**THE UNIVERSITY OF HULL**

# *Attentional biases in post traumatic stress disorder and following acquired brain injury.*

**Being a Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Clinical Psychology**

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**by**

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**A. Overview:**

The portfolio has three parts:

Part one is a systematic literature review, in which the empirical evidence for attentional biases in post-traumatic stress disorder is reviewed.

Part two is an empirical paper, which explores attentional biases, memory for the traumatic event, and post-traumatic stress symptoms, following acquired brain injury.

Part three comprises the appendices, which provide further information regarding the systematic literature review and empirical paper.

## B. Table of Contents:

## C. List of Tables:

**Systematic Literature Review**



**Empirical Paper**

## D. List of Figures:

## Part One: Systematic Literature Review

This paper is written in the format ready for submission to the journal Clinical Psychology Review. Please see Appendix 2.1 for the "Guidelines for Authors".

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**Attentional biases in post-traumatic stress disorder: A systematic review.**

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**Abstract**

*Background:* Attentional biases for trauma-relevant information are considered to be a feature of post-traumatic stress disorder (PTSD). However, there has been no systematic review of the published literature into attentional biases across a range of experimental paradigms.

*Methods:* A systematic search of four key databases identified 30 papers meeting the inclusion criteria. Methodological quality of selected articles was assessed using an adapted checklist. The tasks employed in the studies were assigned a rating of either "yes", "no", or "mixed", depending on the reported evidence for a specific attentional bias effect.

*Results:* A specific attentional bias was found in only 19 of 37 tasks. When attentional biases were found they tended to occur at post-recognition stages of processing and to be interference effects, rather than facilitative effects.

*Limitations:* There were common weaknesses across studies, including unrepresentative participant samples and inappropriate comparison stimuli and participant groups. Furthermore, it is difficult to identify the relative contribution of automatic and strategic processes in ranging cognitive paradigms.

*Conclusions:* Attentional biases in PTSD are not reliably found in published research employing a range of experimental tasks. Future research needs to be carefully designed to clarify the existence and exact nature of attentional biases in PTSD.

**Keywords:** *Attention bias, posttraumatic stress disorder, emotional Stroop, dot-probe, visual search, affective Stroop.*

## Introduction

The experience of a traumatic event commonly results in symptoms of post-traumatic stress, including re-experiencing, hyperarousal, emotional numbing, and avoidance of reminders of the event. For the majority of people, these symptoms improve over the weeks following the event. However, for some individuals, distress can persist for months and even years. The symptoms of re-experiencing, in the form of nightmares, flashbacks, and intrusive thoughts, are considered to be central to this disorder (McNally, 2003). There are also associated difficulties in attention, concentration, and memory function, which can impact on social and occupational functioning. Given the cognitive abnormalities common in PTSD and other anxiety disorders, researchers have sought to understand symptoms from an information-processing perspective (Beck & Clark, 1997; Brewin, Dalgleish, & Joseph, 1996; Foa & Kozak, 1986; Litz & Keane, 1989).

The main posit of an information processing model is that the manner in which emotional information is processed at different stages of cognition is key to understanding the etiology and maintenance of anxiety disorders. Foa and Kozak (1985) proposed that anxiety responses are based in fear structures in memory, which contain information regarding the meaning of threatening stimuli, behavioural responses accompanying the threat, and physiological reactions. A central feature of anxiety is considered to be the erroneous interpretation or appraisal of threat. In an application of this to PTSD, Litz and Keane (1989) propose that fear networks in PTSD are easily activated by a range of stimuli.

In a three-stage information processing model of anxiety, Beck and Clark (1997) proposed that errors in processing occur at the initial perception of threat, during primary appraisal and preparation, and during secondary elaboration. These processes are considered to consist of a mixture of automatic and strategic elements (McNally, 1995). Similarly, in a dual representation theory of PTSD, Brewin, Dalgleish, and Joseph (1996) proposed that traumatic experiences are held in two sorts of memory, verbally accessible memories (VAM) and situationally accessible memories (SAM). The theory holds that the trauma-related information stored in VAMs and SAMs drives biases in attention and perception, particularly when SAMs are associated with high levels of emotional arousal.

Since the 1990s, cognitive psychology paradigms have been increasingly applied to the investigation of the information-processing phenomena associated with PTSD. These approaches have been considered a more accurate measure of intrusive cognitive activity than commonly used self-report measures (MacLeod, 1993). More specifically, researchers have investigated implicit and explicit memory for trauma-relevant information, disturbances in autobiographical memory, and biases in attention. There have been several studies reporting explicit and implicit memory biases for trauma-related words in PTSD subjects (Kaspi, McNally, & Amir, 1995; Vrana, Roodman, & Beckham, 1995). Furthermore, similar to the biases seen in depression, people with PTSD appear to have difficulty retrieving specific autobiographical memories, instead tending to describe overgeneral memories (McNally, Litz, Prassas, Shin, & Weathers, 1994; McNally, Lasko, Macklin, & Pitman, 1995).

The modified emotional Stroop task has been extensively employed to investigate attentional biases in PTSD. In this task, participants are required to name the ink colour of a series of words, while attempting to ignore the meaning of the words. PTSD participants have been found to be slower to name words that are trauma-related, compared to neutral words and to no-PTSD participant groups (Bryant & Harvey, 1995; Cassiday, McNally, & Zeitlin, 1992). The lack of any attentional biases in traumatised people without PTSD, suggests that biases are specific to the development of PTSD and not simply a consequence of trauma exposure. It has been proposed that the interference effect relates to the selective attention of trauma-relevant information in PTSD, or an inability to disregard this information even when it is unrelated to the task at hand (MacLeod, 2005). This interpretation is strengthened by the finding of a correlation between the severity of self-reported intrusive symptoms and response biases on the emotional Stroop (Cassiday *et al.,* 1992).

However, there is some concern that the emotional Stroop is not a true measure of attentional bias, as the interference effect found may be a result of general emotional arousal (Fox, 1994; Martin, Williams, & Clark, 1991). It has also been argued that responses on the emotional Stroop could relate to difficulties in the inhibition of speech articulation, due to the competition between saying the word and naming the colour (Chemtob, Roitblat, Hamada, Muraoka, Carlson, & Bauer, 1999). Furthermore, differing formats of the emotional Stroop task exist, namely a card format and single-trial computer format. In the card format, the stimuli from one word group are presented on a single card and the time taken to colour-name all the words on one card is recorded. In contrast, in the computer format each word is individually presented

and words from different conditions can be randomly intermixed. In the development of the computer format of the Stroop, it was found to result in similar group effects to the card format (Dalrymple-Alford & Budayr, 1966). However, in a correlational analysis of individual interference effects, the two formats of the emotional Stroop were found to have limited convergent validity, indicating they may be measuring different underlying processes (Kindt, Bierman, & Brosschot, 1996).

It therefore seems possible that the attentional bias detected in emotional Stroop tasks may not represent an underlying tendency to differentially process threatening information but may arise only in response to the particular demands of this task. In order to further explore this hypothesis, it seems important to utilise a range of cognitive paradigms in the investigation of attentional biases. Alternative tasks of attentional bias, which have been employed in research with PTSD participants, include the dot-probe (Bryant & Harvey, 1997; Elsesser, Sartory, & Tackenberg, 2004; Elsesser, Sartory, & Tackenberg, 2005) and visual search tasks (Pineles, Shipherd, Welch & Yovel, 2007; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). These tasks involve the allocation of attention to discrete areas of the visual field and in this way may be a more accurate measure of attentional bias. They can also provide a measure of both interference effects, where subjects are slower to respond in a context of trauma-related information, versus facilitation effects, where subjects are faster to respond in a context of trauma-related information.

There have been several reviews of research in this area, with a common consensus being that the existence of attentional biases in PTSD, at post-recognition stages of processing, is a robust finding (Buckley, Blanchard, &

Neill, 2000; McNally, 1998; McNally, 2006; Moore, 2008). The evidence for attentional biases at pre-recognition stages of processing has been considered to be mixed, with some studies detecting differential responding to emotional information presented in a subliminal format (Harvey, Bryant, & Rapee, 1996; McNally, Luedke, Besyner, Peterson, Bohm, & Lips, 1987), and other studies finding no such evidence (McNally, Amir, & Lipke, 1996; Trandel & McNally, 1987). Unfortunately, none of these reviews have used a replicable, systematic methodology. Furthermore, a number of the reviews encompassed a broad focus, reviewing research into deficits in IQ, verbal and visual memory, findings from neuroscience, and cognitive tasks investigating biases in memory, judgement, and attention.

In the only systematic literature review in the area of attentional biases and PTSD, Kimble, Frueh and Marks (2009) examined dissertation abstracts investigating the emotional Stroop effect in PTSD, in addition to the peer-reviewed literature. This was with the aim of controlling for the inherent publication bias occurring in peer-reviewed literature (Dickersin, 1994). The review also excluded studies that did not include a trauma comparison group, due to the difficulty in concluding that attentional biases are specific to PTSD in these studies.

Unsurprisingly, the review found a significantly higher number of studies reporting an absent emotional Stroop effect in the dissertation literature (75%, eight of 12 studies), compared to the peer-reviewed literature (44%, eight of 18 studies). Perhaps more surprising was the finding that even in the peer-reviewed literature, the emotional Stroop effect was not as robust as considered by previous reviews. More specifically, the review found eighteen peer-reviewed

articles, with eight (44%) supporting the interference effect, two (12%) providing partial support, and eight (44%) providing no support for the effect. The authors concluded that previous reviews of the literature have overestimated the occurrence of this effect and that it is at best "extremely weak or extremely subtle, if it exists at all" (p. 653, Kimble *et al.,* 2009).

It is worthy of note that the authors of this review employed strict criteria for the assignment of studies as detecting either 'yes', 'no', or 'partial' Stroop effects. In particular, studies were classified as 'no' if there were no significant differences between the PTSD group and other participant groups, if PTSD participants were slower to respond to all study stimuli, or if PTSD participants were also significantly slower to respond to generally negative stimuli. Studies including two trauma samples, for example sexual abuse and war exposure, were classified as showing 'partial' support if only one trauma group showed an effect. The search strategy used in the review was also limited by the use of only two search terms, namely "PTSD" and "Stroop".

The debate regarding the existence of attentional biases is extremely relevant to the clinical formulation and treatment of PTSD. If attentional biases exist in PTSD, they may represent a reduced threshold for detecting trauma cues and a difficulty disengaging from these cues. Furthermore, if these biases are amenable to measurement through cognitive tasks, then they could play an important role in assessing the severity of symptoms and treatment response. Information processing biases, such as selective attention, strong perceptual priming, and learned associations between stimuli and fear responses, have been highlighted as key maintaining factors in a comprehensive cognitive-behavioural model of PTSD (Ehlers & Clark, 2000). This understanding of PTSD implies

that successful treatment strategies would involve the identification of triggers for intrusions and improving stimulus discrimination (Ehlers & Clark, 2000). Further to this, understanding the automaticity of these attentional processes is extremely pertinent to deciding between exposure-based therapeutic techniques, which may target automatic and unconscious fear associations, and verbally based techniques aimed at consciously challenging erroneous cognitions (McNally, 1995).

The rationale for the current review was based upon the contrasting conclusions of previous reviews and the lack of any systematic review of attentional biases in PTSD across a range of experimental tasks. Therefore, the aim of the current paper was to undertake an up-to-date and thorough systematic literature review of published research specifically in the area of visual attentional biases in PTSD, across experimental paradigms. The review included not only studies using the emotional Stroop task, but also studies using alternative cognitive paradigms, such as the dot-probe task and visual search task. Similarly to Kimble *et al.* (2009), the current review classified studies based on the absence or presence of an attentional bias effect. However, separate ratings were given to different tasks and formats within the same study. Further to this, studies with no trauma comparison group were included in the present review in order to ensure a thorough review of the literature and to make comparisons between study designs. It was beyond the scope of the review to explore all information-processing biases, such as biases in memory, or the use of auditory attention paradigms. The specific research questions that were addressed by the review were as follows:

1. What is the evidence for the existence of attentional biases in PTSD, following different types of traumatic experiences?
2. What is known about the nature of attentional biases in PTSD?
3. Do attentional biases in PTSD change following treatment?
4. What are the common limitations and methodological issues of research in this area?

## Method

*Search Strategy*

A systematic literature search was conducted on April 1st 2010 using the following four databases: PsycINFO; MEDLINE; Web of Science; and Scopus. These databases were selected as they provide access to a comprehensive range of journal abstracts in psychology and related areas from the 1960s onwards. A search was carried out for existing review papers of attentional biases following PTSD to ensure that the review would not be replicating previous work. This search did not identify any systematic literature reviews into attentional biases in PTSD.

The abstracts of all studies retrieved from the initial searches were assessed against the research question and inclusion and exclusion criteria. The full text of all abstracts meeting the criteria were obtained (n=33) and further assessed for eligibility. Articles meeting the criteria at this stage were accepted for review (n=30). The reference lists of all papers meeting inclusion and exclusion criteria were hand-searched to identify further appropriate papers. There were no hand-searched articles eligible for review. Key authors from retrieved literature were also contacted in order to enquire about any additional articles that were not retrieved by the database search. There were no publications highlighted by the authors that had not already been accepted for review. Key information from articles was extracted using a data extraction form, adapted for the aims of the current review (appendix 4.3).

*Search Terms*

Journal titles and abstracts were searched using the following terms: ("post-traumatic stress disorder", "posttraumatic stress disorder", "post traumatic stress disorder", "post-traumatic stress", "posttraumatic stress", "post traumatic stress", "post-traumatic stress symptoms", "posttraumatic stress symptoms", or "post traumatic stress symptoms", or "emoti* trauma*", or the acronyms "PTSD, "PTS", "PTSS") and ("stroop", or "attenti* bias*", or "processing bias*", or "attention* task", or "emotion* attenti*", or "emotion* stroop", or "dot-probe", or "dot probe", or "affective stroop", or "counting Stroop", or "digit detection", "visual search", or "emotion* lexical decision" or "affective lexical decision"). The asterisk (*) truncation was used on some search terms due to common multiple endings and expanded the number of articles retrieved relating to those search terms. The thesaurus catalogue system of the PsycINFO database included a posttraumatic stress disorder category and emotional trauma category, which were included in the search on this database using the terms "Posttraumatic Stress Disorder" and "Emotional Trauma", preceded by the code "DE". The database also included a category related to the Stroop task and a category related to attention. These were also included in the search on this database, using the terms "Stroop Effect" and "Attention", preceded by the code "DE".

*Search Limits*

Specific limits were applied to database searches where options to do so were available. The rationale for this was to restrict retrieval to articles relevant to the research question and eligibility criteria for the review. The limits set were to

include only articles written in the English language, involving human subjects, with adult participants (aged 16 years or older), which had been published in peer-reviewed journals.

*Inclusion Criteria*

The review included studies, which met the following criteria:

- Studies that included a task of visual attentional biases, such as the modified Stroop task, dot-probe task, visual search task, digit detection task, and affective Stroop task.
- Studies that included participants with a primary diagnosis of PTSD and a comparison group of non-PTSD participants.
- Studies that included a standardised assessment of PTSD symptomatology (self report or diagnostic interview).
- Studies published in peer-reviewed journals.
- Studies involving adult participants (aged 16 years old or above).
- Studies published in the English language.

*Exclusion Criteria*

The review excluded studies, which met the following criteria:

- Studies that did not include a task of visual attentional biases.
- Studies that were based upon auditory attention, memory bias, or noise judgement tasks only.
- Studies that did not include a standardised assessment of PTSD symptomatology.

- Studies that did not include a comparison group of non-PTSD participants.
- Studies that did not report findings related to the attentional bias task.
- Studies that investigated attentional biases in acute stress disorder (ASD).
- Studies investigating co-morbidity associated with PTSD, for example substance abuse.
- Studies published in a language other than English.
- Studies not involving human subjects.
- Studies including primarily children and adolescents (participants aged below 16 years old).
- Studies investigating the neuropsychological/cognitive deficits in people with PTSD.
- Case reports.
- Systematic literature reviews.
- Unpublished studies.

*Assessment of Methodological Quality*

The methodological quality of the selected articles was assessed using an adapted checklist for assessing the quality of randomised and non-randomised health care interventions (Downs & Black, 1998). The adapted checklist (appendix 4.1) consisted of 15 items considered to be relevant to assessing the quality of cognitive experimental studies, which comprise the current review. A point scoring system was employed to enable comparisons across studies, where a score of 15 was awarded to a study meeting all 15 criteria of methodological quality. To ensure reliability of the ratings, an independent rater, experienced in

psychological research, also assessed the studies. The combined sets of ratings resulted in a maximum score of 30 points for each study. An overview of the ratings given and the level of agreement for each criterion can be found in appendix 4.2. Overall, there was an 86.2% agreement between raters, which indicates a good level of reliability. There were no studies excluded on the basis of methodological quality.

*Rating of Attentional Bias Effects*

The studies were assigned ratings based on the attentional bias effects detected. Studies including more than one type of attentional task or multiple forms (e.g. computer and card) received separate ratings for each task or format. A 'yes' rating was assigned to tasks detecting a specific attentional bias effect for trauma-related stimuli in the PTSD sample. This rating was only given when no such attentional bias effect was found in other comparison groups of participants. A rating of 'no' was assigned to tasks where there was no specific attentional bias for trauma-related stimuli or where comparison participant groups also showed an attentional bias effect for trauma-related stimuli. A 'mixed' rating was assigned to tasks where there was an attentional bias for trauma material in the PTSD group only, but also additional biases for other emotional stimuli.

## Results

*Overview of Search Results*

The flowchart in Figure 1 outlines the systematic review process, including the numbers of studies retrieved, accepted, and rejected at each stage. Three studies were excluded from the review after obtaining the full text article. The reasons for these exclusions were: the absence of a PTSD group of participants (McNally, Clancy, Schacter, & Pitman, 2000); failing to report the outcome of the attentional bias task (Bremner, Vermetten, Vythilingam, Afzal, Schmahl, & Elzinga *et al.,* 2004) and investigating the length of time trauma stimuli is viewed, rather than specific attentional biases (Amdur, Larsen, & Liberzon, 2000). Furthermore, one study was not included in the review due to the full text being unobtainable from available sources, including electronic journals and the British Library (Naidich & Motta, 2000).

An overview of the 30 studies included in the review can be found in Table 1. A range of traumatic experiences were investigated, including combat stress (n=11), vehicle related accidents (n=9), sexual assault (n=5), crime (n=1), burn injury (n=1), and a mix of trauma (n=4). The studies utilised a range of attentional bias tasks, including the modified emotional Stroop (n=22), dot-probe (n=3), visual search (n=2), digit detection (n=1), affective Stroop (n=1), emotional counting Stroop (n=1), and emotional lexical decision (n=1) tasks. A description of the tasks and their outcome variables can be found in appendix 4.4. There were 24 studies that presented the task on a computer, whilst seven studies used a card format of the emotional Stroop. A total of three studies utilised picture stimuli and 28 studies used word stimuli.

*Figure 1.* Overview of Systematic Review Process.

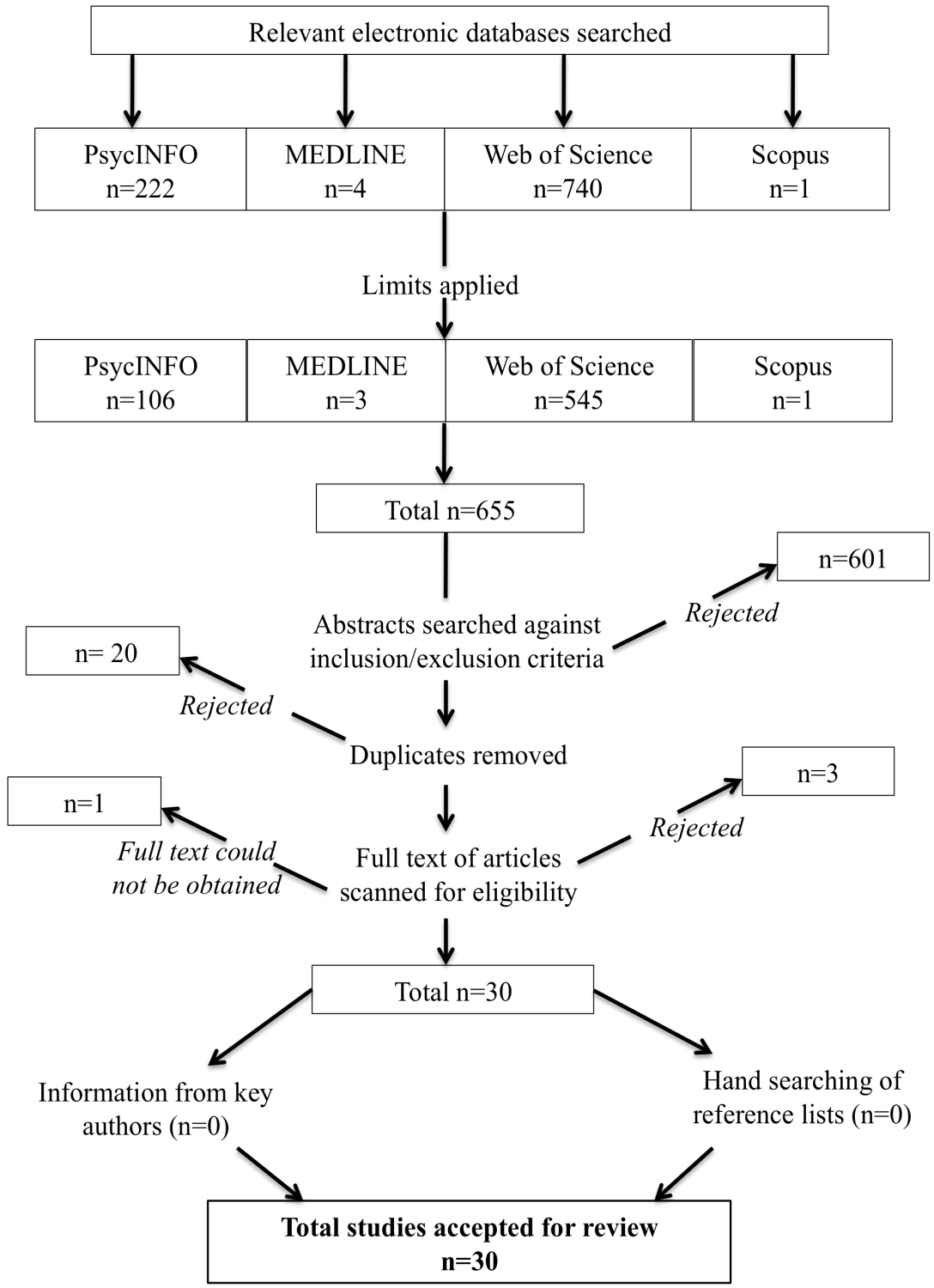

Table 1. Overview of Included Studies.

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Beck et al. (2001)*** *USA* | Mixed design | • PTSD/Pain (28) 42.9<br>• Pain (26) 41.3<br>• No PTSD/No Pain (21) 32.5 | RTA<br><br>RTA<br>RTA | 18.0m<br>34.3m<br>39.1m | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. RTA<br>2. Pain<br>3. Positive<br>4. Neutral | CAPS<br>IES | PTSD/pain group significantly slower respond to RTA and pain words. No PTSD/pain group significantly slower to respond to pain words only. | ✓ | 25 |
| ***Buckley et al. (2002)*** *USA* | Mixed design | • PTSD (30) 40.0<br>• Panic Disorder (30) 39.5<br>• Control (30) 31.4 | RTA<br>No trauma<br><br>No trauma | 6-24m | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal and subliminal (16ms) | Words:<br>1. RTA<br>2. Panic<br>3. Neutral (S) | SCID<br>CAPS<br>PCL | No interference at automatic/ subliminal stage of processing.<br><br>In supraliminal format, PTSD group showed delayed response to RTA and panic words. | ×<br><br>? | 23 |
| ***Buckley et al (2003)*** *USA* | Between -groups | • PTSD (6) 34.7<br>• Actors (6) 26.2<br>• Control (6) 28.7 | RTA<br>Trained<br>No trauma | 6-24m | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. RTA<br>2. Neutral | SCID<br>CAPS<br>PCL | PTSD group showed significant interference to RTA words, compared to controls. Actors were slower than controls but could not feign specific pattern. | ✓ | 23 |
| ***Bryant & Harvey (1995)*** *Australia* | Mixed design | • PTSD (15) 35.47<br>• Specific driving phobia (15) 37.00<br>• Low anxiety (15) 36.27 | RTA<br>RTA<br><br>No trauma | 41.20d<br><br>55.60d<br><br>45.00d | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. Strong-threat<br>2. Mild-threat<br>3. Positive<br>4. Neutral | DSM<br>PTSD-I<br>IES | PTSD group showed a significant interference effect for strong-threat words. No effect of mild-threat words in PTSD group or any significant biases in other participant groups. | ✓ | 25 |
| ***Bryant & Harvey (1997)*** *Australia* | Mixed design | • PTSD (15) 35.6<br>• Sub-clinical PTSD (15) 36.0<br>• Low Anxiety (15) 34.5 | RTA<br>RTA<br><br>RTA | 5.64m<br>5.10m<br><br>5.35m | Dot-Probe | • Computer<br>• Cued and uncued | Words:<br>1. Strong-threat<br>2. Mild-threat<br>3. Positive<br>4. Neutral | DSM<br>PTSD-I | PTSD significantly faster to respond to target when in close proximity to mild threat words, in the uncued condition. No significant differences for strong-threat words. | ? | 19 |
| ***Cassiday et al. (1992)*** *USA* | Mixed design | • PTSD (12) 33.17<br>• No-PTSD (12) 31.70<br>• Control (12) | Sexual<br>Sexual<br>No trauma | 9:05y<br><br>9:05y | Emotional Stroop | • Computer<br>• Random and blocked trials<br>• Supraliminal | Words:<br>1. High-threat<br>2. Mod-threat<br>3. Positive | SCID<br>IES-R | PTSD group significantly slower to colour-name high-threat words compared to other words and other groups. | ✓ | 21 |

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 34.33 | | | | | 4. Neutral | | Moderate-threat words lead to intermediate interference. | | |
| ***Chemtob et al. (1999)*** *USA* | Mixed design | • PTSD (16) 45.81<br>• No-PTSD (27) 51.59<br>• Psychiatric (16) 41.87<br>• Control (20) 41.55 | War<br>War<br><br>No trauma<br><br>Military | NR | Digit Detection | • Projected from computer<br>• Random and blocked trials<br>• Supraliminal | Words:<br>1. War<br>2. Neutral<br>Images:<br>1. War<br>2. Neutral | SCID<br>M-PTSD | No significant differences in response to word distractors.<br><br>PTSD group significantly slower to detect digit in presence of war images. | ×<br><br>✓ | 25 |
| ***Constans et al. (2004)*** *USA* | Mixed design | Assigned to:<br>• Video (16)<br>• Speech (14)<br>• Reward (15)<br>• Control (15)<br>M=50 | War with PTSD | NR | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. Social threat<br>2. War<br>3. Neutral | SCID<br>PCL-M | Interference for war words in reward and control groups. When mildly threatening upcoming event, attention bias suppressed (video and speech). When motivated by reward attention bias not suppressed. | ✓ | 23 |
| ***Devineni et al (2004)*** *USA* | Within-group | PTSD (23) 38.65<br>Pre- and post-treatment | RTA | 6-24m | Emotional Stroop | • Computer<br>• Supraliminal and subliminal (16ms) | Words:<br>1. Trauma<br>2. Neutral | SCID<br>CAPS<br>IES<br>PCL | No differences in biases pre- and post- treatment.) No interference effects in supraliminal condition.<br><br>No effect of subliminal presentation. | ×<br><br>× | 22 |
| ***Elsesser et al. (2004)*** *Germany* | Mixed design | • Recent Trauma (37) 40.32<br>• PTSD (18) 41.72<br>• Control (31) 41.19 | Various<br><br>Various<br>No trauma | 26.2d<br><br>761.4d | Dot-Probe | • Computer<br>• Supraliminal<br>• Random | Images:<br>1. Trauma (I)<br>2. Aversive<br>3. Pleasant<br>4. Neutral | ADIS<br>IES-R | No significant effect of image type, in any of the participant groups. | × | 23 |
| ***Elsesser et al. (2005)*** *Germany* | Prospec-tive mixed | • Recent Trauma (35) 40.94<br>• Control (26) 40.31 | Various<br><br>No trauma | 27.1d<br>2nd =3m | Dot-Probe | • Computer<br>• Random<br>• Supraliminal | Images:<br>1. Trauma (I)<br>2. Aversive<br>3. Neutral | ADIS<br>IES-R | Recent trauma group did not display attentional bias to trauma images, but were significantly slower to respond to trauma images irrespective of probe position. | × | 19 |

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Field et al. (2001)*** *USA* | Mixed design | • Revictim (16)<br>• No Revictim (35)<br>M=38.4 | Sexual<br>Sexual | NR | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. Sexual<br>2. Threat<br>3. Neutral (S) | SCID<br>CAPS<br>TSC-40 | Both groups were significantly slower to colour-name sexual words, but recently revictimised group significantly more so than non-revictimised group. | ✓ | 26 |
| ***Foa et al. (1991)*** *USA* | Mixed design | • PTSD (15) 29.77<br>• No-PTSD (14) 29.77<br>• Control (16) 28.69 | Sexual<br>Sexual<br>No trauma | 217d<br>298d | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. Sexual<br>2. Threat<br>3. Neutral | DSM<br>IES-R | PTSD group significantly slower to respond to rape words. No differences between word types in no-PTSD or control groups. | ✓ | 25 |
| ***Harvey et al. (1996)*** *Australia* | Mixed design | • PTSD (20) 34.0<br>• No-PTSD (20) 32.1<br>• Control (20) 33.8 | RTA<br>RTA<br>No trauma | 2.6m<br>4.1m | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal and subliminal (14.7ms) | Words:<br>1. RTA<br>2. Neutral | DSM<br>PTSD-I<br>IES | PTSD group displayed significant interference effects for RTA words in both supraliminal and subliminal conditions. No such effects in no-PTSD or control groups. | ✓ | 25 |
| ***Kaspi et al. (1995)*** *USA* | Mixed design | • PTSD (30) 41.6<br>• No-PTSD (30) 44.3 | War<br>War | NR | Emotional Stroop | • Computer<br>• Blocked and random<br>• Supraliminal | Words:<br>1. Trauma<br>2. Negative<br>3. Positive<br>4. Neutral | SCID | PTSD interference effect for war words. No-PTSD showed a similar but non-significant trend. Non-significant trend towards stronger effect in blocked format. | ✓ | 24 |
| ***Litz et al. (1996)*** *USA* | Mixed design | • PTSD (24) 42.4<br>• No-PTSD (15) 43.2<br>• Psychiatric (12) 42.33 | War<br>War<br>No trauma | NR | Emotional Stroop | • Computer<br>• Blocked<br>• Supraliminal | Words:<br>1. War-High<br>2. War-Low<br>3. Edu-High<br>4. Edu-Low | SCID<br>M-PTSD | There was no specific attentional bias for war words. PTSD group significantly slower to colour-name all high-threat words, compared to other groups. | ? | 27 |
| ***McNally et al. (1990)*** *USA* | Mixed design | • PTSD (15) 40.7<br>• No-PTSD (15) 43.4 | War<br>War | NR | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. Trauma<br>2. Positive<br>3. OCD<br>4. Neutral | Interview<br>M-PTSD | Significant interference for trauma words in PTSD group. No effects in no-PTSD group. | ✓ | 22 |

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***McNally et al. (1993)*** *USA* | Within-group | PTSD (24) 42.67 | War | NR | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. Trauma<br>2. Positive<br>3. OCD<br>4. Neutral | DSM<br>M-PTSD | Significant interference for war words, compared to other words. Re-administration of task one week later showed good reliability. | ✓ | 15 |
| ***McNally et al. (1996)*** *USA* | Mixed design | • PTSD (14) 47.6<br>• No-PTSD (14) 47.5 | War<br>War | NR | Emotional Stroop | • Card and computer<br>• Random<br>• Supraliminal and subliminal (57ms) | Words:<br>1. Trauma<br>2. Positive<br>3. Neutral | SCID<br>M-PTSD | Card version of Stroop task showed significant interference effect for war words in PTSD.<br><br>No significant interference effects in supraliminal or subliminal computer conditions. | ✓<br><br>× | 22 |
| ***McNeil et al. (1999)*** *USA* | Mixed design | • PTSD (15) 45.6<br>• OCD (26) 39.7<br>• MDD (18) 46.4 | War or sexual | NR | Emotional Stroop | • Computer<br>• Blocked<br>• Supraliminal | Words:<br>1. Anxiety<br>2. Depression<br>3. Neutral | SCID<br>CAPS | PTSD group significantly slower to respond to depression and anxiety words (anxiety words were not trauma-specific). | ? | 21 |
| ***Metzger et al. (1997)*** *USA* | Mixed design | • PTSD (9) 37.0<br>• No-PTSD (10) 31.7 | Various<br>Various | NR | Emotional Stroop | • Computer: key-press response<br>• Blocked<br>• Supraliminal | Words:<br>1. Trauma (I)<br>2. Positive (I)<br>3. Neutral (I) | SCID | Significant interference for trauma words in PTSD group. Further significant effect of positive words, though less pronounced. No effect of word type in no-PTSD group. | ? | 21 |
| ***Paunovic et al. (2002)*** *Sweden* | Mixed design | • PTSD (44) 35.7<br>• Control (39) 36.0 | Crime<br>No trauma | 6.7wks | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal and subliminal (17ms) | Words:<br>1. Trauma<br>2. Positive<br>3. Neutral | CAPS<br>IES<br>PSS | PTSD group significantly slower to respond to trauma and positive words in supraliminal condition. No significant effect of word type in subliminal condition. | ? | 27 |
| ***Pineles et al. (2007)*** *USA* | Mixed design | • High-PTSD (30) 54.69<br>• Low-PTSD (27) 54.30 | War<br><br>War | NR | Visual Search | • Computer<br>• Random<br>• Supraliminal<br>• Facilitation/ interference | Words:<br>1. Trauma<br>2. Neutral (S)<br>3. Neutral | DSM<br>PCL | In interference condition, high-PTSD subjects were significantly slower to identify oddball word. This effect was only apparent for subjects who completed the interference | ✓ | 25 |

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | condition first.<br><br>No effect of word type in facilitation condition. | <br><br>× | |
| ***Pineles et al. (2009)***<br>*USA* | Mixed design | • High-PTSD (24) 46.6<br>• Low-PTSD (19) 47.3 | Sexual<br><br>Sexual | NR | Visual search | • Computer<br>• Random<br>• Supraliminal<br>• Facilitation and interference tasks | Words:<br>1. Trauma<br>2. General<br>3. Neutral (S)<br>4. Neutral | DSM<br>PCL | In interference condition, high-PTSD group were significantly slower to respond to trauma words, compared to other word types and low-PTSD group.<br><br>There was no such effect in the facilitation condition. | ✓<br><br>× | 26 |
| ***Shin et al. (2001)***<br>*USA* | Mixed design | • PTSD (8) 50.6<br>• No-PTSD (8) 54.1 | War<br>War | NR | Emotional counting Stroop | • Computer<br>• Blocked<br>• Supraliminal | Words:<br>1. War<br>2. Negative<br>3. Neutral | CAPS<br>SCID | No significant effect of word type in PTSD or no-PTSD group. | × | 28 |
| ***Sveen et al (2009)***<br>*Sweden* | Within-group | Burn patients with ranging PTSD severity (38) 43.9 | Burn injury | 1y | Emotional Stroop | • Computer<br>• Random<br>• Supraliminal | Words:<br>1. Burn<br>2. Anxiety<br>3. Neutral | SCID<br>IES-R | Whist there was a significant interference effect for burn words compared to neutral words, there was no difference between burn words and general anxiety words. | ? | 23 |
| ***Thomas & Fremouw (2009)***<br>*USA* | Mixed design | • True-PTSD (6)<br>• Simulators (31)<br>• Control (28) M=19.53 | RTA<br>No trauma<br>No trauma | NR | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. RTA<br>2. Malinger<br>3. OCD<br>4. Neutral (S)<br>5. Neutral (S)<br>6. Neutral (S) | PCL<br>CAPS | Significant interference for RTA words in true-PTSD and Simulators. No differences between true-PTSD and PTSD Simulators (subjects told to respond to all tasks as if they had PTSD). | ✓ | 21 |
| ***Thrasher et al. (1994)***<br>*UK* | Mixed design | • High-PTSD (13) 36.6<br>• Low-PTSD (20) 39.7<br>• Control (12) 33.3 | Ferry<br><br>Ferry<br><br>No trauma | 5y | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. Ferry<br>2. Threat<br>3. Positive<br>4. Neutral (S)<br>5. Neutral | IES-R<br>CIV | High-PTSD group significantly slower to respond to ferry-disaster words, compared with threat, neutral, and positive words. | ✓ | 26 |

| *Authors* | *Design* | *Participants* | *Type of Trauma* | *Time since Trauma* | *Task(s)* | *Format* | *Stimuli* | *PTSD Measures* | *Key Findings* | *Bias* | *Quality Rating* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Vrana et al. (1995)*** *USA* | Mixed design | • PTSD (42) 44.8<br>• No-PTSD (15) 47.9 | War<br>War | NR | Emotional Stroop | • Card<br>• Blocked<br>• Supraliminal | Words:<br>1. War-Neg<br>2. War-Neut<br>3. Negative<br>4. Neutral | SCID<br>M-PTSD | There were no significant differences between PTSD and no-PTSD. Both groups were significantly slower to respond to all emotional words in comparison to neutral words. | × | 20 |
| ***Vythilingam et al. (2007)*** *USA* | Mixed design | • PTSD (22) 32.55<br>• No-PTSD (21) 32.48<br>• Control (20) 32.40 | Various<br>Various<br><br>No trauma | NR | Affective Stroop | • Computer<br>• Random<br>• Supraliminal | Images:<br>1. Positive<br>2. Negative<br>3. Neutral | SCID | PTSD group showed significantly greater interference for negative images on the affective Stroop, compared to no-PTSD and Control groups. | ✓ | 24 |
| | | | | | Lexical Decision | | Words:<br>1. High-Neg<br>2. Low-Neg<br>3. Neutral | | PTSD group showed significant facilitation effect for high-negative words, in comparison to other participant groups. | ✓ | |

Notes: Number of participants in each group is reported in brackets, followed by age out of brackets. Y = years; m = months; wks = weeks; d = days; S = semantically related; I = idiosyncratic; NR = not reported in article; OCD = Obsessive Compulsive Disorder; MDD = Major Depressive Disorder; ✓ = yes rating; × = no rating; **?** = mixed rating.

ADIS = Anxiety Disorders Interview Schedule (DiNardo, Brown, & Barlow, 1994); CAPS = Clinician Administered PTSD Scale (Blake, Weathers, Nagy, Kaloupek, Charney, & Keane, 1995); CIV = Civilian Mississippi (Keane, cited in Thrasher, Dagliesh, Yule, 1994); DSM-IV = Diagnostic and Statistical Manual of Mental Disorders (APA, 2000); IES = Impact of Events Scale (Horowitz, Wilner & Alvarez, 1979); IES-R = Impact of Events Scale-Revised (Weiss & Marmar, 1997); M-PTSD = Mississippi Scale for Combat-Related PTSD (Keane, Caddell, & Taylor, 1988); PCL = PTSD Checklist (Weathers, Litz, Herman, Huska, & Keane, 1993); PCL-M = PTSD Checklist for Military Personnel (Weathers *et al.,* 1993); SCID = Structured Clinical Interview for DSM Disorders (First, Gibbon, Spitzer, & Williams, 1996); TSC-40 = Trauma Symptom Checklist 40 (Elliott & Briere, 1992); PSS = PTSD Symptom Scale (Foa, Riggs, Dancu, & Rothbaum, 1993);

*Overview of Attentional Biases*

A significant attentional bias for trauma-related stimuli was found in a total of 19 of the 37 tasks carried out by the studies. There were 12 tasks that found no evidence for a specific attentional bias in PTSD participants and six tasks that were rated as having detected a mixed attentional bias effect. The studies rated as finding a mixed effect reported an additional interference effect for negative (McNeil, Tucker, Miranda, Lewin, & Nordgren, 1999), positive (Metzger & Orr, 1997; Paunovic, Lundh, & Öst, 2002), or general anxiety stimuli (Buckley, Blanchard, & Hickling, 2002; Litz, Weathers, Monaco, & Herman, 1996; Sveen, Dyster-Aas, & Willebrand, 2009) when compared with neutral stimuli. There was one study rated as finding a mixed effect due to finding an attentional bias for mildly threatening words, but no effect for highly threatening words (Bryant & Harvey, 1997).

The studies finding no significant attentional bias employed a range of task formats, including the card version of the emotional Stroop (Vrana, Roodman, & Beckham, 1995), random and blocked formats of the computerised emotional Stroop (Devineni, Blanchard, Hickling & Buckley, 2004; McNally, 1996; Shin, Whalen, Pitman, Bush, Macklin, Lasko, *et al.,* 2001), word stimuli on the digit detection task (Chemtob, Roitblat, Hamada, Muraoka, Carlson, & Bauer, 1999), picture stimuli on the dot-probe task (Elsesser, Sartory, & Tackenberg, 2004; Elsesser, Sartory, & Tackenberg, 2005), and facilitation conditions of the visual search task (Pineles, Shipherd, Welch & Yovel, 2007; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). Hence there was no task format, which commonly failed to find a significant attentional bias.

*Type of Trauma*

*War*

There were 11 studies that investigated attentional biases in Vietnam War veterans, employing a total of 14 tasks. These studies commonly compared performance across veterans with PTSD, veterans without PTSD, and participants with no exposure to war, on a range of word types. Of these studies, there were seven tasks that found a clear attentional bias effect for trauma-related stimuli. There were five tasks that did not find an attentional bias effect and two tasks that found a mixed effect. The studies finding a mixed effect were rated as such due to additional interference effects for depression stimuli (McNeil, Tucker, Miranda, Lewin, & Nordgren, 1999) and threatening words related to education (Litz, Weathers, Monaco, & Herman, 1996). These additional interference effects may be better explained by co-morbid depression and potentially negative school experiences in the veterans with PTSD. Regardless, the evidence is still mixed with regard to existence of specific attentional biases in PTSD following war.

*Vehicle-Related Accidents*

There were nine studies that included participants with PTSD as a result of vehicle-related accidents. More specifically, eight of these studies included participants who had experienced a RTA, and one study involved participants who had been involved in the Zeebrugge ferry disaster of 1987. There were six tasks that found an attentional bias effect in PTSD participants. A total of two tasks found a mixed effect, where there was an additional interference effect for panic related words (Buckley, Blanchard, & Hickling, 2002) and an interference effect for mildly

threatening but not highly threatening trauma-related words (Bryant & Harvey, 1995). There were three tasks that found no attentional biases in PTSD participants (Buckley, Blanchard, & Hickling, 2002; Devineni, Blanchard, Hickling & Buckley, 2004). These included two tasks with stimuli presented in a subliminal format and one task with stimuli presented in a supraliminal format.

*Sexual Abuse*

There were five studies of attentional biases in PTSD following sexual assault. In four of the tasks carried out by these studies, a specific attentional bias for trauma stimuli was found in PTSD participants (Cassiday, McNally, & Zeitlin, 1992; Field, Classen, Butler, Koopman, Zarcone, & Spiegel, 2001; Foa, Feske, Murdock, Kozak, & McCarthy, 1991; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). Of particular interest, mildly threatening stimuli was found to result in less interference than highly threatening stimuli, suggesting that the interference relates to the threat relevance of trauma stimuli (Cassiday *et al.,* 1992). Furthermore, in a study involving victims of childhood sexual abuse, recently revictimised participants were found to be significantly slower to respond to trauma-related words, compared to non-revictimised participants (Field *et al.,* 2001).

A mixed attentional bias effect was found in one task, where both depression and anxiety stimuli resulted in a significant level of interference compared to neutral stimuli (McNeil, Tucker, Miranda, Lewin, & Nordgren, 1999). It should be noted that the anxiety stimuli used in this task was not specifically related to trauma experiences. There was also one task that found no attentional biases in response to stimuli in a visual search task (Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel,

2009). However, this task was an investigation of facilitative biases, the evidence for which is discussed further below. There appears to some evidence for the existence of specific attentional biases in PTSD following sexual assault, although this conclusion is based on only a small number of studies.

*Mixed Traumatic Experiences*

There was one study investigating attentional biases following burn injury (Sveen, Dyster-Aas, & Willebrand, 2009), and five studies investigating biases following a range of traumatic experiences, including rape, assault, RTA, fire, burglary, and war. In these studies, the task stimuli were generally selected on an individual basis, with each control participant receiving the same stimuli as one of the PTSD participants. There were two studies that found no attentional bias for trauma stimuli (Elsesser, Sartory, & Tackenberg, 2004; Elsesser, Sartory, & Tackenberg, 2005), and three studies finding a mixed effect (McNeil, Tucker, Miranda, Lewin, & Nordgren, 1999; Metzger, Orr, Lasko, McNally, & Pitman, 1997; Sveen, Dyster-Aas, & Willebrand, 2009). In another study, attentional biases were found in responses to stimuli on both an affective Stroop task and a lexical decision task (Vythilingam, Blair, McCaffrey, Scaramozza, Jones, & Nakic *et al.,* 2007). However, the tasks in this study used trauma stimuli that were not specifically related to the trauma experiences of participants, which raises the possibility that participants were responding differently to generally negative material, rather than specifically trauma-related material. Thus, there appears to be only limited evidence for attentional biases in studies employing idiographic trauma stimuli and involving PTSD participants following a range of traumatic experiences.

*Nature of Attentional Biases*

*Supraliminal versus Subliminal Processing*

There were five studies included in the review, which investigated attentional biases in PTSD at a subliminal or pre-attentive stage of processing (Buckley, Blanchard, & Hickling, 2002; Devineni, Blanchard, Hickling & Buckley, 2004; Harvey, Bryant, & Rapee, 1996; McNally, Amir, & Lipke, 1996; Paunovic, Lundh, & Öst, 2002). In these studies, the stimuli were briefly presented to participants for a length of time that prevents conscious processing of stimuli (between 14 and 57 milliseconds). Following the brief presentation of each stimulus, a mask consisting of random characters was presented over the target stimulus. The mask was presented in the same colour as the target word and remained on screen until a response was made. Several of the studies used lexical decision tasks to confirm that subjects were unable to identify the words in this presentation format.

Of these studies, only one task found an attentional bias effect for subliminally presented trauma words in PTSD participants (Harvey, Bryant, & Rapee, 1996). Four of the five tasks did not find an attentional bias for trauma material presented at a subliminal stage of processing. However, in studies also presenting information at a supraliminal stage of processing, an attentional bias was found. Although further research is needed, this preliminary evidence appears to indicate that attentional biases in PTSD do not occur at a subliminal stage of information processing.

*Interference versus Facilitation*

There were three studies included in the review, which specifically attempted to determine the precise nature of the attentional bias in PTSD. Attentional facilitation, referring to the faster detection of threatening stimuli, is considered a distinct process from attentional interference, whereby a difficulty disengaging from threat-related information impacts on performance on the primary task. Two of these studies used an "odd-one-out" modified visual search task to distinguish between these attentional processes (Pineles, Shipherd, Welch & Yovel, 2007; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). In attentional facilitation, a neutral target word was presented in an array of threat-related distractor words. In attentional interference, a threat-related target word was presented in an array of neutral distractor words. In both studies, PTSD participants were significantly slower to respond to target stimuli in the interference condition, compared to neutral stimuli and non-PTSD participants. There was no significant effect in the facilitation condition. These results suggest that the attentional biases in PTSD relate to the interference of trauma cues rather than the faster detection of threat, or hypervigilance to threat. Clinically, this suggests that in PTSD there is a difficulty in disengaging from reminders of the trauma, which can result in the clinical symptoms of intrusive thoughts and rumination.

A third study explored attentional interference and facilitation effects in PTSD using two separate tasks: an affective Stroop task and an emotional lexical decision task (Vythilingam, Blair, McCaffrey, Scaramozza, Jones, & Nakic *et al.,* 2007). The affective Stroop task was used to detect attentional interference. In this

task, participants were presented with a numerical display, followed by an emotional distractor, a different numerical display, and the same emotional distractor again. Participants were required to determine which numerical display had the greater numerosity. PTSD participants showed significantly greater interference for negative images, compared to positive and neutral images and the other participant groups. In the emotional lexical decision task, participants had to determine whether a presented letter string was a word or non-word. On this task, PTSD participants were faster to respond to highly negative words in comparison to trauma controls and healthy participants, demonstrating attentional facilitation. Whilst this facilitation effect is in contrast with the previously presented findings (Pineles *et al.,* 2007; Pineles *et al.*, 2009), it should be noted that the negative stimuli used in these tasks were not closely matched to the ranging traumatic experiences in the trauma participant groups. Therefore, the effects seen in this study may reflect a general increased responsiveness in PTSD to negative emotional stimuli, rather than to specific threat-related stimuli.

*Attentional Biases following Treatment*

The review included one study investigating the use of the emotional Stroop as an outcome measure for treatment (Devineni, Blanchard, Hickling & Buckley, 2004). The study was part of a larger investigation of the effectiveness of a ten-week cognitive-behavioural treatment programme for PTSD. Participants completed an emotional Stroop task, involving subliminal and supraliminal formats, at pre-treatment and at the end of treatment. Despite reductions in PTSD severity, improvement was not associated with reduced attentional bias for trauma-related

words at a subliminal or supraliminal level. There was also no association between attentional bias and self-report psychopathology measures, or with treatment modality (cognitive behavioural therapy, supportive psychotherapy, waiting list control). However, it should be noted that at baseline there was no statistically significant attentional bias to trauma words, in the masked or unmasked conditions. This is likely to have impacted on the likelihood of detecting a change from pre- to post- treatment. In considering these issues and the lack of any other studies, the conclusions that can be drawn in this area are limited.

*Limitations and Methodological Issues*

*Validity of the Emotional Stroop*

There has been debate regarding the automatic and strategic elements of performance on the emotional Stroop task (McNally, 1995). Studies investigating the ability of subjects to control their performance on the emotional Stroop task can potentially increase our understanding of the validity of considering the emotional Stroop as a measure of automatic intrusive activity. It is therefore of interest that three studies in the review investigated the ability of people with and without PTSD to mimic or suppress a biased pattern of responding (Buckley, Galovski, Blanchard, & Hickling, 2003; Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004; Thomas & Fremouw, 2009). In a study that recruited students to feign PTSD in their responses to measures and experimental tasks, PTSD simulators were able to mimic a similar pattern of responding to students with true PTSD (Thomas & Fremouw, 2009). Both simulators of PTSD and true PTSD participants displayed a significant

attentional bias to trauma-related words, compared to other word types and control participants.

In contrast, Buckley *et al*. (2003) employed professional actors to mimic PTSD responses on all measures and tasks. PTSD participants displayed an attentional bias to trauma words, but the actors were not able to mimic this specific pattern of responding. Actors were only able to mimic a general slowing effect, when compared to controls. It was noted by the authors that the potential gains for research participants and actors to fake responses on the emotional Stroop may not match the motivations of people seeking help or pursuing litigation.

Finally, the third study explored whether PTSD participants could suppress their attentional bias, under the offer of a receiving a monetary reward for doing so (Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004). Participants were instructed to make their best effort to respond exactly the same to all stimuli in the task. Interestingly, PTSD participants were unable to suppress an attentional bias for trauma stimuli, despite the offer of a reward. Furthermore, suppression of attentional bias did occur in a group of participants who were distracted by an upcoming threatening event, due to a competing anxiety response.

Overall, the evidence appears mixed for the validity of the emotional Stroop as a measure of automatic biases. Whilst one study demonstrated that non-PTSD participants are able to mimic a specific attentional bias, two studies provided evidence to suggest that attentional biases cannot be intentionally altered, even with the promise of a financial reward.

*Slowed Colour-Naming in PTSD*

A robust finding in the majority of the studies was an overall slowing in colour-naming in the PTSD groups compared to the no-PTSD groups, regardless of word type. This delay in colour-naming appears to occur even when PTSD participants taking psychiatric medication are excluded and is unrelated to self-reported symptoms of anxiety and depression (Vrana, Roodman, & Beckham, 1995). Importantly, the no-PTSD participants commonly displayed a similar pattern of interference to PTSD participants, but at a much less pronounced level. The level of interference found in PTSD groups is therefore likely to be heightened by the context of generally slower responding.

It has been proposed that the slower performance may relate to a general cognitive deficit or impaired concentration, a common complaint in PTSD. However, whilst this slowing has been commonly found on the emotional Stroop task, no such differences were found between groups on the classic Stroop task (Litz, Weathers, Monaco, & Herman, 1996). This suggests that the slower responses are not due to a concentration impairment or cognitive deficit per se, but may be a result of a general interference effect whereby there is a carry-over in emotional response or intrusive thoughts from threatening information to neutral information. This hypothesis is in agreement with studies finding a stronger interference effect in blocked formats of the emotional Stroop in comparison to random formats, where carry-over effects can conceal biases for trauma-related information (Kaspi, McNally, & Amir, 1995).

*Selection of Stimuli*

The emotionality of stimuli used in attentional tasks is important to consider following evidence to suggest that any emotional stimulus, whether positive or negative, can elicit an interference effect in anxious subjects (Martin, Williams, & Clark, 1988). If this is the case, the assumption that the attentional biases relate specifically to PTSD symptomatology may be incorrect. It has already been noted that five of the tasks that included an additional emotional group of stimuli found interference effects in PTSD participants for positive, negative, or generally threatening words. Importantly, of the studies included in the current review, the range of stimuli was found to vary widely, with five studies including trauma-related and neutral stimuli only. Some studies did not assess the trauma-relevance or emotionality of the trauma-related stimuli through pilot studies or subjective ratings at the end of the tasks. Furthermore, two studies used stimuli that were not specifically related to trauma experiences (McNeil, Tucker, Miranda, Lewin, & Nordgren, 1999; Vythilingam, Blair, McCaffrey, Scaramozza, Jones, & Nakic *et al.,* 2007). These methodological issues clearly limit the conclusions that can be drawn regarding any attentional biases found.

A further issue with regards to stimuli relates to the semantic-relatedness of trauma stimuli. The neutral and trauma stimuli were commonly matched on lexical characteristics such as word length and familiarity. However, comparison stimuli tended to be unrelated semantically, whereas trauma-related stimuli belong to the same semantic category. To account for this, six of the studies in the review employed a set of neutral stimuli that were semantically related (Buckley, Blanchard, & Hickling, 2002; Field, Classen, Butler, Koopman, Zarcone, & Spiegel, 2001;

Pineles, Shipherd, Welch & Yovel, 2007; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009; Thomas & Fremouw, 2009; Thrasher, Dalgleish, & Yule, 1994). Of these studies, a significant interference effect for trauma stimuli was still found when comparisons were made with semantically related neutral stimuli.

Interestingly, Litz, Weathers, Monaco, and Herman (1996) used an emotional control group of words, all of which were related to education, in their modified emotional Stroop task. In participants with PTSD following combat exposure, an interference effect was found for both highly threatening war stimuli and highly threatening education stimuli. This suggests that the semantic relatedness of trauma stimuli may be an important factor in attentional biases. However, it is noted by the authors that combat veterans with PTSD may have had painful school experiences, leading to an emotional processing bias for education related stimuli that is independent of biases to war stimuli. Therefore, at present it is difficult to reach any firm conclusions with regard to the impact of the semantic relatedness of trauma stimuli.

*Sampling Methodology*

There were several studies that failed to report in sufficient detail the participant recruitment process. Specifically, the studies commonly did not describe the exclusion and inclusion criteria and the numbers of participants declining to take part, being excluded, or withdrawing from the research. These omissions lead to difficulty in assessing whether the participants are representative of the wider PTSD population. In studies where some details of the recruitment process were reported, a common method used was convenience sampling using local advertisements. The

difficulty with this method is the resultant self-selected sample of participants, which cannot be considered representative of the wider population. Further to this, many studies employed a relatively small sample, impacting on statistical power and increasing the chances of Type 1 and Type 2 errors.

In particular, the studies investigating PTSD following combat stress often failed to report several important participant characteristics, including the time since trauma exposure. These studies also included predominantly male participants, whilst studies investigating sexual abuse included predominantly female participants. Further to this, all of the 11 studies investigating combat stress were based upon participants who had served in the Vietnam War. These factors reduce the generalisability of the findings to other war experiences and to female populations. Additional to this, the duration of combat exposure was often greatest in the PTSD group of participants.

A further limitation of research in this area is the inherent co-morbidity in PTSD. The majority of studies acknowledged finding higher rates of depression and anxiety in the PTSD sample. Depression and anxiety symptoms were generally found not to correlate with interference effects on the attentional tasks. However, it seems an important factor for future research to closely attend to, without reducing the representativeness of the PTSD sample.

There were several studies strengthened by the inclusion of a psychiatric comparison group, in order to assess whether the interference effects found relate to having any psychiatric condition, rather than specifically PTSD (Bryant & Harvey, 1997; Buckley, Blanchard, & Hickling, 2002; Chemtob, Roitblat, Hamada, Muraoka, Carlson, & Bauer, 1999; Litz, Weathers, Monaco, & Herman, 1996; McNeil, Tucker,

Miranda, Lewin, & Nordgren, 1999). Unfortunately, some studies were limited by the recruitment of a comparison group from a somewhat different population to the PTSD group, for example student populations (Harvey, Bryant, & Rapee, 1996) and researchers' friendship networks (Beck, Freeman, Shipherd, Hamblen, & Lackner, 2001). This clearly limits the conclusions that can be drawn when making comparisons across groups.

## Discussion

### *Summary and Conclusions*

The current paper aimed to undertake a thorough and systematic literature review of studies investigating attentional biases in PTSD, which have used a range of experimental paradigms and have been published in peer-reviewed journals. The available evidence suggests that attentional biases in PTSD are not reliably found, even when systematically reviewing published literature and including a range of experimental tasks. This finding is in line with a recent review of dissertation abstracts and peer-reviewed literature into emotional Stroop effects in PTSD (Kimble, Frueh, & Mark, 2009). More specifically, a clear attentional bias for trauma information was only found in 19 out of 37 tasks carried out by the studies. The attentional bias effect appeared to be weakest for those studies involving PTSD following exposure to war and mixed trauma experiences, and strongest in studies involving PTSD following sexual abuse. However, even in PTSD following sexual abuse, there was no clear attentional bias in two out of the six tasks. In addition, the findings from several tasks indicated that PTSD participants displayed attentional biases for generally emotional stimuli, in line with the emotionality hypothesis of the emotional Stroop effect (Martin, Williams, & Clark, 1988). It is important to further explore these findings, since they may indicate that attentional biases in PTSD are not specific to trauma material.

The limited evidence suggests that if attentional biases do exist in PTSD, they are more likely to be in the form of interference effects, rather than facilitative effects for trauma-relevant information. Furthermore, attentional biases may only be

present at post-recognition stages of information processing, with only very weak evidence to suggest biases occur at subconscious stages of processing. Finally, attentional biases were not found to change following psychological treatment. However, this conclusion is based on only one study with several limitations, and therefore warrants further investigation.

*Limitations of Findings*

The research in this area is subject to several limitations and methodological flaws. In relation to participant recruitment, the common issues included unrepresentative participant groups, biased sampling methods, small sample sizes, and the lack of appropriate psychiatric and trauma control groups. Further arising issues were related to the stimuli used in the experimental tasks, including the lack of semantically related comparison stimuli and absent assessments of the trauma-relevance and emotionality of trauma stimuli.

The overall slower responding in people with PTSD, may result in more pronounced attentional biases, compared to non-PTSD participant groups. Also, it would seem that attentional biases should not be considered to represent fully automatic processes, but to be influenced by a combination of subconscious and strategic processes (McNally, 1995). The finding that participants in one study were able to feign a biased pattern of responding on an emotional Stroop task strengthens this understanding of attentional biases as involving some conscious, strategic processes (Thomas & Fremouw, 2009). Certainly, it is difficult to identify the relative contribution of automatic and strategic processes across varying cognitive paradigms.

Further limitations relate to the challenges involved in making comparisons across studies including different types of participant groups and using different types of stimuli and task formats. The blocked and card formats of the emotional Stroop have been found to result in stronger interference effects than formats where word stimuli are randomly intermixed (Kaspi, McNally, Amir, 1995). Similarly, there is only mixed evidence for the existence of attentional biases at pre-recognition stages of processing and for facilitative attentional bias effects. This means that findings from tasks using subliminal or facilitation formats are unlikely to be comparable with other task formats, which measure supraliminal attentional biases or interference effects.

Finally, it is important to note that 22 out of the 30 included studies (73.3%) were carried out in the USA, with fewer studies in Australia (10%), Sweden (6.6%), Germany (6.6%), and the UK (3.33%). Whilst studies from the USA provide valuable information, it may not be valid to generalise these findings to other countries or research settings.

*Clinical Implications*

The current review raises important questions over the existence and nature of attentional biases in PTSD. There are several psychological theories, which emphasise the role of automatic and strategic attentional processes in the etiology and maintenance of PTSD (Beck & Clark, 1997; Brewin, Dalgleish, & Joseph, 1996; Litz & Keane, 1989). Indeed, the available evidence indicates that subtle reminders of the traumatic event can result in intrusive cognitive activity at later stages of information processing. These processes may relate to difficulty in disengaging from

trauma cues or ruminative processes (Metzger, Orr, Lasko, McNally & Pitman, 1997). However, the effect may not be specific to PTSD, but may be a consequence of trauma exposure alone. Likewise, the effect may not be specific to trauma-related information, but may be a response to generally emotional information. The overall slower performance of PTSD participants across emotional tasks, but not the classic Stroop task (Litz, Weathers, Monaco, & Herman, 1996), also provides evidence for a generally increased responsiveness in PTSD.

*Limitations of Review*

The current review is subject to several limitations. Firstly, although the search terms were carefully selected to identify studies using a wide range of attentional bias tasks, it is possible that some papers using very rare tasks may have been missed by the search strategy. In addition, it was beyond the scope of the current review to include tasks of auditory attention or memory biases. A systematic review of these studies is likely to further contribute to understanding information processing biases in PTSD.

The review was also limited by only considering articles published in peer-reviewed journals. Whilst this may improve the quality of the studies, it also has the disadvantage of missing potential evidence from unpublished sources, such as dissertations. It is important to consider the publication bias in peer-reviewed literature, which refers to a tendency for only studies with significant findings to be published. In relation to this, it is worthy of note that of the studies finding no significant attentional biases, all had other positive findings to report. These additional findings were generally in relation to other task formats, memory biases,

physiological assessments, or neurological correlates of attentional biases. This suggests that unsystematic reviews of the peer-reviewed literature are likely to lead to an overestimation of the robustness of the attentional bias effect in PTSD, in agreement with Kimble *et al.,* (2009).

*Future Research*

The present review has identified several directions for future research. Firstly, it is imperative that research addresses the current debate over the existence of attentional biases by employing stringent research designs. More specifically, studies need to employ appropriate trauma and psychiatric comparison groups, in order to enable firm conclusions to be made regarding the specificity of attentional bias effects to PTSD. In investigations of PTSD following war, PTSD participants were reported to have greater war exposure, in comparison to non-PTSD trauma control groups. Therefore, it would be beneficial for future studies to endeavor to match PTSD and non-PTSD participants on combat exposure, in order to control for the potential influence of greater war exposure on attentional biases. Furthermore, future studies would benefit from more systematic sampling methodologies and larger sample sizes.

Secondly, the process by which stimuli are selected for experimental tasks needs to be carefully considered and clearly reported in future research. It is important that tasks include semantically related comparison stimuli and emotional control stimuli. In addition, future studies should assess the relevance of trauma stimuli to the traumatic experience, and the perceived emotionality of different stimuli groups.

Thirdly, there are several areas of research where studies present contrasting findings or where few conclusions can be made due to the small number of studies. In particular, further research is needed to clarify the existence of facilitative or interference effects, in order to understand the function of any biases in the maintenance of PTSD symptoms. Furthermore, there is currently contrasting evidence regarding the degree of control participants have over their performance on the emotional Stroop, and hence the relevant automatic and strategic components of the task. This warrants further attention through studies employing actors or participants encouraged to mimic a biased pattern of responding. Finally, it would provide greater generalisability to the research findings for future studies to be carried out in a larger range of countries and research settings.

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## Part Two: Empirical Paper

This paper is written in the format ready for submission to the journal *Brain Injury*.

Please see Appendix 2.2 for the Guidelines for Authors.

Word count (including tables and references): 12,134

**Attentional biases, memory for the traumatic event, and post-traumatic stress symptoms following acquired brain injury.**

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**Abstract**

*Background:* Implicit memory is a proposed mechanism for post-traumatic stress disorder (PTSD) following traumatic brain injury (TBI). The present study explored this hypothesis by investigating attentional biases and memory for the traumatic event (MTE) in people with brain injury of ranging severity.

*Research design:* Three groups of patients were compared within one month to two years of the traumatic event: patients who sustained a TBI following a road traffic accident (RTA) ($n$ = 11), patients with an orthopaedic injury following a RTA ($n$ = 15), and patients who had experienced a range of non-traumatic brain injuries (including stroke, encephalitis, cerebral cyst, and hypoxia) ($n$ = 15).

*Methods:* In the emotional Stroop task, participants named the colours of trauma relevant and emotional words. In the dot-probe task, participants detected the location of a probe following the presentation of RTA, vehicle, or negative images.

*Results:* There were no significant attentional biases across participant groups. There was a significant interaction between responses to RTA images and PTSD severity. In the TBI group, there was a significant positive correlation between a bias towards RTA images and MTE.

*Conclusions:* Attentional biases and PTSD following TBI relate to explicit MTE. The findings do not support implicit memory as a mechanism for PTSD following TBI. Limitations of the study are discussed.

**Keywords:** *Brain injury, emotional Stroop, dot-probe, implicit memory, road traffic accident, post-traumatic stress disorder.*

## Introduction

Post-traumatic stress disorder (PTSD) is characterised by three clusters of symptoms following exposure to a life-threatening event: intrusive memories; avoidance of reminders of the trauma; and physiological arousal [1]. Following exposure to a traumatic event, PTSD has been found to occur in 29.9% of people one month after the event and 17.5% four months after the event [2]. Similarly, the occurrence of PTSD following a road traffic accident (RTA) has been reported to vary between 11-23% in the year following the event [3-5]. Whilst the development of PTSD has been found to be unrelated to the severity of physical injury [6], it has been shown that the area of the body injured and subsequent disfigurement can influence psychological outcome [7, 8].

### *PTSD following TBI*

Traumatic brain injury (TBI) refers to a type of acquired brain injury, where an external force causes damage to the brain. The common causes of TBI include RTA, falls, assaults, and sports injuries. Primary damage to the brain can results from the direct impact to the head or significant acceleration or deceleration of the head. In addition, secondary damage occurs in the aftermath of the initial event, as pressure builds up inside the skull and abnormalities develop in cerebral blood flow. The length of time spent unconscious and the duration of post-traumatic amnesia (PTA) is used as an indicator of the severity of a TBI as mild, moderate, or severe. In the current paper, the word ‘traumatic’ will be used to refer to the emotional and

psychological experience of a distressing event, rather than to describe the physical trauma experienced in TBI.

Controversy exists surrounding the occurrence of PTSD following TBI, as well as the mechanisms by which PTSD may occur. The occurrence of PTSD following TBI was initially considered unlikely due to the loss of consciousness during the traumatic event. It was argued that injury to the brain temporarily precludes the conscious experiencing of events and the encoding of events into memory, with the result that there is no life-threatening event to recall [9]. Supporting this viewpoint, some studies have reported an absence of PTSD following mild TBI [5, 9]. Unfortunately, these studies were limited by a lack of clear criteria for measuring PTSD and mild TBI.

Many more studies have presented evidence to suggest that PTSD can indeed occur after TBI. In a study involving people who had sustained a mild TBI following a RTA, 24% met criteria for PTSD six months after injury [10]. In another study, 40% of RTA survivors who experienced a loss of consciousness during the accident were found to meet PTSD criteria [11]. In a representative sample of people with mild to moderate TBI, a cumulative incidence of 11.3% for PTSD symptom criteria and 5.6% for full diagnostic criteria was found six months after injury [12].

The experience of a severe TBI involves a prolonged loss of consciousness and PTA, to the extent that people may not recall any aspect of the trauma. It has been proposed that the reported instances of PTSD following TBI relate to traumatic memories that occur outside the period of retrograde and anterograde amnesia [13]. Therefore, when exposure to trauma occurs during retrograde or anterograde amnesia, PTSD is considered unlikely to develop.

It is perhaps surprising therefore, that several case studies have described instances of PTSD following severe TBI [14-16]. McMillan [16] presented 10 single cases of PTSD following TBI, drawn from 312 cases referred for neuropsychological assessment or neurorehabilitation. It was noted that PTSD following severe TBI was characterised by fewer reports of re-experiencing symptoms, such as intrusive memories.

In a representative community sample of people with severe TBI, the prevalence of PTSD was found to be 18.2%, with 6.1% having severe symptoms [17]. Similarly, post-traumatic stress symptoms at six and 12 months following mild, moderate, and severe TBI, was found to increase from 11% at six months, to 16% at 12 months [18]. Interestingly, symptoms were not correlated with the severity of TBI or recall of the traumatic event. However, the number of mild and moderate TBI participants in this study was comparatively small, which impacts on the conclusions that can be drawn regarding the influence of TBI severity.

*PTSD following Non-Traumatic Brain Injury*

PTSD has also been found to occur following non-traumatic brain injury (N-TBI), a form of acquired brain injury caused by acute medical complications in the brain, such as stroke, hypoxia, and encephalitis. Following subarachnoid haemorrhage, incidence rates of PTSD have been found to range from 18.5% to 32% [19,20] using self-report measures. Similarly, an incidence of 31% using self-report measures [21] and 9.8% using clinical interview has been found following stroke [22]. It should be noted that research is in this area is clouded by the use of self-report measures and

unrepresentative samples, which may result in biases towards greater psychological difficulty [19].

However, the development of PTSD following N-TBI is interesting for two reasons. Firstly, loss of consciousness and amnesic gaps can also occur during N-TBI, yet PTSD can apparently still develop. PTSD symptoms in people with non-severe stroke have been shown to be unrelated to the severity of amnesia during the stroke [21]. Secondly, it suggests that the trauma of experiencing a brain injury alone is sufficient for the development of PTSD. This factor tends to be overlooked in TBI research, with a focus instead on the external causal event.

*Overlap of PTSD and TBI Symptoms*

Importantly, the reportedly high prevalence of PTSD following TBI has been subject to several criticisms. Firstly, the physical, cognitive, and emotional difficulties associated with TBI tend to significantly impact on day-to-day functioning, making it difficult to determine impairment as a result of TBI or PTSD [23]. Overlapping TBI and PTSD symptoms include impaired concentration, irritability, anxiety, fatigue, and sleep disturbance. This can result in erroneous responses to items on self-report measures, leading to over-diagnosis of PTSD [24]. Secondly, endorsements of items relating to intrusive thoughts about the event have been shown to relate more to a preoccupation with the 'amnesic gap' and retrieval of these memories, rather than intrusions associated with fear [25]. Chalton & McMillan [26] investigated whether the concept of 'partial' PTSD could account for the ranging estimates of occurrence following TBI. In this study, physiological changes, such as heart rate and movement, were recorded in people with TBI while they

completed self-report measures of PTSD. The study did not find the expected changes in heart rate and movement. This was suggested to support the hypothesis that endorsement of items reflects curiosity about the traumatic event, rather than features of PTSD. However, it is important to note that the findings from this study are limited by the absence of a control group.

Converse to this, people with brain injury have been shown to be more likely to generally underreport symptoms [27], suggesting there is also a risk of under-diagnosing PTSD symptomatology. It has also been suggested that acute stress disorder (ASD) can be misdiagnosed as mild TBI [28]. The dissociative reaction associated with trauma exposure results in reduced awareness and encoding of experiences into memory, which can be misinterpreted as a loss of consciousness or organic amnesia for the event. Therefore, the task of identifying and differentiating between the symptoms of TBI, PTSD, and other co-morbidity, is clearly matted with complexity.

*Memory for the Event*

An important consideration is the influence of the nature of memory for the event on the subsequent development of PTSD. In an exploration of the impact of amnesia for the event, Turnbull and colleagues [29] compared people who described having no memories, traumatic memories, or untraumatic memories, following TBI. Interestingly, both those with no memories and those with traumatic memories reported higher levels of distress and higher ratings of PTSD severity, indicating that amnesia does not protect against PTSD. However, having no memory for the event was found to protect against the development of specific re-experiencing symptoms.

Contrary to these findings, a lack of memory for the traumatic event has been found to protect against PTSD [30]. Following mild TBI, people who described having memory for the event were shown to be significantly more likely to develop PTSD than people without memory for the traumatic event. However, the differences between the groups were found to be primarily due to the ratings given to re-experiencing symptoms, supporting the previous suggestion of a different presentation in PTSD following TBI [16]. Therefore, it seems that a lack of memory for the event protects specifically against the re-experiencing symptoms of PTSD.

*Proposed Mechanisms*

As a consequence of the increasing evidence for PTSD following TBI, a further issue has arisen of how to account for the development of trauma symptoms. In a review of the literature, King [28] suggested that PTSD following TBI could occur via four different mechanisms. The first of these relates to instances of mild TBI, where individuals may have intact memory for the traumatic event due to experiencing only a brief period of unconsciousness. Thereby, the individual will have explicit memory for all or some of the traumatic event. Secondly, it has been proposed that "islands" of memory may account for the development of PTSD [31]. These periods of memory could include being in the ambulance, being bloody and injured, or waking up in hospital.

A third mechanism may be through the development of pseudomemories, whereby individuals reconstruct their memory for the event by imagining what happened or by being filled in of the details by others [32]. In support of this view, a case of PTSD has been reported, with no TBI, where the symptoms only developed

after the police told the individual further information [33]. Similarly, examples have been reported of individuals developing PTSD following the death of a friend or family member by murder, despite the individuals not witnessing the event [34]. In these situations, images of what the individuals thought happened were apparently sufficient for PTSD to develop.

Finally, a fourth mechanism would suggest PTSD symptoms develop following implicit processing during the event. King [35] presented the case of an individual who sustained a severe TBI following a RTA. The individual had no conscious memory for events prior to, during, or for a several hours after the RTA. However, he developed significant physiological re-experiencing symptoms in response to a specific cue, which was related to a vehicle involved in the accident. This is suggested to provide an example of "affect without recollection", whereby associative memory and conditioned fear responses can occur without conscious memory for event. Implicit memory is suggested to be the primary mechanism when there is no conscious memory for the event [28].

Implicit memory is supported as a potential mechanism by several influential theories of PTSD. In the dual-representation model of PTSD, trauma-related information is posited to be stored at two levels: verbally accessible memories or situationally accessible memories [36]. Situationally accessible memories are encoded outside of awareness and cannot be accessed explicitly. Support for this comes from the observation that re-experiencing symptoms tend to be based on sensory information, such as emotions and physiological reactions, which can be triggered by a wide range of cues [37]. Moreover, a comprehensive cognitive model

of PTSD [38] emphasises the role of associative memory and perceptual priming, both forms of implicit memory.

To further investigate the influence of implicit memory, Coates [39] used a modified emotional Stroop task to investigate attentional biases to trauma-related information in people with mild TBI. Participants included 15 people with TBI after RTA, a comparison group of 13 people with no TBI after RTA, and a control group of 15 patients with an orthopaedic injury, but no TBI or RTA. Assessments took place between two and 28 days post-injury and included the administration of a self-report ASD questionnaire.

In support of the implicit memory hypothesis, patients who had experienced a RTA, both with and without a brain injury, demonstrated interference effects for RTA-related words, indicating that trauma stimuli elicited a subconscious fear response. Interestingly, there was no correlation between this interference effect and ratings of ASD symptomatology, weakening the hypothesis that implicit processing is a mechanism by which PTSD may develop. Furthermore, two of the TBI participants reported having islands of memory for the event and several may have been informed of details of the event from others. This suggests the interference effect detected may not represent processing at an implicit level.

*Measures of Attentional Bias in PTSD*

The emotional Stroop has been used previously to assess subconscious processing following trauma exposure, in the absence of head injury (for a review see Buckley *et al.* [40]). The task commonly utilises word stimuli to explore whether the emotional meaning of the word results in slower colour-naming, compared to neutral

words. A similar paradigm exists, the dot-probe task, which has been used extensively to investigate attentional biases in a range of anxiety disorders [41, 42], including victims of recent trauma and people with PTSD [43-45]. In the dot-probe task, a threatening stimulus and a neutral stimulus are simultaneously presented on a computer screen, followed by a dot in the location of one of the previously presented stimuli. Reaction times for detecting the location of the dot are shorter if the probe replaces the previously attended image, rather than the unattended image. The dot-probe task has been suggested to provide a more accurate representation of biases in visual attention, compared with the emotional Stroop task, which has been considered to relate to general emotional arousal [46].

Using this task, a facilitative attentional bias for mildly threatening trauma words has been detected in the performance of people with PTSD [43]. Specifically, PTSD participants were shown to respond faster to the dot-probe when it replaced the trauma-related words, compared to other emotional and neutral word types. Further to this, the task has also been used to investigate biases towards images. In a study involving participants with PTSD, recent trauma victims, and healthy controls, there was no bias detected in trauma participants towards or away from trauma images [44]. However, an attentional bias towards images was found to be associated with increased heart rate in participants with PTSD. Furthermore, in recent trauma victims, a bias away from trauma images was associated with severity of reported intrusive symptoms. These findings are important when considering the observation that re-experiencing symptoms in PTSD are commonly based on sensory impressions, in the form of visual images, rather than thoughts [47].

*Current Study*

In summary, the evidence suggests that PTSD can occur following acquired brain injury. There are some concerns surrounding the overlap of PTSD and TBI symptoms, which may result in erroneous responses on self-report measures. The mechanisms that may account for the occurrence of PTSD following TBI are mainly based on hypotheses, with recent investigation focusing on implicit processing. This has involved utilising experimental paradigms from cognitive psychology, in order to elucidate automatic attentional processes that may support the role of implicit processes in the development of PTSD following TBI.

Further investigation is needed into attentional biases to trauma stimuli to ascertain the existence of attentional biases in ranging severity of TBI and to explore the relationships between memory for the event, attentional biases, and symptoms of PTSD. It would also be beneficial to compare TBI with N-TBI, to enable comparisons between TBI and N-TBI with regard to differences in memory for the event and the development of PTSD.

The present study included three groups of participants: TBI as a result of a RTA; N-TBI; and orthopaedic injury as a result of a RTA. The TBI group included participants with ranging severity of TBI. Firstly, the study aimed to investigate attentional biases in the three groups of participants, using computerised versions of the emotional Stroop and dot-probe paradigms. Secondly, the study aimed to investigate memory for the traumatic event (MTE) across the three groups of participants. Thirdly, the study aimed to explore the relationships between attentional biases, PTSD symptoms, and MTE.

It was hypothesised that there would be significant attentional biases on the emotional Stroop and dot-probe tasks for RTA-related stimuli in the TBI and orthopaedic participant groups, because both groups had experienced a RTA, whereas no such effects were expected in the N-TBI group. It was further hypothesised that there would be significant interference effects for brain injury-related words on the emotional Stroop task in the TBI and N-TBI participant groups, because both had experienced a brain injury, with no such interference effects in the orthopaedic group. With regard to MTE, it was hypothesised that the orthopaedic group would have significantly greater MTE in comparison to other participant groups, whereas the N-TBI group were expected to have intermediate MTE, and TBI participants significantly less MTE, due to the loss of consciousness during the event and PTA associated with brain injury. Finally, it was expected that there would be positive correlations between attentional biases, PTSD symptoms, and MTE.

## Method

### *Design*

The study employed a mixed design, with the between-groups factor comprising of TBI, N-TBI, and orthopaedic injury. The within-subjects factors of the emotional Stroop task were the response times in five word-type conditions (RTA, brain injury, OCD, hospital, and positive) and two emotion conditions (emotional and control). The within-subjects factors of the dot-probe task comprised three conditions (RTA, vehicle, and negative) and two probe-stimulus locations (valid and invalid). The study also employed a cross-sectional correlation design to investigate relationships between attentional biases, PTSD symptoms, and MTE.

### *Participants*

There were 11 TBI and 15 N-TBI participants recruited over an eight-month period from three brain injury rehabilitation units and a community brain injury rehabilitation team. TBI participants must have experienced a head injury as a result of a RTA. N-TBI participants must have experienced a non-traumatic brain injury that did not occur in relation to an additional traumatic event (for example, being trapped). The medical diagnoses in the N-TBI group were encephalitis ($n$ = 1), cerebral cyst ($n$ = 1), hypoxia ($n$ = 1), and stroke ($n$ = 12).

A comparison group of 15 orthopaedic injury participants were recruited over a seven-month period from an orthopaedic inpatient ward and an orthopaedic outpatient service. Participants in the orthopaedic group must have experienced an orthopaedic injury as result of a RTA and must not have experienced a loss of

consciousness during the event. Inclusion criteria for all participants were: proficient in English; aged 18 to 65 years of age; and assessed within 1 month to 2 years of the event.

Exclusion criterion for all participants were: unable to comprehend or produce speech to the levels necessary for the tasks; difficulty with reading; evidence of degenerative neurological disease; uncorrected visual impairments (including visual neglect); unable to press buttons on a response box with one hand; unable to give consent to take part, and under the influence of alcohol or drugs during the traumatic event. Participants were also excluded if they had a previous history of severe mental health difficulties (defined as care of a community mental health team or an inpatient admission) or a previous diagnosis of PTSD related to a different past event. Ethical approval was obtained from Hull and East Riding NHS Local Research Ethics Committee (see appendix 3).

*Sample Size Calculation*

There was no appropriate published research available to accurately estimate effect sizes in the current study and it was recognised that only a small total sample size was realistic for these patient groups. However, based on a target recruitment of 15 participants to each group, it was acknowledged that power would be low to detect small effect sizes. For example, a calculation using GPower (Version 3.0.10) software [48] showed that, with 15 participants in each group, using a one-way analysis of variance for a univariate outcome measure, and a 5% significance level, an effect size of 0.48 could be detected with 80% power. According to guidelines [49], this is a large effect size.

*Measures*

*Emotional Stroop Task*

The emotional Stroop task included words from previous research [50], with an additional group of brain injury related words. A total of five word types were used (RTA, hospital, OCD, positive, and brain injury), with six words in each group. The brain injury words were generated through consultation with health professionals working in the area of brain injury rehabilitation. An online psycholinguistic database [51] was used to match each word with a neutral counterpart on the characteristics of word length, syllables, phonemes, familiarity, frequency, and word type. The Kusera-Francis data was used for matching on frequency. A list of the words used in the task can be found in appendix 5.1.

*Dot-Probe Task*

The dot-probe task was included as a measure of attentional biases to emotional stimuli presented in an image format. In the task, pairs of stimuli were simultaneously presented, followed by the appearance of a probe in the position of one of the previously presented stimuli. Participants were required to respond to the location of the probe. It has been shown that reaction times are shorter when the probe replaces the previously attended image than the unattended image [52].

The present dot-probe task used digital, colour images selected from the International Affective Picture System (IAPS) [53]. The IAPS is a large collection of standardised images for use in research, which have been rated for emotionality with regard to pleasantness, arousal, and dominance. The task included the three types of target images (RTA, vehicle, and negative), with three different images in each

group. The content of RTA images involved car wreckages with emergency services in attendance. The vehicle images comprised of two traffic scenes and one motorbike image. The negative images selected were unrelated to RTA themes but matched the RTA images in ratings of emotionality. The neutral images that accompanied target images were selected based on having average emotionality ratings. The orientation, content, and visual characteristics were also taken into account when matching images. A copy of the images used in the task can be found in appendix 5.2.

*Hospital Anxiety and Depression Scale (HADS)* [54]

The HADS was used to explore differences in the level of anxiety and depression among participants (see appendix 5.3). The measure is designed specifically for use with medical populations. It consists of 14 items self-rated on a 4-point scale ranging from the absence of symptoms to maximum symptomatology. The HADS has been shown to have acceptable internal consistency, with Cronbach alphas of 0.80 to 0.93 for the anxiety sub-scale and 0.81 to 0.90 for the depression subscales.

*Memory for the Traumatic Event Questionnaire (MTE questionnaire)* [55]

The MTE questionnaire was developed specifically to investigate the relationship between quality of memory for the event following TBI and the occurrence of PTSD. The MTE is a self-report measure composed of nine items, relating to different aspects of memory for an event. Participants self-rate the quality of their memory on a 4-point scale ranging from 1 (no recollection) to 4 (very good recollection). The authors administered the questionnaire at four time points and found it to be reliable (Cronbach $\alpha = 0.91$).

Following TBI, people with good memory for the event have been shown to be more likely to develop PTSD than those with poor memory for the event [56]. Therefore, the present study used the MTE questionnaire to further explore the differences between group of participants' perceived memory for the event and the relationships with PTSD symptoms and attentional biases. When administering the questionnaire, participants were encouraged to rate the quality of their own memory for the event, rather than making use of details they had been informed of by others. A copy of this questionnaire can be found in appendix 5.4.

*Mayo-Portland Adaptability Inventory-4 (MPAI-4)* [57]

The MPAI-4 is a measure designed to assess the extent of physical, cognitive, emotional, behavioural, and social problems following brain injury (see appendix 5.5). It consists of 29 items divided into three subscales: ability index, adjustment index, and participation index. Participants were asked to rate the severity of their difficulties on a 5-point scale (none, mild, mild and interfering, moderate, severe). The MPAI-4 has been shown to have good item and person reliability when self-rated ($r$ = 0.92 and $r$ = 0.96 respectively). The MPAI-4 was administered to explore any differences between participants in the perceived impact of their injury. This is in relation to the finding that the development of PTSD may be indirectly related to the severity of injury [58].

*Clinician Administered PTSD Scale (CAPS)* [59]

The CAPS is a comprehensive assessment tool consisting of a 30-item structured interview based on the Diagnostic and Statistical Manual of Mental Disorders

(Fourth Edition) (DSM-IV) criteria for PTSD. It measures the frequency and intensity of symptoms and can be used to produce an overall post-traumatic stress symptoms (PTSS) severity score and to determine a diagnosis of PTSD. The measure was administered to ascertain the severity of PTSS and the presence of criteria that would fulfill a diagnosis of PTSD. The psychometric properties of the scale have been subject to extensive review and have demonstrated good reliability and validity [60]. A structured clinical interview for PTSD was chosen over self-report measures due to the reported problems with erroneous responses following TBI [24]. A copy of the interview schedule can be found in appendix 5.6.

*Materials and Apparatus*

*Emotional Stroop Task*

A computerised version of the Stroop task was used in order to present stimuli in a random order and provide a reliable measurement of reaction time and accuracy. The words were also presented in only four different colours: red, black, blue, and yellow. The colour green was omitted due to potential difficulties in discriminating green from red for people with colour blindness. Each word was presented once in each colour, resulting in each word being presented on a total of four occasions. The words were presented on a grey background in order to reduce glare on the screen and provide a contrast to the colour of the word. They were positioned in the middle of the screen in upper case with font style set to arial, size 44.

The word stimuli were presented to participants on an Apple Macintosh laptop using the stimulus presentation software E-Prime Version 2.0 [61]. The E-Prime application was run on a Windows XP [62] operating system that had been

installed onto the laptop using the built-in Boot Camp utility. The E-Prime application can measure reaction times within a few milliseconds and so is highly sensitive to subtle differences in responding patterns.

Computerised versions of the Stroop task use a voice-activated relay key to measure the speed of verbal colour naming, a device that measures the time it takes for a participant to make a vocal response. However, the device cannot record the accuracy of responses and the voice key can potentially be activated by other noises. Therefore, the current task employed a key-press response in order to ensure reliable measurement of the accuracy and speed of responses. Whilst this method is limited by not requiring participants to make a verbal response, an interference effect in PTSD participants has been found by studies using this method [63].

Participants were instructed to respond to the colour of each word using a five-button Cedrus RB-530 response box [64]. The pad was connected to the laptop computer via a Universal Serial Bus (USB). The white central button could be used for reading instructions and beginning the task. The remaining four buttons had coloured covers that corresponded to the four colours of the words presented on the screen.

Participants were instructed to focus on a central fixation cross on the computer screen before the presentation of a word. The order of presentation of the words was randomised across participants. Participants were given 12 practice trials, during which their ability to differentiate between the colours was assessed. A reminder of the instructions followed the practice trials. They were then presented with a total of 240 experimental trials. During the experimental trials participants were given two breaks, the length of which was controlled by the participant. These

breaks divided the task into three sets of 80 trials. The central fixation cross was presented for 1000 milliseconds (ms) and word stimuli were presented either until a response was made or a time-out of 5000ms. The format was carefully considered in order to enable participants with functional difficulties associated with their brain injury to be able to manage the demands of the task.

*Dot-Probe Task*

The dot-probe task was presented to participants using the same equipment as used in the emotional Stroop task. Participants were instructed to focus on a central fixation cross on the computer screen, which was presented for 1000ms before each trial. The target and control images were then simultaneously presented on the left and right of the fixation cross for another 1000ms. The images were immediately followed by a black dot on either the left or the right of a black fixation cross. Participants were required to indicate the location of the dot by selecting the appropriate button on the response pad. Participants had the option of pressing either a left button, positioned on the left-hand side of the response pad and labelled with the letter 'L', or a right button, positioned on the right-hand side of the response pad and labelled with the letter 'R'. The dot remained on the screen until a response was made or a time-out of 5000ms. An inter-trial interval of 500ms was used to provide a break between the presentations of each set of stimuli. Reaction times and accuracy of responses were measured.

The target images were presented in a blocked format (RTA, vehicle, and negative), with the order of presentation counterbalanced across participants. There were 36 trials within each block, totaling 108 trials divided by two short breaks.

Each target and control image was presented on nine occasions. The combination of image and dot locations was random across participants, except for ensuring an equal number of each combination. The target stimulus could appear on either the left or right of the screen. The dot probe replaced either the target image (valid) or the control image (invalid). The visual angles of the images were 10.4% for width and 7.1% for height. The visual angle was 0.3% for both the dot probe and fixation cross. The positioning of the dot and centre point of the images was at a 7.1% visual angle from the left or right of the central fixation cross.

*Procedure*

Participants were recruited through contact with health professionals working on inpatient wards (orthopaedic, neurorehabilitation) and outpatient services (orthopaedic, community neurorehabilitation). Health professionals were informed of the inclusion and exclusion criteria and given a criteria checklist. Potential participants were approached by a member of their healthcare team with a brief information sheet and asked if they would be happy to take part. The primary researcher met with participants who had agreed to take part and provided further information. An opportunity was provided to ask questions before obtaining formal consent.

The primary researcher administered the assessment schedule for all participants. Participants were interviewed on their own and away from distractions, either in a quiet room on the unit (inpatients) or in the participant's own home (outpatients). Participants were offered regular breaks during the session in order to reduce the impact of fatigue. Demographic and injury information was obtained

from participants in the first instance, followed by medical notes if necessary. The length of PTA was estimated by establishing with participants the point at which they regained continuous memory.

The emotional Stroop and dot-probe tasks were administered first, followed by the HADS, MPAI-4, MTE questionnaire, and the CAPS semi-structured interview. The order of tasks was chosen to minimise carry-over effects from talking about the traumatic event during the administration of the MTE questionnaire and CAPS. The order of the emotional Stroop and dot-probe tasks was counterbalanced across participants. The length of time needed to administer the tasks was between 1½ to 2 hours.

The emotional Stroop and dot-probe tasks were introduced with standard written instructions on the computer screen. Participants were first presented with a set of practice trials. The researcher monitored the participants' responses during this stage to ensure the participant understood the task before beginning the experimental trials. The computer tasks were programmed so as to give participants two short breaks during each task. The additional measures were presented with the standard verbal and written instructions accompanying each measure.

## Results

*Data Analysis*

In the analysis of the emotional Stroop and dot-probe data, responses that were incorrect, or two standard deviations above or below each participant's mean score, were removed from further analysis. This was in order to reduce the influence of outliers and erroneous responses and is in line with practice amongst studies using these cognitive paradigms [65-68]. This procedure resulted in 4.5% of data being removed from each of the experimental tasks.

*Participant Characteristics*

An overview of participant characteristics, including self-reported clinical symptomatology, can be found in table 1. A series of chi-square tests were carried out to test for significant differences between groups on the variables comprising nominal data. The chi-square tests for gender, marital status, level of education, employment status, and CAPS diagnosis showed that some cells had expected count less than 5. Therefore, exact significance tests were selected for Pearson's chi-square for these variables. These revealed no significant differences between the three groups in gender, marital status, level of education, employment status, and CAPS diagnosis. A series of one-way ANOVAs revealed there were no significant difference between the groups in scores on the HADS, MPAI-4, and CAPS. However, a significant difference was found between the groups in age ($F_{(2,38)}$ = 7.817, $p$ = 0.001). Bonferroni post-hoc comparisons revealed that the TBI group was significantly younger than the N-TBI group ($p$ = 0.001), whereas there were no

significant differences between the TBI and orthopaedic groups ($p$ = 0.056), and N-TBI and orthopaedic groups ($p$ = 0.338).

Table 1. Participant Characteristics

| *Variable* | *TBI (n=11)* | *N-TBI (n=15)* | *Orthopaedic (n=15)* |
|---|---|---|---|
| Age, mean (SD) | 31.00 (12.05)*** | 51.27 (9.23)*** | 43.60 (16.28) |
| Gender, % (n) | | | |
| Male | 72.7 (8) | 73.3 (11) | 46.7 (7) |
| Female | 27.3 (3) | 26.7 (4) | 53.3 (8) |
| Marital status, % (n) | | | |
| Single | 45.5 (5) | 20.0 (3) | 33.3 (5) |
| Married | 36.4 (4) | 60.0 (9) | 60.0 (9) |
| Partnered | 18.2 (2) | 0.0 (0) | 6.7 (1) |
| Separated/Divorced | 0.0 (0) | 13.3 (2) | 0.0 (0) |
| Widowed | 0.0 (0) | 6.7 (1) | 0.0 (0) |
| Education, % (n) | | | |
| Secondary | 45.5 (5) | 46.7 (7) | 53.3 (8) |
| Further Education | 27.3 (3) | 2 (13.3) | 33.3 (5) |
| Higher Education | 27.3 (3) | 5 (33.3) | 13.3 (2) |
| Postgraduate | 0.0 (0) | 6.7 (1) | 0.0 (0) |
| Employment status, % (n) | | | |
| Employed | 36.4 (4) | 13.3 (2) | 13.3 (2) |
| Self-employed | 9.1 (1) | 6.7 (1) | 13.3 (2) |
| Signed off | 18.2 (2) | 46.7 (7) | 46.7 (7) |
| Unemployed | 18.2 (2) | 20.0 (3) | 13.3 (2) |
| Student | 18.2 (2) | 0.0 (0) | 6.7 (1) |
| Retired | 0.0 (0) | 13.3 (2) | 6.7 (1) |
| HADS, mean (SD) | | | |
| Anxiety | 7.55 (5.11) | 7.73 (5.46) | 8.20 (3.91) |
| Depression | 5.09 (4.87) | 6.40 (4.94) | 6.47 (3.83) |
| Total score | 12.64 (8.50) | 14.27 (9.66) | 14.67 (6.87) |
| MPAI-4, mean (SD) | | | |
| Ability | 41.82 (9.40) | 43.27 (11.63) | 40.07 (7.17) |
| Adjustment | 43.45 (10.60) | 43.13 (8.25) | 47.27 (4.65) |
| Participation | 32.73 (16.55) | 42.20 (15.26) | 36.93 (12.85) |
| Total | 43.09 (9.88) | 45.20 (8.64) | 45.20 (4.23) |
| CAPS Diagnosis, % (n) | | | |
| Yes | 18.2 (2) | 26.7 (4) | 40.0 (6) |
| No | 81.8 (9) | 73.3 (11) | 60.0 (9) |
| CAPS, mean (SD) | | | |
| Criterion B | 5.27 (8.22) | 7.47 (8.84) | 10.87 (10.87) |
| Criterion C | 8.27 (10.19) | 7.60 (9.66) | 11.60 (9.90) |

| | | | |
|---|---|---|---|
| CAPS, mean (SD) | | | |
| Criterion B | 5.27 (8.22) | 7.47 (8.84) | 10.87 (10.87) |
| Criterion C | 8.27 (10.19) | 7.60 (9.66) | 11.60 (9.90) |
| Criterion D | 10.00 (6.59) | 10.07 (9.37) | 14.00 (8.47) |

*Traumatic Event Characteristics*

An overview of information relating to the traumatic events experienced by the three groups can be found in table 2. Chi-square tests revealed no significant differences between the three groups in the need for surgery following the event, or between TBI and orthopaedic groups in their role during the RTA. One-way ANOVAs revealed no significant differences between the groups in days since the event, but significant differences were found in days spent in hospital ($F_{(2,38)} = 7.817$, $p = 0.004$). Bonferroni post-hoc comparisons revealed the N-TBI group had stayed significantly longer in hospital than the orthopaedic group ($p = 0.004$), whereas there were no differences between the TBI and orthopaedic groups ($p = 0.065$), and N-TBI and TBI groups ($p = 1$).

A one-way ANOVA also revealed significant differences between the groups in MTE scores ($F_{(2,38)} = 12.876$, $p < 0.001$). A series of planned, independent t-tests revealed significant differences between the TBI and orthopaedic groups ($t = 5.805$, df = 24, $p < 0.001$), TBI and N-TBI groups ($t = -2.543$, df = 24, $p = 0.018$), and orthopaedic and N-TBI groups ($t = -2.4584$, df = 28, $p = 0.020$), with significantly lower scores in the TBI group (mean = 13.55) than both the N-TBI (mean = 21.60) and orthopaedic group (mean = 28.60), and significantly lower scores in the N-TBI group than the orthopaedic group.

Table 2. Characteristics of Traumatic Events

| *Variable* | *TBI (n=11)* | *N-TBI (n=15)* | *Orthopaedic (n=15)* |
|---|---|---|---|
| Role in accident, % (n) | | | |
| Driver | 45.5 (5) | N/A | 40.0 (6) |
| Passenger | 27.3 (3) | N/A | 26.7 (4) |
| Motorcyclist | 9.1 (1) | N/A | 13.3 (2) |
| Cyclist | 18.2 (2) | N/A | 13.3 (2) |
| Pedestrian | 0.0 (0) | N/A | 6.7 (1) |
| Type of N-TBI, % (n) | | | |
| Encephalitis | N/A | 6.70 (1) | N/A |
| Cerebral cyst | N/A | 6.70 (1) | N/A |
| Hypoxia | N/A | 6.70 (1) | N/A |
| Stroke | N/A | 80.0 (12) | N/A |
| Days since event, mean (SD) | 270.55 (206.78) | 189.47 (120.01) | 111.93 (149.47) |
| Days in hospital, mean (SD) | 44.45 (33.96) | 55.33 (49.53)** | 10.80 (11.33)** |
| Surgery, % (n) | | | |
| Yes | 54.55 (6) | 40.00 (6) | 46.67 (7) |
| No | 45.46 (5) | 60.00 (9) | 53.33 (8) |
| Days unconscious, mean (SD) | 10.55 (15.86) | N/A | N/A |
| PTA, mean (SD) | 10.09 (7.33) | N/A | N/A |
| MTE scores, mean (SD) | 13.55 (6.52)*** | 21.60 (8.88)*** | 28.60 (6.54)*** |

Note: **p < 0.01; ***p < 0.001; N/A = not applicable.

*Emotional Stroop Task*

An overview of the reaction times to the emotional Stroop stimuli can be found in table 3. The mean response time to each set of neutral words was subtracted from the mean response time to the corresponding group of target words (for example, reaction time to control words minus reaction time to emotional RTA words). This procedure controls for differences amongst participants in their ability by collapsing

reaction times into interference scores. The interference scores for the Stroop stimuli across the three groups can be found in table 4.

The interference scores were used in a repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic) as the between-subjects factor, word type (5: RTA, brain, hospital, OCD, positive) as the within-subjects variable, and CAPS score as a covariate. The results showed a significant main effect of group ($F_{(2,37)} = 3.710$, $p = 0.034$), but no main effect of word type ($F_{(4,34)} = 1.234$, $p = 0.281$), or group × word type interaction ($F_{(8,68)} = 0.708$, $p = 0.684$). There was also no word type × CAPS score interaction ($F_{(4,34)} = 0.478$, $p = 0.752$). Bonferroni post-hoc comparisons were carried out to explore the main effect of group. These analyses revealed no significant differences between the groups.

A second repeated measures multivariate ANOVA was conducted, with group (3: TBI, N-TBI, orthopaedic) as the between-subjects factor, word type (3: negative, RTA, vehicle) and emotion (2: emotion, control) as the within-subjects variables, and CAPS score as a covariate. These results showed a main effect of group ($F_{(2,37)} = 6.416$, $p = 0.004$), but no main effect of word type ($F_{(4,34)} = 0.906$, $p = 0.472$) or emotion ($F_{(1,37)} = 0.033$, $p = 0.857$). Bonferroni post-hoc comparisons were carried out to explore the main effect of group. These analyses revealed that the N-TBI participants were significantly slower overall than both the TBI ($p = 0.026$) and orthopaedic groups ($p = 0.006$).

There were no significant two-way interactions for group × word type ($F_{(8,68)} = 0.185$, $p = 0.992$) or word type × emotion ($F_{(4,34)} = 1.324$, $p = 0.281$) and no significant three-way interaction (group × word type × emotion ($F_{(8,68)} = 0.708$, $p = 0.684$). There was also no word type × CAPS score interaction ($F_{(4,34)} = 0.382$, $p =$

0.820) or emotion × CAPS score interaction ($F_{(1,37)} = 0.001$, $p = 0.979$). There was a significant group × emotion interaction ($F_{(2,37)} = 3.710$, $p = 0.034$). Closer inspection of this interaction revealed that the N-TBI group were quicker to respond to emotional words than control words, whereas there was no such difference in the TBI and orthopaedic groups.

Table 3. Reaction times (and standard deviations) in milliseconds for emotional Stroop stimuli across the three groups.

| *Word Type* | *TBI (n=11)* | | *N-TBI (n=15)* | | *Orthopaedic (n=15)* | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| RTA | | | | | | |
| Emotion | 769.30 | 107.44 | 959.78 | 173.10 | 817.11 | 117.29 |
| Control | 777.14 | 116.16 | 981.32 | 177.86 | 813.15 | 131.00 |
| Brain | | | | | | |
| Emotion | 786. 29 | 134.09 | 963.77 | 196.16 | 825.04 | 153.33 |
| Control | 779.61 | 109.37 | 988.59 | 201.48 | 828.14 | 124.43 |
| Hospital | | | | | | |
| Emotion | 790.65 | 114.66 | 960.59 | 155.75 | 831.72 | 127.32 |
| Control | 776.31 | 121.99 | 984.89 | 211.44 | 815.11 | 153.91 |
| OCD | | | | | | |
| Emotion | 779.56 | 121.76 | 983.65 | 200.15 | 829. 02 | 137.00 |
| Control | 770.13 | 99.12 | 965.43 | 184.81 | 817.09 | 124.97 |
| Positive | | | | | | |
| Emotion | 771.52 | 122.89 | 957.58 | 182.89 | 815.93 | 128.13 |
| Control | 764.23 | 116.35 | 967.86 | 196.28 | 826.66 | 136.70 |

Table 4. Interference effects (and standard deviations) in milliseconds for emotional Stroop stimuli across the three groups.

| *Word Type* | *TBI (n=11)* | | *N-TBI (n=15)* | | *Orthopaedic (n=15)* | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| RTA | 7.85 | 30.66 | 21.55 | 69.13 | -3.96 | 40.86 |
| Brain | -6.68 | 42.18 | 24.82 | 65.60 | 3.09 | 47.72 |
| Hospital | -14.33 | 46.47 | 24.31 | 83.84 | -16.61 | 53.54 |
| OCD | -9.43 | 50.15 | -18.22 | 73.71 | -11.92 | 43.54 |
| Positive | -7.29 | 43.05 | 10.29 | 55.12 | 10.73 | 34.16 |

*Dot-Probe Task*

The mean reaction times across participant groups to the dot-probe images, in the valid (dot probe in the same location as target image) and invalid (dot probe in different location to target image) conditions, can be found in table 5. In order to create attentional bias scores for each image type, the mean response time for invalid conditions was subtracted from the mean response time for valid conditions for each participant (for example RTA valid minus from RTA invalid). This procedure also controls for differences amongst participants in their abilities. An overview of the bias scores can be found in table 6.

The interference scores were used in a repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic) as the between-subjects factor, image type (3: RTA, vehicle, negative) as the within-subjects variable, and CAPS score as a covariate. The results showed no significant main effect of group ($F_{(2,37)}$ = 0.415, $p$ = 0.664) and no main effect of image type ($F_{(2,36)}$ = 0.157, $p$ = 0.855). There

was also no group × image type interaction ($F_{(4,72)}$ = 1.832, $p$ = 0.132) and no influence of CAPS score ($F_{(2,36)}$ = 1.484, $p$ = 0.240).

A second repeated measures multivariate ANOVA was conducted, with group (3: TBI, N-TBI, orthopaedic) as the between-subjects factor, image type (3: negative, RTA, vehicle) and validity (2: valid, invalid) as the within-subjects variables, and CAPS score as a covariate. Using Wilks' Lambda, the results showed a main effect of group ($F_{(2,37)}$ = 3.690, $p$ = 0.035), but no main effect of image type ($F_{(2,36)}$ = 1.107, $p$ = 0.342) or validity ($F_{(1,37)}$ = 0.109, $p$ = 0.743). Bonferroni post-hoc comparisons were carried out to explore the main effect of group. These analyses revealed no significant differences between the groups.

There were no significant two-way interactions ((group × image type ($F_{(4,72)}$ = 0.736, $p$ = 0.571), image type × validity ($F_{(2,36)}$ = 0.157, $p$ = 0.855), group × validity ($F_{(2,37)}$ = 0.415, $p$ < 0.664), and no significant three-way interaction (group × image type × validity ($F_{(4,72)}$ = 1.832, $p$ = 0.132). There was no significant interaction between CAPS score and validity ($F_{(1,37)}$ = 0.565, $p$ = 0.457) . However, there was a significant interaction between image type and the covariate of CAPS score ($F_{(2,36)}$ = 5.614, $p$ = 0.008). Further inspection revealed that the quadratic contrast for the image type × CAPS score interaction was statistically significant ($F_{(1,37)}$ = 11.538, $p$ = 0.002). Closer inspection revealed that CAPS score parameter estimates were greater than zero for reaction times to the RTA images. This indicated that as CAPS scores increase, reaction times to RTA images also increase, whereas reaction times to vehicle and negative images decrease.

Table 5. Reaction times (and standard deviations) in milliseconds, on the dot-probe task across the three groups.

| *Image Type* | *TBI (n=11)* | | *N-TBI (n=15)* | | *Orthopaedic (n=15)* | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Negative | 514.88 | 91.08 | 699.08 | 260.78 | 532.32 | 173.78 |
| Valid | 511.59 | 81.99 | 717.08 | 259.97 | 543.39 | 173.45 |
| Invalid | 518.17 | 102.91 | 681.08 | 264.76 | 530.25 | 174.78 |
| RTA | 540.08 | 114.22 | 700.40 | 195.46 | 562.56 | 163.77 |
| Valid | 553.87 | 139.67 | 698.86 | 204.87 | 563.75 | 166.27 |
| Invalid | 526.29 | 97.39 | 701.93 | 188.75 | 561.36 | 163.52 |
| Vehicle | 530.45 | 100.38 | 668.06 | 207.02 | 534.42 | 154.43 |
| Valid | 533.32 | 108.16 | 664.61 | 225.26 | 533.47 | 153.28 |
| Invalid | 527.59 | 96.72 | 671.51 | 194.47 | 535.36 | 156.67 |

Table 6. Bias effects (and standard deviations) in milliseconds, for dot-probe stimuli across the three groups.

| *Image Type* | *TBI (n=11)* | | *N-TBI (n=15)* | | *Orthopaedic (n=15)* | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Negative | -6.57 | 38.00 | 36.00 | 57.92 | 4.14 | 21.86 |
| RTA | 27.58 | 76.19 | -3.07 | 48.77 | 2.39 | 38.55 |
| Vehicle | 5.73 | 42.49 | -6.90 | 75.44 | -1.89 | 26.34 |

*Post-Hoc Analyses*

Following the lack of statistically significant findings on the emotional Stroop and dot-probe tasks, unplanned analyses were carried out using only those participants meeting criteria for PTSD on the CAPS. This was in order to investigate whether

attentional biases for trauma-related information were only present in the performance of participants with PTSD. A series of repeated measures multivariate ANOVAs were conducted, using reaction times and interference scores from the emotional Stroop and dot-probe tasks. These analyses revealed no statistically significant findings. Further details regarding these analyses can be found in appendix 6.

*Correlational Analyses*

A series of Pearson correlations were conducted to explore the relationships between attentional biases, CAPS score, and MTE, within each group. An overview of the correlations for each group can be found in tables 7-9. In the TBI group, there were significant positive correlations between the dot-probe attentional bias for RTA images and MTE ($r = 0.780$, $n = 11$, $p = 0.002$, one-tailed), and between CAPS score and MTE ($r = 0.547$, $n = 11$, $p = 0.41$, one-tailed). In the N-TBI group, there were no significant correlations. In the orthopaedic group, there was a significant negative correlation between CAPS score and MTE ($r = -0.684$, $n = 15$, $p = 0.002$, one-tailed).

Table 7. Pearson correlations between attentional biases, MTE, and CAPS score for the TBI group (n=11).

| *N-TBI* | MTE | CAPS score |
|---|---|---|
| Stroop: | | |
| RTA interference | -0.187 | -0.206 |
| Brain interference | -0.115 | -0.044 |
| Dot-probe RTA bias | -0.096 | -0.001 |
| CAPS score | -0.280 | - |

Note: *p < 0.05; **p < 0.01.

Table 8. Pearson correlations between attentional biases, MTE, and CAPS score for the N-TBI group (n=15).

| *Orthopaedic* | MTE score | CAPS score |
|---|---|---|
| Stroop: | | |
| RTA interference | -0.016 | 0.022 |
| Brain interference | 0.106 | 0.040 |
| Dot-probe RTA bias | 0.156 | 0.210 |
| CAPS score | -0.684** | - |

Table 9. Pearson correlations between attentional biases, MTE, and CAPS score for the orthopaedic group (n=15).

| *TBI* | MTE | CAPS score |
|---|---|---|
| Stroop: | | |
| RTA interference | 0.118 | -0.163 |
| Brain interference | 0.504 | -0.293 |
| Dot-probe RTA bias | 0.780** | 0.336 |
| CAPS score | 0.547* | - |

Note: **p < 0.01.

## Discussion

The current study aimed to investigate attentional biases, post-traumatic stress, and MTE, following acquired brain injury. The hypothesis that there would be significant attentional biases for trauma-related stimuli on the emotional Stroop and dot-probe tasks was not confirmed for any of the participant groups. This is in contrast to the findings from Coates [50], where attentional biases for trauma-related information were found in participants with and without amnesia for the event. However, on the dot-probe task there was a significant interaction between image type and PTSD severity. Further inspection revealed that as PTSD severity increased, reaction times to trials involving RTA images also increased. Converse to this, reaction times on trials involving vehicle and negative images were found to decrease as PTSD severity increased. In the TBI group, there was also a positive correlation found between a bias for RTA-related images and MTE score.

As expected, there were significant differences between the participant groups in their MTE, with TBI participants reporting the most impaired MTE, N-TBI moderately impaired MTE, and orthopaedic participants reporting the greatest MTE. Furthermore, a significant positive correlation was found between MTE and PTSD severity in the TBI group and a significant negative correlation found between MTE and PTSD severity in the orthopaedic group.

The lack of any significant attentional biases in the emotional Stroop task may be understood in a number of ways. Firstly, the emotional Stroop task employed a random format, where stimuli from different groups were randomly intermixed. As the task also involved many trials, it is possible that carry-over effects from trauma

stimuli to non-trauma stimuli masked an underlying attentional bias [69]. Secondly, participants provided their responses through a manual key-press, rather than providing a verbal response. A key-press response was chosen due to the potential confounds of background noise and slower speech articulation when using a voice relay key. Whilst attentional biases in PTSD have been found previously using this method [63], it may be that any attentional biases were too subtle to be detected using this response method. Further to this, it has been suggested that the attentional bias effect on the emotional Stroop task may be related to difficulties in the inhibition of speech articulation [70], which could account for the lack of findings in the present task.

Thirdly, the study employed a broad range of emotional control stimuli, including positive, hospital, and OCD words. The emotional Stroop effect found in anxious subjects has been suggested to be a result of general emotional arousal [71, 72]. Therefore, the lack of any difference between responses to the emotional stimuli may provide support to the emotionality hypothesis. In addition, it has been suggested that the lexical differences between disorder-relevant words and control words may contribute to the slower colour-naming of disorder-relevant words [73]. In the present task, groups of stimuli were stringently matched with neutral control words on a wide range of lexical characteristics, thereby potentially reducing any difference in responses to the word groups.

Fourthly, the presence of attentional biases is considered to be specific to the etiology and maintenance of PTSD [38, 74]. Therefore, attentional biases should not be present in individuals without PTSD. In relation to this, a possible explanation may be that the presence of participants without PTSD masked the detection of

attentional biases in participants with PTSD. However, responses on the emotional Stroop were not found to relate to the severity of PTSD symptoms. Furthermore, post-hoc analyses involving only participants with PTSD found no significant biases for trauma-related material on either the emotional Stroop or dot-probe tasks. In accordance with the current issues, a recent review of dissertation abstracts and published literature concluded that attentional biases in PTSD are not reliably found in studies employing the emotional Stroop task [75].

The findings from the dot-probe task also require closer consideration. Similar to the current findings, previous research using the dot-probe task with PTSD participants has not reliably found significant attentional biases towards trauma-related information [44, 45, 76]. More specifically, whilst Bryant and Harvey [76] found facilitative effects for mildly threatening stimuli, there was no such bias found for highly threatening stimuli.

It is important to consider the significant interaction found between image type and PTSD severity on the dot-probe task. This interaction indicates that as PTSD severity increases, the reaction time to trials involving RTA images also increases. In addition, there was a non-significant trend towards slower responses on trials involving RTA images, in the TBI and orthopaedic participant groups. These findings are similar to that found by Elsseser *et al.* [45], where participants were significantly slower to respond to trauma images irrespective of probe position. It could be argued that viewing trauma-related images results in a general interference effect, rather than a specific attentional bias towards the area of the visual field where trauma information is present. Therefore, the current findings may provide some preliminary evidence for the existence of a general interference effect for

trauma-related images, across participants with and without amnesia for the event. Furthermore, this general slowing in response to RTA images appears to be related to the severity of PTSD.

There was also a positive correlation found in the TBI group between the degree of bias for RTA images and MTE. This finding suggests that when interference effects for trauma images occur following TBI, they are related to the perceived quality of explicit memory for the event. More specifically, better explicit memory for the event is associated with a larger level of interference for RTA images. There was no such correlation found in the orthopaedic or N-TBI groups, suggesting that the role of enhanced MTE in the development of attentional biases is specific to TBI.

It should not be assumed that performance on the experimental tasks reflects automatic, implicit processing. Indeed, since the MTE questionnaire was measuring explicit, episodic memory for the event, the correlation between MTE and bias for RTA images suggests the involvement of explicit, strategic processes. In relation to this, McNally [77] has proposed that attentional biases for information presented at post-recognition stages are likely to involve both automatic and strategic processes. Therefore, it cannot be stated that the current findings reflect implicit, automatic biases for trauma-related information.

The correlations found between MTE and PTSD severity are interesting for several reasons. The finding of a positive correlation between MTE and PTSD severity in the TBI group suggests that impaired explicit MTE is protective against the development of PTSD. In agreement with this, other studies have also found that explicit memory for the event in mild TBI is associated with an increased risk of

PTSD [29, 30, 78]. Further to this, the lack of any relationship between MTE and PTSD severity in the N-TBI group is in agreement with the previous finding that PTSD following stroke is unrelated to the degree of amnesia [21].

There was also a negative correlation between MTE and PTSD severity in the orthopaedic group, where the traumatic event was not associated with loss of consciousness. This indicates that the development of PTSD is associated with fragmented or disorganised memories, in instances where there is no organic amnesia. Indeed, individuals with PTSD have been found to have difficulty in recalling explicit aspects of the traumatic event [79]. Furthermore, disorganised or incomplete trauma memories have been found to be predictive of PTSD symptoms [80, 81]. In an experimental study, Halligan *et al.* [82] investigated the hypothesis that incoherent trauma memories in PTSD are related to excessive data-driven implicit processing, including perceptual and sensory aspects of the event, and a lack of conceptual processing around the meaning and context of the event [38]. They found that data-driven processing was associated with disorganised trauma memories and the development of PTSD-like symptoms. Moreover, this association was independent of other known predictors of PTSD, such as dissociation and depression. The current study appears to support the existing evidence for the relationship between incoherent trauma memories and the development of PTSD, when there is no organic amnesia for the event.

The present study was subject to several important limitations. Firstly, it cannot be assumed that the stimuli used in the experimental tasks were trauma-relevant for all participants or equivalent in perceived emotionality. This issue would have been clarified by asking participants to rate the trauma-relevance and

emotionality of the stimuli following completion of the tasks. Furthermore, the experimental tasks were not administered under standardised laboratory conditions, due to the research being carried out on a laptop computer in the homes of participants or within hospital wards. Whilst every effort was made to ensure the same research procedure and arrangement of equipment across participants, it is likely that there were extraneous variables that impacted on performance.

In addition, the average response times on the tasks were shown to have large standard deviations, particularly in the N-TBI group. This variation in performance suggests that participants were not performing in a similar way, thereby reducing statistical power. The N-TBI participants were also found to be significantly slower overall on the emotional Stroop task and to be responding faster to emotional words than control words, compared to the TBI and orthopaedic groups. Moreover, the N-TBI group were significantly older than the TBI group and experienced a significantly longer stay in hospital than the orthopaedic group. In considering these findings, it seems it may not be valid to compare performance in the N-TBI group with the other participant groups.

The study is further limited by failing to assess the degree to which participants had been informed of details of the event by others, and the emotional reaction to this information. Participants were encouraged to rate their own memory for the event when completing the MTE questionnaire. However, it is possible that participants mistakenly considered as their own memories, details that had been filled in by others or were pseudomemories. A clearer exploration of these issues is needed to clarify the influence of both pseudomemories, and being informed of details of the event by others, on the development of PTSD following TBI.

Further limitations relate to the relatively small sample size employed and the low incidence of PTSD in the TBI group, which limits the conclusions that can be drawn. In addition, the necessary inclusion and exclusion criteria may have impacted on the representativeness of the participant sample. For instance, it is likely that the participants recruited with a severe brain injury had experienced a better recovery than the wider sample of people with severe brain injuries. In addition, it is known that following brain injury there are common deficits in insight and self-awareness [83]. Further to this, it has been shown that people with a brain injury tend to underreport symptoms [27]. Therefore, the self-report ratings given by TBI and N-TBI participants may have been subject to response biases that have resulted in an underrepresentation of current distress.

Future research should aim to further explore implicit processing, through comparing TBI and non-TBI participants with and without PTSD. A larger number of TBI participants with PTSD symptomatology would enable clearer conclusions to be made regarding the existence of implicit biases. The current study has shown MTE to be an important factor in the development of PTSD and future research should continue to explore this variable. However, this may require the development of a more sophisticated tool for assessing the details of the event that have been filled in by others. Furthermore, the validity and reliability of the MTE questionnaire requires further investigation and development. Finally, future studies should carefully consider the design and format of attentional bias tasks and the relative contribution of automatic and strategic processes.

In summary, the current study found no evidence for the hypothesised attentional biases in any of the participant groups. Therefore, the proposal of implicit

processing as a potential mechanism for PTSD following TBI has not been confirmed. However, the lack of an attentional bias in the orthopaedic group, where there was no organic amnesia for the event, indicates that factors relating to methodology may be responsible for the absence of any biases. Therefore, further carefully designed research is needed to answer this important question.

The findings from the dot-probe task suggest that when biases in attention are detected, they are associated with increased PTSD severity. Furthermore, in TBI participants, the bias for trauma-relevant images is related to the degree of explicit memory for the traumatic event, weakening the role of implicit processes. Certainly, it can be concluded that following TBI and orthopaedic injury, the development of PTSD is related to the nature of the trauma memory. However, the role of the trauma memory is different depending on whether there is organic amnesia for the event.

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**Part Three: Appendices**

## Appendix 1: Reflective Statement

In this reflective statement, I aim to present my journey through the research project, including the decisions made, the strengths and weaknesses of the research, and my areas of personal learning.

*Designing the Research*

The planning stage of the research was both exciting and stimulating. It was greatly helped by it being at the beginning of my clinical psychology training, when I was full of energy and enthusiasm! I was keen to design original and groundbreaking research, which would answer important research questions. When thinking of ideas, I was drawn to my areas of interest, namely brain injury and post-traumatic stress disorder. Unsure which avenue to go down, I decided to explore how the two areas overlap, and was excited by the research questions that emerged when reviewing the literature in this area. Following from this, it felt as though the research design quickly formed, in some ways faster than my knowledge base for the area!

In designing my research, it was crucial to seek advice from my supervisor and other relevant people, including health professionals who were going to be assisting with recruitment. At times, it felt difficult to balance the advice from clinicians working in the area of brain injury, with that of academic researchers working in the field of cognitive psychology. The stringent methodology used in experimental psychology was forcefully recommended to me, yet I was aware that these ideas could not be fully implemented when working with participants with injuries in their own homes and on hospital wards. Similarly, clinicians working in

the area were keen to make me aware of issues that could confound the findings, such as lack of insight and confabulation following brain injury. It seemed important to act on these suggestions, yet unmanageable to address all the possible arising issues. At these times, it was important to temper over-ambition and accept that there were limits to what my research could achieve!

It was particularly important to consider the ethical issues regarding presenting images of road traffic accidents. There was also some concern that administering the Memory for the Traumatic Event questionnaire would result in distress to participants through talking about or reliving the traumatic event. It felt difficult to predict how often this would be an issue for my participants. The ethical approval process was reassuring and helpful in developing a plan for managing any arising issues.

In preparing for data collection, it was necessary to go through research and governance approval at four different research sites to maximise recruitment. This process turned out to be variable across sites and was one of the most stressful stages of the research. The NHS governance departments were slow to process paperwork, without making regular phone calls enquiring as to the progress of the application. When phone calls were answered it continually emerged that further documents were required, including occupational health and criminal record bureau (CRB) checks. This process turned out to be time-consuming and felt immensely frustrating due to the delays it created in beginning data collection. I think it would have been smoother if I had been more prepared for these challenges and had begun the process sooner.

*Data Collection*

It was great to begin data collection and finally get my research off the mark. It felt as though this point in the research had been long awaited! It was exciting to be receiving referrals into the project and to have the research measures ready to go. Certainly, meeting participants was one of the most valuable experiences in the course of the research journey. Despite the project involving a series of structured tasks and questionnaires, I was keen to allow time for people to tell their story. Indeed, there was an eagerness from participants to help me learn about their experiences. It was inspiring to hear positive stories of adjustment and coping following injury and trauma. I often met family members as part of visiting participants and noted the value of positive family and social support in aiding emotional recovery.

I was also struck by the differences between seeing people for a one-off research setting, in comparison to an ongoing clinical setting. It felt counterintuitive to be listening to stories without focusing on therapeutic goals or possible interventions. In many ways, it was hugely refreshing to be able to simply listen, and reminded me of the importance of allowing time for this in a clinical setting. I was surprised by the paperwork that came from meeting each participant, and I had to quickly develop a system to make this as easy to manage as possible. Another difference was managing the emotional impact of data collection. In clinical settings, I have always felt continually surrounded by sources of support, whether it be supervisors, colleagues, peers, or administrators. During data collection, I often travelled long journeys to meet participants and it began to feel as though my car was my office! At times, I felt alone in processing the stories I was hearing. During

these times, it was important to talk with my supervisor and other trainees in similar positions.

The data collection process was aided through developing good links with professionals early on in the process. This provided an opportunity for comments to be made about the research design and provided a sense of involvement to health professionals. It also increased my understanding of how the different services worked and my confidence in liaising with the services. The unpredictability of participant referrals was difficult to manage and there were several moments of panic as to where the next participant would come from! The decrease in referrals tended to be due to natural fluctuation in the numbers of appropriate participants accessing the services. However, in a busy clinical setting, it was also important to politely remind services that I was in need of further participants, without pestering and harassing professionals – a difficult balance to achieve!

Further into data collection, it began to emerge that I would not be able to reach my target for the non-traumatic brain injury group, contrary to expectations. This was really frustrating, as the only way around this issue was to apply for research and development approval for a fifth research site, something which filled me with dread! Nevertheless, the additional site could guarantee large numbers of appropriate participants, and so I went ahead. This time, having learned from previous experiences, I was determined that the application would progress quickly. And so I made regular phone calls and emphasised the time pressure on the project. After a lot of hard work, approval was given within one month, and the participants were ready to assess as soon as formal confirmation arrived. I was then able to

quickly reach my target number for the non-traumatic brain injury group. All in all, it felt like this was one of the better decisions made in the course of the project!

*Choice of Journals*

Clinical Psychology Review was chosen due to my systematic literature review presenting information with both theoretical and clinical implications regarding the area of post-traumatic stress disorder (PTSD). In addition, Clinical Psychology Review has a high impact factor (6.763) for psychological journals, which suggests that information is disseminated to a large audience.

For the empirical paper, the journal Brain Injury was chosen due to my paper presenting new research in the area of psychological outcome following brain injury. The journal is multidisciplinary, covering a range of medical, psychological, social, and rehabilitation issues relating to brain injury. Previous articles in the area of traumatic brain injury and PTSD have been published in this journal. Therefore, submitting a further article to this journal provides continuity to the readers of Brain Injury.

*Report Writing*

Initially, it felt overwhelming to reach the stage of writing up the portfolio! The number of sections that needed to be written, the quantity of papers that needed to be read, and the wealth of data analysis to be carried out, felt unmanageable with the impending deadline. This was amplified by the disappointment of finding non-significant results and realising flaws in the methodology. The non-traumatic brain injury participants were emerging to be an inappropriate comparison group and I

began to regret certain decisions regarding the experimental tasks. However, I was also focused on the challenge of making sense of what had been found and presenting the issues clearly and concisely. It was satisfying to be able to link up the issues at the beginning with the findings at the end and incredibly rewarding to see the finished report on the screen. At this point, all my hard work seemed well worth it!

*Summary*

Towards the end of my research journey, I can now look back with a huge sense of achievement. In particular, I have greatly enjoyed the experience of managing my own project and developing working relationships with professionals. I have developed skills in managing the academic, professional, and personal challenges inherent in managing a large project from beginning to end. These are skills that I will be able to take with me to future challenging situations. If I was to repeat my research again, there are undoubtedly several things I would do differently. These would include taming my tendency to be overambitious, allowing more time than initially expected, and carefully considering conflicting advice. However, there are always more learning points to be gained and more questions to be answered. I am looking forward with interest and excitement at what may be learned from future research endeavors alongside clinical work.

## Appendix 2: Guidelines for Submission to Journals

Appendix 2.1: Clinical Psychology Review Author Guidelines

Appendix 2.2: Brain Injury Author Guidelines

*Appendix 2.1: Clinical Psychology Review Author Guidelines*

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• E-mail address
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• Telephone and fax numbers
All necessary files have been uploaded
• Keywords
• All figure captions
• All tables (including title, description, footnotes)
Further considerations
• Manuscript has been "spellchecked" and "grammar-checked"
• References are in the correct format for this journal
• All references mentioned in the Reference list are cited in the text, and vice versa
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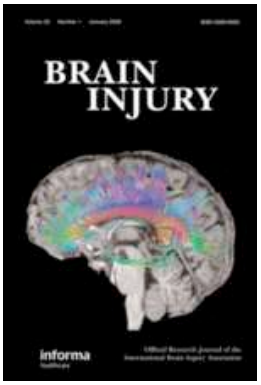
*Appendix 2.2: Brain Injury Author Guidelines*



# Brain Injury
## Instructions for Authors

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Use person-first language throughout the manuscript (i.e., persons with brain injury rather than brain injured persons).

Ethics of Experimentation: Contributors are required to follow the procedures in force in their countries which govern the ethics of work done with human subjects. The Code of Ethics of the World Medical Association (Declaration of Helsinki) represents a minimal requirement.

Abstracts are required for all papers submitted, they should not exceed 200 words and should precede the text of a paper. See below for further information.

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Manuscripts should be compiled in the following order: title page; abstract; main text; acknowledgments; Declaration of Interest statement; appendices (as appropriate); references; tables with captions (on separate pages); figures; figure captions (as a list).

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For review essays, state the primary objective of the review; the reasoning behind your literature selection; and the way you critically analyse the literature; state the main outcomes and results of your review; and state the conclusions that might be drawn, including their implications for further research or application/practice.

The abstract should not exceed 200 words.

**Tables, figures and illustrations**

The same data should not be reproduced in both tables and figures. The usual statistical conventions should be used: a value written 10.0 ± 0.25 indicates the estimate for a statistic (e.g. a mean) followed by its standard error. A mean with an estimate of the standard deviation will be written 10.0 SD 2.65. Contributors reporting ages of subjects should specify carefully the age groupings: a group of children of ages e.g. 4.0 to 4.99 years may be designated 4 +; a group aged 3.50 to 4.49 years 4 ± and a group all precisely 4.0 years, 4.0.

Tables and figures should be referred to in text as follows: figure 1, table 1, i.e. lower case. 'As seen in table [or figure] 1 ...' (not Tab., fig. or Fig).

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*Insert table 2 about here*

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Tables should be used only when they can present information more efficiently than running text. Care should be taken to avoid any arrangement that unduly increases the depth of a table, and the column heads should be made as brief as possible, using abbreviations liberally. Lines of data should not be numbered nor run numbers given unless those numbers are needed for reference in the text. Columns should not contain only one or two entries, nor should the same entry be repeated numerous times consecutively. Tables should be grouped at the end of the manuscript on uploaded separately to the main body of the text.

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Figures must be uploaded separately and not embedded in the text. Avoid the use of colour and tints for purely aesthetic reasons. Figures should be produced as near to the finished size as possible. Files should be saved as one of the following formats: TIFF (tagged image file format), PostScript or EPS (encapsulated PostScript), and should contain all the necessary font information and the source file of the application (e.g. CorelDraw/Mac, CorelDraw/PC). All files must be 300 dpi or higher.

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- All acronyms for national agencies, examinations, etc., should be spelled out the first time they are introduced in text or references. Thereafter the acronym can be used if appropriate, e.g. 'The work of the Assessment of Performance Unit (APU) in the early 1980s ...'. Subsequently, 'The APU studies of achievement ...', in a reference ... (Department of Education and Science [DES] 1989a).
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associated with the Nuffield Foundation [in the 1960s], there has been a shift from heurism to constructivism in the design of [British] science courses'.

- The preferred local (national) usage for ethnic and other minorities should be used in all papers. For the USA, African-American, Hispanic, and Native American are used, e.g. 'The African American presidential candidate, Jesse Jackson...' For the UK, African-Caribbean (not 'West Indian'), etc.
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- n (not N), % (not per cent) should be used in typescripts.
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Acknowledgments and Declaration of interest sections are different, and each has a specific purpose. The Acknowledgments section details special thanks, personal assistance, and dedications. Contributions from individuals who do not qualify for authorship should also be acknowledged here. Declarations of interest, however, refer to statements of financial support and/or statements of potential conflict of interest. Within this section also belongs disclosure of scientific writing assistance (use of an agency or agency/ freelance writer), grant support and numbers, and statements of employment, if applicable.

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**Book chapter**: [2] Kuret JA, Murad F. Adenohypophyseal hormones and related substances. In: Gilman AG, Rall TW, Nies AS, Taylor P, editors. The pharmacological basis of therapeutics. 8th ed. New York: Pergamon; 1990. p 1334-60.

**Conference proceedings**: [3] Irvin AD, Cunningham MP, Young AS, editors. Advances in the control of Theileriosis. International Conference held at the International Laboratory for Research on Animal Diseases; 1981 Feb 9-13; Nairobi. Boston: Martinus Nijhoff Publishers; 1981. 427 p.

**Dissertations or Thesis**: [4] Mangie ED. A comparative study of the perceptions of illness in New Kingdom Egypt and Mesopotamia of the early first millennium [dissertation]. Akron (OH): University of Akron; 1991. 160 p. Available from: University Microfilms, Ann Arbor MI; AAG9203425.

**Journal article on internet**: [5] De Guise E, Leblanc J, Dagher J, Lamoureux J, Jishi A, Maleki M, Marcoux J, Feyz M. 2009. Early outcome in patients with traumatic brain injury, pre-injury alcohol abuse and intoxication at time of injury. Brain Injury 23(11):853-865. http://www.informaworld.com/10.1080/02699050903283221. Accessed 2009 Oct 06

**Webpage**: [6] British Medical Journal [Internet]. Stanford, CA: Stanford Univ; 2004 July 10 - [cited 2004 Aug 12]; Available from: http://bmj.bmjjournals.com

**Internet databases**: [7] Prevention News Update Database [Internet]. Rockville (MD): Centers for Disease Control and Prevention (US), National Prevention Information Network. 1988 Jun - [cited 2001 Apr 12]. Available from: http://www.cdcnpin.org/

## Appendix 3: Ethical and Research Governance Approval

Appendix 3.1: NHS Ethical Approval

Appendix 3.2: Research Governance Approval for NHS Leeds

Appendix 3.3: Research Governance Approval for BIRT

Appendix 3.4: Research Governance Approval for NLAG Trust

Appendix 3.5: Research Governance Approval for HEY Trust

Appendix 3.6: Research Governance Approval for NHS East Riding of Yorkshire

*Appendix 3.1: NHS Ethical Approval*

**REMOVED PRIOR TO HARD-BINDING**

*Appendix 3.2: Research Governance Approval for NHS Leeds*

**REMOVED PRIOR TO HARD-BINDING**

*Appendix 3.3: Research Governance Approval BIRT*

**REMOVED PRIOR TO HARD-BINDING**

*Appendix 3.4: Research Governance Approval for NLAG Trust*

**REMOVED PRIOR TO HARD-BINDING**

*Appendix 3.5: Research Governance Approval for HEY Trust*

**REMOVED PRIOR TO HARD-BINDING**

*Appendix 3.6: Research Governance Approval for NHS East Riding of Yorkshire*

**REMOVED PRIOR TO HARD-BINDING**

## Appendix 4: Supplementary Information for the Systematic Literature Review

Appendix 4.1: Quality Assessment Checklist

Appendix 4.2: Quality Assessment by Rater A and Rater B

Appendix 4.3: Data Extraction Form

Appendix 4.4: Overview of Attentional Bias Tasks

*Appendix 4.1: Quality Assessment Checklist*

*The checklist below is adapted from the criteria developed by Downs and Black (1998).*

Title of Study:
Author:
Reviewer:

| Question | Yes (1) | No (0) |
|---|---|---|
| 1. Is the hypothesis/aim/objective(s) of the study clearly described? | | |
| 2. Are the main outcomes to be measured clearly described in the Introduction or Methods sections? | | |
| 3. Are the characteristics of participants included in the study clearly described? | | |
| 4. Are the experimental tasks clearly described? | | |
| 5. Are the main findings of the study clearly described? *(Simple outcome data should be reported for all major findings so that the reader can check the major analyses and conclusions).* | | |
| 6. Are the main outcome measures used accurate (valid and reliable)? | | |
| 7. Does the study provide estimates of the random variability in the data for the main outcomes? *(In normally distributed data, standard deviation or confidence levels should be reported. In non-normally distributed data, the inter-quartile range of results should be reported. If the distribution of the data is not described, it should be assumed that the estimates used were correct and the question should be answered yes).* | | |
| 8. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes, except where the probability value is less than 0.001? | | |
| 9. Were the statistical tests used to assess the main outcomes appropriate? (*Non-parametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered yes. If the distribution of data is not reported, it must be assumed that the estimates used were correct and the question should be answered yes).* | | |
| 10. Were the subjects asked to participate in the study representative of the entire population from which they were recruited? *(The study should identify the source population for participants and describe how participants were selected. If this cannot be determined, the question should be answered no).* | | |

| | | |
|---|---|---|
| 11. If any of the results of the study were based on 'data dredging', was this made clear?<br>*(Any analyses not made clear at the outset of the study should be clearly indicated. If no unplanned analyses were reported, then answer yes).* | | |
| 12. Do the conclusions drawn provide a clear link between the data and interpretation of the results? | | |
| 13. Are the implications and clinical relevance of the study clearly reported? | | |
| 14. Is there adequate discussion of the limitations of the study? | | |
| 15. Are possible areas for future investigation explored? | | |

*Appendix 4.2: Quality Assessment by Rater A and Rater B*

| **Authors** | **1A** | **1B** | **2A** | **2B** | **3A** | **3B** | **4A** | **4B** | **5A** | **5B** | **6A** | **6B** | **7A** | **7B** | **8A** | **8B** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beck et al. (2001) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| Buckley et al. (2002) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Buckley et al. (2003) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| Bryant & Harvey (1995) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Bryant & Harvey (1997) | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| Cassiday et al (1992) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| Chemtob et al. (1999) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Constans et al. (2004) | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Devineni et al. (2004) | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| Elsesser et al. (2004) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Elsesser et al. (2005) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| Field et al. (2001) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| Foa et al. (1991) | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Harvey et al. (1996) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kaspi et al. (1995) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| Litz et al. (1996) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| McNally et al. (1990) | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| McNally et al. (1993) | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| McNally et al. (1996) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| McNeil et al. (1999) | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Metzger & Orr (1997) | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| Paunovic et al. (2002) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Pineles et al. (2007) | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Pineles et al. (2009) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Shin et al. (2001) | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Sveen et al. (2009) | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| Thomas & Fremouw (2009) | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| Thrasher et al. (1994) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Vrana et al. (1995) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Vythilingam et al. (2007) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| ***Percentage Agreement*** | | ***96.7*** | | ***93.3*** | | ***80.0*** | | ***80.0*** | | ***76.7*** | | ***70.0*** | | ***96.7*** | | ***83.3*** |

| Authors | 9A | 9B | 10A | 10B | 11A | 11B | 12A | 12B | 13A | 13B | 14A | 14B | 15A | 15B | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beck et al. (2001) | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **25** |
| Buckley et al. (2002) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **23** |
| Buckley et al. (2003) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **23** |
| Bryant & Harvey (1995) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **25** |
| Bryant & Harvey (1997) | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | **19** |
| Cassiday et al (1992) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | **21** |
| Chemtob et al. (1999) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **25** |
| Constans et al. (2004) | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | **23** |
| Devineni et al. (2004) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **22** |
| Elsesser et al. (2004) | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | **23** |
| Elsesser et al. (2005) | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | **19** |
| Field et al. (2001) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **26** |
| Foa et al. (1991) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | **25** |
| Harvey et al. (1996) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **25** |
| Kaspi et al. (1995) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **24** |
| Litz et al. (1996) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **27** |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McNally et al. (1990) | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **22** |
| McNally et al. (1993) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | **15** |
| McNally et al. (1996) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | **22** |
| McNeil et al. (1999) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | **21** |
| Metzger & Orr (1997) | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | **21** |
| Paunovic et al. (2002) | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **27** |
| Pineles et al. (2007) | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **25** |
| Pineles et al. (2009) | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **26** |
| Shin et al. (2001) | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **28** |
| Sveen et al. (2009) | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **23** |
| Thomas & Fremouw (2009) | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | **21** |
| Thrasher et al. (1994) | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **26** |
| Vrana et al. (1995) | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | **20** |
| Vythilingam et al. (2007) | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | **24** |
| ***Percentage Agreement*** | | ***93.3*** | | ***80.0*** | | ***93.3*** | | ***100.0*** | | ***93.3*** | | ***93.3*** | | ***63.3*** | ***86.2*** |

*Appendix 4.3: Data Extraction Form*

| | |
|---|---|
| **General Information:**<br>Date of data extraction<br>Author<br>Article Title<br>Journal | |
| **Study Characteristics:**<br>*Research question/aims* | |
| *Study design* | |
| *Participant Characteristics*<br>Participant groups<br>Number in each group<br>Type of trauma<br>Time since trauma<br>Age<br>Gender<br>Ethnicity<br>Geographical region<br>Other information | |
| *Participant Recruitment*<br>Recruitment methods<br>Inclusion criteria<br>Exclusion criteria<br>Number did not participate | |

| | |
|---|---|
| *Measurement of attentional bias*<br>Type of attentional task<br>Type of stimuli<br>Selection of stimuli<br>Format of task (computer, card)<br>Stage of processing<br>Technical details<br>Other information | |
| **Results**<br>*Attentional task*<br>Attentional bias found?<br>Numerical data for main outcomes<br>Variance in data<br>Statistical tests used<br>Results of main statistical tests<br><br>*Symptom measures*<br>Main outcomes<br>Numerical data<br>Variance in data<br>Statistical tests used<br>Results of main statistical tests<br>Relation with task<br>*Other important outcomes* | |
| **Conclusions**<br>*Interpretation of results*<br>*Limitations*<br>*Key links to theory/literature*<br>*Further research* | |
| | |

*Appendix 4.4: Overview of Attentional Bias Tasks*

| Task | Authors | Description | Measures |
|---|---|---|---|
| Emotional Stroop | Emotional Stroop: Gotlib & McCann (1984)<br><br>For a review: Williams, Mathews, & MacLeod (1996). | Subjects are shown words of varying emotional valence and asked to name the colour in which the words are printed, whilst ignoring the meaning of the words. The task typically includes threat-related stimuli and neutral stimuli, and the difference between reaction times to these stimuli is considered to be the 'bias' or 'interference' effect. The emotional Stroop can be administered in a card format, where all the words from the same group are presented in print on a single piece of card, or in a computer format. In this format, each word is presented separately on a computer screen. The words can be presented in a blocked order, where all the stimuli from a group are presented as a set, or in a random order, where stimuli from different word groups are randomly intermixed. | RTs and error rates in colour-naming.<br><br>Card format: a stopwatch is used to measure the time taken to colour-name the list of words on a card.<br><br>Computer format: voice-activated relay measures the time taken to make a vocal response (or key-press response). |
| Dot-Probe | MacLeod, Mathews, & Tata (1986) | A threat stimulus and a neutral stimulus are briefly presented on a computer screen, followed by a probe in the location of one of the previously presented stimuli. Subjects are required to detect the location of the probe on the screen. Reaction times are shorter if the probe replaces the previously attended image, rather than the unattended image. | RTs and error rates in indicating probe location. |
| Visual Search | Neisser (1963) | Subjects are required to identify a discrepant target, from an array of identical targets, presented on a computer screen. In attentional interference, subjects are slower to detect a neutral target in an array of threatening distractors. In attentional facilitation, subjects are faster to detect a threatening target, in an array of neutral distractors. | RTs and error rates in detecting target. |

| | | | |
|---|---|---|---|
| Visual Search | Neisser (1963) | Subjects are required to identify a discrepant target, from an array of identical targets, presented on a computer screen. In attentional interference, subjects are slower to detect a neutral target in an array of threatening distractors. In attentional facilitation, subjects are faster to detect a threatening target, in an array of neutral distractors. | RTs and error rates in detecting target. |
| Digit Detection | Chemtob, Roitblat, & Hamada et al. (1999) | Subjects are instructed to attend to a distractor stimulus for a few seconds, before a digit string is added to a quadrant of the scene. Subjects are required to detect the presence or absence of a target digit in the string. An interference effect occurs for emotional distractors, representing difficulty disengaging from the stimulus. | RTs and error rates in detecting the presence or absence of a target digit. |
| Emotional Lexical Decision | Graves, Landis, & Goodglass (1981) | Subjects are required to determine whether a presented string of letters make a word or non-word. Subjects tend to be faster to recognise as words emotional letter strings compared to neutral letter strings (facilitated attention). | RTs and error rates in determining whether letter string is word or non-word. |
| Emotional Counting Stroop | Whalen et al. (1998) | Subjects are briefly presented with a set of identical words on a computer screen and asked to count the number of words. Subjects are slower to count emotional words, compared to neutral words. | RTs and error rates in determining number of words on the screen. |

## Appendix 5: Supplementary Information for Empirical Paper

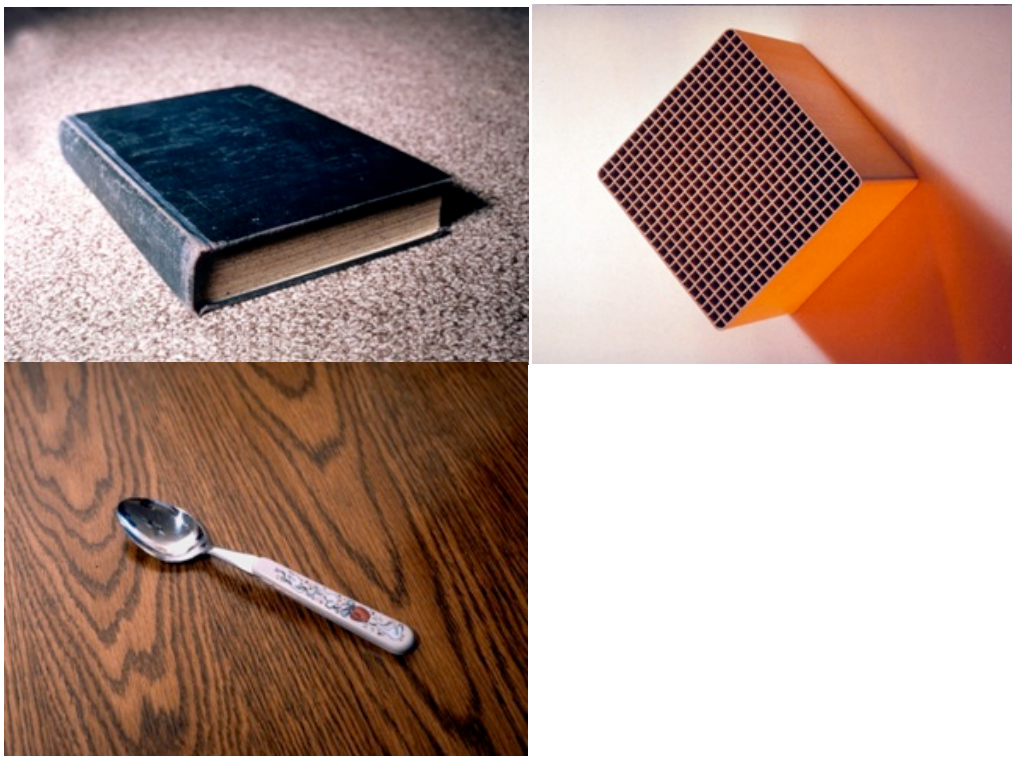
*Appendix 5.1: Emotional Stroop Task Stimuli*

| ***Practice words*** | |
|---|---|
| 1. Apple | |
| 2. Cup | |
| 3. Chimney | |
| ***RTA-related words*** | ***Neutral matched words*** |
| 1. Emergency | 1. Necessity |
| 2. Trapped | 2. Toothed |
| 3. Scream | 3. Sketch |
| 4. Crash | 4. Solve |
| 5. Death | 5. Thing |
| 6. Blood | 6. March |
| ***Brain-Injury-related words*** | |
| 1. Confusion | 1. Institute |
| 2. Memory | 2. Poetry |
| 3. Brain | 3. Brush |
| 4. Unconscious | 4. Forthcoming |
| 5. Impaired | 5. Traverse |
| 6. Neurology | 6. Asparagus |
| ***Hospitalisation-related words*** | |
| 1. Injection | 1. Signature |
| 2. Mask | 2. Hint |
| 3. Doctor | 3. Bottom |
| 4. Treatment | 4. Statement |
| 5. Medicine | 5. Customer |
| 6. Nurse | 6. Sauce |
| ***OCD-related words*** | |
| 1. Germ | 1. Surf |
| 2. Filthy | 2. Polite |
| 3. Faeces | 3. Ballot |
| 4. Dirty | 4. Urban |
| 5. Contaminate | 5. Precipitate |
| 6. Urine | 6. Zebra |
| ***Positive words*** | |
| 1. Lovely | 1. Native |
| 2. Worthy | 2. Subtle |
| 3. Praise | 3. Thread |
| 4. Dearest | 4. Passage |
| 5. Kindness | 5. Chestnut |
| 6. Nice | 6. Nine |

*Appendix 5.2: Dot-Probe Task Stimuli*

*Selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2008)*

**Practice Images:**

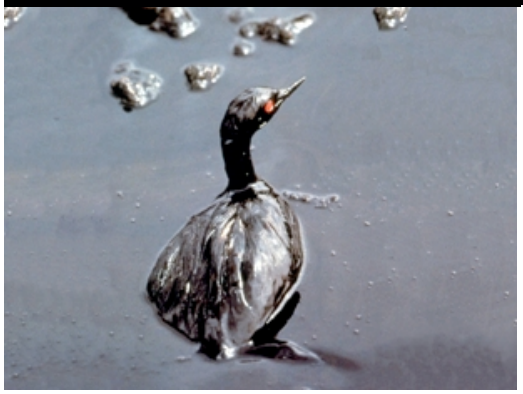


**Road Traffic Accident Images:**

**Vehicle Images:**

**Negative Images:**





**Neutral Comparison Images:**







*Appendix 5.3: Hospital Anxiety and Depression Scale (HADS)*

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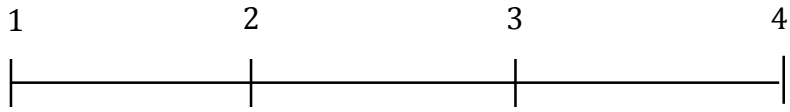
*Appendix 5.4: Memory for the Traumatic Event (MTE) Questionnaire*

MTE Questionnaire (Gil, Kaspi, Zilberman, Koren, & Klein, 2005)

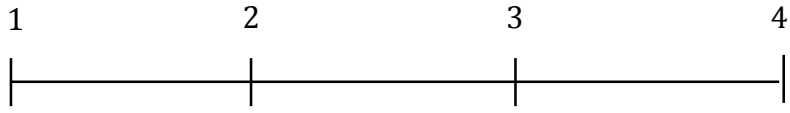
*Please rate your memory for the traumatic event on the following aspects of the event by circling the number that best represents how much you can remember (1 = no recollection, 4 = very good recollection).*

**1. What was the event**



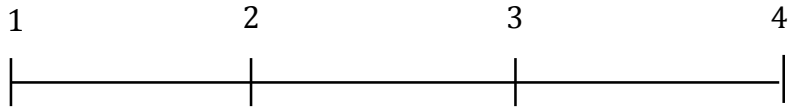

*No recollection* *Very good recollection*

**2. Where did the event take place**




*No recollection* *Very good recollection*

**3. Who (other than you) was involved in the event**

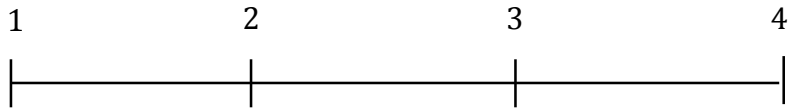



*No recollection* *Very good recollection*

**4. When did the event occur**

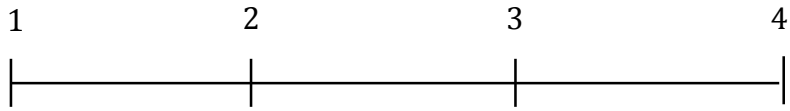

*No recollection* *Very good recollection*

**5. Sights from the event**



*No recollection* *Very good recollection*

**6. Sounds from the event**




*No recollection* *Very good recollection*

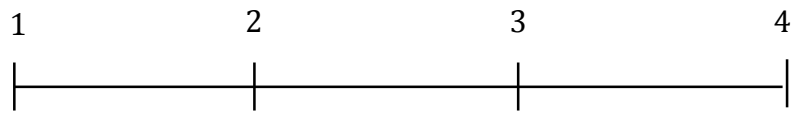
**7. Odours from the event**


*No recollection* *Very good recollection*

**8. Things you said during or after the event**


*No recollection* *Very good recollection*

**9. Things other people said during or after the event**




*No recollection* *Very good recollection*

Total _____

Average_____

*Appendix 5.5: Mayo-Portland Adaptability Inventory-4 (MPAI-4)*

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*Appendix 5.6: Clinician Administered PTSD Scale (CAPS)*

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*Appendix 5.7: Participant Information Sheet*

## PARTICIPANT INFORMATION SHEET: Part 1 & Part 2

***Title of Project: Attentional Biases and Memory after a Medical Event***

***Name of Researcher: Jennifer English***

*We would like to invite you to take part in a research study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish.*

*Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study. Ask us if there is anything that is not clear or if you have any questions. Take time to decide whether or not you wish to take part.*

## PART 1

***What is the purpose of the study?***

The purpose of the research is to find out how people process and form a memory for traumatic events that are associated with physical injury or another medical event. It is hoped the research may help health professionals to understand the occurrence of trauma-related difficulties after medical events and to promote appropriate assessment and treatment.

***Why have I been invited to take part?***

You have been invited to take part in the study by a member of your healthcare team. You will have been asked because you experienced a medical event or a traumatic event within the last 2 years. It is up to you to decide whether you would like to take part. We will describe the study and go through this information sheet, which we will then give you if you agree to take part. We will then ask you to sign a consent form to show you have agreed to take part. You are free to withdraw at any time, without giving a reason. This would not affect the standard of care you receive.

***What will happen to me if I take part?***

If you agree to take part, you will be asked to spend about 1 ½ to 1 ¾ hours completing a series of tasks. This can happen immediately after you have signed the consent form, or we can arrange another time for the researcher to return if you would like more time to think about it. During the session you

will be given the opportunity for short breaks if you become tired. An outline of the tasks you will be asked to complete is as follows:

1. *Information about You*
   This will involve answering some short questions about you and the medical event you experienced. This will take around 10 minutes. Any information which you are unsure of will be collected by the researcher after the session by reviewing your medical records.

2. *Word-Colour Task*
   This task will be administered on a computer. A series of words will be presented on the screen one at a time in different colours. You will be asked to name the colour of each word as quickly and as accurately as possible. This task will take around 10 minutes to complete.

3. *Dot Probe Task*
   This task will also be presented on a computer. You will be asked to look at a fixation point in the middle of the screen. After this two images will briefly appear on the screen, followed by a small dot. You will be asked to specify the location of the dot as quickly and accurately as possible. This task will take around 10 minutes to complete. You may be asked to complete this task before the word-colour task. You do not need to know how to use a computer to do these tasks.

4. *Self-Report Questionnaires*
   You will be asked to complete three short questionnaires. These questionnaires are designed to find out how you have been feeling recently, how you have been functioning on day-to-day basis, and how you would rate the quality of your memory for the event. These will take around 15 minutes.

5. *Interview*
   The researcher will ask you a series of questions relating to the event you experienced and how you have coped since the event. This will take around 45 to 60 minutes.

***What are the possible disadvantages and risks of taking part?***

It is possible that you may find some of the tasks distressing as a result of thinking and talking about the event you experienced, which may trigger difficult feelings. The researcher will regularly check how you are finding the tasks and that you are happy to continue. It is important to let the researcher know if you are finding anything difficult during the session and if you wish to withdraw from the study.

We will allow some time at the end of the session to discuss any concerns or questions. If you are concerned about your wellbeing after the session you can contact the researcher or a professional in your healthcare team. Further details of who to contact is provided in Part 2. If necessary we will discuss with you how to access further support.

We cannot promise the study will help you personally but the information we get from this study will help improve the treatment of people with trauma-related difficulties after medical events.

***Will my taking part in the study be kept confidential?***
Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in Part 2.

*This completes Part I.*

*If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.*

## PART 2

***What will happen if I don't want to carry on with the study?***
You are able to withdraw from the study at any point. There would be no consequences on the standard of care from your healthcare team. At the point of withdrawal we would ask you if you would like the data collected from you to be extracted and destroyed.

***Will my taking part in this study be kept confidential?***
You can expect your confidentiality to be safeguarded in line with the Data Protection Act (1998). All information which is collected about you during the course of the research will be kept strictly confidential, and any information collected about you will have your name and address removed so that you cannot be identified. If you join the study, some parts of your medical records and the data collected for the study will be looked at by authorised persons from the research team at the University of Hull. All will have a duty of confidentiality to you as a research participant. You have the right to check the accuracy of data held about you and correct any errors.

The data will be collated in a computer programme using unique codes to identify individual participants. All computer files will be stored securely and will be password protected. All data in the form of questionnaires and forms will be anonymised and stored securely. The identifiable data will only be accessed by the Chief Investigator in the research team. The anonymised data will accessed by members of the research team at the University of Hull. The anonymised data will be retained for a period of 5 years. After this time the data will be disposed of securely.

There are some circumstances in which there would be limits to confidentiality. This would be if there was serious concern about your safety or someone else's safety. If such a situation were to arise, the researcher may have to share information without your consent. We would do our best inform you if this were to be the case.

*Involvement of your Healthcare Team:*
Your healthcare team will be notified of your participation in the research. This will involve the researcher sending a letter to your named healthcare professional, of which you will receive a copy. The healthcare professional will also be notified of any concerns you or the researcher have related to the research.

***What will happen to the results of the research study?***
The results of the research will be published in a research portfolio, which will be available at the library of the University of Hull. This is to fulfill, in part, the academic requirements for a Doctorate in Clinical Psychology. The results may also be published in an academic journal. You will not be identified in any report or publication, and the information presented will not

render it possible to identify you. The researcher will ask you whether you would like to be informed of the results of the study.

***Who is organising and funding the research?***
The research is being sponsored by Humber Mental Health Teaching NHS Trust and has been organised by the research team at the University of Hull.

***Who has reviewed the study?***
All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by the *Hull and East Riding Local Research Ethics Committee.* It has also been reviewed by professionals working in the Department of Clinical Psychology at the University of Hull.

***Who is responsible for the conduct of the study?***
The study is being monitored by the Department of Clinical Psychology at the University of Hull and by the sponsor, Humber Mental Health Teaching NHS Trust. Any complaints about the conduct of the study should be addressed by the researcher in the first instance, or alternatively the supervisor of the research. The contact details of these people can be found below.

***Further information and contact details***
If you would like further information about any aspect of the project, please see the following:

1. *Specific information about this research project:*

   Jennifer English
   Chief Investigator
   Department of Clinical Psychology
   University of Hull
   Cottingham Road
   Hull
   HU6 7RX
   ☎ 01482 464106

2. *Advice as to whether you should participate:*

   If you are unsure as to whether to participate you may wish to talk to family and friends and/or a member of healthcare team. You may find it useful to speak to *[name]*, from your healthcare team.

3. *Who you should approach if you are unhappy with the study:*

If you are unhappy with any aspect of the study, please contact the researcher in the first instance (contact details above). Alternatively you may prefer to contact the Supervisor of the research:

Dr Catherine Derbyshire
Clinical Tutor
Department of Clinical Psychology
University of Hull
Cottingham Road
Hull
HU6 7RX
☎ 01482 464106

If your concerns are related to difficulties you are experiencing as a result of the research you should contact either the researcher or *[name of assigned professional]*, who works in your healthcare team.

When read, 1 copy to be kept by patient; 1 to be kept in medical notes.

*Appendix 5.8: Participant Consent Form*

Centre Number: .....

Participant Identification Number: .....

## CONSENT FORM

Title of Project: Attentional Biases and Memory after a Medical Event

Name of Researcher: Jennifer English

Please initial box

1. I confirm that I have read and understand the information sheet dated..... (version.....) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without my medical care or legal rights being affected. ☐

3. I understand that relevant sections of my medical notes may be reviewed by the researcher, where it is relevant to my taking part in this research, and data collected during the study will be looked at by professionals at the University of Hull. I give permission for the researcher to have access to my medical records. ☐

4. I am aware some of the tasks may be distressing and that the researcher will regularly check this during the session. I agree to the researcher discussing with me sources of further support if necessary. ☐

5. I am aware that my healthcare team will be informed of my participation in the study. ☐

6. I agree to take part in the above study. ☐

| _____ | _____ | _____ |
|---|---|---|
| Name of Patient | Date | Signature |
| _____ | _____ | _____ |
| Name of Person taking consent | Date | Signature |

When completed, 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical notes

## Appendix 6: Data Analyses for Empirical Paper

Appendix 6.1: Emotional Stroop Repeated Measures Multivariate ANOVA involving only participants meeting PTSD criteria

Appendix 6.2: Dot-Probe Repeated Measures Multivariate ANOVA involving only participants meeting PTSD criteria

*Appendix 6.1: Emotional Stroop Repeated Measures Multivariate ANOVAs involving only participants meeting PTSD criteria*

Table 10. Interference effects repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic) and word type (5: RTA, brain, hospital, OCD, positive).

| *Effects* | *F value* | *Degrees of Freedom* | *Significance (p)* |
|---|---|---|---|
| Word Type | 0.515 | 4,6 | 0.729 |
| Group | 2.214 | 2,9 | 0.176 |
| Word Type x Group | 0.390 | 8,12 | 0.906 |

Note: Wilks' Lamda values are reported for multivariate analyses.

Table 11. Repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic), word type (5: RTA, brain, hospital, OCD, positive), and emotion (2: emotional, control).

| *Effects* | *F value* | *Degrees of Freedom* | *Significance (p)* |
|---|---|---|---|
| Word Type | 1.576 | 4,6 | 0.294 |
| Emotion | 0.668 | 1,9 | 0.435 |
| Group | 2.754 | 2,9 | 0.117 |
| Word Type x Group | 2.163 | 8,12 | 0.110 |
| Emotion x Group | 2.124 | 2,9 | 0.176 |
| Word Type x Emotion | 0.515 | 4,6 | 0.729 |
| Word Type x Emotion x Group | 0.390 | 8,12 | 0.906 |

Note: Wilks' Lamda values are reported for multivariate analyses.

*Appendix 6.2: Dot-Probe Repeated Measures Multivariate ANOVAs involving only participants meeting PTSD criteria*

Table 12. Interference effects repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic) and image type (3: negative, RTA, vehicle).

| *Effects* | *F value* | *Degrees of Freedom* | *Significance (p)* |
|---|---|---|---|
| Image Type | 0.552 | 2,8 | 0.596 |
| Group | 0.112 | 2,9 | 0.895 |
| Image Type x Group | 0.632 | 4,16 | 0.647 |

Note: Wilks' Lamda values are reported for multivariate analyses.

Table 13. Repeated measures multivariate ANOVA, with group (3: TBI, N-TBI, orthopaedic), image type (3: negative, RTA, vehicle), and validity (2: valid, invalid).

| *Effects* | *F value* | *Degrees of Freedom* | *Significance (p)* |
|---|---|---|---|
| Image Type | 1.162 | 2,8 | 0.360 |
| Validity | 0.387 | 1,9 | 0.550 |
| Group | 1.258 | 2,9 | 0.330 |
| Condition x Group | 0.668 | 4,18 | 0.623 |
| Validity x Group | 0.112 | 2,9 | 0.895 |
| Condition x Validity | 0.552 | 2,8 | 0.596 |
| Condition x Validity x Group | 0.632 | 4,16 | 0.647 |

Note: Wilks' Lamda values are reported for multivariate analyses.