Emotion recognition depends on subjective emotional experience and not on facial expressivity: evidence from traumatic brain injury

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Abstract

Background: Recognising how others feel is paramount to social situations and commonly disrupted following traumatic brain injury (TBI). This study tested whether problems identifying emotion in others following TBI is related to problems expressing or feeling emotion in oneself, as theoretical models place emotion perception in the context of accurate encoding and/or shared emotional experiences.

Methods: Individuals with TBI (n = 27; 20 males) and controls (n = 28; 16 males) were tested on an emotion recognition task, and asked to adopt facial expressions and relay emotional memories according to the presentation of stimuli (word & photos). After each trial, participants were asked to self-report their feelings of happiness, anger and sadness. Judges that were blind to the presentation of stimuli assessed emotional facial expressivity.

Results: Emotional experience was a unique predictor of affect recognition across all emotions while facial expressivity did not contribute to any of the regression models. Furthermore, difficulties in recognising emotion for individuals with TBI were no longer evident after cognitive ability and experience of emotion were entered into the analyses.

Conclusions: Emotion perceptual difficulties following TBI may stem from an inability to experience affective states and may tie in with alexythymia in clinical conditions.

Keywords: emotion recognition; facial expressivity; traumatic brain injury; emotional experience; alexithymia

The ability to identify emotions in others is a fundamental skill central to human experiences. Emotional expressions relay important information about the feelings, attitudes and intentions of the expresser (Ekman, 1993; Fridlund, 2014; Salovey & Mayer, 1990), and the ability to quickly and effectively process these cues informs understanding of situational contexts and guides immediate behavioural output. Emotion perception, therefore, represents an important factor underlying the understanding of social contexts requisite for social and interpersonal relationships (Marsh, Kozak, & Ambady, 2007; Marshall & Holtzworth-Munroe, 2010; Oatley & Johnson-Laird, 1987; Zhang & Parmley, 2015). A proliferation of research over the past few decades has shown that individuals with traumatic brain injury (TBI) have difficulty recognizing emotions, with a previous meta-analysis finding that TBI participants perform 1.1 standard deviations below matched controls on tests of basic emotion recognition (Babbage et al., 2011). There is some evidence that emotion recognition difficulties following severe TBI are associated with social integration (Knox & Douglas, 2009), social competence (Milders, Ietswaart, Crawford, & Currie, 2008; Watts & Douglas, 2006), theory of mind (McLellan & McKinlay, 2013) and behavior regulation (Spikman et al., 2013). Difficulties with emotional recognition, therefore, may partly explain the social cognitive and psychosocial deficits routinely experienced by individuals with TBI. Given that emotion perception problems are stable over time (Ietswaart, Milders, Crawford, Currie, & Scott, 2008), worsen with injury severity (Spikman, Timmerman, Milders, Veenstra, & van der Naalt, 2012), and are independent to age of insult (Schmidt, Hanten, Li, Orsten, & Levin, 2010), further understanding of the mechanisms that subserve emotion recognition is needed to identify how these difficulties have such a deleterious effect on functional outcomes following brain insult.

Emotion perception is a complex process, with multiple factors subserving the ability to encode (express) and decode (recognize) facial expressions. The ability to express emotion is central to non-verbal communication and associated with successful interpersonal functioning (Blanchard & Panzarella, 1998; Kornreich et al., 2002; Park, Matthews, & Gibson, 2008), social skill (Riggio, 1986) and models of emotional intelligence (Mayer, Roberts, & Barsade, 2008). Furthermore, the degree to which individuals spontaneously express emotions associated with the quality of social functioning across numerous conditions (Brozgold et al., 1998). Specifically, individuals with TBI report blunted negative affect (Croker & McDonald, 2005; Hornak, Rolls, & Wade, 1996), and have difficulty generating sad expressions either spontaneously or deliberately (Dethier, Blairy, Rosenberg, & McDonald, 2012), supporting that TBI is associated with impairments in the expression of negative affective states. There was a surge of interest in the connection between expressivity and perception of emotion decades ago, yet interest waned after inconsistent empirical evidence concerning the encoding and accurate decoding of nonverbal facial emotions, with some studies finding negative (Lanzetta & Kleck, 1970) and positive (Zuckerman, Lipets, Koivumaki, & Rosenthal, 1975) associations. A more recent meta-analysis (Elfenbein & Eisenkraft, 2010), however, reported that the reason for these discrepant findings was the task used. They found a small, positive correlation between expression and recognition when expression was elicited as a means of intentional communication via explicit instruction (i.e. posed) but that there was no relationship when expressions were elicited spontaneously during naturalistic conversations. The researchers concluded that emotion recognition might be related to the deliberate use of non-verbal skills to convey information, as those who are more aware of and better at expressing emotion themselves are more likely to accurately interpret the affective displays of others.

Early work on the relationship between emotional expression and facial decoding was criticized for failing to consider the role of subjective experience of emotion in the generation and recognition of affective states (Cunningham, 1977), claiming that posed experiments may represent merely artificial performances as opposed to true affective experiences (Russell, Bachorowski, & Fernández-Dols, 2003). Indeed, humans routinely experience internal feelings of emotion and may therefore use these skills to accurately decode the emotions of others. Simulation models of emotion recognition propose that the understanding of others' emotional display relies on simulating similar emotional states in oneself (Gallese, Keysers, & Rizzolatti, 2004; Goldman & Sripada, 2005; Heberlein & Atkinson, 2009; Niedenthal, Mermillod, Maringer, & Hess, 2010). These models are established on the idea that subjective emotional processing overlaps with the decoding of emotion perception via shared body representations across a range of behavioural outputs (Adolphs, 2002; Barsalou, 2003; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). For example, individuals subconsciously mimic observed emotional facial expressions via muscle contractions (Dimberg, 1982; Dimberg, Thunberg, & Elmehed, 2000) or pupil dilation (Harrison, Singer, Rotshtein, Dolan, & Critchley, 2006) and that emotional expression can evoke similar feelings in the observer (Dimberg, 1988; Lundqvist & Dimberg, 1995; Wild, Erb, & Bartels, 2001). Previous studies have also shown that mood-induced emotional states can facilitate the identification of emotion in others. For example, Niedenthal, Halberstadt, Margolin, and Innes-Ker (2000) found that participants induced into a happy emotional state were able to perceive happy expressions more effectively than participants in a sad or neutral condition, with those in a sad condition better at the identification of sad emotional expressions, suggesting that emotional experience facilitates the identification of congruent emotional displays in others. Collectively, these findings support that individuals spontaneously share the observed displays and emotions of others and that this process facilitates the recognition of others' emotional states. However, there is some research that has failed to identify a relationship between mimicry and emotion recognition (Calder, Keane, Manes, Antoun, & Young, 2000; Hess & Blairy, 2001; Keillor, Barrett, Crucian, Kortenkamp, & Heilman, 2002) and as such, the evidence regarding whether subjective emotional experience is instrumental in emotion recognition is still lacking.

Overall, while research over the past 30 years has examined the role of emotional expressivity and subjective emotional experience in the recognition of emotion, there is still a lack of consensus on how humans understand the emotional displays of others and where this process breaks down to produce emotion recognition deficits in clinical groups, such as TBI. In addition, few studies have examined these interactive factors altogether in the one study. Since the findings of their meta-analysis, Elfeinbein et al., (2010) replicated the finding that accuracy in recognizing emotion is positively correlated with posed emotional expressivity (Elfenbein et al., 2010). However, they partially attributed this finding to the induction of emotional experience during their expression protocol (Elfenbein et al., 2010). As such, it is uncertain whether these findings of emotion recognition are attributable to subjective emotional experience, emotional expressivity or a combination of the two. Moreover, neuroanatomical research has shown that spontaneous and artificial facial displays derive from separates pathways in the brain (Borod & Koff, 1991). This implies that spontaneous and posed expressions may differentially affect emotion recognition abilities in clinical conditions, such as TBI. Consequently, further research is needed to elucidate the role of these factors underlying emotion perception across healthy individuals and how these factors subserve difficulties routinely identified across clinical conditions.

The primary aim of this study was to address these limitations by examining the relationship between affective expressivity, the subjective experience of emotion and emotional face recognition in both healthy adults and individuals with TBI. We aimed to determine the unique contribution of these factors after controlling for demographic and cognitive variables related to emotional recognition. It was hypothesized that if emotion recognition was dependent on emotional expressivity or subjective emotional experience, then these constructs would account for a unique contribution to the prediction of emotional recognition. As TBI differentially affects the recognition of emotion, the second aim of this study was to determine whether the relationship between TBI and emotion recognition changed as a function of emotional expressivity and subjective experience. As TBI is associated with impaired ability to express and experience negative affective states, it was hypothesized that emotional expressivity and subjective experience would account for the difference between TBI and healthy control subjects in recognizing negative emotional displays.

Method

Participants

Two groups of participants were recruited to the current study. The clinical group consisted of 25 participants (20 males) who had sustained a TBI of sufficient severity to warrant inpatient rehabilitation. Inclusion criteria included: (1) evidence of a moderate to severe TBI as evident by documented post traumatic amnesia (PTA) of greater than one day or a duration of coma exceeding 24 hours (Corrigan, Selassie, & Orman, 2010); (2) participants were at least 1 year post-injury to ensure stability of their cognitive and rehabilitation recovery; (3) participants had no documented or identified aphasia or agnosia; and, (4) participants were able to understand instructions sufficiently to complete the various task procedures. The participants had an average age of 45.8 years (*SD* = 12.19 years, *range* = 21 – 68 years) and 13.16 years of education (*SD* = 3.00 years, *range* = 9 – 22 years). They had experienced PTA ranging from zero to 189 days (*M* = 78.40 days, *SD* = 60.57 days), a loss of consciousness (LOC) ranging from zero to 74 days (*M* = 25.36 days, *SD* = 20.94 days) and an average Glasgow Coma Scale (GCS) score at the scene of 5.65 (*SD* = 2.85, *range* = 3 to 12). Injuries were sustained at an average of 32.76 years of age (*SD* = 12.40 years, *range* = 12 to 54 years). The TBI group were, on average, 13.04 years post injury at the time of the experimental procedures (*SD* = 9.20 years, *range* = 2 to 40 years).

The non-TBI control group consisted of 28 volunteers from the general community (16 male, 12 female) that were matched as closely to the TBI group on age, gender, and years of education. They were recruited via online and advertisements. They were an average of 41.50 years of age (SD = 14.35, range = 19 to 64) and had achieved an average of 14.68 years of education (SD = 2.803, range = 6 to 20). Both the TBI and controls groups were subject to the same exclusion criteria, which included: (1) a history of developmental, psychiatric, or neurological disorders (with the exception of TBI for the clinical group); (2) uncorrected vision or hearing impairments; (3) extremely severe emotional distress, as measured by and using cutoff scores specified by the DASS-21 (P. F. Lovibond, & Lovibond, S. H., 1995); (4) a history of substance abuse; and, (5) inability to communicate effectively. Both the control and TBI participants had previously taken part in studies assessing emotion recognition and emotional expression production (Dethier et al., 2012; Dethier, Blairy, Rosenberg, & McDonald, 2013; Rosenberg, Dethier, Kessels, Westbrook, & McDonald, 2015; Rosenberg, McDonald, Dethier, Kessels, & Westbrook, 2014). In order to address the current research question, however, only data from participants that had contributed to both the emotion recognition (Rosenberg et al., 2015; Rosenberg et al., 2014) and expressivity (Dethier et al., 2012, 2013) studies were retained for the current analyses. While the data was derived from previous experiments from our laboratory, the research question, analyses, and findings are novel and distinct from these previous studies.

Measures

Emotion Recognition Task

A detailed description of the emotion recognition task (EMT) can be found elsewhere (Frigerio, Burt, Montagne, Murray, & Perrett, 2002). Briefly, the EMT (Montagne, Kessels, De Haan, & Perrett, 2007) is a computer-generated task that shows a series of 216 video clips of facial expressions of varying emotional intensity. The video clips are of four actor's (two male; two female) morphing from a neutral pose to an emotional intense emotion. The emotional intensity of each clip increases by 10% increments from 20% through to 100%. During the task, participants are sequentially presented with 24 video clips from each intensity bracket starting with the lowest intensity (e.g., 24 clips of neutral to 20% emotional intensity). The emotional content of each clip is randomly ordered. Once finished, the participant is asked to select the emotion depicted in the clip by choosing one of six emotional expression labels displayed to the left of the final static image on the screen. There are no time restrictions and the proceeding clip would commence once the participant has selected their response.

Emotional Expressivity

In these tasks, participants were asked to produce an emotional expression based on the stimuli that appeared on the computer screen. In the visual expressivity condition, participants were presented with photos of facial expressions of anger, sadness and happiness (taken from Matsumoto & Ekman, 1998) and asked to imitate the depicted expression. The emotions were randomly ordered and the gender of the faces was counterbalanced between emotions and participants. In the verbal word expressivity condition, participants were shown the words "happiness", "anger" and "sad" on the computer screen and asked to produce an emotional expression congruent to the presented word. The emotional stimuli appeared on the screen and stayed for 10 seconds and the participants were asked to maintain the expression until the stimuli disappeared from the screen. Lastly, in the verbal story condition, the words "anger", "sadness" and "happiness" appeared on the computer screen and the participants were asked to describe a past personal experience that was congruent with the emotional content of the word. They were asked to generate a story that conjured up the highest amount of the depicted emotion and asked to relay the event as if they were telling it to someone for approximately two to three minutes (Dethier et al., 2012).

In order to determine the level of subjective experience of emotion following the presentation of each stimuli, participants were asked to rate the intensity of their feelings of happiness, anger and sadness on a seven-point scale ranging from "not at all" to "very intensely" before the next stimulus was presented. The order of the tasks was counterbalanced between participants and their responses were filmed via a webcam (WB-5400 Megapixel USB2 Webcam Live) placed on top of the computer box with the participant's consent. To determine the facial emotional expressivity produced by the stimuli, two judges watched each video (muted) and assessed the intensity of the facial expressivity of happiness, anger and sadness using a seven-point scale from "not at all" to "very intensely". These scores were then averaged. Our previous study examining posed emotional expressivity using the same participants demonstrated adequate interrater reliability for happiness, anger and sadness expressivity (Dethier et al., 2012).

Cognitive tasks

All participants were assessed using subtests of the Wechsler Adult Intelligence Scale – Third Edition (WAIS-IV; D. Wechsler, 2008) to examine attention and working memory (Digit Span) and processing speed (Digit Symbol Coding). The Logical Memory subtests of the Wechsler Memory Scale (WMS-IV; D. Wechsler, 2009) were used to examine changes in the encoding and retrieval of verbal information. Additional measures included cognitive flexibility (Trail Making Test) (Reitan, 1992) and nonverbal abstract reasoning (Matrix Reasoning, WAIS-III). Premorbid intellectual ability was assessed using the Wechsler Test of Adult Reading (WTAR) (David Wechsler, 2001). All raw scores were transformed to standard scores (mean = 10, SD = 3) based on performances relative to age-matched healthy comparison subjects, where higher score indicated greater functioning. Cognitive assessments were conducted by graduate students who had been trained by clinical neuropsychologists experienced in the assessment of cognitive dysfunction and brain injury.

Psychological symptoms

The 21-item Depression, Anxiety and Stress Scale (DASS-21; P. F. Lovibond & Lovibond, 1995) consists of three subscales that assess an individual's symptoms of depression, anxiety and stress. Participants were required to rate the frequency with which each item applied to them over the previous week, with individual scores ranging from *0 = does not apply to me* to *3 = applies to me very much*. Research has shown the DASS-21 to have excellent internal consistency and good temporal reliability (Gloster et al., 2008).

Procedure

All participants were provided with full details regarding the experimental procedures and gave written informed consent to participate in the studies. The Human Ethics Committee at the University of New South Wales approved all procedures and the experiments were conducted at the neuropsychology laboratory within the School of Psychology. Firstly, participants were asked to complete the cognitive and psychological measures before commencing the emotion recognition or posed expressivity tasks, unless these had been recently completed from other research conducted in our laboratory. They were then asked to complete either the emotion recognition test or the expressivity tasks before completing the remaining task during a second session. These were conducted across separate sessions in keeping with the original aims of these experiments (Dethier et al., 2012, 2013; Rosenberg et al., 2015; Rosenberg et al., 2014). For the emotion recognition and expressivity tests, the instructions and stimuli were presented on a 17-inch computer monitor equipped with E-Prime version 2.0 software (Schneider, Eschmann, & Zuccolotto, 2002), which presented information on the screen and collected responses. All tasks were preceded with practice trials before the experimenter left the room for the duration of the actual tests.

Data Analysis

All data are presented as means and standard deviations. As a first analysis, independent t-tests or chi-square tests were conducted to examine group differences on demographic and clinical variables. Correlations were performed between emotional recognition of happy, angry and sad emotions and additional variables to determine additional factors that may need to be included in subsequent regression analyses (i.e. confounds). Principal analyses involved hierarchical linear regression procedures to evaluate the unique contribution of various predictors on emotional face recognition. Variables such as diagnostic group and age were entered first to account for variance attributable to sample demographics. Given the significant correlations between cognitive factors and dependent variables, cognitive ability was controlled for in the second block of the regression models. Measures assessing emotional expressivity through generation of facial expressions in response to stimuli were entered next, while the last block consisted of measures examining self-reported intensity of felt emotion following the presentation of pictures, words and stories (i.e. the experience of emotion). Ratings of expressivity and emotional experience were entered as separate hierarchies to examine their unique contribution to emotional recognition and to determine whether these factors accounted for unique variance above and beyond demographic and cognitive factors in explaining emotional recognition. The dependent variables represented the average recognition score across all emotional intensities (happy, angry, sad). Analyses were conducted separately for individual emotions and only congruent predictors were entered into each regression model. Significance was held at $p < .05$.

Results

Demographic, Clinical and Neuropsychological Comparisons

Mean scores on demographic and clinical variables by group status are shown in Table 1.

Table 1 about here

Across the entire sample, the participants were predominantly male (67.9%), Anglo-Australian (41.5%), and held qualifications beyond high school (69.8%). There was no statistical difference in the age of TBI and control participants ($t(51) = -1.168$, $p = .248$) and years of education attainment ($t(51) = 1.906$, $p = .062$). There were no differences between groups in terms of distribution of gender ($\chi^2(1, n = 53) = 3.167$, $p = .075$) and pre-injury occupation ($\chi^2(1, n = 53) = 8.403$, $p = .135$). Clinically, there was no difference between TBI and control groups in the frequency of self-reported symptoms of depression ($t(51) = -1.292$, $p = .202$) or stress ($t(43.35) = -.996$, $p = .325$), although the TBI participants reported elevated symptoms of anxiety relative to controls ($t(43.77) = -2.07$, $p = .040$). The TBI participants, on average, demonstrated reduced performance on digit span ($t(51) = 2.29$, $p = .026$), digit symbol coding ($t(51) = 5.72$, $p < .0005$), matrix reasoning ($t(51) = 3.03$, $p = .004$), logical memory 1 ($t(51) = 4.82$, $p < .0005$), logical memory 2 ($t(51) = 4.50$, $p < .0005$), Trails A ($t(30.75) = -3.95$, $p < .0005$), and Trails B ($t(27.43) = -2.80$, $p = .009$) relative to control participants. Furthermore, the TBI participants scored lower than control participants on the WTAR ($t(51) = 3.23$, $p = .002$), a measure of premorbid intellectual functioning. Previous research had demonstrated that measures of premorbid functioning are affected by brain injury severity (Freeman, Godfrey, Harris & Partridge, 2001; Mathias, Bowden, Bigler & Rosenfeld, 2007; Morris, Wilson, Dunn & Teasdale, 2005; Riley & Simmonds, 2003).

Assessment of Bivariate Relationships and Confounds

As can be seen in Table 2, there were we no significant correlations between TBI sample demographics (e.g. age of injury, time since injury and GCS) and the main outcome measures of the study, suggesting that the heterogeneous nature of the sample - consistent with all TBI research - did not impact on the results.

Table 2 about here

The TBI group performed worse than controls across all cognitive variables examined and there were significant inter-correlations between cognition and emotion recognition of happy, angry and sad faces (Table 2). As such, in order to reduce the number of variables considered for subsequent analyses, a single cognition variable was derived from the sum of all the cognitive factors examined. All scores were converted to z scores and the cognitive variable represented the average Z score across tests. Follow-up analyses indicated that overall, TBI participants performed poorer than control participants in the domain of cognition ($t(51) = 4.983$, $p < .0005$) and that cognitive function was positively correlated with emotional recognition of happy ($r = .379$, $p = .006$, bonferroni correction of .05/3) and angry faces ($r = .403$, $p = .003$; bonferroni correction of .05/3).

Assumptions for Hierarchical Regression

Across all regression models, there were small to moderate significant intercorrelations between predictor variables, all tolerance levels were greater than 0.3 and variance inflation factors (VIF) were less than 5, indicating an acceptable level of multicollinearity in the final model (Tabachnick & Fidell, 2001). The assumptions of linearity, homogeneity of variance and normality of residuals were also satisfied.

Prediction of Emotional Recognition of Happy Faces

Table 3 about here

The results of the regressions analyses are presented in Table 3. Demographic variables significantly contributed to the prediction model and accounted for 26.1% of the variance in the recognition of happy faces, $F(2,50) = 8.82$, $p = .001$. The addition of cognitive ability further improved the predictive power of the model, $F(3,49) = 9.31$, $p < .0005$, and accounted for an additional 10.2% of the variance in the recognition of happy faces, $\Delta R^2 = .102$, $p = .007$. Even though the model remained significant, $F(6,46) = 4.757$, $p<.0005$, the addition of measures relating to expressivity of happiness in response to stimuli did not contribute to the overall model, $\Delta R^2 = .020$, $p = .690$. Finally, the inclusion of subjective experience of emotion in response to photos, words and stories demonstrated a unique contribution to the full model and accounted for an additional 11.8% of the variance in the recognition of happy faces, $\Delta R^2 = .118$, $p = .026$. The full model accounted for a total of 50.1% of the variance in happy face recognition.

In the initial model, Diagnostic Group was a significant negative predictor of the recognition of happy faces ($p < .005$), suggesting that individuals with TBI were less accurate in their recognition of happy faces relative to control participants. Diagnostic group ($p < .05$) and Cognitive ability ($p < .005$) were significant negative and positive predictors of happy face recognition in Model 2 and Model 3, respectively. In the final model, Cognitive ability ($p < .05$) and the intensity of happiness experienced in response to a happy story ($p < .05$) were the only significant positive predictors of happy affect recognition in the final model. Diagnostic Group was no longer a significant predictor of happy face recognition after the inclusion of subjective emotional experience in response to happy stimuli in the final model.

Prediction of Emotional Recognition of Angry Faces

Table 4 about here

Demographics significantly contributed to the prediction model and accounted for 34.7% of the variance in the recognition of angry faces, $F(2,50) = 13.277$, $p < .0005$. The addition of cognitive ability further improved the predictive power of the model, $F(3,49) = 13.385$, $p < .0005$, and accounted for an additional 10.4% of the variance in the recognition of happy faces, $\Delta R^2 = .104$, $p = .004$. Even though the model remained significant, $F(6,46) = 6.833$, $p < .0005$, the addition of measures relating to expressivity of anger did not contribute to the overall model, $\Delta R^2 = .021$, $p = .615$. The inclusion of the self-reported experience of anger demonstrated a unique contribution to the full model and accounted for an additional 8.9% of the variance in the recognition of angry faces, $\Delta R^2 = .89$, $p = .046$. The full model accounted for a total of 56.0% of the variance in angry face recognition.

In the initial model, Age ($p < .05$) and Diagnostic Group ($p < .0005$) were significant negative predictors of the recognition of angry faces, suggesting that individuals with TBI were less accurate in their recognition of angry faces relative to control participants and that accuracy in recognizing angry expressions declined with age. Age ($p < .05$) and Diagnostic group ($p < .05$) were negative predictors, and Cognitive ability ($p < .005$) was a significant positive predictor, of angry face recognition in both Model 2 and Model 3. Importantly, Age ($p < .05$) was a significant negative predictor, and Cognitive Ability ($p < .005$) and the intensity of anger experienced in response to an angry story ($p < .005$) were all significant positive predictors, of angry affect recognition in the full model. Again, Diagnostic Group was no longer a significant predictor of angry face recognition after the inclusion of subjective emotional experience in response to angry stimuli in the final model.

Emotional recognition of sad faces

Table 5 about here

Demographics, such as age and diagnostic group, significantly contributed to the prediction of the recognition of sad faces and accounted for 21.1% of the variance, $F(2,50) = 6.685$, $p = .003$. The addition of cognitive ability did not improve the predictive power of the model, $\Delta R^2 = .03$, $p = .171$, but the model remained significant, $F(3,49) = 5.184$, $p = .003$. Similarly, the addition of measures relating to expressivity of sadness in response to photos, words and stories did not contribute to the predictive power of the overall model, $\Delta R^2 = .042$, $p = .449$. However, the inclusion of the self-reported experience of sadness in response to photos, words and stories demonstrated a unique contribution to the full model and accounted for an additional 12.5% of the variance in the recognition of sad faces, $\Delta R^2 = .125$, $p = .04$. The full model accounted for a total of 40.8% of the variance in sad face recognition.

In the initial model, Age ($p < .005$) was a significant negative predictor of the recognition of sad faces, suggesting that that accuracy in recognizing sad expressions declined with age. Age ($p < .005$) remained the sole significant negative predictor of sad face recognition in both Model 2 and Model 3. Lastly, Age ($p < .05$) and the intensity of sadness experienced in response to a sad story ($p < .05$) were all negative significant predictors, while Cognitive Ability ($p < .05$) was a positive significant predictor, of sad affect recognition in the full model.

Discussion

The aim of the current study was to evaluate the unique contribution of emotional expressivity and subjective emotional experience to the recognition of emotion, with the aim of identifying how these processes relate to emotion perception difficulties for individuals with TBI. The results from this study indicate that across all emotions examined (i.e. happy, angry, and sad), subjective emotional experience demonstrated a unique contribution and significantly predicted the ability to recognize emotionally congruent facial expressions. When examining all the individual predictors across the final models, cognitive ability and the intensity of emotion experienced in response to a personal story were unique predictors in the recognition of happy, angry, and sad facial expressions, with age being a significant predictor of the negative (i.e. sad and angry) emotions only.

Simulation models of emotion recognition propose that the ability to identify emotion in others relies on individuals simulating a similar emotional state in themselves as a means to understand it (Gallese et al., 2004; Goldman & Sripada, 2005; Heberlein & Atkinson, 2009; Niedenthal et al., 2010; Van der Gaag, Minderaa, & Keysers, 2007). As subjective emotional experience significantly improved the predictive power of emotion recognition, the findings of the current study support simulation models of emotion recognition in that the emotion recognition process is dependent on the experience of emotion, specifically for personally relevant material. Importantly, these factors were significant after controlling for demographic and cognitive factors, suggesting that emotional experience is an independent determinant of emotion recognition and that this relationship is not referable to variance attributable to diagnostic or cognitive status. While previous studies have shown mixed findings regarding the simulation of emotional states in recognizing emotion (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001), these studies have typically relied on the impact of muscle simulation and/or motor mimicry in simulating emotion. The findings presented here contribute to this body of work by suggesting that explicit subjective experience of emotion is instrumental in recognizing the emotional displays of others. Therefore, we propose that a range of simulation processes may be used to achieve emotion recognition, including facial mimicry, the sharing of subjective emotional states, and body representations and/or postures (Dethier et al., 2013; Gallese et al., 2004; Heberlein & Atkinson, 2009; Keysers & Gazzola, 2006). As the recognition of emotion was greatest when individuals drew on emotional memories that were congruent to the presented affect, at least for happy and angry emotions, it is likely that those who are able to draw on a larger collection of simulation processes are likely to be better recognizers of emotion. However, further research is needed to determine the exact role of emotional experience in the simulation of emotional states and where this fits within the network of simulation processes.

It should follow from the above findings that those who experience increased subjective feelings of emotion would be better at decoding and understanding the emotions of others. Indeed, a large body of research has shown that subjective experience can affect emotional perception by promoting the preference of mood-congruent displays and hindering the processing of mood-incongruent percepts (Bower, 1981). Here, we found that self-reported mood in response to a story for happy and angry material were positively predictive of the recognition of that same emotion, suggesting that those who experience greater feelings of happiness or anger in response to past personal stories are better decoders of happy and angry facial emotions, respectively. These findings are consistent with previous studies that have shown that inducing feelings of happiness can promote the identification of happy emotions (Niedenthal et al., 2010), and when induced into a negative mood, participants are more accurate in identifying angry facial expressions and perceive angry expressions as more intense (Yi, Murry, & Gentzler, 2016). However, it should be noted that in the current study the emotion perception and subjective experience of emotion tasks were conducted on separate days. Therefore, while the findings converge with previous findings on transient and congruent-mood effects, these results extend previous findings by suggesting that those who are able to experience happiness and anger *more generally* are better decoders of emotional affect. Unexpectedly, feelings of sadness in response to a personal story negatively predicted the recognition of sad facial expressions, meaning that greater feelings of sadness were associated with decreased recognition of sad emotional displays. Previous studies have shown that participants induced into a sad condition perceive faces as sadder (Bouhuys, Bloem, & Groothuis, 1995; Niedenthal et al., 2000) and are more accurate in identifying sad facial expressions (Schmid & Mast, 2010). However, there is some evidence that depressed individuals demonstrate decreased accuracy in emotion recognition (Asthana, Mandal, Khurana, & Haque-Nizamie, 1998; Bouhuys, Geerts, & Gordijn, 1999; Mikhailova, Vladimirova, Iznak, Tsusulkovskaya, & Sushko, 1996; Surguladze et al., 2004; Zuroff & Colussy, 1986). While none of our sample endorsed significantly elevated symptoms of psychological distress, those who are more inclined to experience greater subjective feelings of sadness to emotional memories were less able to identify sad emotional displays. As such, the current findings likely relate to individual differences in emotional empathy and emotion perception.

While subjective emotional experience emerged as a unique predictor of emotional face recognition, emotional expressivity failed to improve the predictor power of any of the models examined. Furthermore, individual predictors assessing both posed and spontaneous expressivity in response to words, photos and stories failed to demonstrate unique significant associations with the recognition of emotion. This may suggest that the ability to encode emotion – both deliberately and spontaneously – may not be important in deciphering the affective expressions of others. While these finding converge with the results of a meta-analysis that found no significant relationship between naturalistic expression of emotion and decoding of affect (Elfenbein & Eisenkraft, 2010), they oppose the same study's finding that emotion recognition is correlated with the deliberate use of nonverbal cues via posed expressivity (Elfenbein et al., 2010). However, these researchers only found a small correlation between nonverbal expression and accurate decoding of emotional facial expressions (r = .19), and while this was replicated in a later study with a larger effect size (Elfenbein et al., 2010) the authors concluded that this was likely secondary to the use of emotion induction protocols during their procedure. This is in line with the current finding in that subjective experience of emotion facilitates the identification of emotion recognition and supports early criticisms on the link between emotional expression and perception in that these studies were not assessing true affective experiences (Cunningham, 1977). It should also be noted, however, that the statistical procedure employed in the current study was highly conservative, with multiple predictors with salient associations with the recognition of happy, sad and angry facial displays prioritized in the regression analyses. It is therefore possible that variables that did not reach statistical significance in the presence of alternative predictors will still be of clinical relevance, yet they may not be as salient in promoting emotion recognition as subjective experience and/or cognitive ability. Future studies should employ structural equation modeling procedures using larger sample sizes to model whether emotional expressivity is relevant in decoding emotional expressions of others.

These findings also propose interesting conclusions regarding emotion perception difficulties for individuals with TBI. That is, for the recognition of happy and angry facial expressions, diagnostic group was a significant negative predictor of emotion recognition in the initial stages of the regression procedures, meaning that TBI participants were less accurate in recognizing facial expressions compared to healthy controls. These findings remained significant after cognition and emotional expressivity were entered into the analyses. However, once subjective experience was included, diagnostic group was no longer a unique predictor in the recognition of angry and happy facial expressions. This suggests that the difference between TBI and controls in recognizing happy and angry emotions can be explained by cognitive ability and subjective feelings of emotion. Furthermore, the fact that diagnostic group was still significant after the inclusion of cognition suggests that while cognitive ability is related to emotion perception, it is necessary but not sufficient to explain the difficulties in emotion perception following TBI. Therefore, not only do these results support that the ability to perceive emotion in others depends on the capacity to experience the same emotion in oneself, but that the differences between TBI and healthy controls in recognizing emotion can be explained between a combination of cognitive difficulties and subjective emotional experience. Therefore, individuals with TBI may have difficulty feeling the emotions of others or attributing meaning to the experience they feel. These results tie in with current theoretical models that place altered emotional experience following TBI in the context of alexithymia (Becerra, Amos, & Jongenelis, 2002; C. Williams & Wood, 2010; Wood, Williams, & Kalyani, 2009), where individuals have problems identifying, processing, describing and working with their own feelings (Sifneos, 1973). Indeed, individuals with TBI have a higher incidence of alexithymia compared to healthy control subjects (Koponen et al., 2005; K. R. Williams et al., 2001), which has been associated with poor self-awareness (Allerdings & Alfano, 2001) and lower quality of life (Henry, Phillips, Crawford, Theodorou, & Summers, 2006). As such, it has been suggested that individuals with TBI may have a generalized difficulty in decoding emotional stimuli and experiences, which include internal feelings and emotion perception deficits (Henry et al., 2006; Wood & Williams, 2007). Indeed, self-reported experience of emotion is significantly associated with the ability to recognize emotions following TBI (Croker & McDonald, 2005; Hornak et al., 1996) and interestingly, previous studies have shown that alexithymia is negatively associated with (Parker, Taylor, & Bagby, 1993) and negatively predicts emotion recognition (Cook, Brewer, Shah, & Bird, 2013).

Applying this perspective to emotion recognition difficulties in TBI, therapeutic interventions might be beneficial that target the experience of emotional experience as opposed to the identification of facial perceptual analysis. However, it is uncertain where in the experience of emotion these processes break down for individuals with TBI. Alexithymia is a broad term that encompasses both the inability to experience and/or assign meaning to emotional experiences. As such, it is uncertain whether individuals with TBI fail to subjectively experience emotion or whether they experience the emotional aspects of affect, yet they are unable to assign meaning or salience to these events. Additionally, as we found that the ability to identify emotion is related to the experience of emotion in response to personally relevant material, it is possible that alexithymia following TBI may be due to loss of appropriate retrieval of emotional memories related to representations of emotional experience. Consequently, there may be inhibitory regulation of emotional states that translates into impaired decoding of emotional displays of others. However, this assessment of emotion perception difficulties following brain injury is purely speculative and in need of further empirical support. However, there is evidence that individuals can only recognize emotions of those that they have previously experienced (Preston, 2007), suggesting that the retrieval of previous emotional experience, either consciously or subconsciously, may be an important area for further research for emotion perceptual difficulties following TBI.

There are limitations to the current study that need to be addressed. Firstly, the sample size hampered the use of more robust and advanced statistical procedures. Given that hierarchical regression procedures were used, there were thresholds in power and sample size that needed to be reached when performing analyses with multiple predictors in these models. The entire sample therefore needed to be used and we consequently controlled for diagnostic group as an independent variables in these analyses. While this approach still yielded interesting findings regarding the relationship between emotional expressivity and experience in the recognition of emotion for individuals with TBI, the sample size of each group hindered the examination of TBI and control samples separately, which may have led to other interesting findings. Furthermore, given the sample size, we reduced the number of cognitive variables used in the analyses by combining cognitive performance across all cognitive factors examined. Consequently, we are unable to identify which cognitive processes are specifically implicated in the relationship between emotion perception and emotional experience following TBI. It is also possible that other cognitive factors not assessed in the current study are involved in emotional decoding. Future studies should examine these variables on larger samples sizes to understand whether the same processes are implicated across TBI and healthy controls. Lastly, as inherent to all research on TBI, there is heterogeneity in the location and severity of neuropathology across individuals. As such, it was impossible to control for brain pathology and to examine the role of brain-behaviour relationships in emotion perception difficulties following brain injury in the current study. However, previous studies have shown that ventromedial prefrontal regions and the amygdala are structures involved in emotion perception, both of which are vulnerable to brain jury (Fujiwara, Schwartz, Gao, Black, & Levine, 2008). As such, we suspect a high prevalence of such pathology in our group, and a factor that could explain these difficulties following TBI. However, whether other anatomical structures or more widespread pathology is implicated in these finding remains to be determined.

Conclusions

In summary, this study shows that emotion recognition depends on the subjective experience of emotion and not on accurate encoding of facial affect. This is consistent with a large body of literature that has shown that emotion recognition is associated with mood-congruent facial biases and simulation models of emotion recognition, which propose that individuals share the emotional state of the faces they decode as a means to understand it. Furthermore, we found that differences between patients with TBI and healthy subjects in recognizing emotions were explained by a combination of cognitive ability and subjective experience of emotion. This suggests that individuals with TBI may have difficulty experiencing or stimulating the emotions of those they come into contact that ultimately hinders their accuracy in emotion identification. These findings may therefore provide further support for the role of alexithymia in underlying social cognitive deficits in TBI.

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Declaration of Interest

The authors report no conflicts of interest

Table 1. Group differences in Demographic, Clinical and Cognitive variables

Variable	Control (*n* = 28) Mean (*SD*)	TBI (*n* =25) Mean (*SD*)	Sig. *p* value	Total Sample (*n* = 53) Mean (*SD*)
Demographics				
Age (yrs)	41.50 (14.35)	45.80 (12.19)	0.248	43.53 (13.43)
Education (yrs)	14.68 (2.80)	13.16 (3.00)	0.062	13.96 (2.97)
Gender (*n*)	M = 16 F = 12	M = 20 F = 5	0.08	M = 36 F = 17
Pre-Injury occupation (*n*)			0.14	
unemployed	4	0		4
student	7	4		11
clerical	3	2		5
unskilled trade	3	5		8
skilled trade	2	7		9
professional	9	7		16
Clinical Variables				
DASS-21				
Depression	6.29 (6.27)	8.64 (6.99)	0.20	7.40 (6.66)
Anxiety	2.75 (4.04)	5.52 (5.49)	0.04	4.06 (4.93)
Stress	9.75 (8.32)	12.52 (11.46)	0.33	11.06 (9.93)
PTA (days)	-	78.40 (60.57)	NA	-
GCS	-	5.65 (2.85)	NA	-
LOC (days)	-	25.36 (20.94)	NA	-
Age at Injury (yrs)	-	32.76 (12.40)	NA	-
Time since Injury (yrs)	-	13.04 (12.40)	NA	-
Cognitive Variables				
WTAR	115.24 (11.03)	103.60 (15.05)	0.002	109.75 (14.22)
Digit Span	11.46 (3.53)	9.52 (2.50)	0.026	10.55 (3.21)
Logical Memory 1	12.71 (2.48)	8.92 (3.24)	<0.0005	10.92 (3.42)
Logical Memory 2	13.46 (2.40)	9.84 (3.42)	<0.0005	11.75 (3.42)
Digit Symbol Coding	12.00 (2.92)	7.48 (2.82)	<0.0005	9.87 (3.64)
Trails A	25.64 (7.96)	42.48 (19.95)	<0.0005	33.58 (16.99)
Trails B	57.07 (20.58)	99.24 (72.69)	0.009	76.96 (55.77)
Matrix Reasoning	14.00 (2.57)	11.60 (3.20)	0.004	12.87 (3.10)
Cognition Av. Z score	.75 (.56)	-.52 (1.22)	<0.0005	0.15 (1.12)

TBI = Traumatic Brain Injury; PTA = Post Traumatic Amnesia; DASS = Depression, Anxiety and Stress Scale; GCS = Glasgow Coma Scale; LOC = Loss of Consciousness; WTAR = Wechsler Test of Adult Reading; Av = average; SD = standard deviation; sig = significance; n = years; yrs = years; m = male; F = female

Table 2. Correlations between demographic and cognitive variables with the recognition of happy, angry and sad facial expressions

	Happy Faces	Angry Faces	Sad Faces
Happy Faces	1		
Angry Faces	.549***	1	
Sad Faces	.055	.189	1
Age	-.162	-.302*	-.408**
Education	-.042	.273*	.122
Depression	-.222	-.063	-.185
Anxiety	-.007	.011	-.081
Stress	.080	.084	.152
Age of Injury	.244	.191	-.275
Time Since Inj	-,226	-.294	.037
PTA	-.507***	-.450***	-.468***
LOC	-.303	-.455***	-.301
GCS	.297	.056	-.033
WTAR	.179	.180	.174
Digit Span	.047	.084	.271*
LM1	.170	.367**	.312*
LM2	.271*	.370**	.414**
DSC	.256*	.357**	.104
Trails A	-.461***	-.472***	-.021
Trails B	-.338*	-.270*	-.188
MR	.278*	.400**	.162
Cognition	.379**	.403**	.211

* $p < .05$, ** $p < .005$ *** $p < .0005$

Table 3. Hierarchical regression models predicting the recognition of happy facial expressions

	Model 1		**Model 2**		**Model 3**		**Model 4**	
R^2	.261**		.363**		.383**		.501**	
ΔR^2	.261**		.102**		.020		.118**	
Predictors	**β (SE)**	**B**	**β (SE)**	**B**	**β (SE)**	**B**	**β(SE)**	**B**
Constant	3.875 (0.105)		3.788 (.103)		3.741(.132)		3.361 (.192)	
Age[a]	-.003 (.002)	-.143	-.002 (.002)	-.116	-.002 (.002)	-.102	-.002 (.002)	-.118
Diagnostic Group[a]	-.235 (.062)	-.468**	-.125 (.070)	-.248*	-.126 (.074)	-.251*	-.117 (.071)	-.232
Cognition			.088 (.031)	.391**	.074 (.038)	.329*	.079 (.036)	.351*
Expressivity Photo[b]					.031 (.026)	.200	.033 (.024)	.217
Expressivity Word[b]					-.017 (.023)	-.110	-.025 (.022)	-.162
Expressivity Story[b]					-.005 (.019)	-.0320	-.008 (.018)	-.057
Experience Photo[c]							-.037 (.020)	-.320
Experience Word[c]							.019 (.023)	.155
Experience Story[c]							.088 (.036)	.328*

* $p < .05$, ** $p < .005$ *** $p < .0005$

See statistical analyses section for hierarchical regression strategy

[a]Diagnostic factors [b]Emotional Expressivity in response to stimuli [c]Subjective experience of emotion

Table 4 Hierarchical regression models predicting the recognition of angry facial expressions

Model Fit	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
R^2	.347***		.450***		.471***		.560***	
ΔR^2	.347**		.104**		.021		.089*	
Predictors	**β (SE)**	**B**	**β (SE)**	**B**	**β (SE)**	**B**	**β (SE)**	**B**
Constant	3.65 (0.316)		3.37 (.307)		3.40 (.347)		3.243 (.359)	
Age[a]	-.016 (.007)	-.259*	-.014 (.006)	-.233*	-.014 (.007)	-.237*	-.017 (.006)	-.285*
Diagnostic Group[a]	-.784 (.186)	-.489***	-.430 (.208)	-.268*	-.388 (.214)	-.242*	-.306 (.210)	-.190
Cognition			.283 (.093)	.394**	.306 (.103)	.427**	.358 (.101)	.498**
Expressivity Photo[b]					-.017 (.067)	-.039	-.025 (.065)	-.058
Expressivity Word[b]					-.053 (.076)	-.105	-.108 (.076)	-.213
Expressivity Story[b]					.089 (.077)	.144	.133 (.074)	.213
Experience Photo[c]							.009 (.063)	.025
Experience Word[c]							-.102 (.071)	-.287
Experience Story[c]							.139 (.050)	.341**

* p < .05, ** p < .005 *** p < .0005

See statistical analyses section for hierarchical regression strategy

[a]Diagnostic factors [b]Emotional Expressivity in response to stimuli [c]Subjective experience of emotion

Table 5. Hierarchical regression predicting the recognition of sad facial expressions

	Model 1		Model 2		Model 3		Model 4	
R^2	.211**		.241**		.283*		.408**	
ΔR^2	.211**		.030		.042		.125*	
Predictors	**β (SE)**	**B**	**β (SE)**	**B**	**β (SE)**	**B**	**β(SE)**	**B**
Constant	2.588 (.322)		2.448 (.335)		2.709 (.407)		3.645 (.548)	
Age[a]	-.022 (.007)	-.402**	-.022 (.007)	-.388**	.023 (.007)	-.411**	-.018 (.007)	-.318*
Diagnostic Group[a]	-.248 (.190)	-.166	-.071 (.227)	-.048	-.135 (.232)	-.090	-.089 (.219)	-.060
Cognition			.141 (.101)	.212	.169 (.114)	.254	.384 (.138)	.577*
Expressivity Photo[b]					-.017 (.072)	-.037	-.016 (.068)	-.034
Expressivity Word[b]					-.113 (.083)	-.218	-.161 (.081)	-.310
Expressivity Story[b]					.051 (.075)	.099	.009 (.073)	.017
Experience Photo[c]							.082 (.060)	.242
Experience Word[c]							-.076 (.060)	-.225
Experience Story[c]							-.201 (.085)	-.409*

* $p < .05$, ** $p < .005$ *** $p < .0005$

See statistical analyses section for hierarchical regression strategy

[a]Diagnostic factors [b]Emotional Expressivity in response to stimuli [c]Subjective experience of emotion

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