An investigation of the impact of facial affect recognition impairments in moderate to severe TBI on fatigue, depression, and quality of life

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**ABSTRACT**
Individuals with moderate to severe traumatic brain injury (TBI) have been shown to experience significant problems in facial affect recognition (FAR). However, it is not known how these impairments relate to overall functioning and quality of life (QoL) following TBI. The aim of the current study was to test the hypothesis that worse performance on an FAR task would be associated with reduced QoL (related to social and emotional functioning), worse mood, and increased fatigue. Forty-seven individuals with TBI and 27 healthy controls (HCs) completed the facial emotion identification task (FEIT), as well as questionnaires assessing social and emotional QoL, mood, and fatigue. The TBI group performed significantly worse than HCs on the FEIT. A significant relationship between FAR and fatigue and QoL related to social and emotional functioning was documented, but in an unexpected direction: individuals who performed better on the FEIT reported poorer QoL and greater fatigue. Individuals who have better FAR may require increased effort to perform this task, and thus experience greater fatigue and poorer social and emotional QoL.

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Facial emotion identification task (FEIT); social cognition; emotional processing; traumatic brain injury; quality of life; fatigue

**Introduction**
Individuals with traumatic brain injury (TBI) suffer from a range of cognitive, physical, and psychiatric symptoms (Nicholl & LaFrance, 2009). Additionally, 39–51% of individuals with TBI have difficulty processing emotional information, including impaired facial affect recognition (FAR) (Biszak & Babbage, 2014; Croker & McDonald, 2005; Green, Turner, & Thompson, 2004; Milders, Fuchs, & Crawford, 2003). These deficits are not surprising given the location of brain regions which subserve emotional processing (i.e., prefrontal cortex, amygdala) and the propensity of these regions to be damaged during a TBI. Despite these documented impairments, a clear understanding of how these impairments affect overall functioning in TBI does not exist. In other populations such as schizophrenia and bipolar disorder, research suggests that FAR difficulties are associated with reduced psychosocial functioning, including increased depression (Fulford, Peckham, Johnson, & Johnson, 2014) and poor quality of life (QoL) (Hofer et al., 2009). In TBI, at least two studies have found that social communication abilities (such as FAR) are associated with functioning in the domain of “social integration” (Knox & Douglas, 2009; Struchen et al., 2008). However, to our knowledge, no studies to date have examined other aspects of functioning, including mood, fatigue, or QoL, all of which are shown to be negatively impacted in TBI (Hawthorne, Gruen, & Kaye, 2009; Jorge et al., 2004; Mollayeva et al., 2014). Given the link between FAR and other aspects of overall functioning in other populations, it is important to address this link in TBI. Thus, the current study will examine the relationship between FAR and depression, fatigue, and QoL.

**Methods**

**Participants**
Participants consisted of 47 individuals with TBI and 27 healthy controls (HCs). Individuals with TBI were at least 1 year post-injury at the time of study participation, being 9.6 years post-injury on average (range 13–335 months). To document TBI severity, medical records were reviewed for Glasgow Coma Scale Scores and/or duration of loss of consciousness. When this information was unavailable, a study team member interviewed a family member to obtain duration of loss of consciousness.
Twenty-six participants were involved in motor vehicle accidents, nine were pedestrians hit by a motor vehicle, four were falls, four were victims of violence, three were sports-related accidents, and one participant sustained an injury on unknown cause. TBI severity was categorized as follows: 29 severe, 14 moderate/severe, 1 moderate, 2 mild, and 1 with missing severity information. Among those reports, injury location information was available: eight had anterior (prefrontal) damage, seven had temporal lobe damage, six had posterior (occipital) damage, and three had damage in multiple locations. Additionally, eight individuals reported right hemispheric damage, seven reported left-sided damage, and three reported bilateral lesions (the remaining subjects did not report laterality).

Exclusionary criteria included a history of any neurologic disease/injury (other than brain injury among TBI participants), a history of alcohol/drug abuse, and major psychiatric disturbance (defined by psychiatric inpatient stay or diagnosis of psychiatric disorder prior to brain injury). The mean age of participants with TBI was 39.17 (SD = 11.38), and the mean age of HC participants was 35.41 (SD = 12.26). The mean years of education completed in the TBI group was 13.96 (SD = 1.81) and in the HCs was 14.74 (SD = 1.79). There was no significant difference between the two groups on age (t (72) = −1.33, p = .187), education (t (72) = 1.80, p = .076), or in gender composition (X^2 (2) = 4.97, p = .083).

**Procedures**

Procedures were approved by the Institutional Review Board of Kessler Foundation, including informed consent prior to enrollment. All participants were reimbursed for participation.

Participants were administered neuropsychological measures and questionnaires which assessed mood, fatigue, QoL, and FAR as part of larger study which will be published elsewhere. When possible, all measures were administered in person, and questionnaires were filled out on the day of the study. Due to time constraints, however, some participants returned questionnaires by mail. The following measures were administered.

The facial emotion identification task (FEIT) (Kerr & Neale, 1993) consists of two tasks to measure recognition of the emotions happy, angry, afraid, sad, surprised, and ashamed: (1) Identification: 19 black-and-white photographs with differing facial emotions are presented on a computer screen. Participants identify the emotion portrayed in the photograph. (2) Discrimination: 30 pairs of photographs are presented side by side and participants are asked to determine if the pair is showing the same or different emotion. Dependent variables were accuracy for the identification (ID-Acc) and discrimination (Disc-Acc) trials. Additionally, accuracy scores were created for each of the six emotions separately.

The Modified Fatigue Impact Scale (MFIS) (Fischer et al., 1999; Fisk et al., 1994) is a 21-question self-report measure of three subtypes of fatigue: physical, cognitive, and psychosocial. Participants rate the impact of fatigue on a five-point Likert scale ranging from (0) “Never” to (4) “Almost Always”.

The Health Status Questionnaire (HSQ) (Fischer et al., 1999) is a questionnaire used to assess different aspects of health on QoL. The following variables were examined, which we expected to be associated with FAR: (1) Emotional, which assesses emotional problems that affect work and daily activities; (2) Social, which assesses how emotional/physical problems have affected their level of social activity.

The Chicago Multiscale Depression Inventory (CMDI) (Nyenhuis et al., 1998) is a measure of depression, on which the subject reports on a scale of (1) “Not at all” to (5) “Extremely” the feeling of three subtypes of depression: mood, evaluative, and vegetative.

**Statistical analyses**

Independent sample t-tests were used to examine group differences on the FEIT, as well as on the MFIS total score and three subscales, the CMDI total score and its subscales, and on the subscales of the HSQ. Pearson correlation coefficients were calculated to examine the associations between performance on the FEIT and overall QoL (HSQ), mood (CMDI), and fatigue (MFIS) in the TBI group only. To control for multiple comparisons and correlations, the p value was adjusted to control for overall false discovery rate at 0.05.

**Results**

**Differences between groups**

Failure to return questionnaires resulted in missing data. Thus, data were available for 21/27 HCs and 47/47 TBI on HSQ, 21/27 HCs and 46/47 TBI on MFIS, and 23/27 HCs and 46/47 TBI on CMDI. All participants performed the FEIT.

For the differences between groups, the p values (as well as the p values adjusted for false discovery rate) are provided in Table 1. The TBI group was impaired on both identification and discrimination of emotions (ID-Acc and Disc-Acc). When examining separate emotions, the TBI group was impaired only on the recognition of the
emotions of anger, fear, and sadness. However, once adjusting for multiple comparisons, only fear remained significantly different between groups, although anger and sadness were marginally significant.

The TBI group reported significantly lower QoL compared to HCs in both the emotional and the social domains. The group with TBI reported significantly more fatigue (in total score, physical, cognitive, and psychosocial) on the MFIS compared to HC. Significantly higher levels of depression were documented in the TBI group on the CMDI (mood, evaluative, vegetative, and total) compared to HCs.

### Association of FAR and fatigue, QoL, and depression in TBI

Both $p$ values and $p$ values adjusted for multiple correlations are provided ($p_{adj}$). There was a significant positive relationship between accuracy scores on the identification trial of the FEIT and the MFIS total score ($r = .295, p = .047, p_{adj} = .047$), physical subscale ($r = .306, p = .038, p_{adj} = .047$), and psychosocial subscale ($r = .484, p = .001, p_{adj} = .004$), indicating that individuals with better performance on the FEIT report greater fatigue. Additionally, a significant negative correlation was observed between HSQ social functioning and FEIT performance ($r = -.320, p = .020, p_{adj} = .020$), indicating that persons who perform worse on the FEIT report a greater QoL as it pertains to social functioning. No significant association was found between depressive symptomatology (CMDI) and FAR abilities. Further, no correlations were observed between fatigue, depression, and QoL with Disc-Acc.

Regarding each separate emotion, anger accuracy score was correlated negatively with HSQ social functioning ($r = -.447, p = .001, p_{adj} = .004$), and positively with MFIS physical subscale ($r = .374, p = .006, p_{adj} = .016$) and psychosocial subscale ($r = .515, p = .000, p_{adj} = .002$). Thus, persons who performed better on the recognition of the emotion anger reported lower QoL related to social functioning, as well as increased physical and psychosocial fatigue. The fear accuracy score was correlated positively with MFIS physical fatigue ($r = .323, p = .015, p_{adj} = .02$) and psychosocial fatigue ($r = .344, p = .010, p_{adj} = .016$), as well as total fatigue ($r = .308, p = .020, p_{adj} = .023$), indicating that better recognition of fear was associated with greater fatigue. No correlations were noted between recognition of the emotions of happiness, sadness, surprise, or shame.

### Discussion

In the current study, a significant relationship was observed between outcome (i.e., fatigue, QoL) and deficits in FAR in individuals with moderate to severe TBI. Interestingly, the findings were in the opposite direction than hypothesized: better performance on the task of FAR was associated with poorer QoL and higher fatigue.

Consistent with previous research, the TBI group in the current study was impaired on the overall FEIT performance. Further, no correlations were observed between fatigue, depression, and QoL with Disc-Acc.

### Table 1. Differences between groups on FEIT, quality of life (QoL), depression, and fatigue.

<table>
<thead>
<tr>
<th></th>
<th>TBI</th>
<th>HC</th>
<th>t (df)</th>
<th>p</th>
<th>Adjusted $p^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID Acc</td>
<td>$M = 11.43, SD = 2.68$</td>
<td>$M = 13.89, SD = 2.47$</td>
<td>3.92 (72)</td>
<td>.000</td>
<td>0.0004</td>
</tr>
<tr>
<td>Disc-Acc</td>
<td>$M = 24.83, SD = 2.77$</td>
<td>$M = 26.33, SD = 1.96$</td>
<td>2.478 (72)</td>
<td>.016</td>
<td>0.0215</td>
</tr>
<tr>
<td>Anger</td>
<td>$M = .68, SD = .27$</td>
<td>$M = .81, SD = .23$</td>
<td>2.046 (72)</td>
<td>.044</td>
<td>0.0533</td>
</tr>
<tr>
<td>Sadness</td>
<td>$M = .50, SD = .33$</td>
<td>$M = .66, SD = .30$</td>
<td>2.085 (72)</td>
<td>.041</td>
<td>0.0522</td>
</tr>
<tr>
<td>Fear</td>
<td>$M = .39, SD = .23$</td>
<td>$M = .63, SD = .24$</td>
<td>4.047 (72)</td>
<td>.000</td>
<td>0.0003</td>
</tr>
<tr>
<td>Shame</td>
<td>$M = .53, SD = .28$</td>
<td>$M = .56, SD = .28$</td>
<td>.434 (72)</td>
<td>.666</td>
<td>0.6656</td>
</tr>
<tr>
<td>Surprise</td>
<td>$M = .81, SD = .26$</td>
<td>$M = .89, SD = .20$</td>
<td>1.388 (66.1)</td>
<td>.170</td>
<td>0.1798</td>
</tr>
<tr>
<td>Happy</td>
<td>$M = .97, SD = .10$</td>
<td>$M = 1.00, SD = .00$</td>
<td>1.430 (46)</td>
<td>.160</td>
<td>0.1794</td>
</tr>
<tr>
<td>Quality of life (HSQ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>$M = 60.28, SD = 42.07$</td>
<td>$M = 93.65, SD = 17.06$</td>
<td>4.649 (65.6)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Social</td>
<td>$M = 63.83, SD = 27.98$</td>
<td>$M = 88.10, SD = 23.21$</td>
<td>3.472 (66)</td>
<td>.001</td>
<td>0.0015</td>
</tr>
<tr>
<td>Mood (CMDI)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood</td>
<td>$M = 53.84, SD = 13.68$</td>
<td>$M = 44.58, SD = 6.92$</td>
<td>−3.732 (67)</td>
<td>.000</td>
<td>0.0007</td>
</tr>
<tr>
<td>Evaluative</td>
<td>$M = 58.43, SD = 19.51$</td>
<td>$M = 46.43, SD = 4.63$</td>
<td>−3.954 (54.3)</td>
<td>.000</td>
<td>0.0004</td>
</tr>
<tr>
<td>Vegetative</td>
<td>$M = 57.36, SD = 14.34$</td>
<td>$M = 47.00, SD = 11.26$</td>
<td>−3.279 (54.6)</td>
<td>.002</td>
<td>0.0027</td>
</tr>
<tr>
<td>Total</td>
<td>$M = 58.35, SD = 16.45$</td>
<td>$M = 43.96, SD = 7.11$</td>
<td>−5.058 (66.1)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fatigue (MFIS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>$M = 13.76, SD = 10.55$</td>
<td>$M = 3.62, SD = 5.11$</td>
<td>−5.296 (64.7)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cognitive</td>
<td>$M = 15.37, SD = 11.75$</td>
<td>$M = 4.57, SD = 5.58$</td>
<td>−5.099 (64.8)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Psychosocial</td>
<td>$M = 3.35, SD = 2.55$</td>
<td>$M = 0.95, SD = 1.12$</td>
<td>−5.347 (65)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total</td>
<td>$M = 32.48, SD = 23.09$</td>
<td>$M = 9.14, SD = 11.11$</td>
<td>−5.584 (64.7)</td>
<td>.000</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*To control for multiple comparisons, the $p$ value was adjusted to control for overall false discovery rate at 0.05.
score, as well as the individual negative emotions of fear, anger, and sadness (although on the latter two emotions, significance was marginal) (Croker & McDonald, 2005). Interestingly, negative emotions (ability to recognize anger and fear) correlated with fatigue and QoL, while the other emotions showed no individual relationship with outcome.

Individuals with TBI reported higher fatigue compared to the HCs in all subdomains of the MFIS. Performance on the FEIT (total accuracy on identification trial, as well as fear and anger) was associated with total fatigue, as well as psychosocial and physical fatigue (i.e., individuals who recognized emotions better had increased fatigue). Surprisingly, there was no correlation with cognitive fatigue, perhaps because FAR may not be fully explained by typical cognitive deficits in TBI such as executive dysfunction. The unexpected relationship between fatigue and emotional recognition may indicate that successful emotional processing leads to increased effort which may result in increased fatigue in individuals with TBI. This is consistent with the coping hypothesis (van Zomeren & van den Burg, 1985) which suggests that due to the increased effort to cope with everyday demands, individuals with TBI may experience greater fatigue and increased stress, which may help explain the findings of the current study.

Results also indicated that better performance on the FEIT (total score, and specifically anger) was associated with worse QoL. It has been documented that caregivers and family members of individuals with TBI experience significant amounts of negative emotions including anger (Perlesz, Kinsella, & Crowe, 2000; Saban et al., 2015), as well as psychological distress (Ennis, Rosenbloom, Canzian, & Topolovec-Vranic, 2013; Marsh, Kersel, Havill, & Sleigh, 1998; Perlesz et al., 2000). Thus, compared to the healthy population, individuals with TBI may experience increased exposure to negative emotions (i.e., anger), which may then be associated with decreased QoL. More research is needed to directly measure the relationship between family and caregivers “burden and patients” QoL.

The examination of the relationship between emotional processing and self-reported outcome measures in the current study may be tainted by reduced self-awareness in our sample. Decreased self-awareness is common in TBI and has been shown to negatively impact multiple aspects of life including QoL (Goverover & Chiaravalloti, 2014). Self-awareness similarly influences the accuracy of self-reported levels of fatigue, depression, and QoL (e.g., Chiou, Chiaravalloti, Wylie, DeLuca, & Genova, in press). Thus, future work should examine both self-reported outcome and report of significant others to ensure reports are not confounded by a lack of awareness (Spikman et al., 2013).

There are several limitations in the current study. The measures used in the current study may not have been fully sensitive to outcome impacted by FAR deficits. For example, the QoL measure used in the current study did not examine QoL as it relates to interpersonal relationships. Indeed, some QoL questionnaires may be “too broad” and not specific to functioning which may be impacted by social cognition deficits in TBI (Spikman et al., 2013). Future research should include such assessments to determine how FAR impairments affect those aspects of QoL specifically.

In conclusion, the current study demonstrated that in individuals with moderate to severe TBI, better FAR ability was associated with higher rates of fatigue, possibly due to the increased effort required to effectively perform the task. Better performers on the FAR task additionally reported decreased QoL. These findings were most consistently observed in the ability to recognize negative emotions, specifically anger. These findings thus provide important information regarding emotional processing in individuals with TBI and how they relate to outcome.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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