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ALEXITHYMIA IS ASSOCIATED WITH AGGRESSIVE TENDENCIES FOLLOWING TRAUMATIC BRAIN INJURY

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ABSTRACT

Objective: Aggressive behaviour is a frequent legacy of traumatic brain injury (TBI). This study explores the question of how alexithymia, which is associated with deficits in social cognition and empathy, may predispose individuals to aggressive tendencies after head trauma. **Method:** Forty seven individuals referred for routine neuropsychological assessment and advice on the management of long term neuropsychological sequelae after TBI and 72 demographically matched controls completed the 20-Item Toronto Alexithymia Scale (TAS-20) and Buss Perry Aggression Questionnaire (BPAQ; self and proxy). **Results:** The incidence of alexithymia and aggressive tendencies was significantly higher in the group with TBI. After controlling for covariates, alexithymia explained an additional 29% of variance in BPAQ total scores in the group with TBI and 11.1% in the control group. Of the three TAS-20 sub-scales, '*difficulty describing feelings*' emerged as a consistent unique predictor of aggression scores. **Conclusions:** Higher levels of alexithymia are associated with greater aggressive tendencies post-TBI. The findings offer important theoretical and empirical insights into the prediction of aggression after TBI.

MESH Terms: Alexithymia; Emotional Disturbances; Behaviour; Prefrontal Cortex; Brain Injuries; TBI;

Aggressive behaviour is a serious legacy of traumatic brain injury (TBI). Rao and colleagues [1] found the prevalence of aggression to be 28.4% at three months post-injury whilst McKinlay and colleagues [2] found that 20% of their sample exhibited violent irritability. Brooks and colleagues [3] noted that irritability gradually evolved into impulsive aggression which Tateno, Jorge and Robinson [4] estimated to be present in 33% of their sample at six months post-injury. However, the study by Baguley, Cooper and Felmingham [5] found that 25% of cases continued to exhibit aggressive behaviour five years post injury.

The psychosocial impact of aggression is profound, having been implicated in domestic violence [3, 6], relationship failure [7], unemployment [8], and criminality [9]. It is surprising therefore that little attempt has been made to understand what might predispose individuals to aggressive behaviour after TBI, in a way that might suggest differences in aetiology and offer alternative approaches to treatment [10].

Wood and Thomas [11] addressed the difference between impulsive and episodic aggression, pointing out how the latter is amenable to pharmacological treatment whereas impulsive aggression was less easily treated and required a predominantly psychological approach. A potentially important psychological factor associated with aggressive behaviour and tendencies after TBI is the presence of acquired alexithymia, a multifaceted construct comprising (a) difficulty identifying and describing emotions; (b) a concrete communication style; (c) an externally oriented style of thinking, and (d) limited imaginal capacity [12]. Recent studies have revealed a high incidence of alexithymia following head trauma, with its presence posing a detrimental impact on social cognition and psychosocial outcome [13].

The high incidence of alexithymia following TBI is probably explained by research that has associated alexithymia with ventromedial dysfunction [14, 15]. Injury to this part of the brain is frequently associated with deficits in social cognition, especially a lack of ability to recognise the emotional states of others, or an indifference to their emotional needs, resulting in characteristics similar to those in people with psychopathic personality traits [16]. When acquired as a result of brain injury, such changes in personality and behaviour have been referred to as pseudopsychopathy [17] or acquired sociopathy [18]. The disregard for the emotional welfare of others, which has been associated with such conditions, has been proposed to reflect a lack of empathy, an emotional deficit that has been associated with alexithymia in numerous samples, including TBI [19]. Therefore, individuals are not only less alert to their own emotional state but potentially also less aware of the emotional sensitivities of others and therefore less likely to regulate their behaviour from somatic marker feedback [20]. Consequently, individuals with alexithymia may be less likely to inhibit remarks or behaviours that could be construed as hurtful, even aggressive. Thus, they may be less likely to experience guilt over the adverse impact of their behaviour on others. This potentially exacerbates behaviours associated with weaknesses of inhibitory control, resulting in impulsive aggression. Consistent with this line of thinking, Neumann, Malec and Hammond [21] present preliminary evidence that total alexithymia scores may explain a significant portion of the variance (16.2%) in overall levels of self-reported aggression post-TBI. Unfortunately, that study did not examine the contribution made by the different features that comprise the construct of alexithymia. Other methodological issues also imposed constraints on how the results of the study were interpreted (i.e. variation in recruitment strategy; reliance on self-report measures; limited range of potential covariates).

The purpose of this study was to comprehensively explore the relationship between acquired alexithymia following TBI and aggressive tendencies inferred from responses to the Buss-Perry Aggression Questionnaire, based on the perspective of both individuals with TBI and their significant others. Consistent with previous research [19], it was predicted that the proportion of cases with TBI reporting alexithymia would exceed numbers from a demographically matched healthy control group. Second, owing to known problems of biased perception and limited insight following TBI, it was predicted that, as a group, individuals with TBI would self-report significantly less aggressive tendencies compared to ratings made by their significant-others'. Third, and consistent with previous research [5], significantly higher levels of aggression were expected in the group with TBI compared to controls. Finally, on the premise that the presence of alexithymia may aggravate weaknesses of inhibitory control, it was anticipated that a positive relationship would exist between alexithymia and aggression ratings (total and sub-scale scores), and that this relationship would persist when controlling for the influence of injury related characteristics, demographic variables, and known clinical correlates of aggression.

METHOD

Participants

TBI Group: All cases had been referred to the University Head Injury Clinic for advice on the management of long term neuropsychological sequelae. Participants with TBI were excluded if the impression at clinical interview, or performance on neuropsychological tests, threw doubt on their capacity to provide informed consent to participate in the study. Other exclusion criteria, for both the TBI and control groups, comprised - a pre-accident history of psychiatric and/or personality disorder; a history of previous head trauma or neurological disorder; a developmental history of learning disability, an estimated pre-accident IQ < 70, (which could affect ability to recognise and express emotion); dysphasia or any other neurological disorder that would compromise ability to complete the measures. Participants below the age of 20 years at assessment were excluded because they could be considered socially immature (in respect of the role of the frontal lobes in social maturation), which may influence responses on emotion measures and emotional regulation generally.

Forty-seven participants met the above criteria, of whom 34 were male (72.3%). The mean time between injury and assessment was 2.21 years (SD = 1.61; range 0.10-5.63). Injury severity was determined retrospectively by the length of Post Traumatic Amnesia (PTA; mean: 10.57 days; SD = 18.98, range .007-90 days) [22] and Glasgow Coma Scale scores (GCS) [23] at the time of hospital admission (mean: 11.20; SD = 4.69, range 3-15). Mean age at injury was 36.70 years (SD = 13.43, range 17.33-66.54) and at assessment, 38.91 years (SD = 13.27, range 20.24-72.04). The cohort had achieved an average of 11.72 years of education (SD = 1.28, range 10-16) and pre-morbid intellectual functioning was estimated using the Wechsler Test of Adult Reading (WTAR; mean = 89.96, SD = 10.00) [24]. Prior to injury, 91.5% (n=43) of the cohort were employed on a full time or part time basis, 2.1% (n=1) were in education, 4.3% (n=2) were retired, and 2.1% (n=1) were unemployed. At the time of assessment, 27.7% (n=13) remained in full or part time employment, 2.1% (n=1) were in education, 6.4% (n=3) were retired, and 53.2% (n=25) were either unemployed or working as volunteers. Post-injury employment status was unavailable for 10.6% (n=5) of participants.

Control Group: Adhering to the same inclusion/exclusion criteria as the group with TBI (described above), the control group consisted of 72 participants, of whom 53 (82.8%) were male. Mean age at assessment was 40.79 years (SD=13.44, range 18.77-64.08). The control group had achieved an average of 13.22 years of education (SD=2.48, range 10-19) and intellectual functioning was estimated using the WTAR (mean = 96.39, SD = 10.72). At the time of assessment 80.6% (n=58) of the cohort were employed on a full time or part time basis; 5.6% (n=4) were in education; 6.9% (n=5) were retired, and 6.9% (n=5) were unemployed. None of the control cohort had a formal history of neurological disorder, psychiatric illness, or any kind of pre-injury personality disorder that could be interpreted as evidence of an emotional regulation deficit.

The TBI and control group did not significantly differ on age at assessment (t (117) = -0.751, $p > 0.05$), employment status (pre-injury: X^2 (4, n = 119) = 2.859, $p > 0.05$) or socio-economic status (pre-injury: X^2 (7, n = 119) = 6.490, $p > 0.05$). Similarly, the frequency of males and females did not differ across groups (X^2 (1, n = 119) = 0.247, $p > 0.05$). However, years spent in education (t (117) = -3.814; $p < 0.005$) and WTAR scores significantly differed across groups (t (117) = -3.283, $p < 0.001$).

Measures

The 20-item Toronto Alexithymia Scale (TAS-20) [25]*:* The TAS-20 is composed of 20 items on a five-point Likert-type scale, ranging from 'Strongly Disagree' to 'Strongly Agree'. Total scores can range from 20-100. A score ≥ 61 confirms alexithymia; 51-60 indicates 'possible' alexithymia; ≤ 51 indicates an absence of alexithymia. The TAS-20 also consists of three sub-scales: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT) [12, 25]. The TAS-20 has demonstrated excellent convergent and discriminant validity and scores show high agreement with observer ratings of alexithymia [25, 26). The TAS-20 has been used extensively in both clinical and non-clinical populations [19, 27].

The Buss Perry Aggression Questionnaire – Self and Proxy Version (BPAQ) [28]: The BPAQ consists of 29-items that participants endorse on a 5-point scale, ranging from 'Extremely Uncharacteristic to 'Extremely Characteristic' (e.g., self-rating: 'when frustrated, I let me irritations show'; proxy rating: 'when frustrated, he/she will let their irritations show'). Total BPAQ scores range from 29-145, with higher scores indicating a greater inclination for aggression (i.e., greater aggressive tendencies). The BPAQ also has four empirically derived subscales: Physical; Verbal; Hostility, and Anger. The Physical and Verbal aggression subscale, which involves hurting or harming others, represents the instrumental or motor component of aggression. The Anger subscale represents the emotional or affective component of aggression and involves physiological arousal and preparation for aggression, and the Hostility subscale represents the cognitive element of aggression. Internal consistency coefficients of the BPAQ range from 0.72-0.85 [28] and test-retest reliability from 0.72-0.80 [29]. The BPAQ has been found to be positively related to other measures of aggression, personality, and affect instability, suggesting good levels of construct validity [30, 31]. It has also been used extensively in clinical and non-clinical populations, including TBI [32, 33].

The Wechsler Test of Adult Reading - UK (WTAR) [24]: The WTAR is composed of 50 words that have atypical grapheme to phoneme translations. Scores from the WTAR can be used to estimate an individual's level of intellectual functioning before the onset of injury or illness (assuming a normal developmental of reading skills prior to injury or cognitive decline). Test-retest coefficients range from 0.92 to 0.94, practice effects are minimal, and it has excellent discriminant, construct, and concurrent (0.73 to 0.90) validity [34].

Procedure

The study was conducted in accordance with the Helsinki Declaration and ethical approval was obtained from the Department of Psychology Ethics Committee, Swansea University.

Participants with TBI were administered the WTAR, TAS-20 and BPAQ as part of a routine clinical neuropsychological examination. Demographic details and information relating to head trauma were obtained from practitioner records and hospital case notes. As social desirability has been shown to be a highly significant predictor of self-reported aggression [e.g. 35], and that self-report ratings can be influenced by a lack of insight and biased perception after TBI [36], a proxy rating of aggression was also obtained for participants with TBI. Eligible proxies were significant others of participants who were 18 years of age or older, and had known the person being rated well for at the least the past year. The proxy sample comprised 32 females (61.8%) and 15 males (38.2%), and consisted of 30 spouses/partners (63.8%), 12 parents (25.5%), two friends (4.3%), two sons/daughters (4.3%), and one carer (2.1%).

Control participants were drawn from the same socio-economic catchment area as the group with TBI, and were invited to take part in the study via social media and poster advertisements. Control participants completed the WTAR, TAS-20 and BPAQ, and were asked to provide standard demographic information.

Statistical Analysis

Correlations and univariate analysis of variance tests were performed to investigate the presence of possible confounding variables. A test of proportion [37] was employed to investigate the frequency of alexithymia in the group with TBI compared to controls. A series of t-tests (independent and paired samples) and analysis of covariance tests (ANCOVAs) were performed to compare ratings of alexithymia and aggression across groups, self- and proxy-ratings on the BPAQ, and alexithymia group differences on the BPAQ. Partial correlations and hierarchical regression analyses were utilised to explore relationships between alexithymia and aggression. Effect sizes were interpreted in line with the recommendations by Cohen [38].

RESULTS

TBI Self versus Proxy Ratings on the BPAQ

No significant differences were found between self and proxy ratings on the BPAQ (Table 1). Even so, because of the risks associated with biased perception and limited insight following TBI we used proxy BPAQ ratings by significant others in all future analyses. Self-ratings on the BPAQ were used for the control group.

Possible Confounding Variables

TBI Group: No significant correlations were found between TAS-20 or BPAQ scores and PTA, GCS, time since injury, years in education or WTAR scores ($p > 0.05$). No significant correlation was found between TAS-20 total scores and age at injury ($p > 0.05$), but medium negative significant correlations were found between age at injury and BPAQ total and sub-scale scores. Higher levels of aggression were associated with younger age at injury (BPAQ total: $r = -0.405$, $n = 47$, $p < 0.005$; Physical: $r = -0.374$, $n = 47$, $p < 0.01$; Verbal: $r = -0.315$, $p < 0.05$; Anger: $r = -0.327$, $n = 47$, $p < 0.05$; Hostility: $r = -319$, $n = 47$, $p < 0.05$). A large statistically significant main effect of age at injury was also found when comparing mean BPAQ scores across 'age bands' (18-24; 25- 34; 35-44; 45+ years; $F (3, 43) = 2.973$, $p < 0.05$; $\eta^2 = 0.17$), although post-hoc comparison using Tukey HSD were not significant ($p > 0.05$).

Control Group

Small to medium significant negative correlations were found between TAS-20 total ($r = -0.343$, $n = 72$, $p < 0.005$), DIF ($r = -0.308$, $n = 72$, $p < 0.001$), DDF ($r = -0.287$, $n = 72$, $p < 0.05$) and WTAR scores. Similarly, a small significant negative correlation was found between WTAR and BPAQ Hostility scores ($r = -0.242$, $n = 72$, $p < 0.05$). A small significant negative correlation was observed between years in education and TAS-20 EOT sub-scale scores ($r = -0.238$, $n = 72$, $p < 0.05$), and between years in education and BPAQ Verbal scores ($r = 0.245$, $n = 72$, $p < 0.05$).

Based on the above analyses, WTAR scores and the number of years spent in education were treated as covariates when examining TBI and control group differences on the TAS-20 and BPAQ, and when the relationship between alexithymia and aggression was explored within groups.

Alexithymia Group Differences

A test of proportion revealed a significant difference in the frequency of alexithymia in the TBI group (57.4%) compared to controls (11.1%) ($Z = 5.423$, $p<0.0001$; Table 2).

Insert Table 2 Here

A series of ANCOVAs were performed to compare TAS-20 total and sub-scale scores across the TBI and control groups. After adjusting for covariates (WTAR scores, number of years spent in education), significantly higher TAS-20 total and sub-scale scores were found in the group with TBI. Results also revealed a strong significant relationship between WTAR and TAS-20 total scores (partial $\eta^2 = 0.328$) while controlling for group. The relationship between years in education and TAS-20 total scores was not significant (partial $\eta^2 = 0.001$, $p > 0.05$).

BPAQ Group Differences

After adjusting for covariates there was a moderate significant main effect of group ($F (1, 115) = 17.142$, $p < 0.0005$; partial $\eta^2 = 0.130$), with significantly higher BPAQ total scores in the group with TBI (Table 3). There was no significant difference across groups on the BPAQ Physical sub-scale, but BPAQ Verbal, Anger and Hostility sub-scale scores were significantly higher in the group with TBI compared to controls (Table 3). Within these analyses, significant small to moderate relationships were observed between WTAR scores and the Anger (partial $\eta^2 = 0.034$, $p < .05$) and Hostility sub-scales of the BPAQ (partial $\eta^2 = 0.063$, $p < 0.05$), and between years spent in education and BPAQ Verbal sub-scale scores (partial $\eta^2 = 0.050$, $p < 0.05$). No other significant relationships were observed ($p > 0.05$).

Insert Table 3 Here

Alexithymia Group Differences on the BPAQ

TBI Group: A series of ANCOVAs revealed large significant alexithymia group (alexithymia, possible alexithymia, no alexithymia) differences for BPAQ Total ($F (2, 42) = 6.596$, $p < 0.005$; partial $\eta^2 = 0.239$) and Verbal ($F (2, 42) = 3.492$, $p < 0.05$; partial $\eta^2 = 0.143$) Anger ($F (2, 42) = 5.213$, $p < 0.01$; partial $\eta^2 = 0.199$), and Hostility ($F (2, 42) = 6.050$, $p < 0.005$; partial $\eta^2 = 0.224$) sub-scale scores (Table 4). Physical aggression scores did not significantly differ across alexithymia groups ($F (2, 42) = 2.753$, $p > 0.05$; partial $\eta^2 = 0.116$) and there were no significant relationships between the covariates and BPAQ scores across the alexithymia groups (> 0.05).

Insert Table 4 Here

Control Group: There were no significant alexithymia group differences on BPAQ total ($F (2, 67) = 3.086$, $p > 0.05$, partial $\eta^2 = 0.084$), Physical ($F (2, 67) = 0.995$, $p > 0.05$, partial $\eta^2 = 0.029$), or Verbal ($F (2, 67) = 0.904$, $p > 0.05$, partial $\eta^2 = 0.026$) sub-scale scores. Significant alexithymia group differences emerged on the Anger ($F (2, 67) = 4.354$, $p < 0.05$, partial $\eta^2 = 0.115$) and Hostility sub-scales ($F (2, 67) = 4.811$, $p < 0.05$, partial $\eta^2 = 0.126$), with lower ratings in the group without alexithymia. Apart from years in education and Verbal BPAQ sub-scale scores (partial $\eta^2 = 0.126$, $p < 0.05$), there were no significant relationships between the covariates and BPAQ total or sub-scale scores across the alexithymia groups (> 0.05).

The Relationship between Alexithymia and Aggression

TBI Group: A series of partial correlations were performed between total and subscale scores of the TAS-20 and BPAQ. To account for the possibility of inflated type 1 error, an adjusted p value of 0.01 was adopted. Results revealed moderate to strong significant positive correlations between TAS-20 total, DIF, DDF and BPAQ total and sub-scale scores. In each instance, higher levels of alexithymia were associated with higher levels of aggressive tendencies. No significant correlations were found between the EOT sub-scale of the TAS-20 and BPAQ total or sub-scale scores ($p > 0.01$).

Insert Table 5 Here

A hierarchical regression analysis was performed to determine whether TAS-20 total scores (Block 2) could predict a significant amount of variance in BPAQ total scores, after controlling for the influence of WTAR scores and years in education (Block 1). Block 1 explained 0.9% of the variance in BPAQ total scores ($F (2, 44) = 1.200$, $p > 0.05$). The introduction of TAS-20 total scores in block 2 explained an additional 29% of the variance in BPAQ total scores. The overall model was significant ($F (3, 43) = 7.441$, $p < 0.0005$) and explained 29.6% of the variance in BPAQ total scores. Only TAS-20 total scores made a significant unique contribution to the model ($\beta = 0.544$) (Table 6).

A further hierarchical regression (Block 1 – WTAR, years in education; Block 2 – TAS-20 sub-scale scores) explained 30.2% of the variance in BPAQ total scores ($F (5, 41) = 1.200$, $p < 0.001$). Of the three TAS-20 sub-scales, only DDF made a significant unique contribution to the model ($\beta = 0.390$) (Table 6).

Insert Table 6 Here

Comparable hierarchical regression analyses were performed for each of the four sub-scales of the BPAQ. In each instance, block 1 (WTAR scores and years in education) failed to explain a significant amount of variance in BPAQ sub-scale scores (Physical: $F (2, 44) = 1.713$, $p > 0.05$; Verbal: $F (2, 44) = 0.823$, $p > 0.05$; Anger: $F (2, 44) = 0.550$, $p > 0.05$; Hostility: $F (2, 44) = 1.487$, $p > 0.05$). However, the introduction of TAS-20 sub-scale scores (Block 2) resulted in a significant change in the amount of variance explained (Physical: R^2 Change = .205, F Change = 3.882, $p < 0.05$; Verbal: R^2 Change = 0.232, F Change = 4.330, $p < 0.01$; Anger: R^2 Change = 0.235, F Change = 4.325, $p < 0.01$; Hostility: R^2 Change = 0.228, F Change

= 4.934, $p < 0.005$) and the models were significant (Physical: F (5, 41) = 3.149, $p < 0.05$, adjusted $R^2 = 0.189$; Verbal: F (5, 41) = 3.002, $p < 0.05$, adjusted $R^2 = 0.179$; Anger: F (5, 41) = 2.865, $p < 0.05$, adjusted $R^2 = 0.169$; Hostility: F (5, 41) = 3.715, $p > 0.01$, adjusted R^2 = 0.228). Only DDF sub-scale scores made a significant unique contribution to the variance in Physical BPAQ sub-scale scores (DDF $\beta = 0.386$, $t = 2.220$, $p < 0.05$).

Control Group: Partial correlations revealed small to moderate significant positive correlations between TAS-20 total, DIF, DDF and BPAQ total scores (adjusted alpha level 0.01). Higher levels of alexithymia were associated with higher levels of overall aggression. TAS-20 total scores were also significantly correlated with Anger and Hostility sub-scale scores, DIF with Verbal, Anger, and Hostility, and DDF with Physical and Hostility (see Table 5). No other significant correlations were found ($p > 0.01$).

As with the TBI group, a series of hierarchical regression analyses were then performed. The first regression explored whether TAS-20 total scores (Block 2) could predict a significant amount of variance in BPAQ total scores, after controlling for the influence of WTAR scores and years in education (Block 1). Block 1 explained 2% of the variance in BPAQ total scores and the overall model was not significant (F (2, 69) = 1.707, $p > 0.05$). The introduction of TAS-20 total scores in block 2 explained an additional 11.1% of the variance in BPAQ total scores after controlling for the covariates. Overall, the model was significant (F (3, 68) = 4.258, $p < 0.01$) and explained 12.1% of the variance. Only TAS-20 total scores made a significant unique contribution to the model ($\beta = 0.355$) (see Table 7).

The second regression explored the contribution of TAS-20 sub-scale scores to BPAQ total scores. Block 1 (WTAR and years in education) was not significant ($F (2, 69) = 1.707$, $p > 0.05$), explaining only 2% of the variance in BPAQ total scores. However, block 2 was significant ($F (5, 66) = 3.426$, $p < 0.01$), explaining 14.6% of the variance overall in BPAQ total scores. Of the three TAS-20 sub-scales, only DIF made a significant unique contribution to the model ($\beta = 0.314$) (see Table 7).

Insert Table 7 Here

The final set of regressions considered TAS-20 and BPAQ sub-scale scores. Block 1 (WTAR; years in education) failed to explain a significant amount of variance in BPAQ sub-scale scores (Physical: $F (2, 69) = 0.626$, $p > 0.05$; Verbal: $F (2, 69) = 2.565$, $p > .05$; Anger: $F (2, 69) = 1.741$, $p > 0.05$; Hostility: $F (2, 69) = 2.457$, $p > 0.05$). Introducing TAS-20 sub-scale scores in block 2 resulted in a significant change in the amount of variance explained for all of the BPAQ sub-scales, except verbal (Physical: R^2 Change = 0.115, F Change = 2.924, $p < 0.05$; Anger: R^2 Change = 0.119, F Change = 3.147, $p < 0.05$; Hostility: R^2 Change = 0.178, F Change = 5.179, $p < 0.005$; Verbal: (R^2 Change = 0.092, F Change = 2.417, $p > 0.05$; $F (5, 66) = 2.539$, $p < 0.05$, adjusted $R^2 = 0.098$). DDF sub-scale scores made a significant unique contribution to explaining Physical sub-scale scores ($\beta = 0.298$, $t = 2.156$, $p < 0.05$), and DIF significantly contributed to both Verbal ($\beta = 0.325$, $t = 2.434$, $p < 0.05$) and Anger ($\beta = 0.298$, $t = 2.239$, $p < 0.05$) sub-scale scores of the BPAQ.

DISCUSSION

The proportion of cases with TBI reporting alexithymia exceeded that in a demographically matched healthy control group producing frequencies similar to those reported in previous research on alexithymia after TBI [19]. This adds strength to the assumption that the probable involvement of prefrontal structures in many cases of TBI leads to an acquired form of alexithymia which, in the general population occurs between 7-10% [39] but, after TBI, can increase to 57-61% [19, 40].

The group with TBI, as expected, recorded significantly higher BPAQ total scores compared to the control group. The frequency of aggressive tendencies proved to be partly influenced by a measure of pre-accident intelligence but not years in education or severity of injury as indexed by PTA and GCS scores. After adjusting for WTAR scores and years in education, *Verbal, Anger and Hostility* sub-scale scores of the BPAQ were significantly higher in the group with TBI compared to controls; there was no significant difference between groups on the *Physical* sub-scale, contrasting the preliminary findings of Neumann and colleagues [21]. Overall though, our findings are consistent with both anecdotal and empirical evidence of the predominance of verbal aggression after TBI [1, 41], and with the findings of Dyer and colleagues [35] who noted a higher prevalence of verbal aggression rather than physical aggression in a sample of patients with TBI six months post-injury. Contrary to expectations, the reports of aggression made by the group with TBI were no different from estimates made by their significant others, revealing a degree of insight and reporting accuracy that is often disputed in such cases.

The current study also documented that higher levels of overall alexithymia were associated with aggression post-TBI. Specifically, higher alexithymia scores were found to be related to overall aggression ratings on the BPAQ, as well as higher levels of physical and verbal aggression, anger, and hostility. Extending the preliminary findings of Neumann and colleagues [21], there was no significant correlation between the EOT sub-scale of the TAS-20 and BPAQ total or sub-scale scores, reinforcing opinions concerning the questionable value of this facet of alexithymia when exploring the psychosocial impact of acquired alexithymia [42, 43]. A hierarchical regression analysis found that TAS-20 total scores explained an additional 29% of the variance in BPAQ total scores, even after controlling for WTAR scores and years in education. However, of the three TAS-20 sub-scales, only DDF (difficulty describing feelings) made a consistent significant unique contribution to explaining aggression total and sub-scale scores in the group with TBI. We interpret this as a failure, in those with alexithymia, to recognise their emotional state in such a way that allows them to use emotive language as a form of verbal-mediation to facilitate regulatory control over behaviour, in a manner explained by Wood [44]). In the control group, alexithymia also explained a significant, but a lesser, amount of additional variance in BPAQ scores (11.1%). This is consistent with the preliminary results of Neumann and colleagues [21] who also found evidence that the factors that contribute to aggression may differ between people with and without TBI.

The study is not without limitations. First, the research establishes a correlation, it does not establish causation. Alexithymia and aggression constructs share an underlying dysfunction, with similar neuropathological pathways (ventromedial dysfunction as referenced earlier). However, a systematic analysis of neuroimaging data was not possible as part of this study, and therefore, we cannot explore the potential brain mechanisms that potentially causally connect (or distinguish) pathways and structures implicated in different types of post-TBI aggression. Second, the lack of significant association between indices of severity of injury and aggression could suggest that factors other than TBI are responsible for aggression. However, equally, it cannot be discounted that TBI is an important risk factor for aggression, irrespective of injury severity. Third, whilst we considered the potential role of several demographic, injury-related and other known correlates of aggression, we did not control for several other factors. For example, prior studies have shown that post-TBI aggression is correlated with depression, a history of substance misuse, and the presence of behavioural problems in childhood [1, 4, 32]. Fourth, there is potential for bias in the selection of patients used in this study because they were all referred on the basis that they exhibited problems in everyday behaviour. However, the results of this study provide objective evidence to support the observations of relatives and clinicians that lead to the initial referral for neuropsychological assessment. Fifth, whilst proxy-ratings of aggression were obtained for the group with TBI, alexithymia was examined only via self-report. Consequently, and even though assessment of alexithymia is typically assessed via self-report measures, it nevertheless means that ratings may be vulnerable to influence by a number of variables, including a lack of self-awareness and biased perception. However, it should be noted that as alexithymia is a measure of one's own ability to identify and experience emotion, obtaining information from a proxy rater is arguably of questionable benefit. Finally, we accept that even though the TBI group did not report a pre-accident history of psychiatric, neurological, or personality problems potentially interpretable as alexithymia, or the presence of pre-accident aggressive tendencies, subclinical levels may have been present. This seems unlikely however as relatives who were present during the initial clinical interview of these patients did not report the presence of these characteristics.

In spite of these limitations, the present findings throw additional light on a significant problem associated with TBI. The emotional capabilities of people who suffer TBI are rarely assessed in a comprehensive manner, particularly from the perspective of alexithymia. However, the TAS-20 is quick and easy to administer and could provide important insights at an early stage of recovery to identify those at risk of aggressive and other anti-social tendencies that have an adverse impact on many aspects of social cognition and psychosocial recovery that can be both costly and difficult to remediate once they become chronic. The findings could also offer potentially important insight to the assessment and aetiology of aggression in other populations where high rates of aggressive behaviours and tendencies are frequently observed. For example, Strickland and colleagues [45] recently reported higher rates of alexithymia in a sample of men who were perpetrators of violent offences, and emotion regulation impairments have been shown to be highly prevalent in forensic samples and linked to both negative behaviours and the risk of reoffending [46].

Future research should place greater emphasis on the neuroscience of neurobehavioural disability, such as employing sophisticated neuroimaging techniques to try and provide a link between structure and function in specific forms of disorders, thereby facilitating our understanding of specific brain-behaviour relationships. This could also explore gender differences in aggression and alexithymia, potentially incorporating hormonal measures to determine if these have an impact on how behaviour problems are expressed in those with neurobehavioural disability after TBI.

Declaration of Interest

The information in this manuscript and the manuscript itself is new and original and is not currently under review by any other publication, and has never been published either electronically or in print. The authors have no financial relationships or conflict of interest to disclose. There are no financial sources of support to declare.

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Table 1: TBI Self versus Proxy Ratings on the BPAQ

	TBI Self - Mean (SD)	TBI Proxy - Mean (SD)	t
BPAQ Total	81.30 (24.49)	79.57 (22.40)	0.514
Physical	22.04 (9.25)	20.98 (8.05)	0.817
Verbal	15.49 (5.03)	15.32 (4.78)	0.247
Anger	21.23 (6.20)	22.34 (6.71)	0.110
Hostility	22.53 (7.89)	20.94 (7.42)	1.328

Note: BPAQ – Buss Perry Aggression Questionnaire.

Table 2. Alexithymia Groups

	TBI (n = 47) **n (%)**	**Control (n = 72)** **n (%)**
Alexithymia (TAS-20 score ≥61)	27 (57.4%)	8 (11.1%)
Possible Alexithymia (TAS-20 score 52-60)	15 (31.9%)	12 (16.7%)
No Alexithymia (TAS-20 score ≤51)	5 (10.6%)	52 (72.2%)

Note: TAS-20 - Toronto Alexithymia Scale 20

Table 3. Descriptives for TAS-20 and BPAQ Scores

	TBI (n = 47)		Control (n = 72)	
	Mean (SD)	**Adjusted Mean (SE)**	**Mean (SD)**	**Adjusted Mean**
TAS-20 Total	64.68 (11.01)	63.43 (1.66)	46.11 (11.33)	46.29 (1.32
DIF	23.70 (5.52)	23.31 (0.85)	13.83 (5.87)	14.08 (0.68
DDF	17.38 (3.48)	23.31 (0.61)	12.21 (4.46)	12.46 (0.48
EOT	23.60 (4.85)	23.14 (0.68)	20.07 (4.35)	20.36 (0.54
BPAQ Total	79.57 (22.40)	78.74 (3.12)	68.40 (22.54)	61.65 (2.48
Physical	20.98 (8.05)	20.504 (1.20)	19.55 (7.87)	18.93 (0.95
Verbal	15.32 (4.78)	15.61 (0.64)	12.40 (3.91)	12.20 (0.51
Anger	22.34 (6.71)	22.15 (0.89)	17.0 (7.08)	14.16 (0.71
Hostility	20.94 (7.42)	20.47 (0.98)	15.74 (5.96)	16.04 (0.78

Note: DIF – Difficulty Identifying Feelings; DDF – Difficulty Describing Feelings; EOT – Externally Orie

Aggression Questionnaire; *P< 0.0005

Table 4. Alexithymia Group Differences on the BPAQ.

	Alexithymia		Possible Alexithymia		
	Mean (SD)	**Adjusted Mean (SE)**	**Mean (SD)**	**Adjusted Mean (SE)**	**M**
TBI Group					
BPAQ Total	88.70 (20.35)	88.38 (3.84)	70.47 (18.67)	70.38 (5.16)	57.
Physical	23.22 (7.90)	23.04 (1.47)	19.07 (8.21)	19.18 (1.979)	14
Verbal	16.81 (4.27)	16.84 (0.87)	13.47 (4.65)	13.31 (1.18)	15
Anger	24.74 (6.27)	24.70 (1.20)	20.20 (4.94)	20.13 (1.61)	15
Hostility	23.93 (6.96)	23.78 (1.28)	17.73 (6.08)	17.75 (1.72)	14
Control Group					
BPAQ Total	69.88 (14.89)	70.38 (6.70)	71.17 (22.31)	70.16 (5.54)	61.
Physical	20.63 (6.86)	20.63 (2.81)	21.25 (9.23)	20.92 (2.33)	17
Verbal	13.63 (3.02)	13.97 (1.36)	12.75 (3.49)	12.81 (1.13)	12
Anger	15.75 (3.37)	15.85 (1.80)	18.25 (6.24)	17.98 (1.48)	13
Hostility	19.88 (4.42)	19.92 (1.97)	18.92 (7.63)	18.44 (1.63)	15

Note: BPAQ – Buss Perry Aggression Questionnaire.

Table 5. Correlations between TAS-20 and BPAQ Scores.

	TAS-20 Total	DIF	DDF
TBI Group (N = 47)			
BPAQ Total	0.553****	0.464****	0.457*
Physical	0.407***	0.345*	0.455*
Verbal	0.473**	0.367*	0.444*
Anger	0.478****	0.393**	0.468*
Hostility	0.489***	0.434***	0.468*
Control Group (N = 72)			
BPAQ Total	0.341**	0.368***	0.302
Physical	0.263	0.233	0.311
Verbal	0.170	0.286*	0.100
Anger	0.325**	0.339**	0.237
Hostility	0.369***	0.410****	0.300

Note: * p < 0.01; ** p < 0.005; *** p < 0.001; **** p < 0.0005

Table 6. TBI Group - Hierarchical Regression Analysis**.**

	R	***R^2***	**Adjusted *R^2***	***R^2* Change**	***F* change**	***F* change sig.**	**B**
Regression Model 1 – Block 1	0.227	0.052	0.009	0.052	1.200	0.311	
WTAR Scores							-0.526
Years in Education							.0779
Block 2	0.585	0.342	0.296	0.290	18.945	0.0005	
WTAR Scores							-0.346
Years in Education							.0470
TAS-20 Total Scores							1.107
Regression Model 2 - Block 1	0.227	0.052	0.009	0.052	1.200	0.311	
WTAR Scores							-0.526
Years in Education							0.779
Block 2	0.614	0.377	0.302	0.326	7.150	0.001	
WTAR Scores							-0.279
Years in Education							-0.341
DIF							0.877
DDF							2.510
EOT							0.360

Note: DIF – Difficulty Identifying Feelings; DDF – Difficulty Describing Feelings; EOT – Externally Oriented Thi

Table 7. Control Group - Hierarchical Regression Analysis.

	R	R^2	**Adjusted** R^2	R^2 **Change**	***F* change**	***F* change sig.**	B
Regression Model 1 – Block 1	0.217	0.047	0.020	0.047	1.707	0.189	
WTAR Scores							-0.410
Years in Education							1.043
Block 2	0.398	0.158	0.121	0.111	8.967	0.004	
WTAR Scores							-0.198
Years in Education							1.168
TAS-20 Total Scores							0.613
Regression Model 2 - Block 1	0.217	0.047	0.020	0.047	1.707	0.189	
WTAR Scores							-0.410
Years in Education							1.043
Block 2	0.454	0.206	0.146	0.159	4.403	0.007	
WTAR Scores							-0.131
Years in Education							0.741
DIF							1.048
DDF							0.896
EOT							-0.389

Note: DIF – Difficulty Identifying Feelings; DDF – Difficulty Describing Feelings; EOT – Externally Oriented Th

< 0.005