Brief Communication

The relationship between emotional intelligence and task-switching in temporal lobe epilepsy

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ABSTRACT

Objectives: To examine the role of emotional intelligence (EI) in task-switching performance of patients with temporal lobe epilepsy (TLE).

Methods: An experimental research design conducted at Sheikh Zayed Hospital, Rahim Yar Khan, Mayo and Services Hospital, Lahore, Pakistan from March 2013 to October 2014. Twenty-five patients with TLE and 25 healthy individuals from local community participated in the study. Participants completed measures of intelligence, EI, depression, anxiety, stress, and task-switching experiment.

Results: Patients and controls showed an average intelligence quotient, and normal levels of depression, anxiety, and stress. In contrast to controls, patients showed lower EI and impaired task-switching abilities. This result can be seen in the context of disintegrated white matter and cerebral connectivity in patients with TLE. Emotional intelligence was found to be a significant predictor of task-switching performance.

Conclusion: Emotional intelligence is a potential marker of higher order cognitive functioning in patients with TLE.

Temporal lobe epilepsy (TLE) is the most common type of epilepsy[1] that is known to be associated with impairment across broad cognitive domains.[2] Cognitive impairment may be stopped or even reversed if seizures are controlled[3] and depends on chronicity of epilepsy.[4] Cognitive trajectory of patients with TLE is characterized by performance on measures of memory, intelligence, and executive function.[5] Reduced volumes of the prefrontal cortex, disparate scattering of white and grey matter volumes, cerebellar abnormalities, and disconnection between cortical and subcortical regions are associated with impaired executive functioning in patients with TLE.[6] Temporal lobe is considered to be an important structure in social cognition. Patients with TLE show impaired emotional intelligence (EI) and emotion recognition.[7,8] Emotion recognition deficits in patients with TLE are pronounced in right hemisphere only for negative emotions, whereas no deficits for positive emotions have been observed in left or right-TLE patients.[9] Converging evidence from patient and healthy population data suggests that cognitive functioning and emotion processing are intertwined. Emotions guide and monitor our cognitions to elicit adaptive responses in the environment. Emotional responses determine our perception about the world, attentional modulation, organization of memories and decision-making.[10] Therefore, it is reasonable to suspect that EI could be a contributing factor for executive functioning. We used task-switching as an experimental paradigm[11] to examine cognitive flexibility where participant has to make decisions to faces and respond according to the changed task-rule when the task switches. There is an interference from in competition task-set, which requires extra inhibitory processes to get minimized for an efficient switching.[12] Neurocognitive data suggests an anatomical overlapping between areas involved in task-switching and EI. Our cognitive control system centrally relies on prefrontal cortex. The activation of task-set and inhibitory mechanisms operate through prefrontal cortex.[13] Patients with lesions of the frontal cortex are impaired at adopting new task set and imposing normal inhibition.[14] Prefrontal cortex is implicated in social cognitions such as emotional empathy and shared attention required to form human representation of triadic relations between two minds and object which is required for collaborative work on shared goals.[15] Lesions of the prefrontal cortex are associated with impairment in understanding emotions of others and cognitive flexibility.[16] Degeneration of prefrontal cortex produces rapid decline in empathic concerns, and executive functions as observed in patients with frontal variant of front temporal dementia.[17] Dysfunctions in the prefrontal cortex underlie the impaired ability to form emotional bond with other person and deficient performance on cognitive tasks (advanced theory of mind) in individuals with autism spectrum disorder.[18] Although an extensive research is available on cognitive functioning and EI but it still remains unanswered whether individual differences in EI are involved in executive functioning keeping in view the anatomical overlapping. Based on the above

cited literature, we hypothesized that patients with TLE in contrast to healthy individuals, would show impairment in both EI and task-switching performance (namely larger switch cost) or in any one of these factors. Second, we hypothesized that EI could predict task-switching performance.

Methods. *Participants.* Twenty-five patients with TLE participated in the study at Sheikh Zayed Hospital, Rahim Yar Khan, Mayo and Services Hospital, Lahore, Pakistan from March 2013 to October 2014. The inclusion criteria for patients was the presence of seizures with temporal origin as observed by electroencephalography and unilateral lesions in magnetic resonance imaging. Exclusion criteria for patients were as follows: (i) extra temporal or generalized epilepsy (iii) below average Intelligence quotient (IQ) level (iii) history of oxygen deprivation, other neurological illness, head injury (iv) epilepsy surgery (v) history of psychiatric illness according to the criteria mentioned in diagnostic and statistical manual of mental disorders-IV.[19] Twenty-five healthy volunteers matched for demographic variables such as age, gender, socioeconomic class were included in the study from local community (**Table 1**). Exclusion criteria were the same for the control group except one additional factor (that is experience of seizure). Convenience sampling was used to collect sample. The study was designed in an experimental research design.

Procedure and materials. Approval for the study was obtained from the Board of Studies of the Islamia University of Bahawalpur, Bahawalpur, Pakistan and was conducted according to the principles of Helsinki Declaration. Informed consent was obtained from participants at the beginning of the testing session. Intelligence quotient was measured using Wechsler adult intelligence scale.[20] The test is highly reliable with alpha ranged from 0.70-0.90 and inter-scorer coefficient high as 0.90. Depression, anxiety, and stress were assessed using depression, anxiety, and stress scale.[21] It is a 42-item scale that is used to measure depression, anxiety, and stress on a 4-point Likert scale. Scores on each subscales are categorized as: depression (normal=0-9, mild=10-13, moderate=14-20, severe=21-27), anxiety (normal=0-7, mild=8-9, moderate=10-14, severe=15-19), and stress (normal=0-14, mild=15-18, moderate=19-25, and severe=26-33). Depression, anxiety, and stress scale are highly reliable with Cronbach's alpha 0.96 for depression, 0.89 for anxiety, and 0.93 for stress.[22] Emotional quotient inventory (EQ-i)[23] was used as a measure of EI. It is a 133-item

self-report inventory scale from 1=very seldom/not true of me to 5=very often/true of me. The EI scores were interpretation as 130 and above=atypically well developed emotional capacity, 120-129=extremely well developed emotional capacity, 110-119=well developed emotional capacity, 90-109=adequate emotional capacity, 80-89= underdeveloped emotional capacity, 70-79=extremely underdeveloped emotional capacity, under 70=atypically under developed emotional capacity. The reliability of EQ-i is between alpha 0.60-0.70. In a pilot study, it was ensured that facial expression of emotions presented in photographs were recognizable by patients and healthy individuals (20 patients with TLE and 20 healthy individuals). The inter-rater reliability was 0.70. Images were selected on the basis of accurate ratings by both participating groups. These images were inserted in the task-

Table 1 - Demographic information for patients with temporal lobe epilepsy and control group.

Variables	Patients (n=25)	Control (n=25)
Age at the time of testing mean± SD (min-max)	35±0.50 (20.00-35.00)	34.50±0.62 (20.00-35.00)
Age at epilepsy onset	30 (0.40)	
Gender, n (%)		
Female	13 (52)	13.0 (52)
Male	12 (48)	12.0 (48)
Economic status, n (%)		
Lower	Nil	Nil
Middle	14 (56)	15.0 (60)
Higher	11 (44)	10.0 (40)
Education, n (%)		
Primary	Nil	Nil
Secondary	15 (60)	14.0 (56)
Higher	10 (40)	11.0 (44)
Epilepsy onset, n (%)		
Right Frontal	12 (48)	Nil
Left Frontal	13 (52)	Nil
Seizure frequency per month	12 (1.20)	Nil
Laterality n (%)		
Right focal abnormality n (%)	11 (52)	
Left focal abnormality n (%)	12 (48)	
Bilateral n (%)	2 (8)	
WAIS Full IQ	100.2 (2.68)	101.1 (2.15)†
DASS Depression	4.60 (1.80)*	5.84 (2.09)*
DASS Anxiety	3.60 (1.43)*	4.30 (1.36)*
DASS Stress	2.34 (0.88)*	2.08 (0.94)*
EI	77.84 (15.17)	101.0 (8.66)‡

WAIS - wechsler adult intelligence scale, DASS - depression, anxiety and stress scale, EI - emotional intelligence, *normal, †t (24)= 1.48, p=0.15, ‡t (24)= 50.14, p<0.001

switching experiment. The experiment was designed in an alternating run paradigm of task- switching[11] using E-prime software.[24] Participants were required to switch between emotion -age categorization of faces in 241 trials. The experiment was presented on computer screen and manual responses were made (key press young=1, old=2, happy=3, neutral=4). Half trials of the experiment were switch (that is task changed) whereas other half were repeat trials (that is task repeated).

Statistical analysis. Statistical analysis was performed by the Statistical Package for Social Sciences System (version 12.0, Chicago, IL, USA). (a) A 2-factor analysis of variance (ANOVA) was performed with quotient (IQ and EQ) as within subject and group (patients with TLE versus healthy controls) as between subject factors to examine whether groups were different on IQ and EQ scores. (b) Task-switching data: Response times (RTs) were removed meeting the following criteria: (i) standing above 2.5 standard deviation above the each participants' mean (ii) for the first trial due to a no switch trial (iii) for incorrect trials. Task switch costs were calculated by subtracting mean RTs on repeat trials from mean RTs on switch trials. The RT and error data were submitted to conduct separate repeated measures of ANOVA with factors as trial (switch versus repeat trials: within subject) and group (patients with TLE versus healthy controls: between group). T-test was performed to examine differences between groups on switch costs and RTs on trials. Errors for the first trial were also removed from 2 x 2 ANOVA with trial (switch versus repeat trials: within subject) and group (patients with TLE versus healthy controls: between group) (c) Regression analysis was performed to assess the relationship between task switch costs and scores on EI.

Results. *Intelligence quotient and EQ scores.*
Results showed a significant interaction between quotient and group $F_{(1, 48)}=784.82$, $p=0.001$, $\eta p2= 0.94$, **Table 1**.

Response time data. Main effects of trial $F_{(1, 48)}=122.07$, $p=0.001$, $\eta p2=0.71$ and group $F_{(1, 48)}=21.84$, $p=0.001$, $\eta p2=0.31$ were significant. The RTs were slower on switch trials as compared to repeat trials (M=2750.00 ms versus 1686.00 ms). Patients with TLE performed slower than healthy control subjects (M=2778.49 ms versus 1657.00 ms). The interaction between trial and group was also significant $F_{(1, 48)}=25.09$, $p=0.001$, $\eta p2=0.34$. Switch costs for patients with TLE was larger than healthy controls $t_{(24)}=4.77$, $p=0.001$, M= 773.39 ms versus 291.00 ms. Patients with TLE performed slower as compared to control group both on switch trials $t_{(24)}=5.95$, $p=0.001$,

M=3552.00 ms versus 1948.00 ms and on repeat trials $t_{(24)}=2.62$, $p=0.01$, M=2005.10 ms versus 1366.16 ms. Error data: Main effects of trial $F_{(1, 48)}= 0.18$, $p=0.66$, $\eta p2=.00$ was not significant (switch M=.02; repeat M=.02). The main effect of group was significant $F_{(1, 48)}= 5.87$, $p<0.01$, $\eta p2= 0.10$ was significant. Patients with TLE showed larger errors than healthy controls M=.03 versus .01. The interaction between trial, and group was significant $F_{(1, 48)}= 3.84$, $p=0.05$, $\eta p2= .07$, patients with TLE (switch M= .03, repeat M= .02) controls (switch M=.01, repeat M=.01).

Switch costs and EI. Patients with TLE showed lower EI scores as compared to healthy controls $t_{(24)}= 5.94$, $p=0.001$, patients (M= 77.84, SD=15.17) controls (M= 101.00, SD=8.66). Regression analysis was conducted with EI and laterality as independent and switch cost as dependent variable. The EI proved to be a significant predictor of task switch costs $F_{(2, 49)}= 11.91$, $p=0.001$. $R^2=0.33$. Coefficient of standard regression showed that EI scores had negative contribution towards switch costs, $\beta= -0.57$, $t=2.25$, $p=0.02$ whereas lateralization failed to reach the level of significance $\beta= -0.00$, $t=0.02$, $p=0.97$.

Discussion.
This study was designed to examine (i) the cognitive and emotional profile of patients with TLE (ii) the contribution of EI in task-switching performance. Across different studies, patients with TLE demonstrate cognitive deficits but one aspect of cognitive functioning (that is task-switching) has not been examined. We sought to examine the status of switching between dual-tasks in patients with TLE. In contrast to the traditional task-switching experiments which considered number-letter-word switching, we used faces as stimuli. Social interactions involve rapid switching from various facial attributes. We expected that task-switching, EI or a causal link between these 2 factors possibly could explain social difficulties in patients with TLE.

Our data revealed impaired switching abilities in patients with TLE. In contrast, to healthy individuals, patients with TLE demonstrated a larger switch cost which reflected difficulties in task-set shifting. Switching between tasks requires attentional control in case the task gets alternated and the previously relevant task becomes irrelevant. At this stage, task relevant-rule needs to be retrieved from working memory to make a correct response to the stimuli along with extra inhibitory processes to reduce interference from the irrelevant task-set. Neuropsychological findings suggest that better task-switching and inhibition are correlated with greater integrity of white matter microstructures

that support cortical-subcortical and cross-cortical connections of the prefrontal cortex.[25] The performance on measures of set-shifting correlates with front temporal fiber tract integrity in healthy individuals that remains attenuated or absent in patients with TLE.[26] Thus, there is a failure in formation of a typical bond between structure and function in patients with TLE particularly atypical communication between mesial temporal and frontoparietal neural network. These abnormalities underlie cognitive morbidity in TLE. As compared to healthy individuals, patients with TLE demonstrate worse performance on 2 measures of set-shifting Trail making test-B that measures visuomotor number-letter set-shifting and verbal fluency category switching test that examines verbal ability to alternate between selection of words from 2 different overlearned semantic categories quickly in 60 seconds.[27] Evidence from neuropsychological and neuroimaging studies suggests that set-shifting and working memory in relation to executive functions as measured by Wisconsin card sorting test are compromised in patients with TLE. Various other executive functions such as theory of mind and decision-making are also vulnerable.[28] Patients with TLE show marked deficits in attentional control during elevator counting with distraction and set-shifting as measured by odd-man-out test.[29] Our task-switching data also showed an overall slow processing speed of patients with TLE than healthy individuals. This result can be attributed to disintegrated white matter in the prefrontal cortex and reduced cerebellar volume.[30,31] Patient with TLE were impaired in EI. This result is consistent with previous studies that assessed EI in connection with TLE.[8,9] The important result here is that EI predicted task-switching performance. Studies in the field of neuropsychology revealed overlapping neural system controlling cognitions and social interactions. Frontal cortex has a significant role in task-switching and emotional concerns.[15] Patient studies further strengthened this idea for instance lesions of the prefrontal cortex impair emotion processing, empathy and cognitive flexibility.[16] In frontotemporal dementia where degeneration of the prefrontal cortex occurs, a rapid decline in understanding of emotions and executive functioning has been observed.[17] Dysfunctions of the prefrontal cortex can be seen in autism spectrum disorder where patients show deficits in emotional attachments and cognitive performance.[18]

In conclusion, patients with TLE exhibit marked changes in executive and emotional functioning including task-switching and EI. These changes are believed to be dependent on structural and functional abnormalities in frontal cortex and temporal lobe. The EI successfully predicts task-switching deficits. These findings provide basis for understanding and further study of social cognitions in TLE.

Limitations and future directions. Sample size must be increased to improve the power of fitting in model. Therapeutic interventions based on the development of EI must be formulated to decrease cognitive impairment related with TLE. Future research must examine cognitive binding in stimulus-specific effects.

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