms include abnormal body positioning and movements due to an over activation in one central foci that travels to lateral brain regions.² Frontal lobes monitor working memory, executive control, and emotion processing.³ Dysfunction in the frontal lobes is associated with emotion regulation deficit.⁴ Successful performance of executive function requires focus attention on relevant stimulus dimension, inhibition of irrelevant information, planning, and updating the content in the working memory.⁵ Lesions in the frontal lobes are associated with impaired executive functions (namely, a large number of perseverative errors as measured by Wisconsin card sorting test).⁶ Neuropsychological studies of the frontal lobes suggest that prefrontal damage can impair the ability to establish, change, and maintain or shift a task-set.^{7,8} The time cost of a task switch is increased following damage to the frontal lobes.⁹ The notion that FLE is associated with executive dysfunctions is well-established.¹⁰ Patients with FLE show poor performance on measures of attention, speed, motor coordination, concept formation, response inhibition, anticipatory behavior, and memory span.^{11,12} Patients with FLE show more errors than healthy control subjects on emotion conceptualization, emotion learning tasks, and experience difficulties in social cognition.^{13,14} Task switching is an executive function that involves shifting attention from one task-set to another task-set. In task switching experiments, participants perform more than one task. On switching trials, the task-set changes, which requires an individuals' attention to be in accordance with the task demand/task-set rule.¹⁵ A subsequent delay in selection of a task-set rule is reflected in cost on reaction times, which is called the switch cost.¹⁶ Switch cost simply indexes activation of the relevant rule in the working memory,¹⁷ and extra inhibitory processes to reduce interference from competing "task-sets."¹⁸ Selection and inhibition of task-sets are functions of the prefrontal cortex.¹⁹ Information that is once task relevant becomes irrelevant when the task is alternated. The inhibitory mechanism is required for

efficient control over task interference.²⁰ Poor inhibition is associated with greater intrusive thoughts during thought suppression.²¹ Less frequent inhibition is related to frequent intrusions of unwanted thoughts and personal memories.²² Individuals with poor inhibition experience more intrusive emotionally charged memories.²³ Thought suppression is a mechanism to control intrusive and unwanted experiences, which mainly rely on the prefrontal and anterior cingulate cortex.²⁴ Under conditions of high cognitive load, intentionally suppressed thoughts become more accessible to the cognitive system and fuel the cognitive domain that an individual is trying to avoid.²⁵ Thought suppression can produce binding effects to unwanted intrusive material,²⁶ and blocks the natural process of effective coping and hampers cognitive, emotional, and behavioral functioning.²⁷ On a cognitive level, individuals show an attentional bias toward unwanted information to avoid psychophysiological reactions.²⁸ Suppression hinders the processing of emotion-related information.²⁹ People who suppress their thoughts are no more skilled than people who are not involved in thought suppression at inhibiting emotion-related material.³⁰ As switching in this study requires inhibition of one task to successfully perform the other task, it is expected that patients with FLE would show deficient switching abilities, specifically when one of the tasks is emotion-related. In this case, a larger switch cost for age task would arise than the non-emotion task. Thought suppression is associated with deficient inhibitory control and frequent occurrences of intrusive experiences, memories, and unwanted thoughts.²²⁻²⁴ We hypothesize that thought suppression could predict task switch costs. The objective of this study is to examine the relationship between task switching and thought suppression in patients with FLE.

Methods. Participants. Thirty patients with FLE were recruited from patients admitted to the Jinnah and Services Hospital, Lahore, Pakistan between February and November 2013. To be included in the study, patients needed to meet 3 of the following 4 criteria: (1) EEG (interictal or ictal) evidence that clearly indicated onset in the frontal lobe, from either scalp recordings or intracranial EEG. (2) A seizure semiology consistent with onset in the frontal lobe. (3) An epileptogenic lesion in the frontal lobe identified using MRI. (4) At least average intellectual functioning as measured through Standard Progressive Matrices.³¹ Patients with either an epileptic focus/radiological evidence of dysfunction outside of the frontal regions, history or current psychological illness, and below average

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intellectual function were not included in the study. Lateralization and localization were based on lesion site as examined by MRI and EEG. The control group included 30 healthy individuals, recruited from the local community through an advertisement for the study. The inclusion criteria were as follows: (1) No history of neurological or psychiatric disorder. (2) No signs of any neurological disease. (3) No use of medication. (4) At least average intellectual function. Patients with FLE and controls were matched on the basis of age, gender, education, and economic status. These characteristics are reported in Table 1.

Emotion-age task stimuli. The stimuli were 32 faces with happy (16 faces) and angry expressions (16 faces). The expression of emotion was salient with obvious teeth in happy and angry faces. Among 16 happy faces, half depicted young (18-28 years), and other half portrayed older faces (55 years and above). Images were standardized on 100 x 100 pixels with a white background in colored bitmap format. In pilot testing, participants were asked to identify the emotional expression and age of photographs "how would you describe the salience of expression and age of the face," on a scale from 1 to 10 (1=very poor salience,

10=excellent salience). Selection of photographs was based on the ratings of 44 participants (22 normal, 22 patients with FLE; inter-rater reliability = 0.80) with mean (standard deviation) rating as: happy 7.50 (0.61), angry 7.00 (0.70), young 7.50 (0.50), and old 8.00 (0.70). Faces were embedded in the experiment using a task switching alternating-run paradigm.¹⁶ The experiment was designed in E-prime software (Psychology Software Tools Inc., Pittsburgh, PA, USA).³² Faces were presented in the center of the screen against a colored background, which served as a cue to indicate the task to be performed. Blue color indicated emotion task whereas black background indicated age task. Tasks were counterbalanced across participants. For half of the participants, the experiment started with presentation of an emotion task. For the other half, the age task was presented first. The experiment was displayed on a laptop screen with 241 trials in total with a task sequence as AABBAABB... Each trial consisted of a fixation (+) displayed for 1000 ms, followed by a blank white screen for 1000 ms, then the face appeared in the center of the screen. Manual responses were made to faces by pressing the keys set on the keyboard (old=1; young=2, happy=3, angry=4). Faces remained on the screen until the responses were made.

White Bear Suppression Inventory.³³ The White Bear Suppression Inventory (WBSI) is a self-report 15-item questionnaire designed to measure thought suppression. Chronic suppression results in a state of vigilance and preoccupation with recurring thoughts. The respondents score each item on a 5-point scale from strongly disagree (1), to strongly agree (5). The total score is obtained by summing up the respondents' scores. The total score can range from 15 to 75. Higher scores indicate greater tendencies to suppress thoughts. The WBSI has high internal consistency (alpha coefficient = 0.87 - 0.89) and good convergent validity. The WBSI is negatively correlated with repression, thus suggesting that the thought suppression is different to traditional concepts of repression.³³ People who suppress their thoughts have low self-esteem and negative mood affect.³⁴

Procedure. Participants signed an informed consent form, and they were given a description of the experiment. The study was approved by the board of studies of The Islamia University of Bahawalpur, Bahawalpur, Pakistan. Each participant viewed the experiment on a laptop screen. Participants were told that this was a reaction time experiment, and that they must respond by pressing fixed keys on the keyboard as quickly as possible without sacrificing accuracy. On each trial, participants were presented with a face and they

Table 1 - Demographic and clinical characteristics of patients with frontal lobe epilepsy and healthy controls.

Variables	Patients (N=30)	Control (N=30)
Age at the time of testing Mean (SD) (min-max)	23.50 (0.86) (22.00-25.00)	23.20 (1.12) (21.00-26.00)
Age at epilepsy onset	14.36 (2.56)	N/A
Gender	n (%)	
Female	12 (40)	13 (44)
Male	18 (60)	17 (56)
Economic status		
Lower	Nil	Nil
Middle	20 (66)	18 (60)
Higher	10 (34)	12 (40)
Education		
Primary	Nil	Nil
Secondary	10 (34)	12 (40)
Higher	20 (66)	18 (60)
Epilepsy onset		
Right frontal	15 (50)	N/A
Left frontal	15 (50)	N/A
Localized abnormality		
Prefrontal cortex	10 (33)	N/A
Medial	5 (17)	N/A
Dorsolateral	10 (33)	N/A
Orbitofrontal foci	5 (17)	N/A

N/A - not applicable, SD - standard deviation

were asked to judge emotion (happy/angry) or age (old/young) among faces according to the background color that served as task cue. Each participant completed 241 trials of the experiment in a single session. At the end of the session, each participant was debriefed and thanked for participation.

Statistical analysis. Statistical analysis was performed using the Statistical Package for Social Sciences version 12.0 (SPSS Inc., Chicago, IL, USA). The response times (RTs) were discarded if: (1) above 2.5 standard deviations from each participants' mean, (2) for the first trial because the task had no switch, (3) incorrect trials. Switch costs for both tasks (mean RTs switch minus no-switch trials) were calculated, subsequently mean RTs were submitted to a repeated measures analysis of variance (ANOVA) with factors such as trial (switch versus no-switch: within subject), task (emotion versus age: within subject), and group (controls versus patients with FLE: between subject).

Results. The main effect of trial was significant $F(1, 58) = 476.08, p < 0.001, \eta^2 = 0.89$. The RTs were slower on switch (mean $[M] = 1013.00$ ms) than no-switch trials ($M = 657.53$ ms). There was a significant main effect of task $F(1, 58) = 13.24, p < 0.001, \eta^2 = 0.18$. Responses were faster for the emotion than the age task ($M = 812.16$ versus 858.04 ms). The main effect of group was not significant $F(1, 58) = 0.34, p = 0.56, \eta^2 = 0.00$, patients with FLE ($M = 842.00$) controls ($M = 841.00$). There was a significant interaction between trial x group $F(1, 58) = 19.00, p < 0.001, \eta^2 = 0.24$. Switch cost for patients with FLE was greater than controls $t(29) = 4.38, p < 0.001, (M = 426.00$ versus 284.58 ms). There was a reliable interaction between trial x task $F(1, 58) = 60.00, p < 0.001, \eta^2 = 0.50$. The switch cost for age was larger than the emotion task $t(59) = 7.00, p < 0.001, (M = 396.00$ versus 314.37 ms). The interaction between task x group failed to reach the significance level $F(1, 58) = 1.38, p = 0.24, \eta^2 = 0.02$, emotion (patients $M = 811.56$; controls $M = 813.00$) age (patients $M = 872.25$; controls $M = 844.00$). There was a significant higher order interaction between trial x task x group $F(1, 58) = 19.45, p < 0.001, \eta^2 = 0.25$. This interaction was further analyzed through separate repeated measure ANOVAs for patients and control group with trial (switch versus no-switch) and task (emotion versus age) as within subject factors. For patients, the main effects of trial $F(1, 29) = 241.39, p < 0.001, \eta^2 = 0.89$, switch ($M = 1055.00$ ms) no-switch ($M = 629.05$ ms) and task were significant $F(1, 29) = 19.37, p < 0.001, \eta^2 = 0.40$, emotion ($M = 811.56$ ms)

age ($M = 872.25$ ms). There was a reliable interaction between trial x task group $F(1, 29) = 162.11, p < 0.001, \eta^2 = 0.84$. The switch cost for the age task was larger than the emotion task $t(29) = 13.00, p < 0.001$. For controls, the main effect of trial was significant $F(1, 29) = 262.12, p < 0.001, \eta^2 = 0.90$. Similar to the patient data, no-switch trials were performed faster than switch trials ($M = 686.01$ versus 970.59 ms). On the contrary, the main effect of task $F(1, 29) = 2.16, p = 0.15, \eta^2 = 0.06$ and interaction between trial x task failed to reach significance level $F(1, 29) = 3.60, p = 0.06, \eta^2 = 0.11$. Both tasks were performed with no significant difference in RTs (emotion $M = 813.00$ versus age $M = 844.00$ ms) and switch costs for the tasks were not asymmetric.

Errors. Errors for the first trial were discarded due to the no-switch trial. Mean errors were submitted to a repeated measures analysis of variance (ANOVA) with factors as trial (switch versus no-switch: within subject), task (emotion versus age: within subject) and group (controls versus patients with FLE: between subject). The main effect of trial was significant $F(1, 58) = 19.02, p < 0.001, \eta^2 = 0.24$. Errors were larger on switch ($M = 0.05$) than no-switch trials ($M = 0.04$). The main effect of task was significant $F(1, 58) = 68.22, p < 0.001, \eta^2 = 0.54$, emotion ($M = 0.04$), age ($M = 0.07$). The effect of group was not significant $F(1, 58) = 0.19, p = 0.66, \eta^2 = 0.00$, patients ($M = 0.06$) controls ($M = 0.06$). The interaction between trial x group was not significant $F(1, 58) = 0.89, p = 0.34, \eta^2 = 0.01$, patients (switch $M = 0.05$; no-switch $M = 0.03$) controls (switch $M = 0.04$; no-switch $M = 0.03$). The interaction between task x group was not significant $F(1, 58) = 0.01, p = 0.90, \eta^2 = 0.00$, patients (emotion $M = 0.04$; age $M = 0.07$) controls (emotion $M = 0.04$; age $M = 0.08$). The interaction between trial x task was significant $F(1, 58) = 44.00, p < 0.001, \eta^2 = 0.43$, emotion (switch $M = 0.01$; no-switch $M = 0.06$), age (switch $M = 0.09$; no-switch $M = 0.08$). The higher order interaction between trial x task x group was not significant $F(1, 58) = 0.04, p = 0.83, \eta^2 = 0.00$.

Relationship between switch cost and thought suppression. Patients with FLE scored higher on thought suppression as compared with controls $t(29) = 16.00, p < 0.001$, patients ($M = 51.93, SD = 8.87$) controls ($M = 21.70, SD = 4.25$). The regression analysis with switch cost as dependent variable and thought suppression as independent variable showed that thought suppression was a significant predictor for switch cost $F(1, 59) = 68.74, p < 0.001, R^2 = 0.54$. Thought suppression explained almost 54% of the variance of switch cost.

Standard regression coefficients showed that thought suppression scores made a positive contribution toward the explanation of switch cost $\beta=0.73$, $t=8.29$, $p<0.001$.

Discussion. The present study was designed to examine task switching abilities in patients with FLE. The second objective was to assess the relationship between switching abilities and thought suppression. Normal healthy individuals were recruited as a comparison group. Results showed that patients with FLE had weaker switching abilities than healthy individuals. The first hypothesis of the study was supported by this finding. Patients with FLE had larger switch cost than controls. This finding is consistent with previous studies suggesting a deficient executive functioning in patients with FLE.¹⁰ These deficits are prevalent on major cognitive domains such as attention, speed, motor coordination, concept formation, response inhibition, anticipatory behavior, and memory span.^{11,12} Frontal lobes are involved in higher order cognitions.³ The efficient task switching performance requires successful manipulation of cognitive functions such as attention, inhibition, goal planning, and update of the working memory.⁵ Patients following frontal lobe lesions showed difficulty in set-shifting,⁶ and switching difficulties.⁸ Damage to frontal lobes results in impaired ability to maintain a set and an increased switch cost.⁷⁻⁹

The second hypothesis of the study was supported by observed asymmetries in patients with FLE. A larger switch cost for age than the emotion task was observed. In contrast, these asymmetries were absent in controls. This result reflected an attentional bias in patients with FLE. Their attention was sustained on emotion task, which delayed the computation of age task. The absence of asymmetries in healthy controls showed an equal attentional weightage to emotion and age dimensions of the faces. Patients with FLE show deficit in social cognition specifically in situations where task is emotion-related.^{13,14} Frontal lobes monitor emotion processing.³ Damage to frontal lobes results in emotion dysregulation.⁴ Our results depicted that patients with FLE experienced difficulty in set-shifting when the task was switched as age categorization. Deficient inhibition of the current task-set (namely, emotion in this case) contributed toward a larger switch cost for the age task. The absence of asymmetries in healthy controls showed an efficient update of the working memory context and inhibition of the emotion task-set when the task switched to age categorization. Our results demonstrated that patients with FLE had poor inhibitory mechanism to control the interference between tasks. The weaker inhibition produced task switching deficits. These results

are consistent with previous observations that inhibitory mechanism plays an influential role in overcoming the proactive interference.²⁰ The deficient inhibition leads to greater intrusive and unwanted thoughts, personal, and emotionally laden memories.^{21,22} We found that patients with FLE were more frequent in thought suppression than controls. In addition, thought suppression was a significant predictor of the task switch costs. A larger switch cost for the emotion task showed that patients with FLE suppress emotion-related thoughts, which become rather more accessible to their cognitive system under task switching conditions. Therefore, patients displayed a binding effect to the emotion dimension when there was a need to configure age (namely, non-emotion) dimension among the faces. Emotion dimension among faces seemed to be intrusive, which badly influenced their switching efficiency. Our results showed that higher thought suppression causes task switching deficits. This finding is in line with studies²⁵ suggesting that intentionally suppressed thoughts are highly accessible to the cognitive system during conditions of high cognitive demands. These thoughts form an integration with the domain that an individual is trying to avoid. As a result, the performance on a cognitive, emotional, and behavioral level is disrupted. Moreover, emotional vulnerability and immunological functioning is compromised and psychopathological symptoms arise.^{29,30} These results for the first time highlighted the importance of thought suppression as a disrupting mechanism for cognitive functioning among patients with FLE. The findings would be helpful in formulating therapeutic interventions for patients with FLE. Future studies must examine other epileptic groups in order to clarify our understanding of normal and abnormal switching functions.

Limitations. Future studies must consider a larger sample size than the present study. The emotion task must be comprised of varied emotions.

In conclusion, thought suppression proved to be a strong predictor of task switching abilities (namely, frequent thought suppression is related with higher task switching deficits). Patients with FLE showed binding effects to the emotion attribute of the faces; thus, a larger switch cost for age task was observed. Thought suppression is a significant marker of the task switching impairments in patients with FLE.

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