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Impaired emotional contagion following severe traumatic brain injury

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ABSTRACT

Empathy deficits are widely-documented in individuals after severe traumatic brain injury (TBI). This study examined the relationship between empathy deficits and psychophysiological responsivity in adults with TBI to determine if impaired responsivity is ameliorated through repeated emotional stimulus presentations. Nineteen TBI participants (13 males; 41 years) and 25 control participants (14 males; 31 years) viewed five repetitions of six 2-min film clip segments containing pleasant, unpleasant, and neutral content. Facial muscle responses (zygomaticus and corrugator), tonic heart rate (HR) and skin conductance level (SCL) were recorded. Mean responses for each viewing period were compared to a pre-experiment 2-min resting baseline period. Self-reported emotional empathy was also assessed. TBI participants demonstrated identical EMG response patterns to controls, i.e. an initial large facial response to both pleasant and unpleasant films, followed by habituation over repetitions for pleasant films, and sustained response to unpleasant films. Additionally, an increase in both arousal and HR deceleration to stimulus repetitions was found, which was larger for TBI participants. Compared to controls, TBI participants self-reported lower emotional empathy, and had lower resting arousal, and these measures were positively correlated. Results are consistent with TBI producing impairments in emotional empathy and responsivity. While some normalisation of physiological arousal appeared with repeated stimulus presentations, this came at the cost of greater attentional effort.

1. Introduction

Severe traumatic brain injury (TBI), while heterogeneous in its effects, produces pervasive and chronic social difficulties for the majority of individuals (Cicerone and Tanenbaum, 1997; Hanks et al., 1999). TBI has a propensity to cause damage to the ventral frontal and temporal cortices, due to abrasion of the ventral surfaces of the brain across the rough surfaces of the middle and anterior fossae of the skull during rapid acceleration–deceleration (Bigler and Bigler, 2007), and results in specific neuropsychological deficits in functions and processes linked to these regions (Fujiwaraa et al., 2008). Poor social and emotional functioning is commonly manifested in displays of socially inappropriate behaviour, including emotional lability, insensitivity, and impulsivity (Pettersen, 1991; Tate, 1999).

Increasing evidence in the literature has supported the notion that following TBI there is a reduction in emotional empathy, i.e. a reduction in affective reactions to the emotional displays of others. For example, a large proportion (>60%) of TBI individuals (compared to 35% or less of healthy control participants) self-report emotional empathy deficits (de Sousa et al., 2012; Williams and Wood, 2009; Wood and Williams, 2008). Despite this, the neuropsychological mechanisms underpinning these deficits remain unclear.

According to previous researchers, 'emotion contagion', whereby individuals converge emotionally, or 'catch' one another's emotions, is a key component of emotional empathy (e.g. Hatfield et al., 1994). Moreover, physiological changes are consistently found to occur in response to another's emotions — adults typically demonstrate facial mimicry (Dimberg and Lundquist, 1990; Dimberg and Petterson, 2000; Dimberg and Thunberg, 1998), changes in skin conductance (Merckelbach et al., 1989; Vrana and Gross, 2004) and altered subjective experience (Hess and Blairy, 2001; Wild et al., 2001) when viewing facial expressions.

It is also well-established that physiological responses to emotional stimuli are affected by TBI. Affected responses include impaired facial mimicry (McDonald et al., 2011a), skin conductance (Blair and Cipolotti, 2000; de Sousa et al., 2011; Hopkins et al., 2002; McDonald et al., 2011b), startle potentiation (Saunders et al., 2006), and self-reported levels of arousal (de Sousa et al., 2010; Saunders et al., 2006), especially to aversive stimuli (i.e. angry facial expressions and unpleasant pictures). Interestingly, extant preliminary evidence suggests that the loss of emotional responsiveness after TBI may be linked to impairments in emotional empathy. Specifically, low self-reported emotional empathy has been found to be significantly associated with a loss of mimicry and reduced autonomic arousal to angry facial expressions following TBI (de Sousa et al., 2011). This extends previous research that has linked facial mimicry to emotional empathy in healthy adults

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(Sonnby-Borgström et al., 2003), and suggests an important role for emotional responsivity in the empathy process.

To date, the literature investigating loss of emotional responsiveness following TBI has predominately focused on physiological reactions to static emotional displays. However, in everyday life, emotions are often evoked by extended exposure to dynamic visual and auditory information (for review, see Gross and Levenson, 1995). Film is considered one of the most effective means of eliciting emotions in others (Gerrards-Hesse et al., 1994; Westermann et al., 1996) with higher ecological validity than many other methods (Gross and Levenson, 1995; McHugo et al., 1982; Phillippot, 1993). Film clips can induce specific emotional responses in the observer that are similar to faces and other emotionally salient material. Viewing pleasant films is usually associated with zygomaticus (ZM) electromyographic (EMG) ('smile') activity (Hubert and de Jong-Meyer, 1991), whereas viewing unpleasant films elicits corrugator (CR) EMG ('frown') activity (Hubert and de Jong-Meyer, 1991; Gomez et al., 2005). Viewing emotionally salient films of either valence produces larger skin conductance compared to neutral films (Codispoti et al., 2008; Gomez et al., 2005; Hubert and de Jong-Meyer, 1991).

de Sousa et al. (2012) recently examined the relationship between self-reported emotional empathy and contagion deficits in adults with TBI, and impaired psychophysiological and subjective reactions to emotionally evocative films lasting 90 s. Paralleling previous findings using static stimuli (de Sousa et al., 2010), de Sousa et al. (2012) reported that TBI participants scored significantly lower than the control group on self-report measures of emotional empathy and also demonstrated reduced contagion (i.e. "catching" the emotion of the film). Unlike the control group, the TBI participants did not show greater frowning (CR activity) to unpleasant films compared to other valence films, and they also demonstrated limited smiling (ZM activity) to pleasant films. Participants with TBI also displayed diminished skin conductance levels (SCLs), a measure of arousal, to emotional films compared to the control group. This lowered contagion and arousal in TBI was reflected in subjective film ratings, with the TBI group rating the pleasant films as significantly less pleasant, and unpleasant films as less unpleasant and less arousing than did the control group.

The use of films also provided the opportunity to observe engagement over time. In de Sousa et al. (2012) the control groups' contagion (facial expressions) generally increased over time; in contrast, arousal increased only to pleasant film clips, while a decrement was observed to the negative films. The TBI group did not show this pattern. As emotion regulation is known to be impaired after TBI, this raises the interesting question as to whether TBI affects normal processes of sensitisation and habituation of contagion to affective material. A potential confound, however, is that TBI is associated with significant loss of cognitive ability and commonly affects processing speed. Consequently, failure to respond normally over time may reflect a failure to efficiently process film content. One way to address this is to show the same films repeatedly, providing increased familiarity with film content as well as the opportunity to observe habituation over an extended paradigm. That was the first aim of the current study.

The second aim of the current study was to determine whether emotional contagion to film was related to empathy. In de Sousa et al. (2012) control participants with higher emotional empathy tended to display greater ZM EMG activity and to give more extreme subjective valence ratings; however, this relationship was not present in the TBI sample. By providing repeated exposure to the same films, we will increase the likelihood that the TBI group is fully aware of the content of the films and is, therefore, demonstrating genuine affective contagion that can then be examined in relation to empathy scores.

In addition to EMG and SCL the current study examined tonic heart-rate (HR) changes. HR deceleration is observed during tasks that involve sensory processing and attention to external events, whereas HR acceleration is observed in tasks requiring mental effort and cognitive processing (Lacey, 1967; Lacey and Lacey, 1978; Porges, 1976). McDonald et al. (2011a, 2011b) compared HR responses during passive and active viewing of repeated happy and angry facial expression stimuli. Both controls and TBI participants showed greater HR deceleration for the active versus passive condition. Control participants also showed a valence effect, such that there was increasing HR deceleration to repetitions of happy faces, and reducing HR deceleration to angry repetitions. Despite showing normal attention, HR responses did not change in response to either repetition or valence in TBI participants, in line with their overall impairment in arousal regulation.

In summary, the present study aimed to extend the findings of de Sousa et al. (2012) by investigating physiological responses to multiple viewings of the same emotional film segments, to determine if emotional contagion response patterns in TBI participants normalise with repetitive exposure. Measures of facial mimicry (EMG), arousal (SCL), and sensory processing (HR) to five repetitions of positive, neutral and negative valence film clips were examined. Self-reported affective empathy was also examined in relation to psychophysiological measures.

2. Material and methods

2.1. Participants

Data collection for this study occurred concurrently with data reported elsewhere (de Sousa et al., 2012), which focused on physiological and behavioural responses to the first viewing of each film clip. The current study examined physiological patterns across five separate viewings of each film. Due to equipment failure, two TBI participants included in the original paper have been excluded from this analysis.

Nineteen individuals with TBI (13 males) participated in the study. They were recruited from several brain injury units in Sydney, Australia in response to a request for research volunteers from their individual case managers. All participants with TBI met the following criteria: a) had sustained a severe TBI leading to extensive inpatient rehabilitation, b) were at least 1 year post-injury, c) had no prior history of psychiatric, neurological or developmental disorder, d) had no identified aphasia or agnosia, and e) were able to comprehend and adhere to instructions.

Twenty five control participants (14 males) were recruited from the general community in response to advertisements asking for research volunteers. They reported no history of developmental, neurological or psychiatric disorders, and were matched as closely as possible to the demographic characteristics of the TBI population with regard to gender and years of education.

2.2. Data collection and assessment

2.2.1. Wechsler Test of Adult Reading [WTAR; Wechsler, 2001]

The WTAR is a reliable word reading test (coefficient $\alpha = .87$–$.97$; Wechsler, 2001) that is designed to provide an estimate of premorbid intellectual functioning, with higher scores indicating greater premorbid intellectual functioning.

2.2.2. Questionnaires

Three self-report instruments were utilized to assess empathy and emotional functioning and are described in detail below. While severe TBI is often associated with poor insight into deficits (McDonald et al., 1999), the use of self-report versus relative-report measures was justified by research finding that individuals who are 'head injured are able to reliably complete self-report scales as indicated by the 'close others' similar reports' (Kinsella et al., 1988, p. 57). The empathy and mood self-report measures reported below have been found to be sensitive and valid for use within the severe TBI population (de Sousa et al.,