

FIGURATIVE LANGUAGE AND AGGRESSION AFTER TRAUMATIC BRAIN
INJURY: DOES SARCASM HAVE A ROLE IN MODULATING AGGRESSIVE
BEHAVIOUR?

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Submitted in accordance with the requirements for the degree of Doctor of Clinical
Psychology (D. Clin. Psychol.)
The University of Leeds School of Medicine
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May, 2016

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ACKNOWLEDGEMENTS

I would firstly like to thank my supervisors, Ekaterini Klepousniotou and Andrew James, for their invaluable support and guidance throughout this process. Many thanks are also owed to Imogen Murray for her help with the data collection in Experiment two.

I would like to thank all the participants in this study who have given their time to make this research possible. Thank you to the Brain Injury Rehabilitation Trust and the Disabilities Trust for allowing me to conduct this research. Thank you also to the staff at the various brain injury rehabilitation units who have helped me with the practicalities surrounding this research.

I would also like to thank my family, friends and fellow trainees for their support. Finally, I'd like to thank Ryan for his belief, encouragement and project management.

ABSTRACT

Aggressive behaviour after traumatic brain injury (TBI) has been associated with general language impairments (Alderman, 2007). Figurative language has an important role in modulating emotional intensity (Dews & Winner, 1995), and sarcasm, a form of figurative language heavily linked to social cognition, is considered a socially appropriate communication of aggression (Haiman, 1998). The present research aimed to investigate the processing of sarcasm in individuals with TBI, and in healthy adults, in an attempt to explore whether possible deficits in linguistic performance may contribute to aggressive behaviour. A novel, auditory-visual, computer-based task was developed to test comprehension of factual and attitude (others' intentions) information in sarcastic and literal contexts. Experiment One compared the performance of seven participants with severe TBI with seven matched, healthy control participants. Experiment Two compared 20 low aggressive with 20 moderately aggressive healthy young adults. Reaction time and accuracy data were statistically analysed with parametric and non-parametric tests, and the TBI data was also correlated with neuropsychological and behavioural data. In Experiment One, results suggested that TBI participants were as able as healthy control participants to comprehend sarcasm, given explicit prosodic and contextual cues, though they struggled with drawing literal inferences and did not benefit as much from priming when comprehending questions. Correlations suggested that their difficulties inferring others' literal intentions related to poor emotion identification, and these difficulties also linked to aggressive behaviour. In Experiment Two, reaction times were significantly faster in literal contexts, on factual questions and on the second of the two questions presented. No statistically significant differences were found between the low and moderate aggression groups on their reaction times or error rates. Overall, these findings shed more light on the appreciation of sarcasm after TBI and the role that language, and in particular sarcasm, plays in modulating aggressive behaviour.

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ABBREVIATIONS

ABI: Acquired brain injury
BIRT: Brain Injury Rehabilitation Trust
BPAQ: Buss-Perry Aggression Questionnaire
EET: Emotion Evaluation Test
IQ: Intelligence Quotient
LH: Left hemisphere
MoCA: Montreal Cognitive Assessment
NHS: National Health Service
RH: Right hemisphere
RT: Reaction time
SI-M: Social Inference-Minimal
TASIT: The Awareness of Social Inference Test
TBI: Traumatic brain injury

1. INTRODUCTION

Traumatic brain injury (TBI) is a form of acquired brain injury (ABI) that is commonly seen in children, adolescents, young adults and the elderly, and is more common in men than women (Langlois, Rutland-Brown & Thomas, 2004; Yates, Williams, Harris, Round & Jenkins, 2006). TBI is said to be the leading cause of death and disability in young people (Ghajar, 2000), and, in survivors of TBI, it is associated with devastating cognitive, behavioural and emotional sequelae, collectively referred to as neurobehavioural sequelae (Wood, 2001).

Agitation, irritability and aggression are common following TBI (Silver, Yodofsky & Anderson, 2005). Behavioural and personality changes such as increased temper, irritability and childishness, are commonly reported by relatives in the short term (McKinlay, Brooks, Bond, Martinage & Marshall, 1981) and longer term (Brooks, Campsie, Symington, Beattie & McKinlay, 1986). These changes have been associated with difficulties with social adjustment for the individual (Cattran, Oddy, Wood & Moir, 2011) and the magnitude of behavioural and personality changes have been found to be the best predictor of strain amongst families (Brooks et al., 1986).

In addition to behavioural changes, impairments in language comprehension and production are common after TBI (Levin & Chapman, 1998). It is well known that global language difficulties, such as aphasia, can be detrimental to an individual's wellbeing and social functioning; however, more subtle language deficits can also have significant implications. Research indicates that the location of the brain injury dictates the type of language impairment, with the left hemisphere (LH) broadly being associated with verbal, linguistic processing and the right hemisphere (RH) with non-verbal, emotional elements of language (Buchanan et al., 2000). RH damage after TBI has been associated with many different deficits in pragmatic communication (McDonald, 2000) such as verbosity and inability to identify emotional cues or indirect meanings in language, and approximately 50% of people who suffer a RH TBI will experience some form of associated language difficulty (Joanette, Goulet & Daoust, 1991). Given that communication is so important to social adaptation and psychological wellbeing (Prigatano, Roueche & Fordyce, 1985), further research into the impact of these difficulties is necessary.

Empirical evidence exists that broadly links language deficits and aggressive behaviour in people with TBI (Alderman, Knight & Morgan, 1997; James & Young, 2013), and

Miller, Collins and Kent (2008) have proposed a theory that implicates language skills as central to the modulation of impulsive aggression. Interestingly, it has been suggested that figurative (indirect) language has a role in modulating and often diluting emotional intensity of language (Dews & Winner, 1995; Gibbs, Leggitt & Turner, 2002). However, no research to date has focused specifically on the role of figurative language in modulating aggressive behaviour.

Sarcasm is a particularly interesting form of figurative language as it is considered a form of verbal aggression where negative and critical attitudes are conveyed in a polite and socially appropriate manner (Cheang & Pell, 2008; Haiman, 1998). In addition, sarcasm is associated with social cognition, i.e. relating to and making sense of other people in order to communicate effectively and coordinate with the social world (Fiske & Taylor, 2013). Recently, McDonald (2013) has argued that there is a need for more tests of social cognition that are able to help make predictions about social functioning and to further understand and dissociate deficits following TBI, with a view to guiding rehabilitation.

The current study attempts to tie together two areas of research, namely figurative language difficulties and aggression after TBI, and aims to shed more light on the relationship between the appreciation of sarcasm and aggressive behaviour after TBI.

1.1 Traumatic brain injury

Traumatic brain injury (TBI) is defined as damage to the brain as a result of a single or multiple traumas (Gennarelli & Graham, 2005) and is considered an important global public health problem (Langlois, Rutland-Brown & Wald, 2006). Motor vehicle accidents are a common cause of TBI, along with falls, assaults and sports related injuries (Kraus & Chu, 2005). Often secondary brain injury, as a result of brain swelling and associated problems, is a major cause of disability or even death following the initial TBI (Ghajar, 2000; Murray & Lopez, 1997). Severity of TBI is typically determined by the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) score which reflects level of consciousness at the scene of the injury and is used to grade the TBI as either mild, moderate or severe (see Ghajar, 2000, for more information). Increased severity of injury, as per GCS score, is a reliable predictor of poorer prognosis (Brain Trauma Task Force, 2000).

1.1.1 Prevalence and risk factors

Tennant (2005) reported that, between the years 2001-2002, 112,718 people were admitted to hospital in the UK with a TBI. This reflects an incidence of approximately 229 cases per 100,000 people per year. With regards to prevalence elsewhere around the world, numbers vary greatly, and can even vary within the same area from study to study due to sampling methodology. In the United States, Silver, Kramer, Greenwald and Weissman (2001) found 8.5% of a community population self-reported experiencing a severe TBI, and for mild-moderate injuries that do not require institutionalisation an incidence of 618 per 100,000 people per year was found by Sosin, Sniezek and Thurman (1996), again according to self-report.

Common risk factors include gender, age and socio-economic status. It is consistently the case that rates of TBI are higher in men than in women, and rates are high for children, adolescents and the elderly (Langlois et al., 2004; Yates et al., 2006). Bruns and Hauser (2003) reported that men were up to four times more likely than women to suffer a TBI in late adolescence/early adulthood, and Yates et al. (2006) suggested this was due to their involvement in particular leisure/occupational activities. Socioeconomic status seems to be a risk factor also (Kraus & McArthur, 2006). Tennant (2005) linked the socioeconomic factors of unemployment and being unable to work due to ill health to higher incidence of TBI. In addition, Yates et al. (2006) found that rates were higher for people living in urban compared to rural areas, and social deprivation linked with higher TBI rates in childhood.

Other specific groups of people at high risk of TBI include homeless people, people in prisons and, perhaps unsurprisingly, military personnel. In terms of homelessness, in the UK TBI is significantly more common in homeless populations, compared to matched controls, at a rate of 48% to 21% (Oddy, Moir, Fortescue & Chadwick, 2012). In addition, there is over-representation of TBI in UK prison populations, with one study reporting a prevalence of over 60% (Williams et al., 2010), and a similar picture is seen in prisons around the world (Ferguson, Pickelsimer, Corrigan, Boger & Wald, 2012; Schofield et al., 2006). Williams et al. (2010) highlight that in the UK, individuals with a TBI entered the custodial system at a younger age, spent more time in prison and had an increased rate of repeat offending. In addition, a recent UK study found significant neurobehavioural and neuropsychological disability associated with prisoners who self-reported TBI (Pitman, Haddlesey, Ramos, Oddy & Fortescue, 2015). Finally, considering another high-risk group, military personnel, a US based study reported the prevalence of

mild TBI in soldiers returning from conflicts to be 15% (Hoge et al., 2008), whereas in the UK prevalence rates for mild TBI have been reported at 4.4%, increasing to 9.5% for those in a direct combat role (Rona et al., 2012).

Given the above findings, TBI is more common than many people might expect, is over-represented in certain groups, and consistent risk factors include being young, male and of low socio-economic status.

1.1.2 Impact and consequences of TBI

The impact of TBI can be wide-ranging and difficult to predict, though often it has catastrophic consequences. TBI is reported to be the leading cause of permanent disability in adults under the age of 40 (Fleminger & Ponsford, 2005), and psychological difficulties, incorporating disturbances of mood, cognition and behaviour, are a major cause of this long term disability (Fann, Katon, Uomoto & Esselman, 1995). In addition, TBI can have a significant impact on family members and surrounding systems; relationships are strained and family members feel burdened, particularly at the point of transition from hospital to home (Brooks & McKinlay, 1983; Fisher, Lennon, Bellon & Lawn, 2015; Ponsford et al., 2014; Turner et al., 2007).

It is no surprise, therefore, that TBI is linked to high levels of unemployment (Ponsford et al., 2014; Prigitano, Pepping & Klonoff, 1986), offending and imprisonment, as discussed above (e.g. Williams et al., 2010), and homelessness; 90% of homeless people who self-report a TBI have obtained the injury *prior* to becoming homeless (Oddy et al., 2012). In terms of recovery and change over time, a recent longitudinal study (Ponsford et al., 2014) found little change across three time points (two, five and ten years post-injury) in many areas of cognitive impairment, and an increase in difficulty was reported for planning, socially inappropriate behaviour, following conversations and being understood when speaking. In addition, there was an increase in reports of difficulties with personal relationships, social isolation and making friends, and reported difficulties with anxiety and depression did not change significantly over the three time points.

1.1.2.1 Neurobehavioural sequelae

Considering the psychological impact of TBI, mental health difficulties are very common; for example, prevalence of depression post-TBI has been reported at 42%

(Kreutzer, Seel & Gourley, 2001) and clinically significant levels of anxiety and depression have been reported at a rate of 50% up to 7 years post-TBI (Anson & Ponsford, 2006). In addition, an increased risk of depression, phobia, panic disorder, obsessive compulsive disorder (OCD), substance abuse and suicidality was found post-brain injury (Silver et al., 2001). These difficulties can be longstanding and hugely debilitating. Koponen et al. (2002) found that in a sample of 60 Finnish individuals, on average 30 years post-injury, nearly 50% presented with Diagnostic and Statistical Manual axis 1 disorders (4th edition; DSM-IV; American Psychiatric Association, 1994) that began after their TBI, with major depression, alcohol abuse or dependence, panic disorder and specific phobia being the most common (26.7%, 11.7, 8.3% and 8.3% respectively).

Behavioural difficulties are also very common after brain injury and are frequently reported by relatives (Brooks et al., 1986; Brooks, & McKinlay, 1983; Kinsella, Packer & Olver, 1991). Behavioural difficulties can arise for a number of reasons including impaired behavioural control as a direct result of injury to the brain, confused mental state, frustration and struggling to come to terms with disability and the potential impact of psychological trauma (Johnson & Balleny, 1996). In terms of prevalence, Deb, Lyons and Koutzoukis (1999) reported that one year post-injury, 40% of adults hospitalised after TBI displayed three or more behavioural symptoms such as irritability, lack of initiative and social disinhibition. More recently, in an Australian sample of adults with TBI in community rehabilitation programmes, the rate of post-injury challenging behaviours was reported at 54% (Sabaz et al., 2014). The most common of these behaviours were adynamia, at a rate of 23.1%, aggression, at a rate of 31.9%, and inappropriate social behaviour, at a rate of 33.3%, and more than a third of the sample displayed more than one challenging behaviour. Rates have been found to be much higher when reported by the family members of people with a TBI who have been discharged home, with behaviour change reported in 79% of individuals, with 58% resulting in significant problems at home (Johnson & Balleny, 1996). In this same study, behavioural difficulties, particularly aggression, were reported to worsen over a three year period, as rated by the family members. Aggression will be discussed further in section 1.2 below.

With regards to cognition, TBI is very often associated with multiple and varied cognitive impairments which depend on the location and severity of injury (Lezak, Howieson, Loring, Hannay, & Fischer, 2004). Impairments of processing speed, attention, memory, working memory, perception, visual-spatial and visual-motor skills, abstract reasoning, executive functioning, language and social cognition are common post-TBI. Impairments

in any of these areas can be more or less visible and profound, and this variability is particularly striking in relation to language. Highly visible language impairments such as aphasia, which relates to problems with comprehending or producing language, are familiar to clinicians and researchers in the area and can have hugely debilitating consequences (Levin & Chapman, 1998). There are, however, many more subtle and less visible impairments of language comprehension and production that can present after TBI which can be equally debilitating (e.g. Beeman & Chiarello, 1998). In particular, deficits with understanding and using indirect, figurative language are of particular interest to this study because of their links with social behaviour and social cognition. Figurative language will be further explored in this chapter in section 1.3.

Social cognition has been described by McDonald (2013) as “the capacity to attend to, recognise and interpret interpersonal cues that guide social behavior” (p. 231); social cognition “enables us to predict the behavior of others, share experiences and communicate effectively” (p.231). Deficits in social cognition have been reported after TBI (McDonald, 2013) and findings by Spikman, Timmerman, Milders, Veenstra and van der Naalt (2012) suggest that social cognition impairments (theory of mind, empathy and emotion recognition) were not due to or related to more general (non-social) cognitive deficits. Cummings (1995) and Tekin and Cummings (2002) suggest that impairments of social cognition are associated with injury to subcortical networks of the frontal lobe, incorporating the orbitofrontal cortex and ventromedial prefrontal cortex (terms often used to describe largely overlapping areas; Spikman et al., 2012).

Cognitive and behavioural difficulties are often considered to be the most problematic consequences of severe TBI as rated by patients and carers (Oddy, Coughlan, Tyerman & Jenkins, 1985) and create the most burden for families, even after rehabilitation (Ponsford, Olver, Ponsford & Nelms, 2003). Draper and Ponsford (2008) reported that following rehabilitation, many cognitive and behavioural difficulties are present up to 10 years post-injury. In addition, Oddy et al. (1985) point out that lack of awareness into, and underestimation of, cognitive and behavioural difficulties can often cause more of a problem than the actual difficulties per se. Prigatano, Altman and O’Brien (1990) discuss the underestimation of behavioural limitations in the context of social and emotional interactions, such as handling arguments, control of temper flexibility in the face of unexpected change, and recognising when others are upset by something you have said. These elements of social cognition and aggressive behaviour are of particular interest to this research, and the next section of this chapter will focus on aggression.

1.2 Aggression

Aggression has been defined as any behaviour directed towards another person with an immediate intent to cause harm, and where “the perpetrator must believe that the behaviour will harm the target and that the target is motivated to avoid the behaviour” (Bushman & Anderson, 2001, p. 274).

1.2.1 Types of aggression

Two main dichotomies are used to understand aggression; reactive-proactive, referring to the underlying function of the behaviour, and direct-indirect, which refers to the form of aggression (Little, Henrich, Jones & Hawley, 2003). These are discussed further below.

1.2.1.1 Reactive-proactive aggression

The reactive-proactive dichotomy relates to the similar dichotomies of impulsive-premeditated (Stanford et al., 2003) and hostile-instrumental (Bushman & Anderson, 2001). Vitaro and Brendgen (2005) describe reactive aggression as an impulsive response to real or perceived threat, provocation or frustration, whereby the aim is to hurt the perpetrator. The term relates to the similar concepts of hot-blooded, defensive, hostile, impulsive and emotional aggression. Proactive aggression, on the other hand, is an acquired/learnt behaviour, driven by anticipated gains considered contingent on the aggressive act; “proactive aggression can be used as an instrumental means to secure goods from others or to dominate others” (Vitaro, Brendgen & Barker, 2006, p.15). It is synonymous with the ideas of coldblooded, offensive and instrumental aggression.

These aggressive subtypes have been distinguished by pharmacological and neuropsychological findings (Barratt, Stanford, Felthous & Kent, 1997; Barratt, Stanford, Kent & Alan, 1997). Dodge (1991) describes the roots of these subtypes of aggression being grounded in childhood experiences, with reactive aggression developing out of a threatening and inconsistent environment, and proactive aggression manifesting as a result of a supportive environment but one where role models use aggression to achieve goals and resolve conflict.

1.2.1.1.1 Reactive (impulsive) aggression

With regards specifically to the reactive, or impulsive, subtype of aggression, which is of

particular interest to this study, Miller et al. (2008) describe this form of aggressive act as being a 'hair-trigger' response which is disproportionate to the stimulus. The disproportionate nature and loss of control is often recognised after the event leading to feelings of remorse. Reactive or impulsive aggression can be separated into three subcategories; verbal aggression, physical aggression towards people and physical aggression towards objects (Yudofsky, Silver, Jackson, Endicott & Williams, 1986) which are thought to be distinct and associated with different neurobiological pathways (Miller et al., 2008).

Miller et al. (2008) outline the defensive rage model which has often been used to understand impulsive aggression. Derived from animal research, they describe defensive rage as an automatic reaction to significant threat that involves neurological pathways including the medial nucleus of the amygdala, the dorsal periaqueductal gray and the medial hypothalamus. The anterior cingulate cortex and the orbital prefrontal cortex are thought to be involved in the inhibition of defensive rage, and abnormalities in these areas have been linked to the states of dyscontrol and hyperarousal observed in impulsive aggressors (for a full review see Miller et al., 2008).

1.2.1.2 Direct-indirect aggression

The second major aggression dichotomy, direct-indirect, refers to the form of the aggressive act. Direct aggression is also known as physical aggression, and indirect is also known as social or relational aggression, and this distinction has received psychometric support (Little et al., 2003).

Indirect aggression involves targeting a victim circuitously, often through other people and other relationships, in such a way that the behaviour is seen as not overtly aggressive and yet still causes significant distress to the victim (Archer & Coyne, 2005). This can involve teasing to cause humiliation, ostracism and deliberate social exclusion, spreading of rumours and spiteful gossip and emotional manipulation. Kaukiainen et al. (1999) found that indirect aggression was associated with higher levels of social intelligence and social abilities, such as interpreting the social cues of others and interacting socially to achieve goals. They also found that it linked with lower levels of empathy. Indirect aggression has been shown to be more common in older adulthood, perhaps when social skills are more developed (Walker, Richardson & Green, 2000).

Archer and Coyne (2005) discuss the evolutionary advantages of indirect aggression in having less cost to the aggressor than more direct forms of aggression, for example less retaliatory responses, and suggest it is used more often in environments where there would be more serious repercussions for use of direct aggression, for example in a work place. Furthermore, whilst indirect aggression has been associated with a larger social network and perceived popularity (Green, Richardson & Lago, 1996; Xie, Cairns & Cairns, 2002), direct aggression has been associated with rejection by peer group and symptoms of depression (Leadbeater, Boone, Sangster & Mathieson, 2006).

1.2.2 Gender differences

Considering gender differences in aggression, a meta-analysis by Archer (2004) found that men are more likely than women to display direct aggression, particularly physical and extremely violent aggression. This sex difference was observed as early on in development as two years old, and becomes larger between the ages of 18-30 years. This gender difference has been less clear cut with regards to verbal aggression, particularly in younger groups, whereas in an older population men demonstrate more verbal aggression than women. Interestingly, despite the gender differences in behavioural manifestations of aggression, the subjective experience of anger does not show a gender bias (Fischer et al., 1993). This finding challenges the stereotype that associates anger with men (Plant, Hyde, Keltner & Devine, 2000), and raises the question as to how women manage and respond to their anger differently. This may be explained by findings that females exhibit more indirect aggression than males, particularly in teenage years, for example age 11-17 years (Archer, 2004).

1.2.3 Aggression after brain injury

Aggressive behaviour is frequently seen after brain injury, with verbal aggression being more common than physical aggression (Alderman, 2007). Aggression after TBI has been found to be associated with depression and low satisfaction with life (Alderman, 2007) and with a breakdown in relationships (Wood, Lioffi & Wood, 2005).

1.2.3.1 Prevalence

Agitated and aggressive behaviour is very common after acquired brain injury (ABI). A recent study found that 41% of patients in the early rehabilitation phase following

neurosurgery after a TBI exhibited agitated behaviour, and a third of these were classed as severely agitated (Wolffbrandt, Poulsen, Engberg & Hornnes, 2013). With reference to more overtly aggressive behaviours, Rao et al. (2009) reported that 28.4% of individuals seen within three months of their brain trauma showed aggressive behaviour (verbal and physical), as measured with the Overt Aggression Scale (OAS; Yudofsky et al., 1986). They noted that verbal aggression was much more common in the acute phase. Furthermore, aggression rates across a nine week assessment period in a post-acute residential neurorehabilitation unit indicated that 59.7% of individuals with TBI displayed verbal aggression, and 33.8% displayed acts of physical aggression (James & Young, 2013).

Interestingly, even years after the injury, similarly high rates of aggressive behaviour have been recorded. Again using the OAS, Baguley, Cooper and Flemingham (2006) reported that 25% of patients with a TBI in a specialist rehabilitation service displayed aggressive behaviour, and this rate remained stable over time, up to the last follow-up at the five year point. In addition, one study that obtained reports from family members found that violence and aggression increased significantly over a five year period (Brooks et al., 1986).

1.2.3.2 Why is aggression common after brain injury?

Post-brain injury aggression is often related to injury to the brain's frontal lobes, which leaves an individual less able to regulate and inhibit behavioural impulses, resulting in impulsive behaviour (Grafman et al., 1996; Pardini et al., 2011; Tateno, Jorge & Robinson, 2003). However, some studies do not indicate there being a role of injury location in presence of aggressive behaviour (Alderman, 2007; Baguley et al., 2006; Wood & Lioffi, 2006). In addition, with regards to severity of injury, some studies suggest this is significantly related to aggression (Miller et al., 1999) whereas others have found injury severity to be unrelated to aggression (Tateno et al., 2003; Wood & Lioffi, 2006). Alderman (2007) and Baguley et al. (2006) found that younger age at injury was associated with a higher incidence of aggression and greater severity. In addition, depression has been correlated with aggression after TBI (Baguley et al., 2006; Rao et al., 2009). Baguley et al. (2006) demonstrated the significant role of these factors over time, finding that younger age at injury and presence of depression remained significantly associated with aggression at six, 24 and 60 months post-injury.

Pre-morbid personality and behavioural tendencies are also thought to be important in predicting post-brain injury behaviour. This was supported by Greve et al. (2001) who found that evidence of aggressive behaviour pre-morbidly, as measured by the Lifetime History of Aggression questionnaire (LHA; Coccaro, Berman & Kavoussi, 1997), was more common in individuals who displayed aggression post-TBI than those who did not. In addition, they found that significantly more aggressive TBI patients had impulsive personality traits, as measured by the Barratt Impulsiveness Scale-11 (BIS; Patton, Stanford & Barratt, 1995), compared to TBI patients who were not aggressive. The authors concluded that the combination of a pre-morbid impulsive and irritable personality, and disinhibition and inflexibility as a result of the TBI, is most likely to result in overt aggressive behaviour. The role of pre-morbid aggression was also highlighted by James and Young (2013), however this was only found to predict verbal aggression, but not physical aggression. Alderman (2007), on the other hand, found no such association between post-TBI aggression and pre-morbid characteristics.

Finally, aggression after TBI has been linked to cognitive ability. Wood and Liossi (2006) found that as verbal memory and visuo-spatial test scores decreased, frequency of aggressive behaviour after TBI increased. They argued that verbal ability has a critical role in mediating interpersonal conflict and modulating aggression. This is a central question to this piece of research, and one which will be discussed further in the following section.

1.2.4 Aggression and language

Non-clinical research findings in the aggression literature have linked history of impulsive aggression with low verbal ability in a prison population (Barratt et al., 1997) and in a college sample (Stanford, Greve & Gerstle, 1997). Similar patterns have been found in a brain injury sample. James and Young (2013) explored factors that predicted verbal and physical aggression in individuals with an ABI who were residing in post-acute neurorehabilitation units. They found that, alongside use of psychotropic medication, poor verbal functioning, assessed by the Wechsler Adult Intelligence Scale – 3rd edition (WAIS-III; Wechsler, 1997) Verbal Comprehension Index, was a significant predictor of verbal and physical aggression following ABI.

One way to explore the link between verbal skills and aggression is to look at the triggers for aggressive behaviour after ABI. Alderman et al. (1997) identified the events which occurred prior to an aggressive behaviour (the antecedents) within a hospital inpatient

neurorehabilitation setting. They developed the Overt Aggression Scale - Modified for Neurorehabilitation (OAS-MNR; appendix 1) which is an adapted form of the OAS that incorporates categories to systematically code the type of antecedents to the behaviour and the interventions employed after the behaviour. Their data revealed that most aggressive behaviours were displayed during structured rehabilitation time during which there was verbal interaction with others, e.g. in conversation, following a verbal prompt or in response to others' verbal behaviour. Although the authors noted that crude recording of antecedents is not enough alone to understand why participants behaved aggressively, they hypothesised that poor communication skills may contribute to aggressive behaviour.

A follow-up study, similarly using the OAS-MNR in a neurorehabilitation unit, showed that in cases with no obvious antecedent, low language function was the common factor linking cases of physical aggression towards others (Alderman, Knight & Henman, 2002). The authors also identified that these acts of aggression without clear antecedents were more difficult to manage, and needed more intrusive interventions, than acts by people with preserved language function, or acts by the same individuals where there were clear antecedents. Furthermore, Alderman (2007) reported that over 80% of physical assaults on others were accounted for by brain injured patients who displayed the most neurobehavioural disability and impairment of communication. Thus, these studies highlight the significance of language function to triggering and also managing aggressive behaviours after ABI.

1.2.4.1 Why is language important in regulating aggression?

Wood and Lioffi (2006) have argued that poor verbal skills limit the ability to verbally negotiate and resolve interpersonal conflict, and thus regulate aggressive behaviour. They suggest that this is further impacted by impulsivity.

Miller et al. (2008) attempted to explain the findings discussed above in more detail by describing a model in which language is important in the modulation of impulsive aggression. They argue that linguistic processing is key in helping the regulation of aspects of executive functioning that serve to inhibit aggressive impulses, including cognitive restraint, emotional control and adaptation, deductive reasoning and reflection. They hypothesise that activation of brain regions associated with language processing helps to dampen down limbic (e.g. amygdala) responses which might otherwise result in

a purely emotional and behavioural response, i.e. impulsive aggression. They discuss the significance of the anterior cingulate cortex and the pre-frontal cortex in integrating information and inhibiting responses, in particular defensive rage.

In studies which have explored the neuroanatomy of behavioural inhibition, Pietrini, Guazelli, Basso, Jaffe and Grafman (2000) linked right hemisphere homologues of left hemisphere language processing regions with the cognitive restraint of aggression. In addition, orbitofrontal cortex activation (seen through PET study) in response to anger has been proposed to play a key role in the inhibition of aggressive behaviour (Dougherty et al., 1999). Furthermore, considering emotional regulation, which seems inextricably linked with behavioural control, research exploring its neural correlates has demonstrated the involvement of Broca's area (associated with language production), the amygdala and the premotor cortex in a task requiring verbal cognitive reappraisal of fear responses to wilfully regulate emotions (Kim & Hammon, 2007). Ochsner, Bunge, Gross and Gabrieli (2002) argued that the prefrontal cortex has an important role in the use of cognitive strategies to modulate responses to emotional stimuli. They used fMRI to monitor neural activity during a task in which participants were asked to mentally reappraise negative stimuli until they no longer elicited a negative emotion. The reappraisal involved creating an alternative story about the image they saw, for example seeing a woman crying outside a church and interpreting the context as a wedding rather than a funeral. This reappraisal reduced the participants' subjective negative experience of the stimuli and, in terms of neural activity, increased activation was seen in the lateral and medial prefrontal regions, along with a reduction of activity in the medial orbitofrontal cortex and the amygdala. This study, then, suggests that internal verbal reappraisal strategies can influence some control over the emotion processes that have a role in evaluating the contextual and emotional relevance of a stimulus.

Furthermore, Gyurak et al. (2009) considered the role of executive function on the behavioural manifestation of emotional regulation, operationalised by measuring facial expression and body movement in response to a startling stimulus. They found that higher scores on a verbal fluency task were significantly related to the ability to regulate emotions. No other test of executive function that they utilised (tests of working memory, task-switching and inhibition) had the same relationship with emotional regulation. Again these results link verbal skills with control over emotionally driven behaviour.

Miller et al. (2008) also suggested an alternative explanation of the language-aggression link whereby defensive rage causes inactivation of the language processing brain regions

and thus verbal modulation or reappraisal becomes impaired, leading to impulsive aggression. They concluded that impulsive aggression may result from multiple aetiologies and they recommended that further research is conducted into the dimensions of language processing that may be involved.

Although there is research demonstrating an association between language impairment and aggression, the language impairments and verbal skills that are discussed in the literature have been described very broadly to date. The generality of the discussions around the role of language in aggression are not very helpful for furthering understanding given that language impairment following brain injury is often multifaceted and incredibly complex. Research that has concentrated on more specific aspects of language in relation to emotion and behaviour, particularly aggression, focuses on figurative, non-literal language. Gibbs et al. (2002) discuss the idea that figurative language has an important role in modulating emotional intensity. They explain that unlike literal language, figurative language has the ability to communicate subtle nuances of emotion whilst maintaining emotional control. Figurative language, such as irony and sarcasm, has been found to dilute the emotional impact of language (Dews & Winner, 1995). For example, when an individual feels angry towards another individual, by using indirect, figurative language in communicating this anger, the risk of offending or upsetting the individual is reduced. This further highlights the role that language seems to have in modulating aggression, and these more indirect, non-literal uses of language will now be explored.

1.3 Figurative language and sarcasm

This section will first discuss different forms of figurative language, and will then focus specifically on sarcasm. The use of sarcasm in everyday language will be explored, followed by how sarcasm can be affected after brain injury.

Figurative language is a heterogeneous group of speech forms that imply more than their literal meanings, and which require the non-literal meaning to be processed in order to grasp the intention of the speaker (Rapp & Wild, 2011). It is generally accepted that metaphors, idioms, proverbs, metonymy, irony and sarcasm are among the most important forms of figurative language (Rapp & Wild, 2011).

1.3.1 Role of the right hemisphere in figurative language

Figurative language is most commonly associated with involvement of the right hemisphere (RH) of the brain in processing. Although less widely recognised, and often less overtly apparent, the RH does play an important role in language processing. It is generally accepted that the RH is involved in affective/non-verbal processing and the left hemisphere (LH) with linguistic processing (Buchanan et al., 2000). The lack of awareness into the contributions of the RH to language comprehension and production may be due to the more subtle impact on language after RH damage, compared to the more overtly catastrophic consequences of LH damage (Lindell, 2006). Beyond the widely recognised aphasia disturbances associated with LH damage, there are many other specific and subtle language impairments, often resulting from damage to the brain's RH, which can have a huge impact on an individual's linguistic functioning and quality of communication (Beeman & Chiarello, 1998).

RH language deficits have been researched using neuroimaging, visual hemi-field tests, dichotic listening tests, as well as looking at deficits evident in brain injured individuals (Kacirik & Chiarello, 2007; see Tompkins, Klepousniotou & Scott, 2013 for a review). Aspects of language function that have become associated with the RH include prosody (Pell, 1999), pragmatics (Kaplan, Brownell, Jacobs & Gardner, 1990), discourse (Beeman, 1993; Lojek-Osiejuk, 1996), interpretation of humour (Johns, Tooley & Traxler, 2008; Shammi & Stuss, 1999), interpretation of metaphor (Bottini et al., 1994; Klepousniotou, Gracco & Pike, 2014; Winner & Gardner, 1977) and interpretation of sarcasm (Shamay-Tsoory, Tomer & Aharon-Peretz, 2005). Joannette, Goulet and Daoust (1991) report that approximately 50% of individuals with RH damage will experience difficulty in at least one of these areas.

1.3.1.1 Impact of RH damage

Although RH language deficits are considered 'subtle', they can have significant psychological and functional impact on the individual with the injury and the people around them. Prigatano et al. (1985) discuss the impact of RH damage on social adaptation, suggesting that the ability of the individual to communicate in social and vocational settings is very often compromised and can lead to unemployment and social isolation. They also highlight that non-aphasic disorders are likely to persist for longer than aphasic disorders. Unfortunately, RH language deficits are often neglected, or even go unnoticed, because common language tests are not designed to pick up on these RH

functions (Abusamra, Cote, Joannette & Ferreres, 2009).

When considering the impact that specific RH language deficits might have on receptive language, problems can arise with inferring intended meanings or emotional valence, leading, therefore, to miscommunications and misunderstandings (e.g. Beeman, 1993; Johns, Tooley & Traxler, 2008). In terms of language production, RH deficits may also cause problems for the speaker in communicating intentions, e.g. as a result of monotonous intonation (prosody) or less informative speech content (discourse), and may risk damaging relationships by being unable to use subtle, polite, indirect language (as in irony and sarcasm). Of particular interest to the present study is the RH contribution to the interpretation of sarcasm which is explored further below.

1.3.2 Sarcasm

Sarcasm has been described as a form of verbal irony, and is sometimes used interchangeably with irony. For the purpose of clarity these terms will be defined. Irony has been defined as “expressions in which the intended meaning of the words is different from or the direct opposite of their usual sense” (Cheang & Pell, 2008, p. 366). The same authors describe sarcasm as “verbal irony that expresses negative and critical attitudes toward persons or events” (Cheang & Pell, 2008, p. 366). Haiman (1998) states that the main differences between the two are that, firstly, whereas situations can be ironic, only people can be sarcastic, and secondly, whilst irony can be unintentional, sarcasm requires intention. He describes sarcasm as “overt irony intentionally used by the speaker as a form of verbal aggression” (Haiman, 1998, p.20) and states that we are ostensibly communicating a message whilst framing it with a meta-message that implies we do not really mean what we are saying; in fact we may mean the exact opposite.

1.3.2.1 Types of sarcasm and frequency of use

Sarcasm can be considered positive or negative (McDonald, 1999). In negative sarcasm, a positive comment is used to convey something negative, such as “you’ve been a big help!” when the person was not considered to be helpful. With positive sarcasm, a negative comment is said to communicate something positive, such as “you did a terrible job!” when someone did something very well. Positive sarcasm is thought to be less frequently used than negative sarcasm (Gibbs, 2000; Kreuz & Glucksberg, 1989; Slugoski & Turnbull, 1988).

The terms positive and negative sarcasm are closely related to the concepts of ironic insults and ironic compliments (Pexman & Olineck, 2002a). Ironic insults are similar to negative sarcasm (e.g. “a fine friend you are” when implying the friend is a bad friend) and ironic compliments are similar to positive sarcasm (e.g. “you’re a terrible friend” when meaning the friend is a good friend). In terms of frequency of use, in line with the more frequent use of negative sarcasm, Dews and Winner (1995) found that ironic insults were more frequently present in scripted American TV shows than were ironic compliments, with ironic statements overall being present on average four to five times per 30 minute episode. A similar pattern was seen in the case of everyday, spontaneous speech, with 69% of sarcastic remarks being negative sarcasm, 15% being positive sarcasm and 17% either being difficult to classify by this distinction or not fitting with this idea of a direct opposite implied meaning (Gibbs, 2000).

As raised by the Gibbs (2000) study, some instances of sarcasm cannot be understood as meaning the direct opposite of what is said. Channon, Pellijeff and Rule (2005) introduced the terms direct and indirect sarcasm to distinguish these types of sarcasm. Direct sarcasm refers to instances when the implied meaning is the direct opposite to the remark, and this is the most common use of sarcasm, whereas with indirect sarcasm the meaning is different, though not the direct opposite, to the remark. For example, in the context of someone burning a meal, the comment “you’re a great cook” would be considered direct sarcasm, whereas the comment “I’d hire you as a chef” would be considered indirect sarcasm. This distinction has been referred to by other researchers as direct and indirect irony (Dews et al., 1996) and simple and complex irony (Bucciarelli, Colle & Bara, 2003).

Considering the frequency of irony use in day to day conversations, Gibbs (2000) found that on average there were 4.7 instances of irony per 10 minute recorded conversation between college friends in the USA. He calculated that approximately 8% of their conversational exchanges included some form of irony. The term ‘irony’, in this study, was referring to jocularity, hyperbole, rhetorical questions, understatement and sarcasm. Sarcasm was rated as the second most likely form of irony, accounting for 28% of the ironic comments, and was used more by men than women (64% and 36% respectively). Furthermore, Rockwell and Theriot (2001) found a similar gender bias; men were more sarcastic overall than women, and both men and women used more sarcasm when interacting with men. In addition, Jorgensen (1996) showed that sarcasm was most commonly used between people who were familiar to one another, rather than unfamiliar, and was more often directed specifically at a present rather than absent individual.

Given the frequency of this style of communication, it is important to consider why it is so often used, and what communicative purpose it serves.

1.3.2.2 The function of sarcasm

Sarcasm is thought to have a number of functions such as to provide humour, to enhance the critical nature of a comment or conversely to reduce the critical nature of a comment and protect the speaker from coming across as overly critical, insulting or aggressive (Blum-Kulka, 1987; Colston, 1997; Dews, Kaplan & Winner, 1995; Gibbs, 2000; Haiman, 1998). In Gibbs' (2000) study, 74% of the sarcastic comments were considered humorous. Interestingly, 90% of sarcastic comments were considered mocking of other people, events or objects, and 54% were considered critical. These critical and mocking functions were significantly more common with sarcasm than any of the other forms of irony considered in the study.

In Jorgensen's (1996) research, the most common use of sarcastic irony was to criticise or complain to close friends, especially about trivial errors. The sarcasm served to save face so that the speaker was able to get their point of concern across more politely, without appearing to be insulting, unfair or thoughtless. Similarly, in their study about irony more generally, Dews et al. (1995) reported that irony functioned to allow the speaker to be perceived as more in control of their emotions, to soften an insult and in turn maintain relationships.

There is mixed evidence regarding how sarcasm is perceived. In some experimental studies, sarcastic criticisms have been judged as more polite (Brown & Levinson, 1978) and less aggressive (Dews & Winner, 1995) than direct criticism. However, other studies have found the opposite; sarcastic criticisms have been perceived as more offensive and aggressive than literal criticisms (Toplak & Katz, 2000). In an attempt to resolve these inconsistencies, Pexman and Ollineck (2002a) suggested that the perception of the sarcasm varies depending on the type of sarcasm used and specifically what is being asked to be judged, the social impression (e.g. politeness) or the intention of the speaker (e.g. to mock). They suggest that when compliments are made sarcastically (e.g. "you look terrible" when implying that someone looks great), they are judged as more mocking and less polite than direct compliments. On the other hand, insults made sarcastically (e.g. "you look great" when implying someone looks terrible) are again perceived as more mocking, but this time *more* polite than direct insults.

In terms of how people respond to sarcasm, in Gibbs' (2000) study, 33% of sarcastic remarks were responded to with some form of irony, 23% with a literal remark indicating understanding of the sarcasm and 13% with simple laughter thought to represent acknowledgement of the sarcasm. Twenty nine per cent of the time the addressee changed the subject or ignored the sarcasm and four per cent of the time the addressee's response indicated that they clearly did not grasp the sarcastic intent.

The above research indicates that the majority of the time receivers of sarcastic remarks identify these as sarcastic, however, occasionally this communication fails and the sarcasm is missed. The next section will consider what elements of the communication help to identify sarcasm as sarcasm indeed.

1.3.2.3 Identifying sarcasm

The ability to identify sarcasm is thought to depend on a number of different factors including specific acoustic and prosodic cues (Cheang & Pell, 2008; Haiman, 1998; Rockwell, 2000), context (Woodland & Voyer, 2011), beliefs about the speaker (Pexman & Olineck, 2002b), and socio-cultural factors (Katz, Blasko & Kazmerski, 2004).

Bryant and Fox Tree (2002) demonstrated that when sarcastic comments taken from a radio show were presented in writing, without any context, they were not rated as sarcastic. As soon as those comments were presented either auditorily or with a written context they were rated as sarcastic. This demonstrates the importance of prosodic cues and context in the identification of sarcasm. There has been debate in this research area regarding the relative roles of context and prosody. Whereas some researchers pay more attention to the role of context (e.g. Ivanko & Pexman, 2003), specific prosodic cues have been favoured by others. For example, a study conducted by Voyer, Bowes and Techentin (2008) suggests that pitch alone is sufficient to identify sarcasm.

Considering speech cues, Rockwell (2000) reported that sarcasm is indicated by slower speed, lower pitch and raised volume. Haiman (1998) has identified a number of additional prosodic cues observed in sarcastic speech including comments being accompanied by sneers and laughter, presence of an inverse pitch obstruction (where the stressed syllable has a lower pitch than the neighbouring syllables), emotively inappropriate intonation (e.g. positive words stated with negative tone), exaggeration and caricature, flattening of affect/apathy, sing-song like melody, monotonous tone and

separation with pauses. In addition, Haiman (1998) also highlights that some specific words or phrases have become closely linked to sarcasm, due to frequent use, that they automatically signal sarcasm without the need for prosodic cues.

In response to criticisms of the term ‘ironic tone of voice’ (which features slower tempo, heavy stress and an increased nasal sound; Kreuz & Roberts, 1995) as being too general and unhelpful in reference to sarcastic speech, Cheang and Pell (2008) have considered more specifically the sarcastic tone of voice. They conducted acoustic analyses of utterances spoken in English that were sarcastic, humorous, sincere or neutral. They found that compared to the other types of utterance, sarcastic utterances were associated with reductions in mean fundamental frequency (related to pitch variation) and harmonics to noise ratio (related to changes in voice quality), which in practice means sounding lower in pitch and more monotonous. Nasal resonance and speech rate also played a part in communicating sarcasm.

Recently, Woodland and Voyer’s (2011) research has highlighted an important interaction between both discourse context and tone of voice in the identification of sarcasm. In addition to this, Katz et al. (2004) highlight the role of socio-cultural context as well as context and prosody. They state that males are more likely to use sarcasm than females, and sarcastic comments spoken by males have been rated as more sarcastic than by females. In addition, they argue that social class and occupation play a role; lower classes and occupations such as comedians and factory workers are more likely to use sarcasm and irony and thus comments made by people in such occupations are perceived as more sarcastic.

1.3.2.4 Neural basis of sarcasm and sarcasm comprehension deficits

Consistent with the evidence discussed above implicating the RH with indirect, non-literal language, the ability to recognise sarcasm is also thought to be lateralised to the RH of the brain. Dichotic listening tasks, where processing of sounds directed to one ear indicates involvement of the opposite brain hemisphere (e.g. Grimshaw, Kwansy, Covell & Johnson, 2003), have been useful for demonstrating such lateralisation in non-clinical groups. For example, Voyer, Bowes and Techentin (2008) found that when sarcastic and sincere statements were played to either the left or the right ear, there was an overall left ear (RH) advantage for sarcastic stimuli, and a right ear (LH) advantage for sincere stimuli.

Difficulties interpreting sarcasm are present in many different groups of people. Some of these will be discussed below, and where the research references brain areas and pathways this information will be presented. This will be followed by a discussion about sarcasm comprehension difficulties after brain injury.

1.3.2.4.1 Sarcasm comprehension deficits

It is widely known that children struggle with fully decoding non-literal language (Ackerman, 1981; Capelli, Nakagawa & Madden, 1990). Interestingly, similar difficulties have also been observed at the opposite end of the age spectrum. Phillips et al. (2015) found that older adults (ages 65-86 years) were impaired at understanding sarcastic intent in verbal stories and in videos (from the Social Inference-Minimal task from The Awareness of Social Inference Test; TASIT; McDonald, Flanagan, Rollins & Kinch, 2003), when compared to younger and middle aged adults. They also found that the results on the video based task were mediated by emotional recognition, based on identification of emotions in facial expressions. These findings were in line with other reports of age related declines in a wide variety of social cognition tasks where decoding of mental state was tested (Henry, Phillips, Ruffman & Bailey, 2013).

In terms of clinical groups, difficulties interpreting non-literal language, including sarcasm, have been observed in individuals with semantic dementia (Rankin et al., 2009), frontotemporal dementia (Kipps, Nestor, Acosta-Cabronero, Arnold & Hodges, 2009), temporal lobe epilepsy and lobectomy (Cohn, St-Laurent, Barnett & McAndrews, 2015), Parkinsons Disease (Pell et al., 2014) and, perhaps most famously, autism spectrum disorders (Channon, Crawford, Orłowska, Parikh & Thoma, 2014).

In the semantic dementia group, Rankin et al. (2009) found that poor performance on the Social Inference-Minimal task from the TASIT was related to atrophy in three areas of the brain, and these areas have each been associated with a particular role in sarcasm comprehension as follows. Firstly, the reduced volume in the posterior parahippocampi was associated with inability to identify abnormal paralinguistic speech patterns. Secondly, the temporal poles were implicated and thought to be important for interpretative processing. Finally atrophy of the right medial frontal pole has been linked to difficulty reading social cues and inferring a speaker's intentions.

The role of the temporal lobe was further indicated in the cases of temporal lobe epilepsy and lobectomy (Cohn et al., 2015). The study indicated a link between overall social

inference abilities and left side hippocampal atrophy. Whereas sarcasm comprehension more specifically was linked to left anterior atrophy of the temporal lobe neocortex, considered by the authors to be “a convergence zone of higher-order perceptual and emotional processes, and of stored representations” (p.636).

1.3.2.4.2 Sarcasm comprehension deficits after brain injury

Further examples of the role of the RH in processing sarcasm can be seen in cases of ABI. For example, Giora, Zaidel, Soroker, Batori & Kasher (2000) found that when aphasia was controlled for, individuals with RH brain damage performed worse on a test of sarcasm comprehension than individuals with LH damage and healthy controls. This difference remained significant even when the ability to perceive emotional prosody was controlled for, suggesting that there is RH involvement in the comprehension of sarcasm that goes beyond detection of prosody.

Beyond the role of sarcastic prosody in identifying sarcasm, Channon et al. (2005) discuss the role of theory of mind, i.e. the ability to infer the mental states and intentions of others. They looked at comprehension of direct and indirect sarcasm in adults with ABI and healthy control participants. They presented sincere and sarcastic written sentences incorporating a context and a remark; participants were asked to explain the intended meaning of it. The results of their task demonstrated that participants with ABI were impaired on the sarcasm task compared to controls, and they struggled to comprehend the sarcastic comments significantly more than the sincere comments. However, there were no differences between type of sarcasm (direct or indirect). From the error analysis, the authors suggested that ABI participants were able to access the non-literal meanings, but were unable to correctly interpret these. This is in contrast to previous research (McDonald & Pearce, 1996) indicating that errors are usually due to making literal interpretations. Channon et al. (2005) suggested that, in their study, participants with ABI demonstrated an element of grasping the non-literal nature of the comments but they had difficulties working out the precise intended meaning. Channon et al. (2005) related the difficulties with interpreting intended meanings in sarcasm to difficulties with mentalising, i.e. being able to infer mental states and perspectives of others. Being able to appreciate a speaker’s intentions is important for all speech where alternative meanings are implied. This was evidenced in a study by Winner, Brownell, Happe, Blum and Pincus (1998) in which participants with RH brain damage had difficulty distinguishing lies from ironic jokes. The authors concluded that this was the result of being unable to attribute correctly the mental states of others. Channon and

Crawford (2010) studied this further and found that a group of patients with ABIs were consistently worse than healthy control participants on a number of measures assessing mentalising and the ability to take others' perspectives.

This social cognition element of sarcasm comprehension is suggestive of frontal lobe involvement, since theory of mind and mentalising is associated with the frontal lobes (and often the right frontal lobes) of the brain (Rowe, Bullock, Polkey & Morris, 2001; Stuss, Gallop & Alexander, 2001). Indeed the involvement of the frontal lobes in sarcasm comprehension has been supported by studies showing patients with prefrontal brain damage having difficulty interpreting sarcastic utterances and written scenarios (Channon et al., 2007; McDonald & Pearce, 1996; Shamay, Tomer & Aharon-Peretz, 2002).

In particular, Shamay-Tsoory et al. (2005) attempted to localise the neural bases for understanding sarcasm. They compared individuals with prefrontal lesions to individuals with posterior lesions on tasks requiring comprehension of sarcasm and social cognition. The sarcasm task consisted of audio recordings of conversational exchanges between two people, each ending with a comment that was either sarcastic (spoken with sarcastic intonation) or neutral (spoken with neutral intonation). Participants were then asked two questions assessing story comprehension (factual question) and comprehension of the speaker's true meaning (attitude question). Results demonstrated that patients with right ventro-medial prefrontal lesions had most difficulty detecting sarcasm compared to patients with posterior lesions and healthy control participants. The authors suggested that an integration of theory of mind (requiring frontal lobe involvement) and identification of emotions (associated with the RH) is necessary in order to understand sarcasm.

1.3.2.4.3 Impact of impaired sarcasm comprehension after brain injury

It is important to consider the effects of impaired sarcasm comprehension for individuals with brain injuries, and the people around them. We know that the ability to communicate is considered fundamental to social adaptation and psychological wellbeing (Prigatano et al., 1985), and the literature clearly indicates that communication difficulties after TBI are related to poor social integration and reduced quality of life (Galski, Tompkins & Johnston, 1998). In relation to the links to aggressive behaviour, it may be that people with TBI who experience difficulties identifying the non-literal meanings in sarcasm may experience offence in relation to comments, or simply not understand them, leading to frustration and in turn more overt displays of aggression. In addition, it is possible that

reduced ability to interpret sarcasm correctly might also indicate inability to actually use sarcasm. Thus, the lack of skills at communicating aggression subtly and socially appropriately may again manifest as more overt aggression.

These subtle difficulties over time may lead to communication breakdowns, further impacting relationships, having a compounding effect of frustration tolerance and aggressive behaviour. Thus, it is important to explore such potential links in more detail in order to assist understanding and development of rehabilitation and family support strategies.

1.4 Theories of sarcasm comprehension

Several theories have been suggested to account for the language deficits observed after RH brain damage, and the inability of such patients to appreciate non-literal language and alternative interpretations including sarcasm. Some of the most prevalent theories are outlined below. The first two models focus solely on processing non-literal language in the intact brain and do not make predictions about processing in the impaired brain. In contrast, the remaining three models make predictions about the processing of non-literal language not only in the intact brain but also following brain damage, and receive experimental support from studies with patients with LH and RH damage (in addition to evidence from studies with healthy participants).

1.4.1 The standard pragmatic model

Traditional theoretical positions have argued that sarcasm (and all figurative language) must be processed through typical linguistic routes first, after which context and pragmatics are considered. This manifests in slower reaction times when reading sarcastic material as the literal interpretation must be accessed first, before reaching the non-literal interpretation. This was the position of Grice (1975; 1978) and Searle (1975; 1979), whose work and theories have come to be referred to as the standard pragmatic model.

There is little experimental evidence in favour of this model and it has been criticised for being too simplistic in assuming a simple meaning substitution accounts for the complexity of processes that go on to interpret a comment as sarcastic (Kreuz & Glucksberg, 1989). In addition, evidence contradictory to this model has shown that non-

literal interpretations can be accessed before the literal if the context biases the non-literal interpretation (Gibbs, 1980; Turner & Katz, 1997).

1.4.2 The direct access model

Challenges to the standard pragmatic model as the ones raised above led to the development of theories which argue that the processing of literal and non-literal language follow similar mechanisms, resulting in similar reading/response times for literal and sarcastic material. Gibbs (1982; 1983; 1984) proposed the direct access model according to which literal meanings of indirect requests and non-literal language do not have to be activated before reaching the intended, non-literal meaning, assuming that there is an appropriate context. Therefore, unlike the standard pragmatic model, the literal meaning can be bypassed and the non-literal meaning directly activated.

Early evidence for this theory came from studies of healthy participants in which reading times for literal and non-literal utterances did not differ (Gibbs, 1986; Inhoff, Lima & Carroll, 1984). Furthermore, using methodology which tapped into on-line processes, Blasko and Connine (1993) found that whereas unfamiliar metaphors were processed literally before their non-literal interpretations were accessed, familiar metaphors could be processed and interpreted figuratively in parallel with the literal interpretation. However, later evidence did not consistently support this model. Giora (1995) found that literal meanings were being activated before the non-literal when processing ironic utterances.

1.4.3 The graded salience hypothesis

As a result of the contradictory evidence in relation to the previous two models, Giora (1997) presented the graded salience hypothesis. This hypothesis posits that literal and figurative language is processed and understood in terms of the salience of the language, i.e. what is the first meaning to be accessed. Factors that contribute to salience include familiarity, frequency and conventionality (Giora, 1999), therefore salience can be culture specific. For example, the interpretation of the word 'bank' might be interpreted as a financial institution for an urban-dweller, and a river-side for a rural-dweller.

When it comes to figurative language, Giora (1999) argues that there can be conventional (salient) and unconventional (non-salient) metaphors and ironies. When metaphor or irony is conventional (e.g. commonly used), the non-literal (figurative) interpretation is

the most salient and will be accessed first. In contrast, with non-conventional (e.g. novel) metaphor or irony, the literal meaning would be accessed first, as it is the most salient. If the activated salient interpretation is in fact incorrect and does not 'fit' (e.g. in unconventional irony), the non-salient interpretation is then accessed. Giora (1999) also states that conventional ironies can have both literal and non-literal interpretations in the mental lexicon, meaning both salient and non-salient interpretations can be activated.

Giora (1999) highlighted existing research that provides support for the graded salience hypothesis. For example, McGlone, Glucksberg and Cacciari (1994) showed conventional idioms to be processed faster than less conventional idioms. In addition, Turner and Katz (1997) found that the figurative meanings of familiar proverbs were accessed as quickly as the literal (non-figurative) meanings, whereas figurative meanings of unfamiliar proverbs were harder to access than the literal interpretations (the most salient).

When assessing sarcasm (where the figurative interpretations were considered non-salient) and metaphor (where the figurative interpretation was considered salient) comprehension in LH and RH brain damaged patients, Giora et al. (2000) found that RH damaged patients performed as well as controls on metaphor comprehension and that LH patients performed significantly worse. In contrast, on the sarcasm test, RH patients performed significantly worse than LH patients and controls. The authors argued that the RH is specialised for processing non-salient figurative language while the LH is responsible for salient figurative language processing.

1.4.4 The coarse semantic coding hypothesis

In a similar manner, the coarse semantic coding hypothesis (Beeman et al., 1994; Beeman, 1998) suggests that, when comprehending language, the LH activates narrow semantic fields (information closely related to the target word) and the RH activates wide semantic fields (distantly related words and concepts).

Evidence for this theory comes primarily from studies with healthy participants. Bowden and Beeman (1998) demonstrated that on problem solving tasks, information processed by the RH (left visual field) led to more creative and insightful solutions than information presented to the LH (right visual field), as the RH enables activation of distantly related concepts and less common interpretations. In addition, using functional brain imaging techniques, Seger, Desmond, Glover and Gabrieli (2000) found increased RH brain

activity when participants produced unusual verbs in a language task requiring distant associations to be made, as opposed to usual verbs. Furthermore, using a dichotic listening task, Techentin and Voyer (2007) demonstrated a left ear (RH) advantage for identifying the emotion in words when the word and the emotional tone were incongruent. The authors suggested that the RH advantage was observed because of the flexibility of the RH for creating distant associations.

The coarse semantic coding hypothesis attempts to explain the language deficits seen after RH injuries. For example, if the brain is unable to access large semantic fields, and relations cannot be made between semantic concepts which are distantly connected, it will be difficult to interpret non-literal, figurative language and draw inferences from ambiguous information. Though no study has looked directly at how this theory explains sarcasm and deficits in sarcasm interpretation after ABI, it follows that in order to understand the meaning of statements which are not literally true, or have double meanings, wide semantic activation may be required in order to access the multiple meanings and then draw the accurate inferences. Thus, the RH would be differentially involved when processing non-literal, sarcastic statements.

1.4.5 The suppression deficit hypothesis

Finally, the suppression deficit hypothesis, proposed by Tompkins and Lehman (1998), arose from the work of Gernsbacher, Varner and Faust (1990). Gernsbacher and colleagues put forward the idea of a mechanism that suppresses information that is irrelevant to the interpretation of a word. They suggested that people who show poor comprehension skills are less able to suppress irrelevant information than people with better comprehension skills (Gernsbacher & Faust, 1991). This research led to Tompkins and Lehman (1998) suggesting that individuals with RH brain damage, who display characteristic language deficits, are experiencing a suppression deficit; they struggle to suppress alternate and eventually incompatible word meanings.

Evidence for this theory comes primarily from studies with patients with brain damage. For example, Tompkins, Baumgaertner, Lehman and Fossett (1997) used 'on-line' computer based tasks to investigate the processing of words with multiple meanings (lexical ambiguities), e.g. 'spade'. Participants with and without brain injury were asked to judge whether an auditorily presented probe word (e.g. cards) fitted with the meaning of a short sentence with a lexical ambiguity (e.g. 'he dug with a spade') and without a lexical ambiguity (e.g. 'he dug with a shovel'). The ability to suppress the probe word

was measured by response times. Results showed that individuals with RH damage were slower to respond when there was a lexical ambiguity. This was interpreted to support the suppression deficit hypothesis as RH damaged patients found it more difficult to suppress irrelevant meanings of the probe word.

Although no studies have directly attempted to explain sarcasm comprehension in relation to the suppression deficit hypothesis, the theory might predict that difficulty comprehending sarcasm, following brain injury, is the result of an inability to suppress the literal interpretation of a sarcastic comment and select the inferred, intended meaning.

1.5 Research questions, hypotheses and predictions

In an attempt to further explore the hypothesis that language has a role in modulating impulsive aggression (Miller et al., 2008), this study attempted to consider the relationship between language comprehension, and more specifically sarcasm comprehension, and aggression. The study aimed to address the following research questions:

- 1.) Does TBI affect language comprehension (of both literal and sarcastic material)?
- 2.) Does TBI differentially affect sarcastic language comprehension?
- 3.) If TBI does differentially affect language, and in particular sarcasm, comprehension, does this link to aggressive behaviour?
- 4.) Does reduced ability to comprehend sarcasm in a non-clinical, young adult group relate to increased self-rated aggression?

These research questions were investigated in two experiments. Experiment One included a group of individuals with TBI and a group of healthy matched control participants. Experiment Two included young, healthy adults who were split into two groups (low and moderate aggression) by their scores on a self-report aggression measure, the Buss-Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992; appendix 5). In each experiment, all participants completed a computer-based task that involved reading and listening to audio vignettes, and responding to questions which assessed factual information (referring to details of the vignette) and attitude information (referring to the intent of the speaker in the vignette), following the method that Shamay-Tsoory et al. (2005) used. The audio vignettes were framed with either a sarcastic or non-sarcastic (i.e. literal) context. The two experiments were complementary in nature and have allowed us to

study a broad spectrum of aggression in individuals, from a clinical population that typically exhibits high aggression (i.e. TBI patients) to healthy young control participants on the low end of the aggression scale. The following predictions were made for each experiment:

In Experiment One, a group of TBI participants was compared to a group of matched healthy control participants. We hypothesised that, across both groups, literal contexts would be facilitated (producing faster reaction times; RTs) compared to sarcastic contexts. Furthermore, it was hypothesised that factual questions would be facilitated (producing faster RTs) compared to attitude ones. In addition, we expected differences to emerge between the TBI group and the control group. In particular, we expected the TBI group to perform significantly slower and make more errors than the control group, and to have more impaired performance for sarcastic contexts and attitude questions compared to the healthy control group. Finally, we expected aggression scores to relate to difficulty on the sarcasm task; i.e. BPAQ scores (additionally the OAS-MNR for the TBI group) would correlate with RTs and errors on the sarcasm task.

In Experiment Two, a group of self-rated low aggressive individuals was compared to a group of self-rated moderately aggressive individuals. We hypothesised that, similarly to Experiment One, across both groups, literal contexts would be facilitated (producing faster RTs) compared to sarcastic contexts. Additionally, it was hypothesised that factual questions would be facilitated (producing faster RTs) compared to attitude ones. We also expected that some differences may emerge between the low aggression group and the moderate aggression group. In particular, it was hypothesised that the moderate aggression group may be slower and make more errors than the low aggression group, and may also show decreased performance in sarcastic contexts and on attitude questions, compared to the low aggression group.

1.5.1 Predictions from models of non-literal language processing

The findings from the sarcasm experiment will be interpreted in the context of existing theories of non-literal language processing. Whilst it is not possible to directly test the predictions of the coarse semantic coding hypothesis and the suppression deficit hypothesis, as this would require an experimental design with distinct patient groups determined by laterality of injury, these two theories will be used as frameworks to understand the results. However, the predictions of the first three theories discussed above (standard pragmatic model, direct access model and graded salience model) can be

directly tested by the current experimental design as they concern non-literal language processing in general, rather than in relation to specific hemispheric processing. These three models/theories make different predictions about the processing of sarcastic comments compared to literal ones, as follows:

The standard pragmatic model assumes that figurative language is processed by first accessing the literal interpretation, and only when that interpretation does not fit with the context is the non-literal interpretation activated. This model would therefore predict that responses to answering the questions in the sarcastic context would be slower compared to the literal context.

The direct access model argues that non-literal meanings can be activated without the need to activate the literal meaning first if the context biases the non-literal meaning. Given that in the present studies, the sarcastic comments are incorporated in vignettes that support the sarcastic interpretation, this model, would predict similar performance when answering the questions in the sarcastic and literal contexts.

Finally, according to the graded salience hypothesis, salient meanings are activated first regardless of whether they are literal or non-literal. The sarcastic remarks in the current experiments are considered non-salient since they are conversational in nature and not always associated with sarcasm (i.e. would not be interpreted sarcastically without prosodic cues and/or context) and therefore would not have a sarcastic interpretation stored in the mental lexicon. Therefore, this theory would predict increased response times when answering the questions in the sarcastic contexts, compared to the literal, as salient meanings are accessed before non-salient ones.

2. METHOD

2.1 Ethical clearance

Ethical approval was obtained from the School of Psychology, University of Leeds (ref: 14-0339, date: 19.12.14; appendix 2), for recruitment and testing of non-clinical participants. Ethical clearance was also obtained from an NHS research ethics committee (ref: 15/LO/1220, date: 15.7.15; appendix 3) and the Disabilities Trust (parent organization of the Brain Injury Rehabilitation Trust; BIRT) research ethics committee (date: 22.09.15; appendix 4) for the recruitment and testing of participants with brain injury. As the sites being accessed for recruitment and testing purposes were non-NHS sites, the required management permissions were obtained from each BIRT service being accessed (there were two Yorkshire based sites).

2.2 Experiment One

2.2.1 Design

Experiment One was designed to address the first three research questions, exploring the impact of TBI on comprehension of literal and sarcastic material and any links between language, and in particular sarcasm, comprehension and aggression. Experiment One followed a 2 (Group; TBI or control) x 2 (Context: literal or sarcastic) x 2 (Question Type: factual or attitude) x 2 (Question Order: first or second) mixed effects design to consider the research questions; Group was a between-subjects factor and Context, Question Type and Question Order were within-subjects factors. The dependent variables were the accuracy and reaction time (RT) data on the computer-based sarcasm experiment.

2.2.2 Participants

2.2.2.1 Power analyses

A power analysis was conducted to calculate the minimum number of participants needed to achieve the necessary power and effect sizes. A total sample size of 28 participants (14 in each group) ($F(5,130)=2.28, p=.05$) was calculated to be sufficient to obtain a power of .95, with an effect size of .25. This was calculated on the basis of two groups (TBI and control) and six measurements (sarcastic statement, neutral statement, factual question,

attitude question, order first, order second). According to Cohen (1988), an effect size of .1 is considered small, .3 is considered medium and .5 is considered large. The small-medium effect size of .25 was used in this power analysis in line with effects seen in the literature (e.g. James & Young, 2013).

2.2.2.2 TBI participants

Seven individuals with TBI were recruited from brain injury rehabilitation units. The individuals were recruited only if they were medically stable and in the post-acute phase of their recovery, as deemed by not being in post-traumatic amnesia (PTA; the period from injury to the time that new memories can be consistently stored; Russell & Smith, 1961). The individuals were all male native English speakers and were right handed (pre-morbidly) according to the Briggs and Nebes (1975) handedness inventory. The participants had no lifetime pre-morbid history of language disorders, learning disability, autism-spectrum disorders, neurological disorders, personality disorder, and they had no significant mental health diagnoses in the five years prior to their injury, according to their self-report and review of medical records. In addition, none of the participants had any current personality disorder diagnosis or major mental health diagnoses (e.g. depression, schizophrenia, bipolar disorder), and none were aphasic (i.e. they had intact receptive and expressive language skills), according to the assessments conducted by the speech and language therapists upon admission to the neurorehabilitation units. All participants were considered by their clinical leads to have the mental capacity to consent to participate in the study. Demographic information for the TBI participants is presented in Table 1.

2.2.2.3 Control participants

Seven individuals without a TBI were recruited as age, education and gender matched control participants. Similarly the individuals were all male, right-handed, native English speakers, and did not have any current or lifetime history of language or developmental disorders, diagnosed personality disorder, neurological disorders or drug/alcohol addictions. None had current or recent-historical (past 5 years) mental health disorders, and none were taking psychiatric medication. The demographic information for the control participants is also presented in Table 1.

2.2.3 Screening tests

All participants were administered the following screening tests; scores are displayed in Table 1:

- Sixteen-question interview to obtain demographic information and to establish suitability for participation according to the inclusion criteria (appendix 6).
- Handedness inventory (Briggs & Nebes, 1975; appendix 7): a 12-item questionnaire rating on a five-point scale preferred hand for use in various different tasks (-2 always left, -1 usually left, 0 no preference, +1 usually right, +2 always right). The scoring range is -24 - +24 and a score of +9 or more indicates right handedness. This was administered to assess for most probable language lateralisation, in an attempt to limit heterogeneity in the hemispheric lateralisation of language.
- Montreal Cognitive Assessment (MoCA, Nasreddine et al., 2005; appendix 8): a brief screening test of global cognitive ability which was developed to identify mild cognitive impairment. It assesses various cognitive domains including orientation to time and place, visuospatial abilities, short term memory, attention and working memory, executive function and language (fluency, naming and repeating). The MoCA takes approximately ten minutes to complete and is administered in interview format. Scores of 26 and above are considered to be in the normal range.
- Buss-Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992; appendix 5) to assess self-reported aggressive characteristics. This is a 29 item self-report measure of aggression tapping into physical aggression, verbal aggression, hostility and anger via questions about aggressive behaviours and feelings. All 29 items are responded to on a five-point Likert scale where 1 = extremely uncharacteristic and 5 = extremely characteristic, and there are two reverse scoring items (numbers 9 and 16). The BPAQ is considered to have good psychometric properties (Buss & Perry, 1992; Harris, 1995, 1997).

Table 1. Experiment One participant demographics

Demographics & screening tests	TBI (N=7)	Control (N=7)
Age (mean, SD)	36y 9m (9y 12m)	36y 9m (14y 2m)
Gender ratio (male:female)	7:0	7:0
Years in education (mean, SD)	14.14 (2.67)	15.8 (2)
Handedness (range -24 – +24)	19.29 (5.06)	18.14 (5.15)

(mean, SD)		
MoCA (Max = 30) (mean, SD)	22.57 (3.51)	28.71 (0.95)
BPAQ (Max = 145) (mean, SD)	70.14 (24.92)	59.14 (12.54)

MoCA = Montreal Cognitive Assessment; BPAQ = Buss-Perry Aggression Questionnaire

One-way Analyses of Variance (ANOVA) found no significant group differences on age [$F(1,12)=0, p=1, \eta^2=.0$], number of years in education [$F(1,12)=1.72, p=.21, \eta^2=.13$], handedness [$F(1,12)=.18, p=.68, \eta^2=.01$], and the BPAQ [$F(1,12)=1.09, p=.32, \eta^2=.08$]. However, the two groups were found to differ significantly on the MoCA [$F(1,12)=20.03, p<.01, \eta^2=.63$].

2.2.4 Neurocognitive and neurobehavioural data for TBI participants

As a part of the assessment package at the neurorehabilitation units, comprehensive neurocognitive assessments were conducted and assessment information relevant for this study was gathered, where available, and is presented in Table 2. The following clinical information was obtained:

- Date of injury to calculate time since injury at the point of my first meeting.
- Cause of injury.
- Rough location of injury.
- Severity of injury; mild, moderate or severe (Ghajar, 2000), according to the Glasgow Coma Scale score (GCS; Teasdale & Jennett, 1974) or the length of post-traumatic amnesia (PTA). Where no GCS or PTA information was available, the injury severity was estimated by the assessing consultant based on other available clinical information.
- Index scores from the Wechsler Adult Intelligence Scale – 4th edition (WAIS-IV; Wechsler, 2008). The WAIS-IV is the up to date version of the most widely used test of intelligence and general cognitive function. The test comprises 15 subtests (10 core, 5 supplemental) which contribute towards 5 index scores; namely, a full-scale intelligence quotient (FSIQ) score, a verbal comprehension index (VCI), a perceptual reasoning index score (PRI), a working memory index score (WMI), and a processing speed index score (PSI). In the case of one participant there was no PSI score range (due to only partial assessment being possible), thus the group mean on this index is not a true group mean, only reflecting six participants. Scores on each of these indexes are scaled (in accordance with age) against a normal population mean of 100 and a standard deviation (SD) of 15.

- Estimate of pre-morbid IQ from the Test of Pre-morbid Function, UK version (TOPF UK; Wechsler, 2011). The TOPF UK comprises a list of 70 English words with atypical grapheme-phoneme translations which are read aloud by the participant. The ability to correctly pronounce irregular words is known to be stable even after brain injury and accurately predicts pre-morbid IQ, as a function of previously learnt vocabulary. The total number of points scored for correct pronunciation is converted to reflect pre-morbid functioning according to the WAIS-IV index scores (mean = 100, SD = 15).
- The Awareness of Social Inference Test (TASIT; McDonald, Flanagan & Rollins, 2002) scores. This is a standardised clinical tool developed to assess social skills in clinical populations, including TBI, consisting of three parts: The Emotion Evaluation Test (EET), The Social Inference-Minimal (SI-M), and The Social Inference-Enriched (SI-E). The EET and the SI-M scores are reported below. The SI-E was not routinely administered in the neurorehabilitation settings sampled. The SI-M is particularly important for the present study as this assesses comprehension of sarcastic exchanges, as well as sincere exchanges. The sarcastic exchanges include simple and paradoxical sarcasm. In exchanges of simple sarcasm, the sarcasm can only be interpreted by identification of paralinguistic cues, not by the content of the speech. Whereas, in exchanges of paradoxical sarcasm, there are no paralinguistic cues indicative of sarcasm and the verbal exchanges only make sense if interpreted sarcastically. In cases where the TASIT was not routinely administered during the neurorehabilitation unit's assessment process this was administered as part of the current study's procedure.

In addition to the structured cognitive assessment information obtained, as outlined above, neurobehavioural data was also obtained in relation to observed aggression. Levels of observed aggression were routinely monitored and recorded, using the Overt Aggression Scale - Modified for Neurorehabilitation (OAS-MNR; Alderman et al., 1997; appendix 1), as part of the structured assessment and rehabilitation programme at the BIRT neurorehabilitation units. For the purpose of this study, the total OAS-MNR scores were collected for the four week period prior to the first testing session in addition to the four week period following that first meeting. For the two recently discharged individuals, the scores of their final 8 weeks in the units were used (it is of note that no aggressive behaviours were recorded for either of these individuals in the last 3 months, or longer, of their stays, so these scores can be considered an accurate general reflection of aggression rather than simply being related to imminent discharge). Any observed aggressive behaviour was coded as one of four categories: verbal aggression (VA),

physical aggression against objects (PO), physical aggression against the self (PS) and physical aggression against other people (PP). A weighted (w) score was calculated as per the set numerical values ascribed to each type of behaviour within each category (i.e. 1-4 as per the descriptions seen in appendix 1), which were then multiplied in line with the severity of the aggression type (i.e. multiplied by 1 for VA, multiplied by 2 for PO, multiplied by 3 for PS, and multiplied by 4 for PP). An overall weighted physical aggression score (wPA) was calculated as a sum of the three physical categories, and an overall weighted aggression total (wA) was also calculated to reflect overall physical and verbal aggression.

The injury information, cognitive assessment information and behavioural data for the TBI participants are displayed in Table 2.

Table 2. Experiment One TBI participant clinical information

Assessment tool	TBI participants
Time since injury (mean, SD)	2y 2m (2y)
Severity of injury	
Severe (N)	7
Moderate (N)	0
Mild (N)	0
Cause of injury	
RTA (N)	4
Fall (N)	1
Assault (N)	2
Broad location of injury	
LH (N)	1
RH (N)	2
Bilateral (N)	4
WAIS-IV (mean=100, 1 SD=15)	
VCI (mean, SD)	81.29 (8.71)
PRI (mean, SD)	85.00 (17.86)
WMI (mean, SD)	85.86 (16.2)
PSI (mean, SD)	73.83 13.29
FSIQ (mean, SD)	77.00 (14.24)
TOPF (mean=100, 1 SD=15)	
Estimated pre-morbid VCI (mean, SD)	91.57 (5.44)

Estimated pre-morbid PRI (mean, SD)	95 (6.95)
Estimated pre-morbid WMI (mean, SD)	92.71 (7.99)
Estimated pre-morbid PSI (mean, SD)	93 (5.29)
Estimated pre-morbid FSIQ (mean, SD)	91.57 (7.48)

TASIT

Part 1 (max=28) (mean, SD)	18.86 (4.81)
Part 2 (max= 60) (mean, SD)	47 (3.92)

OAS-MNR (total score over an 8 week period)

wVA (mean, SD)	17.86 (24.07)
wPO (mean, SD)	2.26 (3.35)
wPS (mean, SD)	0
wPP (mean, SD)	7.43 (14.68)
wPA (mean, SD)	9.71 (15.51)
wA (mean, SD)	27.57 (39.53)

RTA = road traffic accident; WAIS-IV = Wechsler Adult Intelligence Scale – 4th edition; VCI = verbal comprehension index; PRI = perceptual reasoning index; WMI = working memory index; PSI = processing speed index; FSIQ = full-scale intelligence quotient; TOPF = Test of Premorbid Functioning; TASIT = The Awareness of Social Inference Test; OAS-MNR = Observed Aggression Scale-Modified for Neurorehabilitation; wVA = weighted verbal aggression; wPO = weighted physical aggression against objects; wPS = weighted physical aggression against self; wPP = weighted physical aggression against other people; wPA = weighted physical aggression (overall); wA = weighted aggression (overall).

2.2.5 Materials

2.2.5.1 Sarcasm experiment

The sarcasm experiment is a test of sarcasm comprehension based on a paradigm originally developed by Ackerman (1981) and adapted and used in research by Shamay-Tsoory et al. (2005). The experiment involves reading and hearing short stories with an exchange between two characters in which either a sarcastic or a sincere comment is made. This is followed by two questions to elicit the understanding of the scenario (factual question) and the beliefs of the individual (attitude question). The main differences between the current paradigm and that of Shamay-Tsoory et al. (2005), is that the current study developed and used significantly more stimuli (60 compared to 16), there were example and practice phases (not evident in the Shamay-Tsoory et al. study) and alongside auditory presentation of stimuli, as in Shamay-Tsoory et al.'s study, the stimuli were also presented in writing.

2.2.5.1.1 Description and development of the materials

Thirty four different scenario themes were developed, each with a sarcastic and a non-sarcastic (literal) version, creating 68 individual scenarios in total. All the scenarios featured two main characters, in a variety of social, family and work contexts, and began with one to two sentences to provide a brief context, followed by a spoken comment from one character directed to and about the other. There was a consistent theme between the two scenario versions (sarcastic and literal) though the context was altered slightly to appropriately set up the sarcastic or literal comment. The words used in the spoken comment remained the same regardless of context, though the prosody and intonation changed in accordance with whether it was sarcastic or literal. In the sarcastic versions, the comment was contextually incongruent and had an alternate implied meaning. On the other hand, in the literal versions the comment was congruent with the context and the literal meaning was implied. The comment always referred to the other character personally, rather than to a situation, an item or another person. In the sarcastic scenarios the comments always communicated negative sarcasm, i.e. when a positive comment is used to communicate something negative. In the literal versions, the same positive comment was used to literally communicate something positive (see Table 3 for examples of the experimental stimuli).

Before the scenarios were voice recorded, a group of 20 (5 males, mean age = 30.25, SD = 8.95) healthy, adult, native English-speaking volunteers rated how sarcastic the scenarios were in their written form. This was done through an online survey which the volunteers could complete by following a website link (using the Bristol Online Surveys platform. The volunteers rated on a Likert scale of 1-7 (1 = not at all sarcastic, 7 = very sarcastic) how sarcastic they thought each scenario was (including both the sarcastic and literal versions). On the whole, the sarcastic scenarios were rated as highly sarcastic ($M = 6.29$, $SD = 0.6$), and the literal scenarios as not at all sarcastic ($M = 1.51$, $SD = 0.44$). Statistical analysis confirmed the ratings of the sarcastic and the literal statements to be significantly different from each other [$t(60)=35.84$, $p<.01$], as intended. Two outliers were identified and adapted in line with feedback obtained from free response boxes on the online survey.

Once the scenarios were finalised, they were recorded by a female actor and performing arts student from the University of Leeds, using the computer program Audacity 1.3 Beta (Audacity Team, 2008), and they were edited into their final form. The recordings were made in a generic (non-regional specific) English accent. The sarcastic comments

followed traditional prosodic patterns seen in sarcasm including slower tempo, lower pitch and louder intensity (Rockwell, 2000). The literal comments had a contextually congruent prosody. These audio recordings were then rated for their perceived level of sarcasm. As audio files could not be incorporated into an online survey, these were rated manually by playing clips to 14 (5 male, mean age = 34.43, SD = 12.74) healthy adult native English-speaking volunteers and asking them to rate the perceived level of sarcasm on the same 1-7 Likert scale (1 = not at all sarcastic, 7 = very sarcastic) as above. On the whole the sarcastic scenarios were rated as highly sarcastic ($M = 6.37$, $SD = 0.29$), and the literal scenarios as not at all sarcastic ($M = 1.75$, $SD = 0.29$). There were no outliers and on statistical analysis the ratings of the sarcastic and literal scenarios were significantly different from each other [$t(64)=63.86$, $p<.01$], as intended.

The finalised scenarios varied in length between 21 and 35 words, with a mean of 28.5 words ($SD = 3.69$), and there was no statistically significant difference between the sarcastic ($M = 28.65$, $SD = 3.6$) and the literal ($M = 28.35$, $SD = 3.83$) versions [$t(66)=0.33$, $p=.75$]. In terms of the running times of the audio recordings, the scenarios varied between 7 and 14.36 seconds, with a mean of 10.32 seconds ($SD = 1.56$). On analysis, there were no statistically significant differences between the mean running times of the sarcastic ($M = 10.47$, $SD = 1.62$) and the literal ($M = 10.18$, $SD = 1.52$) scenarios either [$t(66)=.76$, $p=.45$]. In terms of the content/themes of the scenarios, there was an equal gender split between the scenarios, a mix of relationships (friendships, spouses, working relationships, family relationships) and a mix of contexts (work, leisure, home, sport).

Each scenario was followed by two questions that were presented one after the other; a factual question and an attitude question in a pseudo-random order. The questions required a yes or no answer and participants responded by pressing the mouse buttons (left mouse button = yes, right mouse button = no). The computer mouse had labels on as reminders. The factual question assessed the understanding of the story generally and the attitude question assessed the understanding of the spoken comment i.e. the speaker's beliefs and intentions. The order in which the questions were presented was pseudo-randomised to avoid being able to predict the following question, with half of the scenarios having factual questions first and half having attitude questions first. In addition, half of the questions were positively phrased (e.g. Did Ryan play well?) and half negatively (e.g. Did Ryan play badly?). The pairings of positively and negatively phrased questions was also pseudo-randomised, with an equal split between positive-positive, negative-negative, positive-negative and negative-positive question pairs to avoid

strategies in being able to predict the question that followed and thus pre-empt the answer. The questions were only displayed visually for the participants to read as auditory information was not deemed necessary.

The experimental stimuli are presented in full in appendix 9, and examples of four of the different scenario combinations are given in Table 3.

Table 3. Examples of the experimental paradigm stimuli combinations

Combination	Scenario	Question 1	Question 2
Sarcastic Q1: Att-Neg-Yes Q2: Fac-Pos-No	Liz was playing tennis with a friend and kept hitting shots out of the court. Her friend said to her “You’re playing really well today Liz!”	Did Liz’s friend think Liz was playing badly?	Was Liz playing tennis well?
Literal Q1: Fac-Neg-No Q2: Att-Neg-No	Liz was playing tennis with a friend and kept hitting winning shots. Her friend said to her “You’re playing really well today Liz!”	Was Liz playing tennis badly?	Did Liz’s friend think Liz was playing badly?
Sarcastic Q1: Att-Pos-No Q2: Fac-Neg-Yes	Ian was attempting some DIY plumbing. His girlfriend came home to see the bathroom flooded. She said to him “Nice work. I see those DIY lessons came in handy!”	Did Ian’s girlfriend think Ian had done a good job?	Had Ian done a bad job?
Literal Q1: Fac-Pos-Yes Q2: Att-Pos-Yes	Ian was attempting some DIY plumbing. His girlfriend came home to see a new bathroom fitted. She said to him “Nice work. I see those DIY lessons came in handy!”	Had Ian done a good job?	Did Ian’s girlfriend think Ian had done a good job?

Q1 = Question one; Q2 = Question two; Fac = Factual; Att = Attitude; Pos = Positive; Neg = Negative.

2.2.5.1.2 Building the experiment

The software package E-Studio2 (Schneider, Eschman & Zuccolotto, 2002) was used to build the experiment into a computer-based paradigm with four blocks; an example block, practice block and two separate experimental blocks. The example block consisted of four scenarios and the two corresponding questions (factual and attitude) for each scenario. As this was an example and learning exercise only, the participant did not have to respond with the mouse and was instead encouraged to say what they thought the answer might be and the correct answer was provided on the computer screen after each question. In the practice block, there were four new scenarios and the participant was encouraged to respond to the questions with the mouse and was not given the correct answers (akin to the experimental phases). The practice session was repeated if necessary until it was clear to the participants what the task required.

The two experimental blocks each contained 30 scenario-question combinations and each had a short one minute break programmed half way through (after the first 15 scenario-question combinations). The two versions (sarcastic and literal) of the same scenario were never presented in the same block. Each scenario was presented auditorily through the computer speakers and visually on the screen for a maximum of 18000ms. After hearing and reading the scenario the participant could press a keyboard or mouse key when they were ready for the questions, or the screen would time out and automatically move on to the questions. After a delay of 1500ms, the first question appeared on the screen for a maximum of 15000ms. Once participants responded (or the screen timed out), and after a delay of 1500ms, the second question was presented on the screen for a maximum of 15000ms. After participants responded to the second question (or the screen timed out), there was a delay of 1500ms before the next scenario was presented visually and auditorily. Accuracy and reaction time (ms) data was recorded by the computer. The experiment took approximately 40-50 minutes to complete. An example of the sequence of screen displays of one scenario-question combination is represented in Figure 1.

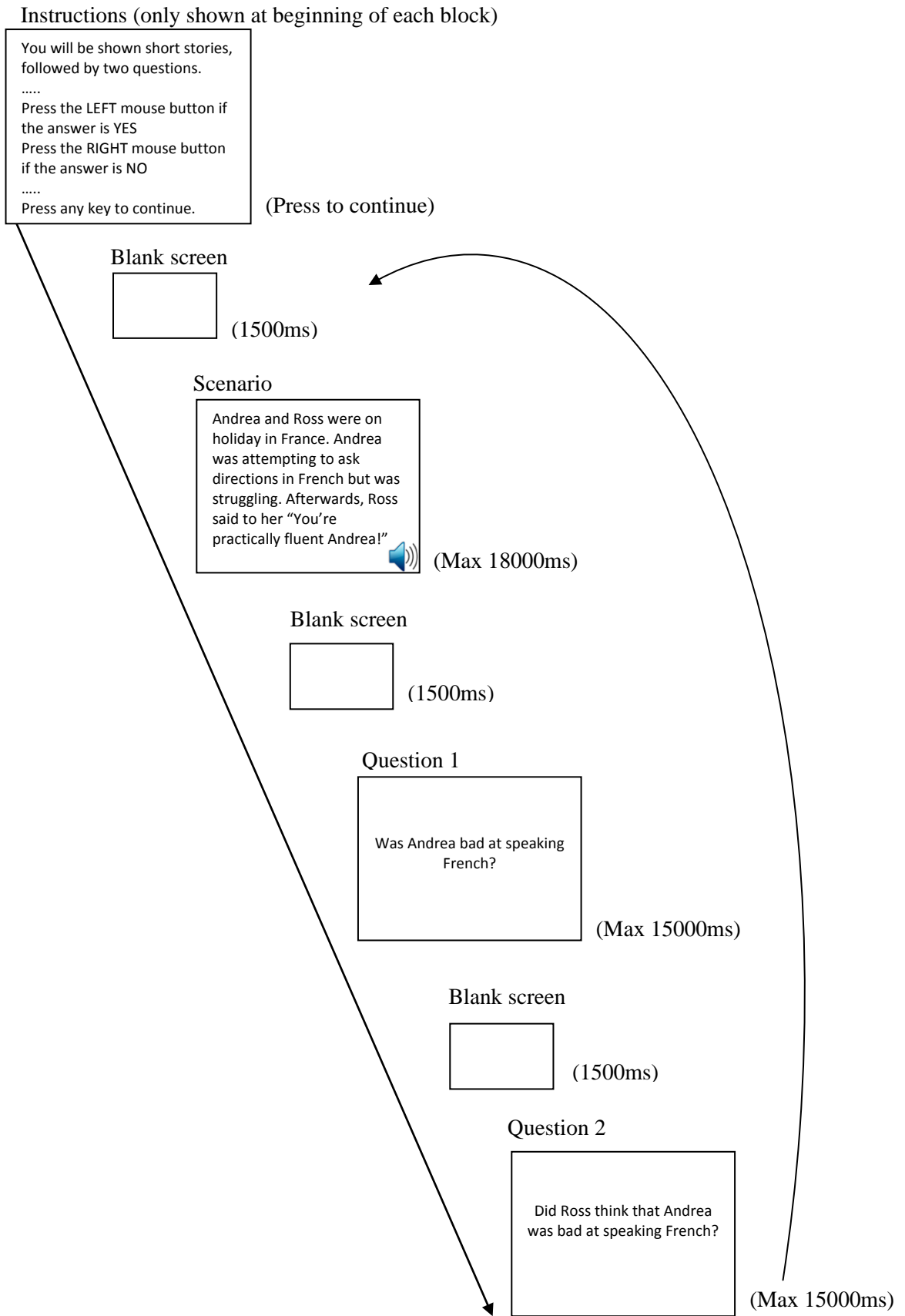


Figure 1. Example of one scenario-question sequence

2.2.5.2 Sarcasm questions

After the computer-based experiment, the participants were asked two questions about their use of sarcasm (appendix 16). They were asked to rate how sarcastic they would describe themselves on a 0-10 scale (0 = not at all sarcastic, 10 = extremely sarcastic), and how frequently they use sarcasm in day to day conversations on a 1-7 scale (1 = never, 2 = extremely rarely, 3 = rarely, 4 = not very often, 5 = often, 6 = very often, 7 = extremely often). Previous studies have suggested that frequent use of sarcasm in one's own communication improves the ability to detect sarcasm in others' speech (Ivanko, Pexman & Olineck, 2004) and a similar frequency question was asked in Woodland and Voyer's (2011) study.

2.2.6 Procedure

Data collection with the healthy control participants was completed in one session that lasted approximately one hour.

With each TBI participant the data collection process took approximately two to three hours, spread over two to four sessions, depending on which clinical assessments were to be administered, in addition to the individual's level of concentration, attention and fatigue. For the five TBI participants residing in neurorehabilitation units the data collection took place in quiet assessment rooms at the units. For the two participants who had recently been discharged from the neurorehabilitation units, data collection took place in a quiet meeting room at the University of Leeds for one individual, and for the other in a quiet meeting room at their place of work.

Initially, the study was explained to all participants and they were given an information sheet (TBI appendix 10; control appendix 11) and the chance to ask any questions about the study they may have. Participants then completed an informed consent form (TBI appendix 12; control appendix 13). Following this, screening tests were administered in the following order: inclusion criteria interview, handedness inventory, MoCA. All participants were then asked to complete the BPAQ. The handedness inventory and the BPAQ were completed independently by most participants, though for some of the TBI participants the questions were read out and the participant responded verbally, with the researcher making note of the responses.

Next, the participants completed the computer-based sarcasm experiment. A Toshiba laptop with 15½ inch screen with internal speakers was used. A computer mouse was plugged in which had “yes” and “no” stickers on the left and right keys respectively. The E-prime software recorded the response accuracy and reaction times (in ms). In total, this process took between 40-50 minutes to complete. A script was developed to ensure consistency when giving instructions (appendix 14). After completing the experiment, all participants were asked to answer the two sarcasm questions (appendix 15).

With regards to the TASIT, some TBI participants had already completed Part 1 or Part 1 and Part 2 throughout their assessment phase at the neurorehabilitation units, whereas others had not previously done any part of it. Relevant sections were therefore administered. For some participants this was completed before the sarcasm experiment stage and for some afterwards, a decision made based on time available. If the TASIT was administered, this was always done during a different testing session to the sarcasm experiment.

2.3 Experiment Two

2.3.1 Design

Experiment Two addressed the final research question and aimed to explore links between sarcasm comprehension and self-rated aggression in a non-clinical group of low and moderately aggressive young adults. In order to address this research question, Experiment Two followed a 2 (Group: low or moderate aggression) x 2 (Context: literal or sarcastic) x 2 (Question Type: factual or attitude) x 2 (Question Order: first or second) mixed effects design; Group was a between-subjects factor and Context, Question Type and Question Order were within-subjects factors. The dependent variables were the accuracy and reaction time data from the computer-based sarcasm experiment.

2.3.2 Participants

Given that the same design was used as in Experiment One, the same power analysis calculations (see section 2.2.2.1) applied to Experiment Two. Again, a small-medium effect size was opted for, in line with findings in the non-clinical literature (e.g. Phillips et al., 2015). More participants were recruited than the calculated total of 28, in accordance

with previous literature, and in an attempt to increase the possibility of capturing any small effect, if one was indeed present.

Forty healthy participants (13 male, mean age 23y 3mo, SD=5y 2mo) were recruited for Experiment Two. Recruitment and data collection was supported by an undergraduate psychology student at the University of Leeds who used this data set for their final year research dissertation. All participants were native English speakers and were right handed according to the Briggs and Nebes (1975) handedness inventory. As gathered by self-report, the participants had no diagnosed language disorders, learning disability, neurological disorders or acquired brain injury. They did not report alcohol or drug problems or any significant mental health diagnoses, nor were they taking any psychiatric medication.

The 40 participants were split in two groups (low aggression vs moderate aggression), at the median point, according to the self-reported BPAQ aggression scores. The demographic information for the two groups is displayed in Table 4. One-way ANOVAs demonstrated no significant group differences on handedness [$F(1,38)=2.05, p=.16, \eta^2=.05$], number of years in education [$F(1,38)=2.46, p=.12, \eta^2=.06$], age [$F(1,38)=.1, p=.76, \eta^2=.01$], or the MoCA [$F(1,38)=.05, p=.82, \eta^2=.01$]. The two groups differed significantly in their BPAQ scores [$F(1,38)=81.01, p<.01, \eta^2=.68$].

Table 4. Experiment Two participant demographics

Demographics & screening tests	Low aggression (N=20)	Moderate aggression (N=20)
Age (mean, SD)	23y 5mo (5y 10mo)	23y 1mo (4y 7mo)
Gender ratio (male:female)	6:14	7:13
Years in education (mean, SD)	15.10 (1.21)	15.6 (0.75)
Handedness score (range -24 – +24) (mean, SD)	20.85 (2.92)	19.35 (3.66)
MoCA score (Max = 30) (mean, SD)	28.35 (1.46)	28.45 (1.23)
BPAQ score (Max = 145) (mean, SD)	48.55 (6.85)	73.2 (10.15)

MoCA = Montreal Cognitive Assessment; BPAQ = Buss Perry Aggression Questionnaire

2.3.3 Screening tests and materials

The same screening tests were administered and materials used as in Experiment One.

2.3.4 Procedure

A similar procedure to that in Experiment One was used. Participants volunteered to participate in the study mostly through a research participation scheme as part of the requirements of the University of Leeds psychology undergraduate degree course, and these participants received research credits in return for their participation. Additional participants were recruited through word of mouth or a research participation emailing list, and these participants received a small cash payment for their time.

Since there were two researchers administering the testing session, a script was developed to ensure consistency (appendix 14). As in Experiment One, the procedure was verbally explained and the participants were given an information sheet (appendix 11) prior to obtaining their informed consent (appendix 13) to participate. The screening questionnaire was then administered, followed by the handedness questionnaire, the MoCA and the BPAQ. Participants then completed the sarcasm experiment as in Experiment One. This was administered in the same testing room in the School of Psychology, University of Leeds for each participant, using a computer with two external speakers placed either side of the 20 inch screen. The computer mouse had stickers indicating “yes” and “no” on the left and right keys respectively. Finally, participants answered the two sarcasm questions. The whole procedure was completed in one session that lasted approximately one hour in total.

3. RESULTS

3.1 Experiment One

Experiment One compared the performance of individuals with TBI with a matched control group to explore comprehension of literal and sarcastic material, and whether this has a role in the modulation of aggression. In this section, firstly, the scores from the Montreal Cognitive Assessment (MoCA), the aggression questionnaire (BPAQ), and the two sarcasm questions are considered. Secondly, the reaction time (RT) and error data from the sarcasm experiment is presented, and statistically analysed using parametric statistics. Finally, for the TBI group only, the TASIT data is considered and correlational analyses are presented in order to explore the relationships between the various clinical measures used and results from the sarcasm experiment.

Table 5. Experiment One TBI and control participant MoCA, BPAQ and sarcasm scores

Characteristic	TBI (N=7)	Control (N=7)
MoCA (Max=30) (mean, SD)	22.57 (3.51)	28.71 (0.95)
BPAQ (Max=145) (mean, SD)	70.14 (24.92)	59.14 (12.54)
Self-rated sarcasm identity score (0-10) (mean, SD)	5.79 (3.16)	6.29 (1.5)
Self-rated sarcasm frequency (1-7) (mean, SD)	4.86 (1.21)	4.71 (.95)

MoCA = Montreal Cognitive Assessment; BPAQ = Buss Perry Aggression Questionnaire

Table 5 presents the results of the MoCA, the BPAQ, and the sarcasm questions for the two groups. The above data was analysed with one-way Analyses of Variance (ANOVAs). There were significant differences only in the MoCA scores [$F(1,12)=20.03$, $p<.01$, $\eta^2=.63$] between the two participant groups. There were no statistically significant differences on the BPAQ [$F(1,12)=1.09$, $p=.32$, $\eta^2=.08$], the self-rated sarcasm identity score [$F(1,12)=0.14$, $p=.71$, $\eta^2=.12$], or the self-rated sarcasm frequency [$F(1,12)=.06$, $p=.81$, $\eta^2=.01$], showing that the TBI group and their matched control group did not differ significantly in self-rated aggression scores or subjective evaluations of how sarcastic they consider themselves to be.

3.1.1 Sarcasm experiment data preparation

A set of instructions were developed to assist the data preparation process (appendix 15). In order to prepare the sarcasm experiment data for statistical analysis, errors and outliers

were removed from the data set. Errors were removed first and this was completed in two stages. Firstly, if there were any errors in response to factual questions, these were removed along with the associated attitude question, regardless of whether the attitude question had been answered correctly or incorrectly. This was to allow for more robust analysis of the attitude data, since an incorrect response on the factual question suggested not grasping the factual information in the story and thus limited the validity of the attitude question (see also Shamay-Tsoory et al., 2005, for a similar approach). Secondly, any errors on attitude questions where there was not an associated error on the factual question, as these had been removed in the first step, were removed. Once all errors were removed, outliers in the RT data were calculated as per two standard deviations above or below each participant's mean per condition (Context and Question Type), and were removed from the data set.

In the TBI participant data set, there were 11.9% errors made on factual questions, errors made on attitude questions when there were factual errors comprised 6.67%, and errors made on attitude question when the factual question was correct comprised 5.48%. Outliers comprised 4.32% of the remaining correct responses. For the control participants' data, errors on factual questions comprised 2.14%, errors made on attitude questions when there were factual errors comprised 0.48% and errors made on attitude questions when the factual question was correct made up 1.67% of the data. Of the correct responses, outliers comprised 4.85%.

The RT data was examined first, followed by the error data.

3.1.2 Reaction time analysis

3.1.2.1 Descriptive statistics and checks prior to analysis

Firstly, descriptive statistics were performed in order to obtain a greater understanding of the data. These can be seen in Table 6. Secondly, in order to ensure the data was suitable for parametric analysis, the parametric assumptions were checked. Outliers were considered initially. There were four outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. Due to the data collection method (computer collected RT data) these outliers were considered genuinely unusual values, rather than data entry or measurement errors. Due to small sample size it was decided to retain these data points rather than remove them, and this will be taken into consideration in the interpretation of the results.

Next, the distribution of the data was considered. The assumption of normality was satisfied as assessed by the Shapiro-Wilk test; all conditions but one did not reach statistical significance at the $p < .05$ level, whereas one condition did reach statistical significance at the $p < .05$ level, but not at the $p < .01$ level. Taking a conservative stance, this was considered to still meet the assumption of normality given the mixed effects ANOVA being relatively robust to violations of normality. In addition, to assess for normal distribution, skewness and kurtosis scores were calculated and are displayed in Table 6. Skewness and kurtosis Z scores were calculated, which fell within the acceptable range (± 2.58) on all levels.

Table 6. Experiment One TBI and control participant RT (ms) data descriptive statistics

Level	Mean RT (SD)	Skewness (SE)	Kurtosis (SE)
TBI			
Literal Factual Q1	2119.94 (675.06)	.47 (.79)	.52 (1.59)
Literal Factual Q2	2063.4 (528.87)	-.36 (.79)	-1.18 (1.59)
Literal Attitude Q1	2795.89 (574.07)	-.26 (.79)	-1.12 (1.59)
Literal Attitude Q2	2728.02 (705.41)	.77 (.79)	.92 (1.59)
Sarcastic Factual Q1	2203.64 (532.5)	-.06 (.79)	-1.88 (1.59)
Sarcastic Factual Q2	2135.23 (628.5)	.92 (.79)	1.72 (1.59)
Sarcastic Attitude Q1	3016.16 (703.54)	.29 (.79)	.94 (1.59)
Sarcastic Attitude Q2	3070.83 (709.03)	1.01 (.79)	1.32 (1.59)
Control			
Literal Factual Q1	1409.13 (334.32)	.46 (.79)	-1.67 (1.59)
Literal Factual Q2	1302.01 (355.21)	.64 (.79)	-1.25 (1.59)
Literal Attitude Q1	1992.85 (675.55)	1.15 (.79)	.79 (1.59)
Literal Attitude Q2	1888.03 (533.14)	.77 (.79)	-1.4 (1.59)
Sarcastic Factual Q1	1602.83 (417.18)	.29 (.79)	-1.24 (1.59)
Sarcastic Factual Q2	1364.25 (249.26)	.25 (.79)	-2.17 (1.59)
Sarcastic Attitude Q1	2225.65 (894.62)	1.77 (.79)	3.22 (1.59)
Sarcastic Attitude Q2	2131.22 (593.49)	.31 (.79)	-2.23 (1.59)

Finally, there was homogeneity of variances, as indicated by Levene's test for equality of variances ($p > .05$).

3.1.2.2 Statistical analyses

As the parametric assumptions were met, a mixed effects ANOVA was carried out. The RT data was subjected to 2 (Group: TBI or control) x 2 (Context: literal or sarcastic) x 2 (Question Type: factual or attitude) x 2 (Question Order: first or second) mixed effects repeated measures ANOVA, for participants (F1) and items (F2). Group was a between effects factor, while Context, Question Type and Question Order were within effects repeated measures factors. All significant main effects and interactions were investigated further with Newman-Keuls ($p < .05$) post-hoc tests. Additional Analyses of Covariance (ANCOVAs) were carried out to explore the same conditions as above, whilst controlling for group differences in cognitive ability, according to the MoCA.

The 2 x 2 x 2 x 2 ANOVA revealed significant main effects of Group [$F(1,12)=7.27$, $p < .05$, $\eta^2=.38$; $F(1,224)=329.79$, $p < .01$, $\eta^2=.6$], Context [$F(1,12)=24.57$, $p < .01$, $\eta^2=.67$; $F(1,224)=20.42$, $p < .01$, $\eta^2=.08$], and Question Type [$F(1,12)=78.86$, $p < .01$, $\eta^2=.87$; $F(1,224)=283.65$, $p < .01$, $\eta^2=.56$]. There was no significant main effect of Question Order. In addition, a significant Context x Question Type interaction was found [$F(1,12)=5.83$, $p < .05$, $\eta^2=.33$; $F(1,224)=4.19$, $p < .05$, $\eta^2=.02$]. This RT data is displayed in Figure 2.

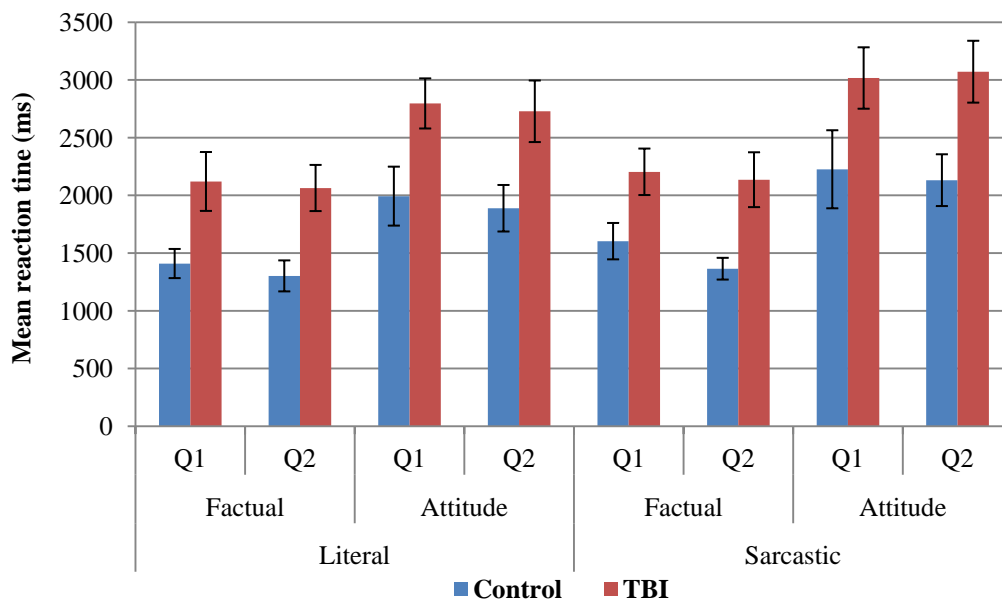


Figure 2. Mean reaction time data (with standard error) for TBI and control participants

Post-hoc analyses using Newman-Keuls ($p < .05$) revealed the following differences: for the Group main effect TBI participants were significantly slower than control participants ($p < .05$), for the Context main effect RTs were significantly slower in the sarcastic

compared to the literal context ($p < .01$), and for the Question Type main effect RTs were significantly slower on attitude compared to factual questions ($p < .01$). The significant Context x Question Type interaction indicated that RTs were faster in the literal factual condition compared to literal attitude ($p < .01$), sarcastic factual ($p < .05$) and sarcastic attitude ($p < .01$) and were the slowest in the sarcastic attitude condition compared to sarcastic factual, literal attitude and literal factual conditions (all $p < .01$). As there was no significant interaction with group this suggested the two groups performed similarly.

As there was a significant difference between the groups on MoCA scores, a further analysis was carried out factoring in these scores as a covariate. A $2 \times 2 \times 2 \times 2$ ANCOVA demonstrated that when group differences in MoCA scores were accounted for, the significant main effect of Group was lost [$F(1,11)=2.21, p=.17, \eta^2=.17$]. There was, however, still a main effect of Context [$F(1,11)=4.84, p=.05, \eta^2=.31$] and a new main effect of Question Order [$F(1,11)=10.27, p < .01, \eta^2=.48$]. Importantly there were also significant Context x Group [$F(1,11)=4.69, p=.05, \eta^2=.3$] and Question Order x Group [$F(1,11)=9.97, p < .01, \eta^2=.48$] interactions, and the Context x Question Type x Group interaction nearly reached statistical significance [$F(1,11)=4.49, p=.06, \eta^2=.29$].

Post-hoc Newman-Keuls ($p < .05$) analyses of the main effects seen in the above ANCOVA demonstrated, regarding Context, significantly slower RTs in the sarcastic than the literal context ($p < .01$), and with regards to Question Order, a trend for faster RTs on the second question ($p=.06$). The post-hoc analysis of the significant Context x Group interaction showed that both TBI ($p < .05$) and control participants ($p < .01$) took longer to respond to sarcastic contexts than literal contexts. With regards to the significant Question Order x Group interaction, post-hoc analysis showed that the control participants were significantly faster on the second question compared to the first ($p < .05$); however, this was not the case for TBI participants as there was no significant difference in RT between questions that appeared first and those that appeared second ($p=.56$). Considering the trend for the Context x Question Type x Group interaction, a Newman-Keuls ($p < .05$) analysis demonstrated that for the control participants, the literal factual condition was always the most favourable (yielding faster RTs) in comparison to the literal attitude, sarcastic attitude (both $p < .01$) and the sarcastic factual ($p < .05$) conditions. However, for the TBI participants there was no significant difference on factual question RTs between the literal and the sarcastic contexts ($p=.2$), whilst the RTs on attitude questions were significantly faster in the literal context than the sarcastic ($p < .01$). In both the literal and the sarcastic contexts, RTs were faster on factual questions than attitude questions for TBI and control participants (all $p < .01$).

3.1.2.2.1 Additional reaction time analysis

At the analysis stage it became apparent that an oversight during the development of the experiment meant that the lengths of the two questions (factual and attitude) were significantly different in word count; attitude questions had significantly more words ($M=8.77$, $SD=1.5$) than factual questions ($M=5.55$, $SD=1.38$) [$F(1,118)=149.1$, $p<.01$], which could have explained any main effects or interactions of Question Type in the previous analyses. In an attempt to establish whether any effects of Question Type seen in the above full data analyses were influenced by length of question (and the associated additional reading time), or rather by something beyond this (e.g. related to social cognition), a sample of the vignettes was taken where the questions did not differ significantly in word count. Data from 23 factual questions (12 sarcastic, 11 literal; reflecting 38% of all factual questions) (word count $M=6.83$, $SD=.58$) and 23 attitude questions (11 sarcastic, 12 literal; reflecting 38% of all attitude questions) (word count $M=7.22$, $SD=.95$), which were not significantly different [$F(1,44)=2.85$, $p=.1$], were analysed and are presented in Figure 3.

This smaller data set was considered for the same parametric analyses as conducted on the full data set. The assumption of normality was satisfied (according to skewness and kurtosis scores, and the Shapiro-Wilk test) as was the assumption of homogeneity of variance (according to the Leneve's test).

The same analyses were run as above; a 2 x 2 x 2 x 2 ANOVA and ANCOVA with MoCA scores as a covariate. The ANOVA reported results consistent with the main analysis reported above; main effects of Group [$F(1,12)=8.52$, $p<.05$, $\eta^2=.42$] and Question Type [$F(1,12)=70.83$, $p<.01$, $\eta^2=.86$], a trend for a main effect of Context [$F(1,12)=3.3$, $p=.09$, $\eta^2=.22$], and no significant main effect of Question Order. A Question Type x Question Order interaction was seen [$F(1,12)=16.94$, $p<.01$, $\eta^2=.59$].

The ANCOVA with MoCA as covariate for this smaller analysis also produced results similar to the ANCOVA of the full data set. There was no main effect of Group, as before, and there were still significant main effects of Context [$F(1,11)=12.55$, $p<.01$, $\eta^2=.53$] and Question Order [$F(1,11)=6.86$, $p<.05$, $\eta^2=.38$], and significant interactions of Context x Group [$F(1,11)=6.54$, $p<.05$, $\eta^2=.37$], and Question Order x Group [$F(1,11)=9.66$, $p<.01$, $\eta^2=.47$]. Furthermore, there were significant interactions of Context x Question Type x Question Order [$F(1,11)=8.12$, $p<.05$, $\eta^2=.43$] and Context x Question Type x Question Order x Group [$F(1,11)=5.03$, $p<.05$, $\eta^2=.31$].

Overall, the findings for this subset of the full data, in which factual and attitude questions were controlled for length, confirmed the findings of the full analysis, showing that attitude questions indeed take longer to process and respond to than factual questions, suggesting different cognitive processes are involved in processing and responding to factual and attitude questions.

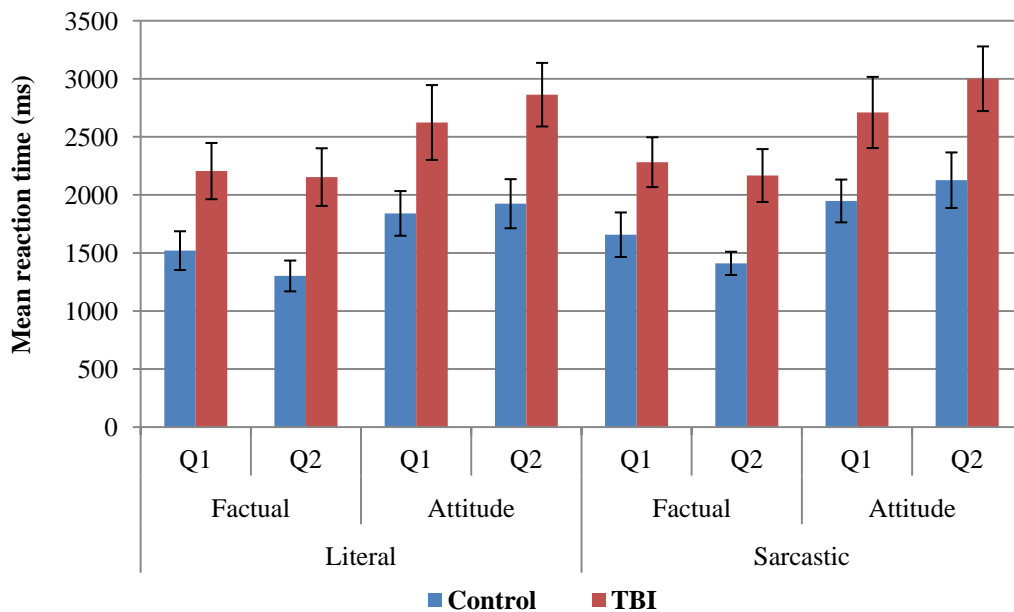


Figure 3. Mean reaction time data (with standard error) for TBI and control participants, on a smaller subset of questions statistically similar in length

3.1.3 Error analysis

3.1.3.1 Descriptive statistics and checks prior to analysis

The error data was explored and considered for statistical analysis. Error rates are presented in Figure 4. The attitude question errors reflect a combination of errors made both when there were and were not factual errors as well. To help understand the pattern of errors made by each participant in each group, overall numbers and percentages of errors made are displayed in Table 7. In Table 7 the error rates have been collapsed across the within-subjects factor ‘Question Order’ as there were very few errors, and on initial visual inspection of the data there was little difference evident across this factor. On visual inspection of this data it is clear that error rates were very low for the control group, suggesting they performed at or just below ceiling level.

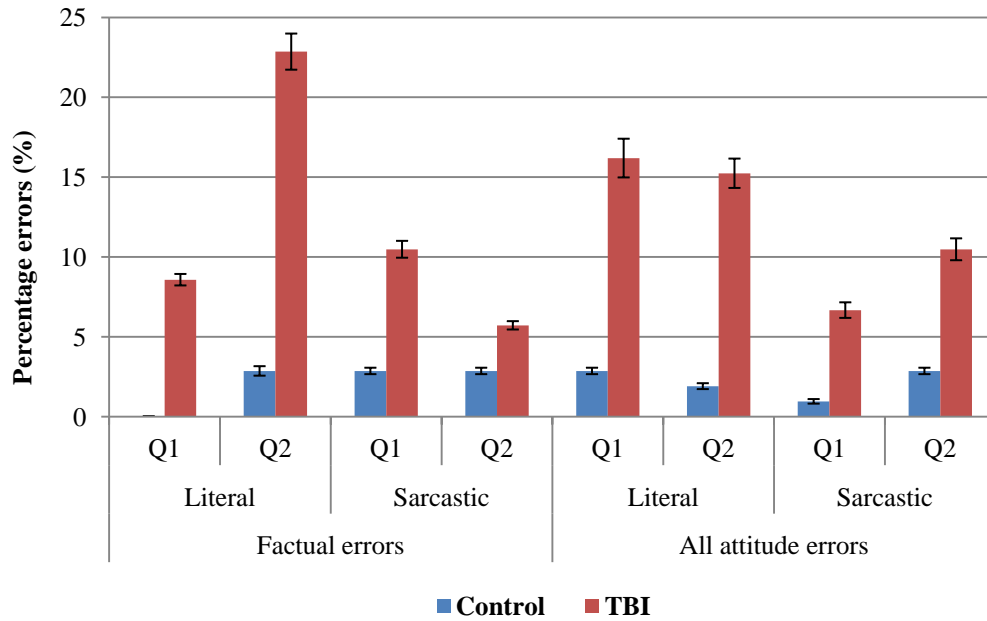


Figure 4. Percentage of factual and total attitude errors (with standard error), for TBI and control participants

Table 7. Experiment One total number (and percentage) of literal and sarcastic errors for each TBI and control participant

TBI participant	Literal		Sarcastic		Total errors
	Factual	Attitude	Factual	Attitude	
P01	2 (6.67%)	3 (10%)	0	0	5
P02	1 (3.33%)	1 (3.33%)	3 (10%)	1 (3.33%)	6
P03	4 (13.33%)	7 (23.33%)	3 (10%)	7 (23.33%)	21
P04	10 (33.33%)	12 (40%)	0	0	22
P05	4 (13.33%)	1 (3.33%)	4 (13.33%)	4 (13.33%)	13
P06	2 (6.67%)	2 (6.67%)	2 (6.67%)	0	6
P07	10 (33.33%)	7 (23.33%)	5 (16.67%)	6 (20%)	28
Control					
Control participant	Factual	Attitude	Factual	Attitude	Total errors
C01	0	1 (3.33%)	1 (3.33%)	2 (6.67%)	4
C02	1 (3.33%)	1 (3.33%)	0	0	2
C03	0	0	1 (3.33%)	0	1
C04	0	1 (3.33%)	1 (3.33%)	1 (3.33%)	3
C05	0	0	1 (3.33%)	0	1
C06	0	1 (3.33%)	1 (3.33%)	0	2
C07	2 (6.67%)	1 (3.33%)	1 (3.33%)	1 (3.33%)	5

The error data was considered for parametric analysis, as conducted on the RT data. On initial exploration of the data, when separated by the three within-subjects factors, there were seven outliers and the data from both groups did not satisfy assumptions of normality. When the 'Question Order' factor was collapsed and data were explored according to the two remaining within-subjects factors, there were still two outliers on inspection of box-plots and whilst the TBI group was normally distributed, the control group was not. Log transformation of the control data was unsuccessful due to so few errors in this group. Collapsing again across 'Question Type' meant both groups' data met assumptions of normality. T-test analysis (with unequal variances assumed) demonstrated that the TBI group made significantly more errors in the literal context than the control group did [$t(6.24)=2.88, p<.05$], whereas the difference between the groups on the number of sarcastic errors did not reach statistical significance [$t(6.53)=1.98, p=.09$]. Looking at number of errors overall (collapsed also across Context), t-test analysis (with unequal variances assumed) confirmed that the TBI group made significantly more errors ($M=14.43, SD=9.29$) than the control group ($M=2.57, SD=1.51$) [$t(6.62)=3.33, p<.05$].

Further t-tests for the TBI group demonstrated that there were no significant differences between the number of errors made between literal and sarcastic contexts, and no significant differences between the factual and the attitude questions. It is likely that the statistical power of any analysis is limited by the small sample size. In addition, on visual inspection of the TBI group error data (Table 7), there is clear variability in performance. There appears to be an overall pattern towards participants making more literal errors than sarcastic; this being the case for five TBI participants with only two showing the opposite pattern. Interestingly, one participant (P04) seemed to perform markedly different as they made 22 literal errors and no sarcastic errors at all. However, these patterns could not be further supported by statistical analysis.

3.1.4 TBI group clinical data and correlations

3.1.4.1 TASIT scores

In order to gain more insight into the performance of the TBI group on additional measures of social inference, and particularly sarcasm comprehension, the TASIT scores were compared with the mean scores of the healthy sample used in the development of the TASIT (taken from Table 2 and Table 4 of the test manual; McDonald et al., 2002). In the current study, six members of the TBI group received form A of the TASIT and one participant received form B (due to past unsuccessful attempts at administering form A

rendering it invalid), thus six form A means and one form B mean were used from the McDonald et al. healthy comparison group. On the EET, the TBI group scored significantly worse ($M=18.86$, $SD=4.81$) than the healthy comparison group ($M=24.76$, $SD=.27$) [$F(1,12)=10.5$, $p<.01$, $\eta^2=.47$], suggesting the TBI group experience difficulty with emotional evaluation compared to a healthy comparison group. Similarly, the TBI group performed significantly worse on the SI-M ($M=47$, $SD=3.92$) than the healthy comparison group ($M=53.93$, $SD=.46$) [$F(1,12)=21.65$, $p<.01$, $\eta^2=.64$], suggesting they also experience difficulty making social inferences in the context of sarcastic exchanges. Thus, the above data suggests that significant difficulty is experienced by TBI participants on emotion evaluation and drawing social inferences, in comparison to a healthy (albeit non-matched) comparison group. These findings mirror the significant group differences in errors found in the sarcasm experiment above.

In an effort to further explore the nuances of the TASIT performance, and get a sense of the individual performances of the TBI participants, the scores from the SI-M subtest of the TASIT, broken down by the type of exchange, are displayed in Table 8.

Table 8. Experiment One TASIT SI-M scores for each TBI participant, comparing sincere exchanges with simple sarcastic exchanges and paradoxical sarcastic exchanges

Participant number	Sincere (Max=20)	Simple sarcasm (Max=20)	Paradoxical sarcasm (Max=20)
P01	13	18	16
P02	20	12	14
P03	17	14	14
P04	6	17	17
P05	11	18	20
P06	17	17	16
P07	14	20	18
Mean (SD)	14 (4.62)	16.57 (2.7)	16.43 (2.15)

As can be seen in Table 8, the means for simple and paradoxical sarcasm are very similar, suggesting similar performance across these two forms of sarcasm. Whereas, the mean for the sincere exchanges is lower than the means for both of the sarcastic exchanges, a pattern similar to that found in the error analysis of the current sarcasm experiment (as more literal errors were made than sarcastic). However, despite these visible numerical differences, no statistically significant differences were seen between the scores on the

sincere exchanges and either the simple sarcasm [$t(6)=-1.04, p=.34$] or the paradoxical sarcasm [$t(6)=-1.03, p=.34$].

The performance of the TBI group in the current study was also compared to the performance of the TBI group and the healthy, matched, non-TBI comparison group used in the development of the TASIT (taken from Table 8 of the test manual, McDonald et al., 2002), on form A only (as only these were available). Interestingly, on sincere exchanges, the TBI group from the current study performed significantly worse ($M=14, SD=4.62$) than the McDonald et al. TBI group ($M=18.25, SD=1.86$) [$F(1,12)=5.93, p<.05, \eta^2=.33$], whereas they did not perform significantly differently to the non-TBI group ($M=16.08, SD=3.48$) [$F(1,12)=1.42, p=.26, \eta^2=.11$], (n.b. the McDonald et al. non-TBI group actually performed slightly worse than their TBI group on the sincere exchanges). Therefore, the difficulties seen on literal items by the current TBI group on the on-line sarcasm experiment, are also apparent via difficulties on the sincere (literal) items of the TASIT. The fact that these difficulties were not observed for the TBI participants tested by McDonald et al. suggests this may be a difficulty unique to the TBI group of our study, and could possibly relate to the degree of severity of injury and impairment with which they presented.

With regards to the sarcastic exchanges, looking at a combination of both the simple and paradoxical sarcasm, the opposite pattern is revealed; the TBI group in the current study performed statistically similarly ($M=33, SD=4.58$) to the McDonald et al. TBI group ($M=30.75, SD=9.07$) [$F(1,12)=1.68, p=.22, \eta^2=.12$], and significantly worse than the McDonald et al. non-TBI group ($M=38.58, SD=2.81$) [$F(1,12)=10.38, p<.01, \eta^2=.45$]. This suggests sarcasm comprehension, as judged by the TASIT SI-M, is similar across these two TBI groups, both being impaired in comparison to healthy control participants.

3.1.4.2 Correlation analyses

In order to further explore any relationships between the performance of the TBI group on the sarcasm experiment and other clinical factors, and to specifically consider the third research question exploring links between sarcasm comprehension and aggression, correlation analyses were carried out. As described above, the TBI error data was normally distributed when collapsed across Question Order, and explored across the two factors Context and Question Type. There were, however, still outliers in this data set which, due to small sample size, were not removed. Therefore, given the small sample

size and presence of outliers, findings are to be interpreted with caution. Figure 5 and Figure 6 plot the number of errors made in each condition of the sarcasm experiment against the TASIT SI-M and EET scores, respectively.

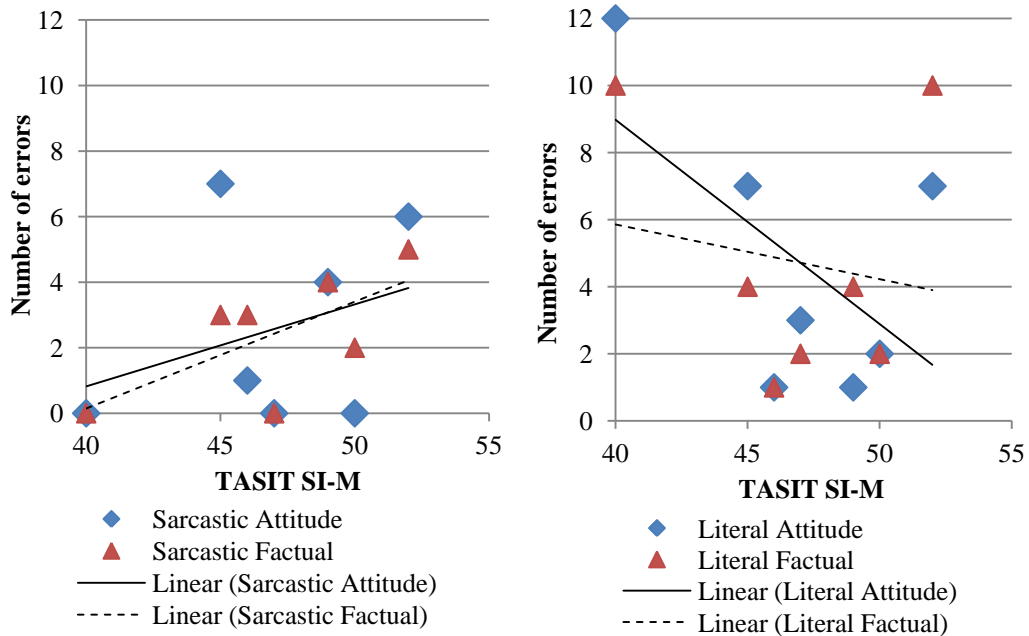


Figure 5. Relationship between number of errors on the sarcasm experiment and performance on the TASIT Social Inference – Minimal (SI-M) subtest, for TBI participants

As displayed in the left hand scattergram in Figure 5, moderate-strong, positive, non-statistically significant relationships were found between TASIT SI-M score and the number of sarcastic attitude errors [$r(5)=.32, p=.47$], and TASIT SI-M score and the number of sarcastic factual errors [$r(5)=.67, p=.1$]. On the other hand, as displayed in the right hand scattergram of Figure 5, negative, non-significant relationships were seen between SI-M score and the number of literal factual errors [$r(5)=-.17, p=.72$] and between SI-M score and the number of literal attitude errors [$r(5)=-.58, p=.17$], with the former reflecting a weak relationship and the latter reflecting a strong relationship. Whilst the latter correlation does not reach statistical relationship, the strong correlation coefficient suggests that 33.64% of the variance is shared between TASIT SI-M score and number of literal attitude errors.

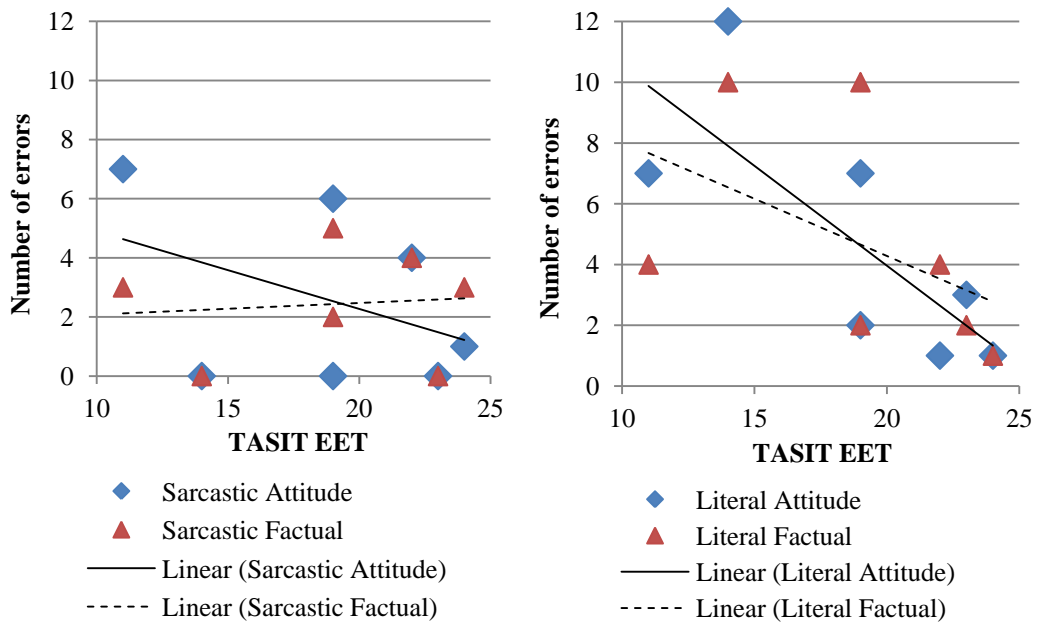


Figure 6. Relationship between number of errors on the sarcasm experiment and performance on the TASIT Emotion Evaluation Test (EET), for TBI participants

With regards to the TASIT EET (data displayed in Figure 6), as performance improved (i.e. higher score) the number of errors in the literal attitude condition decreased statistically significantly [$r(5)=-.77, p<.05$], and the r value suggests this is a strong relationship, where there is 59.29% shared variance. Similarly, a negative correlation was seen between EET score and number of literal factual errors [$r(5)=-.48, p=.28$], and whilst this reflects a moderate relationship it was not statistically significant. In addition, a moderate, non-significant, negative relationship was found between EET and sarcastic attitude errors [$r(5)=-.41, p=.36$], and a weak, non-significant, negative relationship was seen between EET and sarcastic factual errors [$r(5)=.1, p=.83$]. These findings may suggest that there is a link between the identification of emotion and the interpretation of literal information, in particular from another person's perspective (as implied from the attitude questions).

In Figure 7, below, the number of errors in each condition was plotted against the observed aggression scores (OAS-MNR). These correlations reveal that as observed aggressive behaviour increases, sarcastic errors decrease on both factual [$r(5)=-.7, p=.08$] and attitude questions [$r(5)=-.27, p=.55$], though both non-significantly. In contrast, as observed aggressive behaviour increases, literal errors increase; a moderate positive, but non-significant correlation is seen with literal factual question errors [$r(5)=.48, p=.28$], and a strong, statistically significant positive correlation is observed between OAS-MNR and literal attitude question errors [$r(5)=.81, p<.05$]. Whilst this is a small sample, with

the potential influence of extreme data points skewing the strength of the relationships, the patterns may suggest that aggressive behaviour relates to the ability to interpret literal information from others' perspectives.

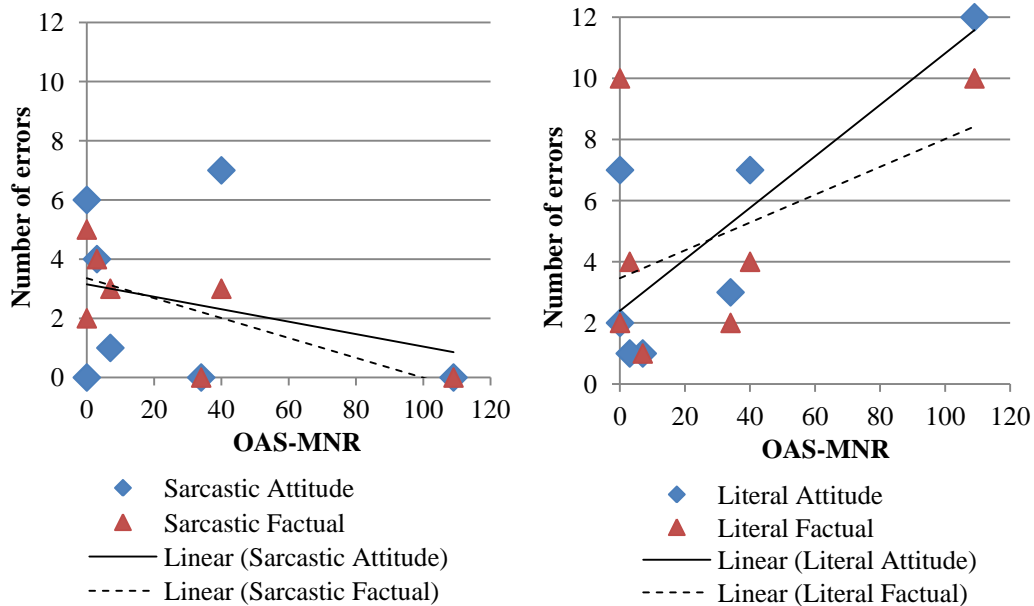


Figure 7. Relationship between number of errors on the sarcasm experiment and observed aggression as per the OAS-MNR, for TBI participants

Further correlational analyses were conducted to explore additional factors potentially related to observed levels of aggression. Whilst a moderate negative correlation was found between OAS-MNR scores and self-rated aggression (via the BPAQ), this was not statistically significant [$r(5)=-.36, p=.42$] and most likely skewed by presence of outliers, as apparent from inspection of the scattergram (see Figure 8). Similarly, moderate, yet non-significant, negative correlations were found between OAS-MNR scores and the WAIS-IV index scores Verbal Comprehension Index (VCI) [$r(5)=-.40, p=.37$] and Full Scale IQ (FSIQ) [$r(5)=-.31, p=.5$], and again scattergrams (see Figure 9) suggested these relationships may be influenced by extreme data points. Whilst these relationships must be interpreted with caution, outliers were not removed due to small sample size and anticipated variability in performance due to heterogeneity expected within any TBI sample.

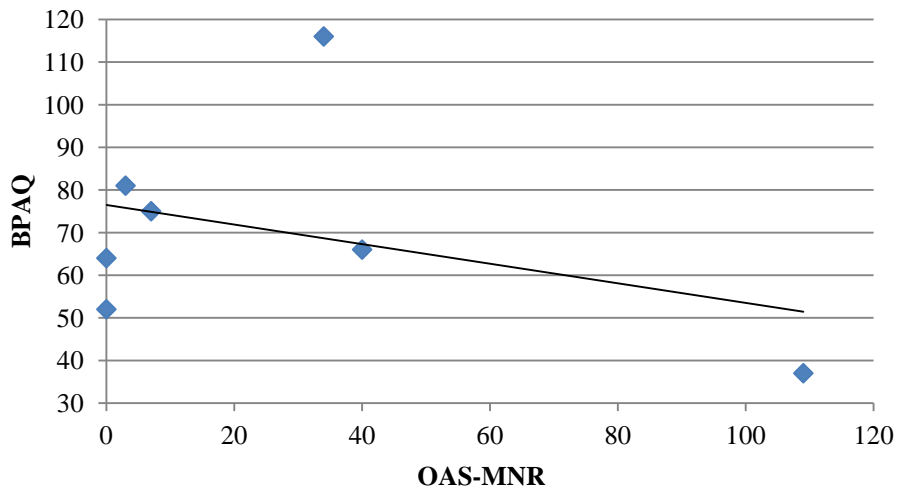


Figure 8. Relationship between self-rated aggression as per the BPAQ, and observed aggression as per the OAS-MNR, for TBI participants

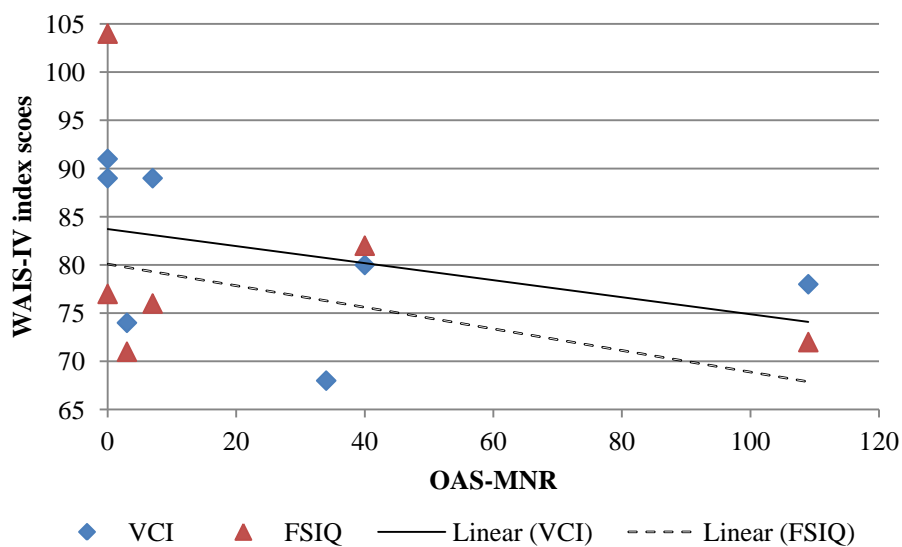


Figure 9. Relationship between WAIS-IV Verbal Comprehension Index and Full Scale IQ, and observed aggression as per the OAS-MNR, for TBI participants

Finally, OAS-MNR scores were plotted against TASIT SI-M and EET scores. As demonstrated in Figure 10, negative correlations were produced between the TASIT scores and OAS-MNR scores; as TASIT SI-M and EET scores worsen, observed aggressive behaviour increases. Both correlations demonstrated strong relationships, and whilst the negative correlation with the TASIT EET is not statistically significant [$r(5) = -.58, p = .18$], the negative correlation with the TASIT SI-M subtest is statistically significant [$r(5) = .91, p < .01$], suggesting a link between aggressive behaviour and making social inferences.

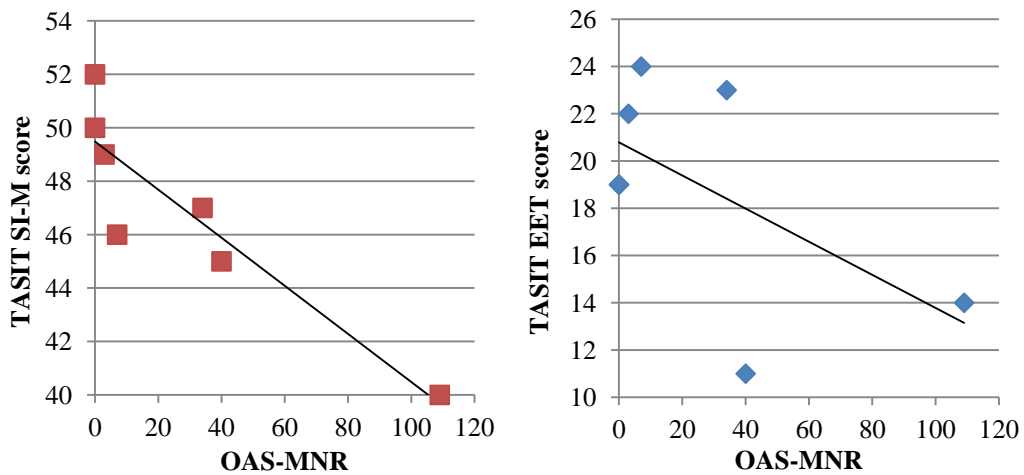


Figure 10. Relationship between TASIT Social Inference-Minimal (SI-M) subtest and Emotion Evaluation Test (EET) scores, and observed aggression as per the OAS-MNR, for TBI participants

3.1.5 Experiment One summary

In summary, the RT analysis showed that TBI participants performed slower than control participants, but this difference was predicted by the difference in overall cognitive ability (according to the MoCA). When difference in cognitive ability was statistically controlled for, overall RTs were significantly slower when responding to questions in the sarcastic context compared to the literal. Whilst the control and TBI groups both performed faster on attitude questions in the literal context compared to sarcastic, only the control group showed a similar benefit of context on factual questions (performing significantly faster in the literal context); the TBI group RTs did not significantly differ on factual questions between the two contexts. In terms of the order in which the questions were presented, control participants showed a benefit for questions appearing second, demonstrated by significantly faster RTs, whereas TBI participants did not show such priming effects as their RTs across the first and second question did not statistically differ.

The error analysis revealed that TBI participants made more errors overall than control participants. Whilst the TBI group did not make statistically more sarcastic errors than the control group, they did make statistically more literal errors. Though the within group analysis of the TBI group data found no statistical difference in the number of errors between the sarcastic and literal contexts, the high number of literal errors made by TBI participants was unexpected. Interestingly, this finding was in line with the errors made

on the sincere (literal) exchanges in the TASIT SI-M, indicating that literal language comprehension may be compromised in TBI. Near-ceiling performance of the control group limited further statistical analysis of errors on the task.

With regards to the TBI group, observed aggressive behaviour, as per the OAS-MNR, was significantly positively correlated with number of literal attitude question errors, suggesting more aggressive behaviour is related to difficulty interpreting literal information from another person's perspective. This was the only statistically significant relationship between performance on the sarcasm test and aggressive behaviour (self-rated or observed), most likely due to small sample size. However, scores on the TASIT SI-M did significantly negatively correlate with OAS-MNR, suggesting aggressive behaviour and poor social inference skills are related. In addition, the number of literal attitude errors on the sarcasm task significantly negatively correlated with TASIT EET score, suggesting a relationship between interpreting literal information from another person's perspective and the ability to identify others' emotional states.

3.2 Experiment Two

Experiment Two was designed to address the fourth research question investigating differences in sarcasm comprehension between healthy participants who rate themselves as low aggressive and moderately aggressive. Firstly, the MoCA, BPAQ and sarcasm question scores are considered. Then, the sarcasm experiment RT and error data are displayed and statistically analysed.

The 40 healthy, young adults who participated were ranked by their BPAQ score and split into two groups at the median point, creating a low aggression and a moderate aggression group, each with 20 participants. The term 'moderate' was used as, on the whole, this group's mean (73.2; see Table 9) was not particularly high, being similar to the average scores obtained from a healthy sample in the development of the measure (men = 77.8, women = 68.2; Buss & Perry, 1992). However, the moderate aggression group did include some higher scoring individuals, as reflected by the standard deviation (10.15, see Table 9).

Table 9 presents the results from the screening tests, and sarcasm questions, for the low and moderate aggression groups. In addition, in order to take any gender differences into

consideration, the scores on the BPAQ and sarcasm questions are outlined for males and females.

Table 9. Experiment Two low and moderate aggression groups' MoCA, BPAQ and sarcasm scores, mean (SD)

Characteristic	Low aggression (N=20; Female=14, Male=6)	Moderate aggression (N=20; Female=13, Male=7)
MoCA (Max=30)	28.35 (1.46)	28.45 (1.23)
BPAQ (Max=145)	48.55 (6.85)	73.2 (10.15)
Female	50.67 (4.27)	72.69 (11.52)
Male	47.64 (7.65)	74.14 (7.71)
Self-rated sarcasm identity score (0-10)	5.65 (2.41)	6.9 (1.8)
Female	5.5 (1.29)	7.15 (1.86)
Male	6 (2.28)	6.43 (1.72)
Self-rated sarcasm frequency score (1-7)	5.2 (1.15)	5.5 (1.05)
Female	5.14 (2.53)	5.62 (1.04)
Male	5.33 (0.82)	5.29 (1.11)

MoCA = Montreal Cognitive Assessment; BPAQ = Buss Perry Aggression Questionnaire

The data above was analysed with one-way ANOVAs comparing the scores between the two groups. The ANOVA confirmed that there was no significant difference between the groups on the MoCA [$F(1,38)=.05, p=.82, \eta^2=.01$]. The ANOVA also confirmed that the median split by BPAQ score created two distinct groups as the BPAQ scores differed significantly between the groups [$F(1,38)=81.01, p<.01, \eta^2=.68$]. There were no significant differences on the BPAQ between males and females in the low aggression group [$F(1,38)=.81, p=.38, \eta^2=.04$] and the moderate aggression group [$F(1,38)=.09, p=.77, \eta^2=.01$]. Even when all male participants were compared to all female participants (collapsing across the low and moderate aggression groups) their BPAQ scores did not differ significantly (males: $M=63.31, SD=13.63$; females: $59.71, SD=15.91$; [$F(1,38)=.49, p=.49, \eta^2=.01$]). Thus, given the absence of any significant differences between male and female participants, and the smaller number of male participants compared to female participants, the low and moderate aggression groups were not further divided by gender.

There was no significant difference between the groups on the sarcasm frequency score [$F(1,38)=2.45, p=.13, \eta^2=.02$]. The sarcasm identity scores approached significance

[$F(1,38)=3.45, p=.07, \eta^2=.08$], with higher scores in the moderate aggression group, suggesting that the more people rated themselves as aggressive, the more they identified as being sarcastic. The BPAQ scores across both groups were correlated with the sarcasm identity and frequency scores. Whilst sarcasm frequency rating and BPAQ score did not show a statistically significant relationship, BPAQ scores correlated positively and significantly with sarcasm identity ratings [$r(38)=.34, p<.05$], suggesting that aggression and sarcasm are related. This significant relationship is displayed in Figure 11.

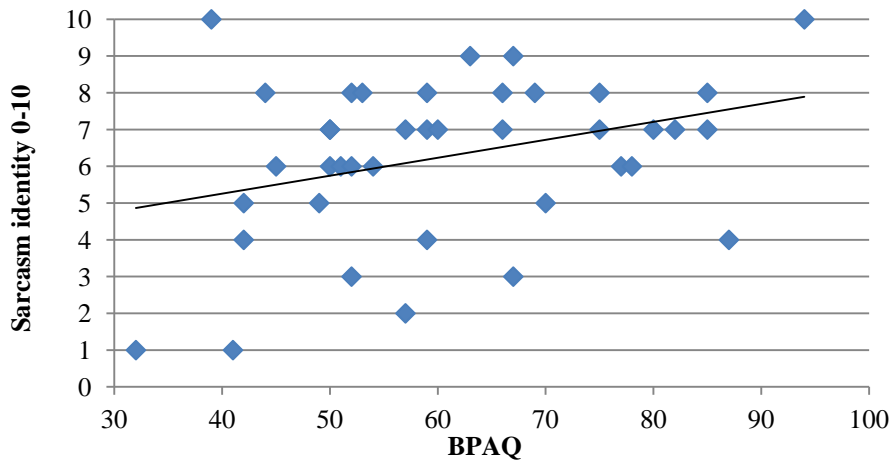


Figure 11. Relationship between BPAQ and sarcasm identity score, both groups combined

3.2.1 Sarcasm experiment data preparation

The data collected by the University of Leeds psychology undergraduate student was prepared for statistical analysis by this same individual. The step by step instructions developed by the lead researcher, with guidance from the lead supervisor (appendix 15), were used to ensure accuracy and consistency in the process. The data preparation process involved errors and outliers being removed in the same manner as described in Experiment One.

In terms of errors, for the low aggression group, errors made on factual questions comprised 2.92%, errors made on attitude questions when there were factual errors comprised 0.58%, and errors made on attitude question when the factual question was correct comprised 1.75%. Outliers comprised 4.84% of the remaining correct responses. For the moderate aggression group, errors made on factual questions comprised 1.75%, errors made on attitude questions when there were factual errors comprised 0.5%, and errors made on attitude question when the factual question was correct comprised 1.08%. Outliers comprised 4.28% of the remaining correct responses.

3.2.2 Reaction time analysis

3.2.2.1 Descriptive statistics and checks prior to analysis

The following steps were carried out by the lead researcher of the current study, not by the undergraduate student who assisted data collection.

In order to ensure the data was suitable for parametric analysis, the parametric assumptions were checked. Box-plots were examined for outliers, and none were found. Next, the distribution of the data was considered. The assumption of normality was first assessed by the Shapiro-Wilk test. Within the low aggression group, all but one condition satisfied this assumption ($p > .05$), and one condition was significant ($p < .01$). Within the moderate aggression group, four conditions satisfied the assumption and four were significant at the $p < .05$ level, but not the $p < .01$ level. Since not all the findings of this test fully satisfied the assumption of normality, skewness and kurtosis scores were examined also. These values are displayed in Table 10. Skewness and kurtosis Z scores were calculated, which fell within the acceptable range (± 2.58) on all levels, thus suggesting normality of distributions.

Table 10. Experiment Two low and moderate aggression groups RT (ms) data descriptive statistics

Group	Mean RT (SD)	Skewness (SE)	Kurtosis (SE)
Condition (Within-subjects factor)			
Low aggression			
Literal Factual Q1	1402.12 (395.02)	.53 (.51)	-.93 (.99)
Literal Factual Q2	1375.65 (385.95)	.22 (.51)	-.9 (.99)
Literal Attitude Q1	1786.70 (383.22)	.41 (.51)	-1.18 (.99)
Literal Attitude Q2	1608.74 (419.78)	.68 (.51)	-.55 (.99)
Sarcastic Factual Q1	1528.62 (387.24)	.27 (.51)	-1.24 (.99)
Sarcastic Factual Q2	1396.82 (286.92)	.17 (.51)	-1.01 (.99)
Sarcastic Attitude Q1	1774.54 (413.02)	.49 (.51)	-.89 (.99)
Sarcastic Attitude Q2	1623.74 (405.75)	.9 (.51)	-.4 (.99)
Moderate aggression			
Literal Factual Q1	1456.88 (391.25)	.57 (.51)	-.86 (.99)
Literal Factual Q2	1406.33 (347.68)	.71 (.51)	.08 (.99)
Literal Attitude Q1	1905.47 (678.26)	.8 (.51)	-.71 (.99)

Literal Attitude Q2	1771.80 (529.43)	.91 (.51)	-.26 (.99)
Sarcastic Factual Q1	1622.94 (387.68)	.3 (.51)	-1.47 (.99)
Sarcastic Factual Q2	1440.93 (341.96)	.4 (.51)	-.63 (.99)
Sarcastic Attitude Q1	1916.11 (726.81)	.69 (.51)	-.85 (.99)
Sarcastic Attitude Q2	1797.32 (693.54)	.59 (.51)	-.88 (.99)

To assess the homogeneity of variance assumption, Levene's test was considered. Three within-subjects factors violated this assumption, suggesting there were unequal variances between the two groups on the 'literal attitude question one' ($p < .01$), 'sarcastic attitude question one' ($p < .05$), and 'sarcastic attitude question two' ($p < .01$) factors.

As the assumption of homogeneity of variance was violated, and the outcomes of the assumption of normality tests were inconsistent, the data were transformed. Because of the positive skew of the data, a Log 10 transformation was carried out. After transformation, the parametric assumptions were checked again. Firstly, there remained no outliers. Secondly, normality was still satisfied as per the skewness and kurtosis scores (as before the transformation) and all but one condition satisfied the Shapiro-Wilk test at the $p < .05$ level, and one condition at the $p < .01$ level, thus confirming the transformation had been successful at reducing the abnormality of the distribution. With regards to the homogeneity of variance assumption, Levene's test results on this transformed data showed that whilst three within-subjects factors remained significant at the $p < .05$ level, they were no longer significant at the $p < .01$ level. Thus, the transformation had successfully reduced the heterogeneity of variances between the groups. Parametric analysis of the transformed RT data was then conducted.

3.2.2.2 Statistical analysis

The raw (non-transformed) RT data is presented in Figure 12. The transformed RT data was subjected to a 2 (Group: low aggression or moderate aggression) x 2 (Context: literal or sarcastic) x 2 (Question Type: factual or attitude) x 2 (Question Order: first or second) mixed effects ANOVA for participants (F1) and items (F2). All significant main effects and interactions were investigated further with Newman-Keuls post-hoc tests ($p < .05$).

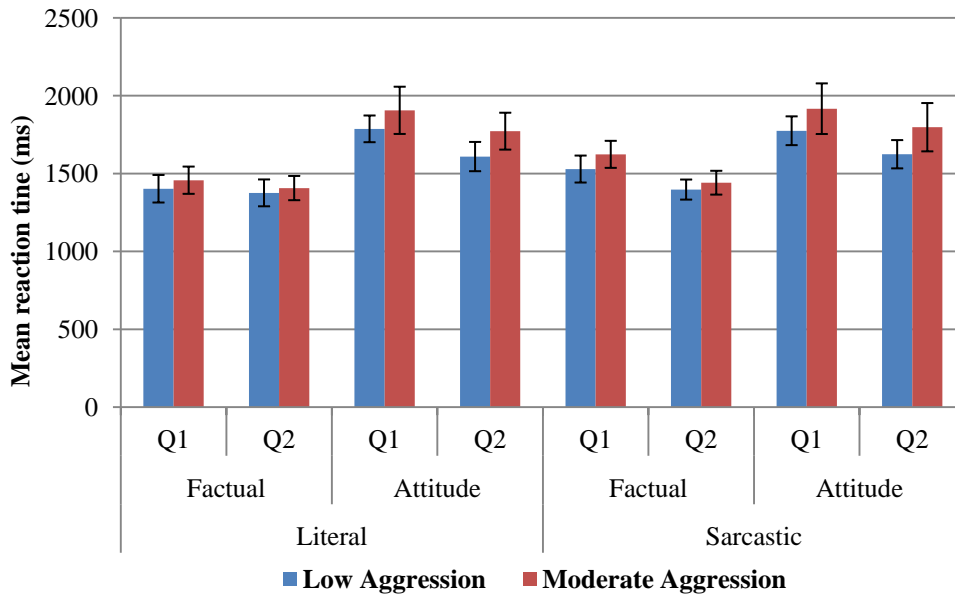


Figure 12. Mean reaction time data (with standard error) for the low and moderate aggression groups

The ANOVA for the transformed RT data revealed no main effect of group or group interactions. Main effects of Context [$F(1,38)=7.17, p<.05, \eta^2=.16; F(1,224)=2.44, p=.12, \eta^2=.01$], Question Type [$F(1,38)=51.56, p<.01, \eta^2=.58; F(1,224)=122.9, p<.01, \eta^2=.35$], and Question Order [$F(1,38)=32.59, p<.01, \eta^2=.46; F(1,224)=18.27, p<.01, \eta^2=.08$], were observed, along with a two-way significant interaction of Context x Question Type [$F(1,38)=22.31, p<.01, \eta^2=.37; F(1,224)=2.17, p=.15, \eta^2=.01$], and a significant three-way interaction of Context x Question Type x Question Order [$F(1,38)=5.11, p<.05, \eta^2=.12; F(1,224)=1.38, p=.24, \eta^2=.01$].

Newman-Keuls ($p<.05$) post-hoc analyses demonstrated the following in relation to the main effects and interactions. With regards to Context, RTs were faster in the literal than the sarcastic condition ($p<.01$). Looking at Question Type, RTs were faster for factual than attitude questions ($p<.01$). Finally, considering Question Order, RTs were faster for questions coming second than those coming first ($p<.01$). In terms of the Context x Question Type interaction, RTs were faster on factual questions in the literal context ($p<.01$), and there was no difference in RTs on attitude questions between the two contexts. In terms of the three-way interaction of Context x Question Type x Question Order, on factual questions in the literal context there was no significant difference in RTs between the questions ordered first or second. On attitude questions in the literal context, factual questions in the sarcastic context and attitude questions in the sarcastic context, RTs were significantly faster for the questions ordered second (all $p<.01$).

3.2.2.2.1 Additional reaction time analysis

As was the case for Experiment One, additional analyses were conducted on a subset of the vignettes for which the word count of factual and attitude questions were statistically similar, in an attempt to control for any effects of question length and therefore reading time. As in Experiment One, the data from the sample of 23 attitude and 23 factual questions were looked at.

This smaller data set was considered for parametric analysis. As in the larger analysis, outliers were present (three data values greater than 1.5 box-lengths from the edge of the box) and the data set violated both the normality assumption (both according to skewness and kurtosis scores, and the Shapiro-Wilk test), and also the homogeneity of variance assumption (according to the Levene's test). Consequently, the data were Log transformed in line with the procedure in the full data set analysis. Once the data was Log transformed outliers were no longer present and the assumption of normality was fully satisfied (according to skewness and kurtosis scores, and the Shapiro-Wilk test). With regards to the homogeneity of variance, the Levene's test results suggested the data transformation was successful in reducing the heterogeneity of the variance, with all but one within-subject factors being non-significant at the $p < .05$ level, and one factor significant at the $p < .05$ level but not the $p < .01$ level. This transformed data was therefore considered suitable for parametric analysis. The raw (non-transformed) data is presented in Figure 13.

The 2 x 2 x 2 x 2 repeated measures ANOVA yielded no main effect of Group (as was found in the main analysis) but main effects of Context [$F(1,38)=21.16, p < .01, \eta^2=.36$], Question Type [$F(1,38)=91.08, p < .01, \eta^2=.71$], and Question Order [$F(1,38)=38.88, p < .01, \eta^2=.51$]. In addition, a significant interaction of Context x Question Type [$F(1,38)=33.63, p < .01, \eta^2=.47$] was seen as well as a Question Type x Question Order interaction [$F(1,38)=4.63, p < .05, \eta^2=.11$]. Finally, a significant three way interaction of Context x Question Type x Question Order was produced [$F(1,38)=24.24, p < .01, \eta^2=.39$].

Overall, then, the findings in this subset of the data largely mirrored the findings of the analyses of the full data, confirming further the differences observed between the factual and attitude questions in the full analyses.

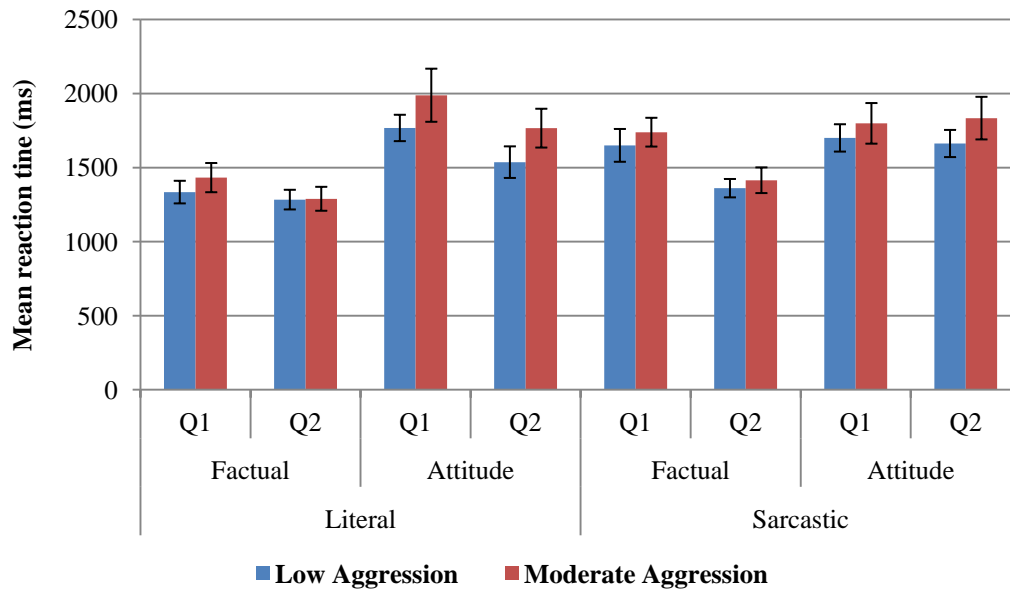


Figure 13. Mean reaction time data (with standard error) for low and moderate aggression groups, on a smaller subset of questions statistically similar in length

3.2.3 Error analysis

The error rates across Context, Question Type and Question Order for both the low and moderate aggression groups are displayed in Figure 14. As can be seen, error rates overall were very low, in line with the low error rates seen for the control group of Experiment One. The error data was considered for suitability for parametric analysis; on initial inspection outliers were present and data was non-normally distributed. The data was collapsed across the Question Order factor and still did not meet parametric assumptions. Due to many zero data points (where no errors were made), the data were not suitable for transformation. As a result of the violation of parametric assumptions, non-parametric Mann-Whitney U tests and Wilcoxon signed-rank tests were conducted to look for differences between the groups and on the within-subjects factors, respectively.

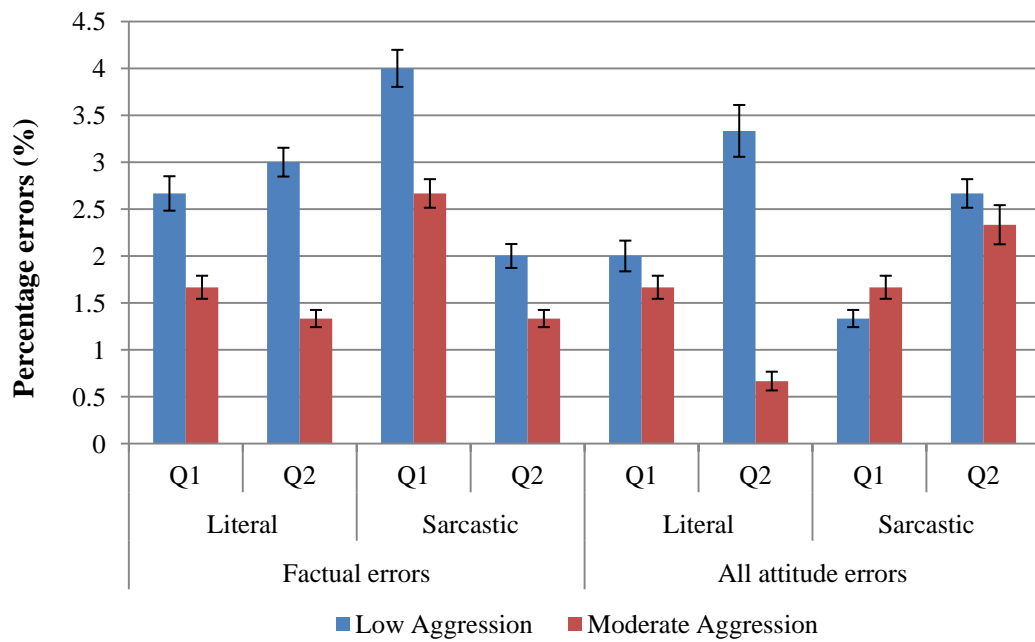


Figure 14. Percentage of factual and total attitude errors (with standard error), for low and moderate aggression groups

The Mann-Whitney U test found no significant differences in the number of errors made overall (collapsed across Context, Question Type and Question Order) between the low and moderate aggression groups [$U=161.5, p=.29$]. There were also no significant differences between the groups on total number of literal errors made [$U=151.5, p=.16$], total sarcastic errors made [$U=186.5, p=.7$], total factual question errors [$U=163.5, p=.3$] or total attitude question errors [$U=166.5, p=.33$]. Within the low aggression group, the Wilcoxon signed-rank test found no significant differences between the number of errors made in the sarcastic context and the literal context [$Z=-.44, p=.66$], or between the factual questions and the attitude questions [$Z=-1.25, p=.21$]. Within the moderate aggression group, again there were no significant differences in errors made between the two contexts [$Z=-1.41, p=.16$] or between the two question types [$Z=-.36, p=.72$].

3.2.4 Experiment Two summary

Overall, then, the RT analysis revealed that across both low and moderate aggression groups, RTs were faster in the literal context, on factual questions and on questions being presented second in order. There were no statistically significant differences in error rates between the contexts or question types. Finally, no between group differences were observed on the RT analysis or error analysis.

4. DISCUSSION

The present study set out to explore the dimensions of language processing that may have a role in the modulation of impulsive aggression (Miller et al., 2008). Although verbal ability has been linked to aggression both in clinical (Alderman, 2007; James & Young, 2013) and non-clinical groups (Stanford et al., 1997), no research to date had considered the specific role of sarcasm, or even non-literal language more generally, on aggression recognition and modulation. This study has focused specifically on the role of sarcasm because of the importance sarcasm plays in the communication and modulation of emotion, particularly anger (Gibbs et al., 2002). This was investigated in two separate experimental phases by comparing performance on a test of sarcasm comprehension between 1) individuals with TBI (and who, as a group, typically exhibit difficulties with processing of non-literal language and who often display impulsive aggression) with healthy, matched control participants, and 2) healthy, young adults who score in the low range on a self-rated aggression measure with healthy, young adults who score in the moderate range. The main findings of each experiment will be discussed in turn, in the context of existing research findings, followed by a more general discussion combining the two sets of findings, along with a consideration of study limitations, implications and future directions.

4.1 Experiment One

Experiment One found slower reaction times (RTs) on sarcastic compared to literal vignettes, and on attitude (accessing the speaker's implied meaning) rather than factual questions (accessing information about the facts of the story). These findings supported the hypotheses that, across both groups, literal contexts would be facilitated (producing faster RTs) compared to sarcastic contexts, and factual questions would be facilitated (producing faster RTs) compared to attitude questions. These findings will be discussed in more detail, alongside the findings from Experiment Two, in the general discussion section below.

With regards to the performance between the two groups, and in an attempt to address the first and second research questions regarding the role of TBI on language comprehension, and specifically sarcasm comprehension, significant differences were observed. TBI participants performed significantly worse than controls on the on-line sarcasm experiment; they were slower and made more errors, as hypothesised. When group

differences in the MoCA, a brief measure of general cognitive functioning, were controlled for through analysis of covariance in the RT analysis, significant interactions with group remained. In particular, only healthy control participants benefited from seeing a question second, while TBI participants did not show any facilitation for questions presented second, possibly indicating lack of priming or difficulties realising that the two questions were linked. Furthermore, while control participants showed clear facilitation for factual questions in literal contexts, TBI participants did not show any differences for factual questions presented in literal or sarcastic contexts, indicating that they may not fully use contextual information to their advantage. With regards to errors, TBI participants displayed significantly more errors overall than the control participants, as hypothesised. Interestingly, however, the TBI group did not make more errors in sarcastic contexts compared to the literal contexts; rather they appeared to make more errors in literal than sarcastic contexts, though this difference was not substantiated by within-group statistical analysis. The TBI group did, however make significantly more literal errors than the control group. This finding will be discussed in more detail below. Finally, no group differences were seen in errors across the two question types; TBI participants did not show worse performance than control participants on attitude questions compared to factual, as hypothesized. Thus, in terms of the comprehension of sarcastic material, the findings of the present study suggest that when overall differences in cognitive function were controlled for, there were some similarities between the TBI and control participant groups, as well as some striking differences.

Looking at the similarities in performance first, both the TBI and the control group took longer to process sarcasm compared to literal information, and made a statistically similar number of errors in sarcastic contexts. These findings were contrary to the expected result, based on existing research which demonstrated that individuals with TBI experience difficulties comprehending sarcasm compared to control participants (e.g. Giora et al., 2000; McDonald et al., 2003; Shamay-Tsoory et al., 2005). It is possible that the sarcastic material in the present study was more clearly sarcastic, and thus easier to identify as sarcasm indeed. After all, there were clear prosodic and contextual cues aiding comprehension. Additionally, though the current study used a paradigm based on Shamay-Tsoory et al. (2005), the current paradigm used both visual display of the stimuli (i.e. in writing) as well as auditory presentation; Shamay-Tsoory only used auditory presentation. Thus, the additional aids in the present study could have assisted with the identification of the sarcasm. Alternatively, these findings may suggest that comprehension of sarcasm was not impaired for the participants in the current sample. After all, the sample size was small and location of injury was not considered in the

inclusion criteria. With regards to injury location, past research has associated sarcasm comprehension difficulties with frontal lobe and right hemisphere injury (Giora et al., 2000; Shamay-Tsoory et al., 2005). Although some of the participants in the TBI group had frontal lobe injuries and right hemisphere injuries only, there were also bilateral and specific left hemisphere injuries, thus creating a relatively heterogeneous group in terms of injury profile.

This being said, however, looking at the performance of the TBI group on The Awareness of Social Inference Test (TASIT; McDonald et al., 2002), the participants do clearly show difficulties. Although the TASIT was not administered to the control participants in this study, the means of the control participants presented in the TASIT manual (McDonald et al., 2002) have been used as comparison means. When an analysis was run on these figures, the TBI group performed significantly worse than the TASIT healthy control participants on both the Emotion Evaluation Test (EET) and the Social Inference-Minimal (SI-M) subtest, a test exploring the perception of social exchanges, many of which incorporate sarcasm. Therefore, it may be that the sarcasm tested in the current study (direct negative sarcasm), with multiple cues provided (prosodic and contextual), did not challenge the current TBI participants to the same extent that the sarcasm in the TASIT SI-M did. Performance on the SI-M involves multiple complex cognitive processes including recognition of emotion, interpretation of paralinguistic cues, comprehension of spoken language and knowledge of social customs (McDonald et al., 2003). In addition, there are two forms of sarcasm tested in the SI-M; simple and paradoxical sarcasm. Simple sarcasm relies on paralinguistic cues alone (e.g. tone of voice, prosody, body language, facial expression) to indicate sarcasm, without which the spoken remark could be interpreted and make sense literally. In contrast, in the paradoxical sarcasm there were no paralinguistic cues to indicate sarcasm, only a mismatch between context and content of the speech, thus only on detection of this incongruence would sarcasm be inferred and the sentence make sense. The sarcasm experiment developed for this study could be considered a combination of both simple and paradoxical sarcasm, i.e. paralinguistic cues (sarcastic prosody) and contextual mismatch (comment incongruent with context) were both present. Therefore, the fact that the experimental paradigm developed in the present study did not elicit sarcasm comprehension difficulties in the TBI group, when the results of the TASIT did, may suggest that a combination of cues supports the identification of sarcasm. In addition, the results showed that the TBI group performed similarly on the simple and paradoxical sarcasm items of the TASIT SI-M, suggesting that neither paralinguistic cues nor context-comment incongruity alone are differentially more important than the other. Whilst some

studies have suggested that prosody alone may be sufficient to accurately infer sarcasm (e.g. Voyer et al., 2008), the current findings do not support this. In fact, they support studies which favour the mutually supportive roles of prosody and context (Bryant & Fox Tree, 2002; Woodland & Voyer, 2011) in the identification and interpretation of sarcasm.

However, the finding from the sarcasm experiment that TBI participants made significantly more errors in the literal context compared to the control participants, does raise further questions about interpretation of social exchanges, and of prosodic cues more specifically. Considering the nature of the literal remarks, they were all positively framed and spoken sincerely, for example “nice parking!”, “looks great, perfect fit!” and “you could play professionally in goal!”, and they were congruent with the preceding context. The analysis did not indicate a significant difference between the literal errors made on factual and attitude questions, suggesting that difficulty was experienced similarly when interpreting the facts of a literal situation and the intentions of the speaker. It could be that the literal/sincere social exchanges created more ambiguity for the TBI participants, in contrast to the clearly sarcastic exchanges, leading to misinterpretation of information.

It is considered noteworthy at this point to comment on the validity of the experimental stimuli. During the development of the experimental materials, the audio recordings of the literal vignettes were rated as not at all sarcastic and were found to be significantly different from the sarcastic vignettes, suggesting that they did indeed reflect literal statements. Also, since this pattern of errors was only observed in the TBI group and not the control group, this does suggest a specific difficulty unique to the TBI group, rather than being a product of misleading stimuli. Furthermore, difficulty inferring literal meanings was also observed for the TBI group on the TASIT SI-M sincere exchanges. The mean score for the TBI group on the sincere (literal) items was actually lower than the sarcastic items, mirroring the findings of the sarcasm experiment. Interestingly, the current study’s TBI group performed significantly worse on the sincere items than the McDonald et al. (2002) TBI group (data taken from the TASIT manual). Again this points to a specific difficulty in comprehending and judging sincere/literal conversational exchanges, unique to the current TBI group.

Having looked closely at the performance of each participant in the TBI group, it was apparent that the majority of participants (5 of 7) made more literal errors than sarcastic errors (collapsing across attitude and factual questions). Whilst for two participants this difference was not striking, three participants had five or more additional literal errors

than sarcastic errors, one of whom, in particular, performed very differently to the rest of the group, making 22 literal errors and no sarcastic errors. Although it is possible that this one participant's data skewed the sample such that this effect appeared much larger, since error rates were relatively low on this task, the fact remains that the majority of the TBI group made more literal compared to sarcastic errors, revealing possible problems with the interpretation of prosodic and contextual cues.

Although there was no formal way of exploring the nature of the errors made, anecdotally it was apparent to the investigator that for some of the individuals a lot of the literal material was being incorrectly interpreted as sarcastic, as judged by their verbal reactions and responses when completing the task. Considering this finding, in addition to the explanations purported above regarding a difficulty utilising prosodic cues and grasping speaker intentions, it is also possible that there was a problem of perseveration, i.e. inappropriate repetition of behaviour. Alternatively, or additionally, there may have been an element of priming and expectancy, i.e. once sarcasm was identified it was expected thereafter and continued to be incorrectly identified. Perseveration is a difficulty often seen after TBI, particularly after injuries to the frontal lobes and is considered an impairment of executive function (Lezak et al., 2004). It is worth noting that the individual who made markedly more literal errors did sustain a frontal lobe injury. It is possible that perseveration contributed to the overall higher number of literal errors for this individual, and perhaps the others who made more literal errors. Interestingly, perseveration has been considered a contributing factor to violent assaults and even murder (Hall, 1993). Considering the performance of the individual who made 22 literal errors, it is noticeable that their observed aggression score is the highest compared to the other TBI participants (OAS-MNR weighted aggression score of 109 over an 8 week period), and their self-reported aggression score the lowest (BPAQ score of 37).

Although the findings are limited by small sample size, and no firm conclusions can be made in relation to the findings of one individual, this is still an interesting and novel discovery. Single case analysis could be conducted to further investigate this individual's performance and further explore the research question considering the link between language comprehension and aggression. In addition, with regards to this particular individual, and others with similar difficulties, it could be useful in future research to explore in more detail the antecedents to aggressive displays, from the perspective of these subtle but significant communication impairments and poor insight around aggressive behaviour.

Returning to the group findings, most of the sarcastic material seems to have been interpreted correctly (i.e. non-literally) by the TBI participants, based on the result of relatively few sarcastic errors which were not significantly different in number to the control participants. This finding was not dissimilar to the findings of Channon et al. (2005) who found that brain injured participants did not often make incorrect literal interpretations of sarcastic material. Interestingly, Channon et al. reported that many errors made on sarcastic material were due to incorrect non-literal interpretations being made. In line with the current study findings, Channon et al. also found that their brain injured participants performed marginally worse than their control group on processing of sincere remarks, which they interpreted as a reflection of a subtle pragmatic difficulty. They note that sincere remarks are still open to interpretation, and misinterpretation may have been made more likely by the interspersed of sincere and sarcastic (i.e. non-sincere) items; the current study also interspersed sarcastic with literal (sincere) items, possibly contributing to the misinterpretation. This has clinical implications given the common interspersed of literal and non-literal language in day to day conversational exchanges.

An additional finding of this experiment was that the position of the question (appearing first or second) made a significant difference in RTs for control but not TBI participants; when MoCA scores were statistically controlled for, control participants responded faster on questions presented second than first. This suggests that they benefitted from priming effects; the first question prepared them for the second question, so they responded faster. The TBI participants, however, did not show this benefit in terms of RT. This difference between the TBI and control participants could be due to reduced capacity for new learning in the TBI group and working memory impairments; reduced working memory capacity limits the ability to hold on to information in the short term and use it to influence subsequent cognitive processes and behavioural responses. This comparative deficiency may impact people with TBI in social situations, limiting their capacity to effectively follow and hold on to spoken information and respond appropriately, thus potentially causing subtle difficulties in social communication.

Finally, and to directly consider the third research question regarding language, and in particular sarcasm, comprehension and aggression in people with TBI, it was hypothesised that aggression scores would relate to performance on the sarcasm task, i.e. higher aggression was expected to correlate with worse task performance. Some findings were in support of this hypothesis since the number of literal attitude errors made on the sarcasm experiment significantly positively correlated with observed aggressive behaviour, as per the OAS-MNR; the more errors made, the more aggressive behaviour

was observed. In addition, significant negative correlations were found between TASIT SI-M scores and OAS-MNR scores, showing that the lower the TASIT SI-M score (indicating poorer performance) the more aggressive behaviour was observed. Whilst these correlations must be interpreted cautiously given the small sample size and heterogeneity of the TBI group, they do highlight a relationship between language comprehension, and social cognition more generally (including mentalising and reading of paralinguistic cues), and aggressive behaviour. Although directional causality cannot be concluded since these are correlation analyses, it could be inferred that poor social cognition skills and impaired language comprehension contribute to increased aggressive behaviour, and thus could have a role in modulating aggressive behaviour. This furthers Miller et al.'s (2008) model proposing a role for language and executive function in the modulation of aggressive behaviour, indicating an important role for social cognition. It cannot be inferred, however, that it is purely the sarcastic language comprehension that links to aggressive behaviour, as the sarcasm experiment found most errors were made comprehending literal remarks, and the TASIT showed that difficulty was experienced on both literal and sarcastic material. Therefore, whilst we cannot conclude that sarcasm comprehension difficulties relate to aggression, more general language comprehension does appear to play a role.

Furthermore, the significant negative correlation between number of literal attitude errors on the sarcasm experiment and TASIT EET scores suggests a role for emotion recognition in correctly inferring mental states of others, since better emotion evaluation skills link with fewer literal attitude errors. This finding is in line with existing theory of mind studies. For example, Bodden et al. (2013) identified distinct and overlapping neural correlates for cognitive theory of mind (inferring others' mental states), and affective theory of mind (recognising others' emotions). In addition, though the above correlation relates to literal language comprehension, Phillips et al. (2015) found relationships between emotion perception and sarcasm comprehension difficulties, suggesting a role for emotional identification in both literal and non-literal language comprehension when there is mentalising involved.

Looking again at the current evidence for links between general language impairments and aggressive behaviour, Alderman and colleagues have reported predictive relationships between language function and aggressive behaviour (Alderman et al., 2002). Interestingly, patients with TBI whose communication function was considered severely impaired accounted for over 80% of recorded physical assaults on others (Alderman, 2007). In addition, James and Young (2013) found that poor verbal function

increased chances of observed aggressive behaviour. In the current study, although measures of general verbal ability (WAIS-IV Verbal Comprehension Index) showed a moderate correlation with observed aggressive behaviour, this was not statistically significant and it was based on a small sample size which was likely impacted by extreme outlier values.

In addition, poor awareness and insight into deficits is common after brain injury (Manchester & Wood, 2001; Stuss et al., 1991) and Alderman (2003) has suggested that limited insight may contribute to aggressive behaviour. In the current study, there was a moderate, negative relationship between observed aggressive behaviour and self-rated aggression in the TBI group, perhaps being suggestive of limited insight. However, this correlation did not reach statistical significance and again must be interpreted cautiously as the correlation was based on a small group of heterogeneous individuals. Nevertheless, the question of insight into post-TBI difficulties is important to consider in future research given the significance this may have on social integration; if insight into one's behavioural difficulties is so severely limited, especially when the difficulties relate to aggression which is a highly socially unacceptable behaviour, it is likely that this will have a significant impact on social relationships and communication. Furthermore, insight is an important point to consider when using self-report methodology with people with TBI, as this may limit the validity of the data obtained, a point further discussed by Alderman, Bentley and Dawson (1999).

A final point to consider is the importance of neurobehavioural profile more generally, and global personality traits, in relation to aggressive behaviour after brain injury (Alderman, 2003; Miller, 1994). For example, Greve et al. (2001) found that impulsive personality traits featured significantly more in TBI patients who were aggressive than non-aggressive, and Wood and Liossi (2006) identified more disinhibition and impulsivity in aggressive than non-aggressive ABI patients. It is possible that these factors play a key role in contributing to aggressive behaviour, in combination with the explanations discussed above. Miller et al.'s (2008) model accommodates such processes via the role of executive function. Pulling these ideas together, it could be that communication difficulties (i.e. misinterpreting cues and intentions of others) trigger misunderstandings and feelings of frustration, which, as a result of impaired executive control (e.g. impulsivity and disinhibition), manifest as overt aggression.

4.1.1 Limitations and future research

As has been stated throughout the above discussion, Experiment One was limited by the small sample size and heterogeneity of the sample. Unfortunately, due to the necessary yet stringent exclusion criteria many potential participants were excluded, which, alongside time limitations, meant only seven individuals were recruited to the TBI group. Thus, the study recruited half the number of participants considered necessary in preliminary power analyses. Having only seven individuals in each group limited the statistical power, i.e. the ability to identify any effects, and the generalisability of findings due to being a potentially unrepresentative group.

In terms of gender and severity of injury, the TBI group was a relatively homogenous sample. The group reflects males with severe TBI, and this is important since gender plays a key role in aggression levels (Archer, 2004) and severity of injury has been related to aggressive behaviour after TBI (Miller et al., 1999). This does mean, however, that the results cannot be easily generalised to females with TBI and to people who have experienced less severe TBIs. However, although there were strict exclusion criteria, the TBI group still reflected a heterogeneous group, as seen in the variability in performance across the sarcasm task, and on the other measures (e.g. OAS-MNR, TASIT). This is, though, not unusual in TBI samples because of individual differences in functional neuroanatomy and patterns of healing after brain injury (seemingly similar injuries will often produce very different cognitive and behavioural profiles). Therefore, large variance was anticipated in the TBI group.

In addition, given the small sample size, the data was at risk of including outliers and being skewed, further limiting the generalisability of findings. Multiple steps were taken pre-analysis to limit the impact of this. Firstly, in the data preparation stage, within-group outliers were removed from each participant's data set. Secondly, the between-groups data was scrutinised in advance of the parametric analyses, and all necessary transformations were adopted in order to minimise the influence of outliers and skewing on the analysis of the data. In the correlational analyses, however, caution has been advised in interpreting the findings due to limited sample size and potential influence of extreme data points. It is possible that the performance of one or two TBI participants in particular (P04 and P07) skewed the data set, and this has been pointed out in the results section. Given the small sample size, and expectation of variability within the TBI group, it was not considered appropriate to remove the extreme data points. However, this may have led to relationships appearing stronger and more significant due to the effects of

skewing. Looking further at the data of one individual in particular who made 22 literal errors and no sarcastic errors (P04), and perhaps also participant P07 who also made many more literal than sarcastic errors, might help to illuminate the heterogeneity within the TBI group and allow greater consideration of the impact of the variability on the overall results. Whilst it was not considered viable at this stage due to limited and variable data, looking at these individual cases in future, perhaps in a case series format, may help to shed further light on the study findings.

A further limitation pertains to the pre-morbid abilities of the TBI group. Although we have some insight into pre-morbid cognitive function via the Test of Pre-morbid Function (TOPF; Wechsler, 2011), which indicated mean pre-morbid scores on all WAIS-IV indices to be within the normal range (FSIQ $M=91.57$, $SD=7.48$), other areas of pre-morbid function were not explored due to limited scope of the study. An interesting and potentially relevant factor, touched upon above, is the influence of pre-morbid aggression and personality traits, particularly impulsivity. Since this was not considered in the present study, it is difficult to disentangle the various influences on post-TBI aggression in the current study. There is, however, mixed evidence surrounding how much pre-morbid aggression plays a role in aggression post-TBI, with some evidence suggesting a central role (Greve et al., 2001) and other evidence not (Miller et al., 1999). Perhaps future research could offer some clarification.

Finally, with regards to the suitability of the control group, whilst efforts were taken to match this group according to gender, age and educational attainment, as per standard practice in this area of research, there are still factors limiting the validity of this control group as a 'matched' group. For example, the effects of having experienced a significant traumatic event were not taken into consideration when recruiting control participants. This is significant since the emotional distress associated with, for example, being in hospital for a significant amount of time, or being permanently disabled in some way, may have a significant or subtle impact on an individual's capacity to integrate and communicate socially, and may subtly or even obviously impact performance on a task such as that used in the current experiment. It would be advisable in future research to consider recruiting a more suitably matched control group who have been through similar traumatic experiences, but who have not sustained brain injury, for example significant orthopaedic trauma.

4.1.2 Summary of Experiment One

Overall, then, Experiment One revealed significant similarities as well as differences between the TBI and control participants. In particular, on the sarcasm experiment, although TBI patients did not show decreased performance on sarcastic contexts, they did show impairments when processing literal items in comparison to the control group. Performance on the TASIT for the TBI group was suggestive of difficulties in emotion recognition and broader features of social cognition, importantly including perception and comprehension of sarcasm. For the TBI group, the TASIT SI-M subtest also showed impairment on sincere items as well as sarcastic items, suggesting that they also experience difficulties interpreting literal information from the perspective of another person, indicating theory of mind impairments. The results suggest that sarcasm comprehension is facilitated for the TBI participants by identification of sarcastic prosody and contextual cues, even though there may be an impairment of theory of mind. In addition, there is evidence to suggest relationships between such theory of mind abilities and observed aggressive behaviour.

4.2 Experiment Two

Experiment Two was conducted to explore further whether non-literal language processing, and in particular sarcasm, plays a role in the modulation of impulsive aggression in young healthy adults who were divided into two groups, low and moderate aggression, according to their self-rated BPAQ scores.

The results of this experiment indicated that context, question type and question order all led to significant effects. Increased facilitation, reflecting greater ease of processing, was observed when the story context was literal rather than sarcastic, and when the question was factual rather than attitude, in line with the hypotheses that literal contexts and factual questions would facilitate processing. These findings are consistent with findings from Experiment One, and will be discussed in the general discussion section.

In addition, although there was no associated hypothesis, questions which appeared second in order were answered significantly faster than those which appeared first. This finding mirrored the performance of the control participants in Experiment One and is thought to reflect a priming effect; the first question sets up the second question, allowing it to be answered faster, regardless of whether it is a factual or an attitude question.

Considering the performance between the two groups, no statistically significant differences were observed between the low aggression and moderate aggression groups on RTs or error rates. Interestingly, the pattern of the RT data (as seen in Figure 12) shows slightly longer RTs in the moderate aggression group compared to the low aggression group, however this difference did not present on statistical analysis. With regards to errors, overall very few errors were made by participants in Experiment Two, with most participants performing at or near ceiling, making it difficult to identify any effects of context, question type or question order on error rates, if indeed there were any.

Whilst existing research in non-clinical adult groups has demonstrated an association between poor verbal skills and aggressive behaviour in healthy populations (Barratt et al., 1997; Stanford et al., 1997), no such association can be inferred from the performance on the current task as group differences were not large enough to reach statistical significance. Barratt et al., (1997) used the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955) prorated verbal IQ score to reflect verbal skills, and Stanford et al. (1997) used the Controlled Oral Word Association Test (COWAT; Lezak, 1995). These previous studies therefore considered verbal skills quite generally, whereas, Experiment Two aimed to shed more light on the specific nature of the poor verbal skills in sarcasm comprehension. Whilst the current study did not identify a significant effect, this does not rule out a potential difficulty with figurative language comprehension, and more specifically sarcasm comprehension, in more aggressive individuals. It is possible that a population with higher aggression scores might be necessary to capture such differences in sarcasm comprehension. Furthermore, it is possible that the task developed and completed by this healthy young adult sample may not have been sensitive enough to detect subtle differences in performance between the groups; after all, the task was developed with a clinical population in mind and thus had to be pitched appropriately.

Interestingly, across the two groups, self-rated BPAQ scores significantly positively correlated with self-rated sarcasm identity score; the more aggressive characteristics people reported, the more sarcastic they identified as. In line with this pattern, the moderate aggression group rated themselves as more sarcastic than the low aggression group, and this finding approached statistical significance. Interestingly, however, despite the relationship between the level of identification as a sarcastic person and self-rated aggression, sarcasm comprehension as assessed by the current task was not different between the low and moderate aggression groups.

4.2.1 Limitations and future research

Due to the recruitment process mainly targeting university students, the resultant sample cannot be considered broadly representative of young healthy adults as there is a lack of diversity with regards to educational attainment and therefore associated socioeconomic status. In addition, there was not an even gender split in the sample. There was, however, a fair distribution of males between the two groups with six males in the low aggression group and seven in the moderate group.

With regards to gender differences in aggression, past research indicates that males are more directly aggressive than females (Archer, 2004), and mean BPAQ scores in past research have indicated higher scores for men than women (77.8 and 68.2 respectively; Buss & Perry, 1992). However, although there were not equal numbers of males and females in the current experiment, the mean BPAQ scores did not differ significantly between males and females within each group, and on the whole with groups collapsed (63.31 and 59.71 respectively). Gender differences were not considered in the analysis of the sarcasm experiment data; this was not deemed necessary since BPAQ scores did not differ significantly between males and females and, due to the relatively small number of participants, splitting the data into additional groups by gender would have further limited the statistical power of the study. However, it would be interesting to consider gender differences in any future studies of sarcasm comprehension, especially since gender has been reported to play a role in the perception of sarcasm, in that men are considered more sarcastic than women (Katz et al., 2004).

Moreover, although there was a statistically significant difference between the BPAQ scores of the two groups, this experiment was limited by relatively low to average aggression scores reported on the whole; as can be seen by the scores outlined in the above paragraph, the BPAQ scores in this study were lower than those reported by Buss and Perry (1992) in the development of the measure. This was, however, not surprising given the sample targeted. In an attempt to further explore the research question in a healthy adult population, it would be important to recruit participants who self-report much higher aggression scores, thus allowing a greater variation between low and high aggressive groups, which may result in more notable differences on the experimental task between the groups.

Although all healthy participants completed the MoCA and scored within the normal range, they were not screened with any further measures of executive control. Future

research, in particular, should consider the role of executive function in contributing to aggressive behaviour. Executive weaknesses have been related to aggressive behaviour in healthy adults in past research and it has been suggested that aggression impulses may be sensitive to subclinical deficits of executive function (for a review see Hawkins & Trobst, 2000). It would be interesting for future research to explore the differential and combined effects of non-literal language difficulties and executive dysfunction, in particular in relation to impulse control, on overt aggressive behaviour.

4.2.2 Summary of Experiment Two

Experiment Two was unable to provide further evidence in support of the relationship between aggressive behaviour and comprehension of sarcasm as no significant differences were seen between the low and moderately aggressive healthy individuals. Similarities in performance on the task across both groups will be discussed in the following section.

4.3 General discussion

The present findings shed light on the appreciation of sarcasm, and social cognition more generally, after TBI, and the role that language plays in modulating aggressive behaviour, which was the unique focus of this research. The significant relationships between observed aggression and literal attitude errors on the sarcasm experiment and with TASIT EET and SI-M scores for the TBI participants in Experiment One provide evidence for a role of language comprehension and theory of mind in modulating aggressive behaviour. These findings support and further the hypothesis put forward by Miller et al. (2008) that language is important in modulating impulsive aggression. In particular, Miller and colleagues proposed that linguistic processing is important for the regulation of aspects of executive functioning that help to inhibit aggressive impulses, including reflective functioning, cognitive restraint, emotional control and adaptation and deductive reasoning. They suggested that activation of language processing brain regions helps to dampen down limbic responses, via the anterior cingulate cortex (ACC) and the orbital prefrontal cortex (OFC), which might otherwise result in emotionally driven impulsive behaviour (Miller et al., 2008).

Past research associated language processing brain regions with the inhibition of aggressive behaviour (Dougherty et al., 1999; Pietrini et al., 2000) and hypoactivation of

ACC and OFC regions have been seen in people displaying impulsive aggression (Best, Williams & Coccaro, 2002). Therefore, the results of the current set of studies could be explained by subtle abnormalities due to the trauma in the brain regions proposed to be significant in these pieces of research.

Furthermore, the findings from this study have highlighted a role for social cognition, particularly mentalising, in the modulation of aggressive behaviour. Previous studies highlighted links between aggression and social skills. For example, Kaukiainen et al. (1999) found that indirect aggression was associated with higher levels of social intelligence and social abilities, as well as low levels of empathy. It would be useful in future to study more specifically the different subcategories of aggression, and see how this links to language function and use of sarcasm, for example by using the Indirect Aggression Scale (Forrest, Eatough & Shevlin, 2005) which measures indirect aggression in addition to the direct aggression measures used in the current study.

With regards to the main effects and interactions of question type seen across both experiments, attitude questions took significantly longer to be answered than factual questions, even when question length was controlled for. This indicates that the added complexity of having to consider someone else's perspective, in comparison to simply reflecting on factual information, requires additional cognitive processes. This is in line with the multiple complex mechanisms thought to be involved in such mentalising tasks, including recognising that others have different perspectives to our own, recognising that beliefs do not necessarily correspond to reality, and recognising that beliefs not reality determines behaviour (Gallagher & Frith, 2003).

4.3.1 Evidence for theories of non-literal language processing

In an attempt to use this study's findings to enter the debate around how non-literal language is processed in the healthy brain, evidence from the two experiments discussed above will be considered together here. Experiment Two demonstrated that context (sarcastic or literal) plays a significant role in the processing and response times for healthy young adults. In addition, this same main effect was seen for the healthy control group in Experiment One (as well as the TBI group, though this is less relevant for a consideration of processing in the healthy brain). Since the sarcastic material in this experiment was considered to be appropriately cued, i.e. with a spoken comment incongruent to the preceding context, and sarcastic intonation, this finding supports theories that argue for an additional stage of processing for non-literal material. For

example early models of non-literal language processing, such as the standard pragmatic model (Grice, 1975; Searle; 1979), suggested that non-literal information is processed literally first before being processed non-literally. This model would predict slower RTs for sarcastic compared to literal material, given the additional stage of processing required. This was the pattern observed across Experiments One and Two in the present study.

The results, therefore, did not support the direct access model, proposed by Gibbs (1982; 1983; 1984), which suggested that, assuming there is appropriate context, a non-literal interpretation can be accessed at a similar rate to the literal. As previously stated, appropriate cueing was provided in the sarcastic vignettes in the current experiment; nevertheless sarcastic vignettes were processed significantly slower than literal ones.

The present findings are also consistent with the Graded Salience Hypothesis (GSH; Giora, 1997). This theory purports that literal and figurative language is processed and understood in terms of the salience of the meaning. For a word or phrase to be considered salient it must be stored in the mental lexicon, and salience is influenced by familiarity, frequency and conventionality (Giora, 1999). According to Giora et al. (2000), conventional metaphors and familiar proverbs, for example, would be considered salient, whereas “conversational implicatures constructed on the fly” (pp.64) would be considered as non-salient. Based on the GSH, the salient meaning is always interpreted first, regardless of whether it is literal or non-literal, or within an appropriate context or not. According to Haiman (1998) some sarcastic remarks are so well-used and familiar that regardless of an appropriate context they would be interpreted sarcastically; due to their familiarity and position in the mental lexicon they would be considered salient. However, the sarcastic comments in the present study were simply conversational remarks, not specific to sarcasm, that in isolation would not be considered sarcastic (e.g. “you’re playing really well today”, “you look beautiful” or “you’re a big help”). Therefore, despite the context that sets them up as sarcastic, and the auditory cues implying sarcasm (see Rockwell, 2000), the GSH would consider the remarks as non-salient. Therefore, the present findings are consistent with the GSH; the non-salient sarcastic stimuli took significantly longer to be processed than the literal stimuli.

Therefore, the current study findings support both the standard pragmatic model and the GSH. Further sarcasm studies that incorporate salient sarcasm would be helpful to shed more light on these two hypotheses. Salient sarcasm might include key words or remarks which automatically signal sarcasm regardless of their sentence context or prosody, for

example the remark ‘nice try’, or the use of commonly used adjectives that represent extreme descriptions (e.g. ‘hilarious’, ‘ecstatic’, ‘fascinating’, ‘hideous’), though these would vary cross-culturally and depend on familiarity within a cultural context. If salient sarcasm was incorporated, the GSH would predict equal processing times for sarcastic and literal material, while the standard pragmatic model would still predict processing facilitation for literal material only.

Regarding the theories about the role of the two cerebral hemispheres in processing non-literal language, it was not possible to directly explore them due to the small patient sample and heterogeneity of injury profile. Nevertheless, it is important to note that both the coarse semantic coding hypothesis (Beeman et al., 1994; Beeman, 1998) and the suppression deficit hypothesis (Tompkins & Lehman, 1998), implicate the RH in non-literal language processing, but for different theoretical reasons. The coarse semantic coding hypothesis suggests that the RH activates wide semantic fields which are necessary for interpretation of non-literal language, as opposed to the LH being involved in narrow semantic field activation. On the other hand, the suppression deficit hypothesis contends that the integral role of the RH in non-literal language comprehension relates to its suppression of alternate and irrelevant interpretations. Although neither of these theories can be supported directly from the findings of the current study, it is worth noting that the majority of the TBI group did have some RH damage (6 of 7 patients) allowing some insight about how this might have affected performance. In accordance with past research, we concur that the importance placed on the RH in the comprehension of figurative language, is relevant for understanding the role of language in modulating impulsive aggression (see also Bowden & Beeman, 1998; Seger et al., 2000; Tompkins et al., 1997). In particular, past research related RH homologues of LH language regions to cognitive constraint of aggression (Pietrini et al., 2000), and Miller et al. (2008) argued for a role of RH language processing regions, in connection with frontal lobe areas associated with executive function in the modulation of aggressive behaviour.

As mentioned above, although the majority of the TBI sample in the present study did have some RH damage (6 of the 7 patients), future studies with larger sample sizes, which are able to separate groups by LH or RH injury, could help to contribute to the understanding of hemispheric processing of non-literal language and could provide evidence to support or challenge the coarse semantic coding hypothesis and the suppression deficit hypothesis. Support found for either of these hypotheses could be extremely helpful; a clearer idea of whether there is a suppression deficit impairment or an impairment of broad activation would help to better understand difficulties in language

processing and the role it plays in the modulation of aggression and possibly help to tailor more appropriate interventions after brain injury.

4.3.2 Implications of findings

The findings of the current study which link impairments of social cognition and aggression after TBI, and in particular sarcasm comprehension and aggression, raise the potential to introduce new techniques in rehabilitation in order to support the assessment and management of aggressive behaviour after TBI, which could have wide implications for patients, family and loved ones, and services.

The ability to communicate is considered fundamental to psychological wellbeing (Prigatano et al., 1985) and the literature clearly indicates that communication difficulties after TBI are related to poor social integration and reduced quality of life (Galski et al., 1998). Furthermore, cognitive and behavioural difficulties are considered the most problematic and burdensome consequences of severe TBI according to patients, carers and families (Oddy et al., 1985; Ponsford et al., 2003). Given the current findings, there is a case for conducting more standardised assessment of social cognition and non-literal language comprehension for individuals after TBI, since this might have a role in behavioural control. Social cognition is particularly important given the findings of Spikman et al. (2012) who recently demonstrated that social cognition tests access a unique aspect of cognition, not accounted for by other cognitive assessments. More detailed assessment information such as this would contribute to a more comprehensive clinical formulation for the client, which in turn would lead to more appropriate and targeted interventions. In addition, social skills awareness and training could be incorporated into rehabilitation plans for individuals post-TBI. Furthermore, a greater awareness of these links may be important for awareness of likely triggers for aggressive behaviour; for example if specific language difficulties, such as impaired or incorrect identification of sarcasm, were identified as triggers for an individual's aggression, aggressive incidents could be anticipated in future and plans employed to limit these as much as possible.

As well as being able to tailor rehabilitation interventions appropriately for the benefit of the patient, it is pertinent to communicate any findings of social cognition or literal and non-literal language difficulties with the family and support networks around the individual with the TBI, and make them aware of the potential links to aggressive behaviour. This could help to increase the family's/carers' understanding of the specific

difficulties and needs of their loved ones, with a view to them being able to better communicate with and support them. Increased knowledge and awareness for the people around the brain injured individual is particularly important since family support is known to be extremely influential in improving quality of life for people with TBI (Webb, Wrigley, Yoels & Fine, 1995). After all, the starting point for any rehabilitation programme has been said to be with the patient and their family (Wilson, Winegardner & Ashworth, 2014). Additionally, and importantly, when considering the well-being of the families and carers of people with TBI, emotional and behavioural disturbances are highly likely to influence family wellbeing (Koskinen, 1998). Thus, the current research has significant clinical implications that could help improve the quality of life of TBI individuals and their families and/or carers.

4.3.3 Limitations and recommendations for future research

Potential limitations and recommended adaptations of the design of the experimental task which span both Experiment One and Two will be discussed. This will be followed by a broader discussion of potential opportunities for development in this area of research.

4.3.3.1 The methodology, materials and paradigm

Firstly, with regards to the experimental stimuli, although the materials attempted to achieve a balance between gender, relationships and social and occupational roles, these factors were not considered in the analysis. Katz et al. (2004) discussed the importance of social and cultural context on perception of sarcasm, and report that men produce more sarcasm and are considered more sarcastic than women. Thus, it is possible that greater difficulty is observed decoding the sarcastic comments of women than men. Although gender was controlled in the creation of the stimuli in the present study, it would be useful to consider gender effects in future investigations in this area. In addition, in relation to irony more generally, Pexman and Olineck (2002b) found that occupational stereotypes influenced detection of ironic intent. Therefore, exploration of the perception of sarcasm in vignettes with characters of different implied social and occupational contexts could be an interesting development.

Secondly, something which was not rigorously controlled in this experiment was use of direct versus indirect sarcasm. Since comprehension of direct and indirect sarcasm did not appear to differ for people with head injury in Channon et al.'s (2005) study, the

current study incorporated both types, using mostly direct sarcasm. It would be useful in future, however, to further explore Channon et al.'s (2005) finding through further research, especially since indirect sarcasm has been associated with additional cognitive demands (Bucciarelli et al., 2003).

This study did, however, control for positive versus negative sarcasm as all the sarcastic experimental stimuli featured negative sarcasm, i.e. saying something positive to communicate something negative. This was selected as it is the more common form of sarcasm (Gibbs, 2000). However, it might be useful in future to also explore and test positive sarcasm, since positive sarcasm uses negative remarks which if misinterpreted, (i.e., the non-literal meaning was not identified and the literal negative meaning inferred) they could be perceived as highly critical and offensive.

Regarding the specific experimental paradigm used in the current study, the yes-no response methodology was utilised, as opposed to more complex methodologies such as those seen in the TASIT (McDonald et al., 2002) and paradigms developed for off-line research (e.g. Channon et al., 2005), as this more easily enabled assessment of on-line processing through RT data (as well as accuracy scores). In addition, this approach was chosen in order to minimise cognitive load, given that individuals with severe brain injuries and cognitive impairments would participate in the studies. However, there have been criticisms in the past towards experiments for which a simple yes or no response is required. For example, Channon et al. (2005) argue that these responses do not capture the subtle differences involved in the processing of the sarcastic comments. For example, as was the case in the current study, it was not clear what kind of error was made, i.e. was the sarcastic comment interpreted literally, or non-literally but incorrectly. As mentioned previously, Channon and colleagues reported that the errors made on the sarcastic material in their task represented some literal interpretations but mostly inadequate and inaccurate non-literal interpretations. Although this was not directly explored in the current study, anecdotally, comments from the TBI participants to the experimenter during the experiment indicated that many literal remarks were being interpreted non-literally, and it would have been helpful to investigate more rigorously the nature of these literal errors in particular. Future studies that ask participants to explain sarcastic or literal vignettes may provide more insight in this domain.

In relation to the measures of aggression, although the BPAQ is a well validated measure (Buss & Perry, 1992; Harris, 1995, 1997), and does distinguish between verbal and physical aggression, it does not assess other types of aggression. It might be useful in

future research to consider aggressive behaviour in terms of the impulsive-premeditated divide, using the Impulsive/Premeditated Aggression Score (IPAS; Stanford et al., 2003). Furthermore, as previously mentioned, more specific measures of indirect aggression, such as the Indirect Aggression Scale (Forrest et al., 2005), would also be a valuable addition.

Moreover, use of self-report measures has limitations, especially in brain injured individuals who may have limited insight into their difficulties (Manchester & Wood, 2001; Stuss et al., 1991). However, there are also limitations of the self-report methodology for non-brain injured individuals in relation to concern regarding how one is perceived by others, exemplified by the social desirability bias (Fisher, 1993). This problem was overcome in the TBI group by obtaining data of observed aggressive behaviour (OAS-MNR), which was possible given the residential nature of the rehabilitation setting. This would, however, not be a feasible tool for a non-clinical group. However, a proxy-report measure, perhaps completed by a family member, carer or friend, would be a valuable adjunct to a self-report measure in non-clinical samples as well, if that was feasible.

4.3.3.2 Opportunities for development

Suggestions for amendments and developments of the experimental task and analysis techniques have been made above. In terms of wider developments of this research, it would be a helpful development and natural way forward to consider not only the comprehension of sarcasm, but the spoken use of sarcasm by people with TBI, and how this links to displays of overt aggression. Since sarcasm is a socially acceptable way to communicate aggression, perhaps people who had a TBI and are more overtly aggressive, are unable to successfully generate sarcasm. No studies currently exist that explore the ability of such individuals to produce and appropriately use sarcasm.

The current study captured a reflection of all participants' cognitive ability, including aspects of executive function, by use of the MoCA, which was used as a control variable in the analyses. However, further explicit links with executive function should be explored, using more detailed measures. Executive function has been implicated in the processing of sarcasm and pragmatics, (e.g. McDonald & Pearce, 1996; Pearce, McDonald & Coltheart, 1998), and Miller et al.'s (2008) proposed hypothesis notes the importance of language in conjunction with executive skills in the modulation of

impulsive aggression. As has been highlighted throughout this discussion, executive function seems to play a key role in the modulation of aggression (Villemarette-Pittman, Stanford & Greve, 2002). Verbal working memory, in particular, seems central. This has been linked to behavioural control via internal verbal processes such as deductive reasoning, reflection, rehearsal and self-instruction (Baddeley, Chincotta & Adlam, 2001; Gruber & Goschke, 2004). More in depth testing in this area may be important to consider in future research of sarcasm and aggression.

In terms of methodology for future research, single case studies may be a valuable way forward for research in the TBI field. Alderman et al. (1999) raise issues with group level research in this clinical area due to the heterogeneity of the individuals, and they support single case methodology. Though it was not within the scope of the current research, this could have been useful to gain a more in depth analysis of the performance of some of the individuals with TBI.

4.3.4 Summary

The present study investigated the ability to understand and interpret sarcasm correctly and whether this links with aggressive behaviour in a group of individuals with TBI as well as healthy control participants. Although the TBI group exhibited deficits on the TASIT, they did not demonstrate difficulty with the sarcastic items of the on-line sarcasm comprehension task, suggesting that the combination of prosodic and contextual cues supported comprehension. The TBI participants did, however, demonstrate difficulty interpreting literal comments both on the TASIT and the on-line sarcasm comprehension task. These findings may point to deficits in the comprehension of ambiguous contexts as well as perseveration deficits once they had detected a sarcastic context. Furthermore, TBI participants showed an inability to effectively link prior questions to subsequent questions in order to aid understanding. Significant links were found between observed aggression and errors made on literal attitude items, and performance on the TASIT SI-M, indicating that poor social cognition and language processing impact aggression modulation. These findings did not extend to a non-clinical group, as explored in Experiment Two; individuals who self-reported low and moderate aggression levels performed statistically similarly on the on-line sarcasm experiment and in line with the control group in Experiment One. Overall, then, the present study sheds further light on the link between language, executive function and impulsive aggression, as proposed by Miller et al., (2008), suggesting that social cognition should be incorporated into future models of language processing and modulation of aggression.

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APPENDICES

- Appendix 1: Overt Aggression Scale - Modified for Neurorehabilitation (OAS-MNR; Alderman et al., 1997)
- Appendix 2: University of Leeds ethics approval email
- Appendix 3: NHS research ethics committee approval letter
- Appendix 4: Disabilities Trust (parent organisation of the Brain Injury Rehabilitation Trust; BIRT) research ethics committee approval letter
- Appendix 5: Buss-Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992)
- Appendix 6: Screening questionnaire
- Appendix 7: Handedness inventory (Briggs & Nebes, 1975)
- Appendix 8: Montreal Cognitive Assessment (MoCA, Nasreddine et al., 2005)
- Appendix 9: Experimental stimuli
- Appendix 10: TBI patient participant information sheet
- Appendix 11: Control participant information sheet
- Appendix 12: TBI patient participant consent form
- Appendix 13: Control participant consent form
- Appendix 14: Script for experimental procedure
- Appendix 15: Data preparation instructions
- Appendix 16: Sarcasm questions

Appendix 2: University of Leeds ethics approval

From: "Ethics.Committee@webhost02h.leeds.ac.uk"
<Ethics.Committee@webhost02h.leeds.ac.uk>
Date: 19 December 2014 13:16:22 GMT
To: Ekaterini Klepousniotou <E.Klepousniotou@leeds.ac.uk>
Subject: Ethics form decision

Ekaterini Klepousniotou
Institute of Psychological Sciences
University of Leeds
Leeds LS2 9JT
19-Dec-2014

Dear Ekaterini Klepousniotou,

Title of study: Sarcasm and aggression after traumatic brain injury

Ethics reference: 14-0339

I am pleased to inform you that the above research application has been reviewed by the IPS Research Ethics Committee and has been approved. Please note that this approval only relates to the particular version of documentation supplied in this specific application (ref no: 14-0339; date approved: 19-Dec-2014). If you wish to make any amendments to the approved documentation, please note that all changes require ethical approval prior to implementation.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at <http://ris.leeds.ac.uk/EthicsAudits>

Yours sincerely,

IPS Research Ethics Committee
(Chair: Donna Lloyd)

Appendix 3: NHS Research ethics committee approval letter



Health Research Authority

NRES Committee London - Bromley
Level 3, Block B
Whitefriars
Lewins Mead
Bristol
BS1 2NT

Telephone: 01173421390
Fax: 01173420445

15 July 2015

Miss Joanne Allen
Trainee Clinical Psychologist
Leeds Teaching Hospitals Trust
Charles Thackrah Building
101 Clarendon Road
Leeds
LS2 9LJ

Dear Miss Allen

Study title:	Sarcasm and aggression after traumatic brain injury
REC reference:	15/LO/1220
IRAS project ID:	181132

Thank you for your letter of 14th July 2015, responding to the Proportionate Review Sub-Committee's request for changes to the documentation for the above study.

The revised documentation has been reviewed and approved by the sub-committee.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this favourable opinion letter. The expectation is that this information will be published for all studies that receive an ethical opinion but should you wish to provide a substitute contact point, wish to make a request to defer, or require further information, please contact the REC Manager Miss Georgina Castledine, nrescommittee.london-bromley@nhs.net. Under very limited circumstances (e.g. for student research which has received an unfavourable opinion), it may be possible to grant an exemption to the publication of the study.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

A Research Ethics Committee established by the Health Research Authority

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at <http://www.rdforum.nhs.uk>.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations.

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publically accessible database. This should be before the first participant is recruited but no later than 6 weeks after recruitment of the first participant.

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g. when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to request a deferral for study registration within the required timeframe, they should contact hra.studyregistration@nhs.net. The expectation is that all clinical trials will be registered, however, in exceptional circumstances non registration may be permissible with prior agreement from NRES. Guidance on where to register is provided on the HRA website.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" above).

Approved documents

The documents reviewed and approved by the Committee are:

A Research Ethics Committee established by the Health Research Authority

Document	Version	Date
Copies of advertisement materials for research participants [Recruitment poster uni students]	1	22 June 2015
Copies of advertisement materials for research participants [Recruitment poster neurorehab unit staff]	1	22 June 2015
Copies of advertisement materials for research participants [Recruitment letter family member]	1	22 June 2015
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [BIRT Insurance information]	1	11 March 2015
IRAS Checklist XML [Checklist_25062015]		25 June 2015
Letter from sponsor [Email from sponsor 12.3.15]	1	12 March 2015
Other [University of Leeds risk assessment]	1	18 December 2014
Other [University of Leeds ethics approval email]	1	19 December 2014
Other [Debrief sheet]	1	22 June 2015
Other [Sarcasm experiment stimuli]	1	25 June 2015
Other [Buss Perry Aggression Questionnaire]	1	25 June 2015
Other [Montreal Cognitive Assessment]	1	25 June 2015
Other [Info about the TASIT]	1	25 June 2015
Other [Response to validation queries]		25 June 2015
Other [Email clarification]		24 June 2015
Other [Info about the TOPF]	1	25 June 2015
Other [Info about the BDAE]	1	25 June 2015
Participant consent form [Patient consent form]	2	13 July 2015
Participant consent form [Control consent form]	2	13 July 2015
Participant information sheet (PIS) [Patient information sheet]	2	13 July 2015
Participant information sheet (PIS) [Control information sheet]	2	13 July 2015
REC Application Form [REC_Form_24062015]		24 June 2015
Referee's report or other scientific critique report [Transfer viva report 6.3.15]	1	06 March 2015
Research protocol or project proposal [Research protocol]	3	22 June 2015
Summary CV for Chief Investigator (CI) [Chief investigator CV 22.6.15]	1	22 June 2015
Summary CV for supervisor (student research) [Academic supervisor CV]	1	23 June 2015
Summary, synopsis or diagram (flowchart) of protocol in non technical language [Protocol flowchart]	1	22 June 2015

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website:

<http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance>

We are pleased to welcome researchers and R & D staff at our NRES committee members' training days – see details at <http://www.hra.nhs.uk/hra-training/>

15/LO/1220

Please quote this number on all correspondence
--

With the Committee's best wishes for the success of this project.

Yours sincerely



Ms Carol Jones
Chair

Email: nrescommittee.london-bromley@nhs.net

Enclosures: *"After ethical review – guidance for researchers" [SL-AR2]*

Copy to: *Faculty Research Ethics and Governance
Mr Derek Norfolk, Leeds Teaching Hospitals Trust*

Appendix 4: Disabilities Trust (parent organisation of the Brain Injury Rehabilitation Trust; BIRT) research ethics committee approval letter

32 Market Place
Burgess Hill
West Sussex
RH15 9NP
Tel: 01444 239123
Fax: 01444 244978
Email: info@thedtgroup.org

Ms Joanne Allen
XXXXXXXXXXXXXX
XXXXXXXXXX
XXXXXXX

22nd September 2015

Dear Ms Allen,

THE DISABILITIES TRUST RESEARCH ETHICS COMMITTEE (DTREC) APPROVAL

Study Title: Sarcasm comprehension and aggression after traumatic brain injury (TBI).

We are pleased to inform you that the DTREC has APPROVED the above mentioned project.

The documents reviewed are:

- a) DTREC Brief Application Form dated 11 March 2015
- b) DTREC Full Application Form dated 10 April 2015
- c) Approved University of Leeds Research Ethics Committee Application, dated 18 December 2014
- d) Study protocol, dated 11 March 2015
- e) Participant Information Sheet, dated 16 June 2015
- f) Participant Consent Form, 16 June
- g) NHR Research Ethics Committee approval letter, dated 15 July 2015
- h) Amendments and clarifications to study protocol, dated 11 June 2015
- i) University transfer report, dated 20 February 2015

The approval period is from **07 September 2015 to 06 September 2016**.

The following are to be observed upon DTREC approval:

- 1) The study will be conducted in accordance with Trust's relevant policies.
- 2) The Researcher should promptly report the DTREC of:
 - i. Deviations from, or changes to the protocol.
 - ii. New information that may affect adversely the risk to the participants or the conduct of the study.
 - iii. Completion of the study.

- 3) A Study Status Report should be submitted for the following:
 - i. Study completion or termination: the Final Report is to be submitted within three months of study completion or termination.
- 4) Any dissemination of the findings should acknowledge the support of the Brain Injury Rehabilitation Trust and The Disabilities Trust in the study.

On behalf of the DTREC, I would like to wish you the best with your study.

Yours sincerely,

A handwritten signature in black ink that reads "Sue Copstick". The signature is written in a cursive, flowing style.

Dr Sue Copstick
Clinical Director
Graham Anderson House
1161 Springburn Road
Glasgow
G21 1UU

Appendix 5: Buss-Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992)

Buss-Perry Scale

Please rate each of the following items in terms of how characteristic they are of you, using the 5 point scale below.

	1 Extremely uncharacteristic	2 Somewhat uncharacteristic	3 Neither uncharacteristic nor characteristic	4 Somewhat characteristic	5 Extremely characteristic
1. Some of my friends think I am a hothead.					
2. If I have to resort to violence to protect my rights, I will.					
3. When people are especially nice to me, I wonder what they want.					
4. I tell my friends openly when I disagree with them.					
5. I have become so mad that I have broken things.					
6. I can't help getting into arguments when people disagree with me.					
7. I wonder why sometimes I feel so bitter about things.					
8. Once in a while, I can't control the urge to strike another person.					
9. I am an even-tempered person.					
10. I am suspicious of overly friendly strangers.					
11. I have threatened people I know.					
12. I flare up quickly but get over it quickly.					
13. Given enough provocation, I may hit another person.					
14. When people annoy me, I may tell them what I think of them.					
15. I am sometimes eaten up with jealousy.					

	1 Extremely uncharacteristic	2 Somewhat uncharacteristic	3 Neither uncharacteristic nor characteristic	4 Somewhat characteristic	5 Extremely characteristic
16. I can think of no good reason for ever hitting a person.					
17. At times I feel I have gotten a raw deal out of life.					
18. I have trouble controlling my temper.					
19. When frustrated, I let my irritation show.					
20. I sometimes feel that people are laughing at me behind my back.					
21. I often find myself disagreeing with people.					
22. If somebody hits me, I hit back.					
23. I sometimes feel like a powder keg ready to explode.					
24. Other people always seem to get the breaks.					
25. There are people who pushed me so far that we came to blows.					
26. I know that "friends" talk about me behind my back.					
27. My friends say that I'm somewhat argumentative.					
28. Sometimes I fly off the handle for no good reason.					
29. I get into fights a little more than the average person.					

Appendix 6: Screening questionnaire

Screening Questionnaire

Participant Code: _____ Date: _____

Sex: _____

Before starting, I need to ask some important questions to make sure you qualify for the study. Am I right in thinking you have seen the inclusion criteria? If yes, clarify that they deem themselves suitable. If no, show the criteria (on poster) and double check they are eligible. I am just going to ask some questions to confirm you fit the criteria. Please ask if you want anything clarifying.

1. What is your date of birth? _____
2. (If student) what is your current year of study? _____
(If non-student) when did you leave school? Did you study after school, and if so up to what level? _____
3. What is your dominant hand? Right Left
4. Which hand do you write with? Right Left
5. Which hand do you throw with? Right Left
6. What is your native language? _____
7. What is your parents' native language? _____
8. Do you speak any other languages equally well to your native language? Yes No
If yes, which languages? _____
9. Were you born in the United Kingdom? Yes No
10. Is your hearing within normal limits? Yes No
11. Is your vision normal or corrected to normal? Yes No
12. Do you have a history of (pre-morbid) neurological disorders, learning disability or language disorders? Yes No
13. Do you currently, or have you in the past 5 years, had any psychiatric diagnoses? Yes No
14. Are you currently taking any psychiatric medication for mental health difficulties? Yes No
15. Do you have historical or current alcohol or drug problems? Yes No
16. Are you prone to migraines? Yes No

Appendix 7: Handedness inventory (Briggs & Nebes, 1975)

Indicate hand preferences	Always left (-2)	Usually left (-1)	No preference (0)	Usually right (1)	Always right (2)
1. To write a letter legibly					
2. To throw a ball to hit a target					
3. To play a game requiring the use of a racquet					
4. At the top of the broom to sweep dust from the floor					
5. At the top of a shovel to move sand					
6. To hold a match whilst striking it					
7. To hold scissors to cut paper					
8. To hold thread to guide through the eye of a needle.					
9. To deal playing cards					
10. To hammer a nail into wood					
11. To hold a toothbrush while cleaning teeth					
12. To screw the lid of a jar					
Column total:					
Total score (range – 24 to +24)					
Designation:	<ul style="list-style-type: none"> - Right handed (+9 and above) - Mixed handed (-8 - +8) - Left handed (-9 and below) 				

Are either of your parents left handed? If yes, which? _____

How many siblings of each sex do you have? Male _____ Female _____

How many of each sex are left handed? Male _____ Female _____

Which eye do you use when only using one? Eg, telescope, keyhole. _____

Have you ever suffered any severe head trauma? _____

Appendix 8: Montreal Cognitive Assessment (MoCA, Nasreddine et al., 2005)

NAME : _____
Education : _____ Date of birth : _____
Sex : _____ DATE : _____

VISUOSPATIAL / EXECUTIVE									
		Copy cube	Draw CLOCK (Ten past eleven) (3 points)						
[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
									___/5
NAMING									
[]	[]	[]							
									___/3
MEMORY									
Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.									
	FACE	VELVET	CHURCH	DAISY	RED				
1st trial									
2nd trial									
									No points
ATTENTION									
Read list of digits (1 digit/ sec). Subject has to repeat them in the forward order [] 2 1 8 5 4 Subject has to repeat them in the backward order [] 7 4 2									
Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors [] FBACMNAAJKLBAFAKDEAAAJAMOF AAB									
Serial 7 subtraction starting at 100 [] 93 [] 86 [] 79 [] 72 [] 65 4 or 5 correct subtractions: 3 pts, 2 or 3 correct: 2 pts, 1 correct: 1 pt, 0 correct: 0 pt									
									___/2
									___/1
									___/3
LANGUAGE									
Repeat : I only know that John is the one to help today. [] The cat always hid under the couch when dogs were in the room. []									
									___/2
Fluency / Name maximum number of words in one minute that begin with the letter F [] ____ (N ≥ 11 words)									
									___/1
ABSTRACTION									
Similarity between e.g. banana - orange = fruit [] train - bicycle [] watch - ruler									
									___/2
DELAYED RECALL									
	Has to recall words WITH NO CUE								
		FACE	VELVET	CHURCH	DAISY	RED			
		[]	[]	[]	[]	[]			
Optional									
	Category cue								
	Multiple choice cue								
									___/5
ORIENTATION									
	[] Date	[] Month	[] Year	[] Day	[] Place	[] City			
									___/6
© Z.Nasreddine MD www.mocatest.org Normal ≥ 26 / 30									TOTAL ___/30
Administered by: _____									Add 1 point if ≤ 12 yr edu

Appendix 9: Experimental stimuli

Phase	Story Type	Story	Question 1	Correct Answer 1 (1 = yes, 2 = no)	Question 2	Correct Answer 2 (1 = yes, 2 = no)
Examples	Sarcastic	Richard was trying to help his wife with a dilemma at work. When he made an unhelpful suggestion, his wife said to him “Thanks, you're full of great ideas!”	Did Richard suggest a bad idea?	1	Did Richard’s wife think Richard suggested a bad idea?	1
	Neutral	Richard was trying to help his wife with a dilemma at work. When he made a helpful suggestion, his wife said to him “Thanks, you're full of great ideas!”	Did Richard’s wife think Richard suggested a good idea?	1	Did Richard suggest a bad idea?	2
	Sarcastic	Ryan had been bragging to his friend about how good he is at squash. When Ryan got badly beaten later, his friend said to him “Yeah, you're really good at squash!”	Did Ryan play well?	2	Did Ryan’s friend think Ryan played badly?	1
	Neutral	Ryan had been bragging to his friend about how good he is at squash. When Ryan won a game later, his friend said to him “Yeah, you're really good at squash!”	Did Ryan’s friend think Ryan played badly?	2	Did Ryan play badly?	2
	Sarcastic	Liz was playing tennis with a friend and kept hitting shots out of the court. Her friend said to her “You’re playing really well today Liz!”	Did Liz’s friend think Liz was playing badly?	1	Was Liz playing tennis well?	2

Practices

Neutral	Dennis was doing a speech at a local function and wanted his friend Lisa to go with him. Lisa was fully engaged, asking questions throughout and afterwards said to Dennis “That was a thrilling speech!”	Did Dennis do a dull speech?	2	Did Lisa think that Dennis had done an interesting speech?	1
Sarcastic	Claire was making a cake and baked it in the oven for too long until it was black. Her mum said to her “That looks delicious!”	Did Claire’s mum think that Claire was a good baker?	2	Was Claire a good baker?	2
Neutral	Roger was playing golf and hit his first ball straight into the hole he was aiming for. Bryan shouted “Great shot, hole in one!”	Did Roger take a good first shot?	1	Did Bryan think Roger had taken a good first shot?	1
Sarcastic	Andrea and Ross were on holiday in France. Andrea was attempting to ask directions in French but was struggling. Afterwards Ross said to her “You’re practically fluent Andrea!”	Was Andrea bad at speaking French?	1	Did Ross think that Andrea was bad at speaking French?	1
Neutral	Peter worked in a call centre and one day spent half an hour listening to the complaints of an angry customer. His colleague Rebecca said “Peter, you’re so patient with customers!”	Did Peter have bad customer service skills?	2	Did Rebecca think Peter had good customer service skills?	1
Sarcastic	Zoe and Edward were lawyers. One day Edward did a poor job in Court and lost his case. Zoe said to Edward afterwards “You handled that case well!”	Did Zoe think Edward had handled the case well?	2	Did Edward handle the case well?	2
Neutral	Sam cooked his girlfriend a celebratory meal which tasted delicious. When she tried it she said to him “You should be a chef!”	Was Sam a good cook?	1	Did Sam’s girlfriend think Sam was a bad cook?	2

Neutral	Rob and his friend James had just finished an exam. Rob had answered every question correctly but didn't want to brag about it. James said to him "You shouldn't be so modest!"	Did James think Rob was modest?	1	Was Rob boastful?	2
Sarcastic	Patrick and his dad were watching a game show on TV. Patrick got every question wrong and his dad said to him "You're good at this aren't you!"	Did Patrick's dad think Patrick was good at the game show?	2	Was Patrick bad at the game show?	1
Neutral	Helen was learning to drive. She had to parallel park in front of all her friends and she did it on her 1st attempt. When she got out of the car Andy shouted "Nice parking!"	Was Helen bad at parking?	2	Did Andy think Helen was bad at parking?	2
Sarcastic	Dennis was doing a speech at a local function and wanted his friend Lisa to go with him. Lisa fell asleep in the middle and afterwards said to Dennis "That was a thrilling speech!"	Did Lisa think that Dennis had done a dull speech?	1	Did Dennis do a dull speech?	1
Sarcastic	Joan's son Paul asked her what she had done for her birthday last year. When she couldn't remember he said to her "You've always had a great memory haven't you!"	Did Joan have a bad memory?	1	Did Paul think Joan had a good memory?	2
Neutral	Jess was going out and was ready half an hour before her taxi was due. Her boyfriend said to her "Super organised, as usual!"	Did Jess's boyfriend think Jess was disorganised?	2	Was Jess organised?	1
Sarcastic	Steve was moving into his new house. His friend Mark came to see him but instead of offering to carry any boxes he stood and watched Steve. Steve said to Mark "You're a big help!"	Did Steve think Mark was helpful?	2	Was Mark unhelpful?	1

Neutral	Susan had picked a play to take her friend Vicky to see. The play turned out to be excellent and Vicky said to Susan “What a fantastic play you picked!”	Did Vicky think Susan had picked a bad play?	2	Did Susan pick a bad play?	2
Sarcastic	Gary was bowling with friends when he sent another ball straight into the gutter. His friend said “Another strike, well done!”	Was Gary bad at bowling?	1	Did Gary’s friend think Gary was good at bowling?	2
Sarcastic	Matt and his brother John were going on a night out. When John arrived at Matt’s wearing odd shoes and a scruffy shirt Matt said to him “Looking stylish!”	Did John look unstylish?	1	Did Matt think John looked unstylish?	1
	Joe came to work and immediately sat down and started working. His boss noticed his behaviour and said, “Joe, don’t work too hard!”	Did Joe's boss think that Joe was working hard?	1	Did Joe work hard?	1

Part 1

1 minute break

Neutral	Kate was a model and was showing her friend her new photos, including one that she was really pleased with. Her friend said “You look beautiful in that one!”	Did Kate look bad in the photo?	2	Did Kate’s friend think Kate looked good in the photo?	1
Sarcastic	Nathan and Janice went to a dance lesson. Nathan was struggling to pick it up and was forgetting all his steps. Janice said to him “You’ll be teaching the class before long!”	Was Nathan good at the dance lesson?	2	Did Janice think Nathan was good at the dance lesson?	2
Neutral	Gemma was picking up her sister Daniella to go out. Gemma turned up exactly on time and Daniella said to her “As prompt as ever Gemma!”	Was Gemma late?	2	Did Daniella think Gemma was prompt?	1

Neutral	Jen was telling Alice a story about her night out. The ending was dramatic and Alice was surprised. She said to Jen “Another thrilling story Jen!”	Did Alice think Jen had told an exciting story?	1	Did Jen tell a boring story?	2
Sarcastic	Chelsea and Sarah had fallen out at school. When Chelsea saw Sarah running out of the hairdressers with messy, green hair she said to her “Nice hair!”	Did Chelsea think that Sarah’s hair looked bad?	1	Did Sarah’s hair look good?	2
Sarcastic	Kenneth was landscaping his garden but had got distracted and barely started. His grandson came to have a look after a week and said “I can see you’ve been working hard!”	Had Kenneth been working hard on his garden?	2	Did Kenneth’s grandson think Kenneth had been working hard on his garden?	2
Neutral	Chloe and Ben were in a university tutorial group. Ben answered a question correctly and Chloe said to him “Nice answer!”	Did Chloe think that Ben gave a poor answer?	2	Did Ben give a poor answer?	2
Neutral	Claire was making a cake and baked it in the oven until it was a perfect golden colour. Her mum said to her “That looks delicious!”	Was Claire a bad baker?	2	Did Claire’s mum think that Claire was a bad baker?	2
Sarcastic	Melanie was singing to herself thinking no one was listening. She sang in a silly voice and missed every note. Her friend appeared and said “You have the voice of an angel!”	Did Melanie have a bad singing voice?	1	Did Melanie’s friend think Melanie had a good singing voice?	2
Neutral	On Tom’s first football match playing as goal-keeper he let no goals in. His team-mate Chris said “You could play professionally in goal!”	Did Chris think Tom was good at goal-keeping?	1	Was Tom bad at goal-keeping?	2

Sarcastic	Mary was entering her vegetables into a competition but her produce was smaller than the other competitors. Her good friend Jane saw her entries and said “You’ve got some winning vegetables there!”	Did Jane think Mary was likely to win the competition?	2	Was Mary likely to win the competition?	2
Sarcastic	Lauren had been teaching her mum how to use her new computer. After the 10th explanation of sending an email, her mum did it herself. Lauren said “You’re a computer whiz mum!”	Did Lauren’s mum struggle using computers?	1	Did Lauren think her mum struggled using computers?	1
Sarcastic	Tina and her friend were trying on dresses in a shop. Tina had got the wrong size and when she couldn't do the zip up her friend said “Looks great, perfect fit!”	Did Tina’s friend think Tina looked good in the dress?	2	Did Tina look bad in the dress?	1
Neutral	Ian was attempting some DIY plumbing. His girlfriend came home to see a new bathroom fitted. She said to him “Nice work. I see those DIY lessons came in handy!”	Had Ian done a good job?	1	Did Ian’s girlfriend think Ian had done a good job?	1
Neutral	Simon was always punctual at work and enthusiastic about his job. In his appraisal he was told he wouldn’t get a bonus. He told his colleague Geoff who said “Shame, you’re such a hard worker!”	Did Geoff think Simon was a hard worker?	1	Was Simon a hard worker?	1

End of part 1

Break while setting up next part

Start of part 2

Sarcastic	Sam cooked his girlfriend a celebratory meal but badly burned it. When she saw it she said to him “You should be a chef!”	Did Sam’s girlfriend think Sam was a bad cook?	1	Was Sam a good cook?	2
Sarcastic	Susan had picked a play to take her friend Vicky to see. The play turned out to be terrible and Vicky said to Susan “What a fantastic play you picked!”	Did Susan pick a bad play?	1	Did Vicky think Susan had picked a bad play?	1
Sarcastic	Gemma was picking up her sister Daniella to go out. Gemma turned up 20 minutes late and Daniella said to her “As prompt as ever Gemma!”	Did Daniella think Gemma was prompt?	2	Was Gemma prompt?	2
Neutral	Kenneth was landscaping his garden and had completely transformed it. His grandson came to have a look after a week and said “I can see you’ve been working hard!”	Did Kenneth’s grandson think Kenneth had been working hard on his garden?	1	Had Kenneth been working hard on his garden?	1
Sarcastic	Jess was going out but was frantically looking for her keys whilst the taxi was waiting. Her boyfriend said to her “Super organised, as usual!”	Was Jess organised?	2	Did Jess’s boyfriend think Jess was disorganised?	1
Neutral	Melanie was singing to herself thinking no one was listening. She sang well and hit every note. Her friend appeared and said “You have the voice of an angel!”	Did Melanie’s friend think Melanie had a good singing voice?	1	Did Melanie have a bad singing voice?	2

Sarcastic	On Tom's first football match playing as goal-keeper he let 12 goals in. His team-mate Chris said "You could play professionally in goal!"	Was Tom good at goal-keeping?	2	Did Chris think Tom was bad at goal-keeping?	1
Neutral	Matt and his brother John were going on a night out. When John arrived at Matt's wearing smart shoes and a designer shirt Matt said to him "Looking stylish!"	Did Matt think John looked unstylish?	2	Did John look unstylish?	2
Sarcastic	Rob and his friend James had just finished an exam. Rob had answered every question correctly and bragged about it. James said to him "You shouldn't be so modest!"	Was Rob modest?	2	Did James think Rob was modest?	2
Neutral	Steve was moving into his new house. His friend Mark came to see him and offered to help Steve carry in his boxes. Steve said to Mark "You're a big help!"	Was Mark helpful?	1	Did Steve think Mark was unhelpful?	2
Neutral	Andrea and Ross were on holiday in France. Andrea was confidently and clearly asking for directions in French. Afterwards Ross said to her "You're practically fluent Andrea!"	Did Ross think that Andrea was bad at speaking French?	2	Was Andrea good at speaking French?	1
Sarcastic	Peter worked in a call centre and one day hung up the phone on an angry customer mid-complaint. His colleague Rebecca said "Peter, you're so patient with customers!"	Did Rebecca think Peter had bad customer service skills?	1	Did Peter have bad customer service skills?	1

Sarcastic	Kate was a model and was showing her friend her new photos, including one where the camera caught her sneezing. Her friend said “You look beautiful in that one!”	Did Kate’s friend think Kate looked good in the photo?	2	Did Kate look bad in the photo?	1
Neutral	Zoe and Edward were lawyers. One day Edward did a great job in Court and won his case. Zoe said to Edward afterwards “You handled that case well!”	Did Edward handle the case well?	1	Did Zoe think Edward had handled the case badly?	2
Neutral	Joan’s son Paul asked her what she had done for her birthday last year. When she recounted the day perfectly he said to her “You’ve always had a great memory haven’t you!”	Did Paul think Joan had a bad memory?	2	Did Joan have a bad memory?	2

Part 2

1 minute break

Neutral	Patrick and his dad were watching a game show on TV. Patrick got every question right and his dad said to him “You’re good at this aren’t you!”	Was Patrick bad at the game show?	2	Did Patrick’s dad think Patrick was good at the game show?	1
Sarcastic	Helen was learning to drive. She had to parallel park in front of all her friends and it took her 5 attempts. When she got out of the car Andy shouted “Nice parking!”	Did Andy think Helen was bad at parking?	1	Was Helen bad at parking?	1
Neutral	Liz was playing tennis with a friend and kept hitting winning shots. Her friend said to her “You’re playing really well today Liz!”	Was Liz playing tennis badly?	2	Did Liz’s friend think Liz was playing badly?	2

Neutral	Tina and her friend were trying on dresses in a shop. Tina had got the right size and when she zipped it straight up her friend said “Looks great, perfect fit!”	Did Tina look good in the dress?	1	Did Tina's friend think Tina looked bad in the dress?	2
Sarcastic	Chloe and Ben were in a university tutorial group. Ben answered a question incorrectly and Chloe said to him “Nice answer!”	Did Ben give a poor answer?	1	Did Chloe think that Ben gave a good answer?	2
Neutral	Lauren had been teaching her mum how to use her new computer. Without any explanation, her mum managed to send her first email by herself. Lauren said “You’re a computer whiz mum!”	Did Lauren think her mum struggled using computers?	2	Did Lauren’s mum struggle using computers?	2
Sarcastic	Ian was attempting some DIY plumbing. His girlfriend came home to see the bathroom flooded. She said to him “Nice work. I see those DIY lessons came in handy!”	Did Ian’s girlfriend think Ian had done a good job?	2	Had Ian done a bad job?	1
Neutral	Mary was entering her vegetables into a competition and her produce was bigger than the other competitors. Her good friend Jane saw her entries and said “You’ve got some winning vegetables there!”	Was Mary likely to win the competition?	1	Did Jane think Mary was likely to win the competition?	1
Neutral	Gary was bowling with friends when he sent another ball straight down the middle towards the pins. His friend said “Another strike, well done!”	Did Gary’s friend think Gary was good at bowling?	1	Was Gary good at bowling?	1
Sarcastic	Jen was telling Alice a story about her night out. The ending had an anti-climax and Alice was unimpressed. She said to Jen “Another thrilling story Jen!”	Did Jen tell a boring story?	1	Did Alice think Jen had told a boring story?	1

Sarcastic	Simon was often late for work and uninterested in his job. In his appraisal he was told he wouldn't get a bonus. He told his colleague Geoff who said "Shame, you're such a hard worker!"	Was Simon a hard worker?	2	Did Geoff think Simon was a hard worker?	2
Neutral	Chelsea and Sarah were friends from school. When Chelsea saw Sarah coming out of the hairdressers after a haircut she said to her "Nice hair!"	Did Sarah's hair look bad?	2	Did Chelsea think that Sarah's hair looked good?	1
Neutral	Nathan and Janice went to a dance lesson. Nathan picked it up really quickly and could remember all his steps. Janice said to him "You'll be teaching the class before long!"	Did Janice think Nathan was good at the dance lesson?	1	Was Nathan good at the dance lesson?	1
Sarcastic	Joe came to work, and instead of beginning to work, he sat down to rest. His boss noticed his behaviour and said, "Joe, don't work too hard!"	Did Joe work hard?	2	Did Joe's boss think that Joe was working hard?	2
Sarcastic	Roger was playing golf and hit his first ball straight into the sand bunker, far from the hole. Bryan shouted "Great shot, hole in one!"	Did Bryan think Roger had taken a bad first shot?	1	Did Roger take a good first shot?	2

End of experiment



Patient participant Information sheet – Version 2

Research study: Sarcasm and aggression after traumatic brain injury

Invitation paragraph

I would like to invite you to take part in a research study. Before you decide whether or not to take part you need to understand why the research is being done and what it would involve for you. Please read this sheet, talk to others if you wish or ask me for more information.

What is the purpose of the study?

I am a Trainee Clinical Psychologist from the University of Leeds and am conducting this research as a part of my doctorate qualification. I am interested in exploring the links between language and aggressive behaviour after brain injury.

Why have I been invited?

You are being invited to take part as you have suffered a traumatic brain injury. I would like to investigate how you process language and if this relates to certain aspects of behaviour including aggression.

Do I have to take part?

It is up to you to decide. I will describe the study and go through this information sheet, which I will then give to you. I will then ask you to sign a consent form to show you have agreed to take part. You are free to withdraw from the study during the experiment and for two weeks following your testing date, without giving a reason. This would not affect the care you receive.

What will happen to me if I take part?

I will visit you to ask you to complete some questionnaires and a computer-based experiment. I will need to see you 1 or 2 times and each visit will take about an hour of your time.

Will my taking part in the study be kept confidential?

All information about you will be handled in confidence. At no time will you be identified by name and no information that I keep will be able to be linked to you personally.

What are the possible benefits of taking part?

We hope that your taking part in the study will inform research into language and behaviour after traumatic brain injury which will be of benefit to services assessing and treating people who have suffered brain injury.

What will happen to the results of the research study?

The results will be written up for a doctoral thesis. In addition, the results may be published in psychological journals and disseminated at research seminars and conferences. Results from this project may be included in future projects. You will not be identified in any way in the thesis or in any published reports. If you would like me to send you a copy of any papers published, please let me know.

Who is organising the research?

The principle investigator for this study is Joanne Allen at the Leeds Institute of Health Sciences at the University of Leeds.

Who has reviewed the study?

The research has been reviewed by a panel organised by the University of Leeds as part of the requirements of the main researcher's doctoral training. It has been reviewed and approved through University of Leeds Institute of Psychological Sciences Research Ethics Committee, the Brain Injury Rehabilitation Trust Research Ethics Committee and the NHS Research Ethics Committee.

Where can I find out more information or report a problem/concern?

If you would like more information about taking part in this project, please contact the principal investigator, Joanne Allen, or the project supervisor, Dr Ekaterini Klepousniotou, on the details below. If you want to make a complaint please do so via Dr Ekaterini Klepousniotou.

Joanne Allen

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Dr Ekaterini Klepousniotou

School of Psychology
University of Leeds
Lifton Place
Leeds, LS2 9JT
Tel: 0113 343 5716
Email: E.Klepousniotou@leeds.ac.uk

Thank you for thinking about taking part in this study.



Control participant Information sheet – Version 2

Research study: Sarcasm and aggression after traumatic brain injury

Invitation paragraph

I 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. Ask me if there is anything that is not clear or if you would like more information. Please take time to decide whether or not you wish to take part.

What is the purpose of the study?

I am a Trainee Clinical Psychologist from the University of Leeds. I am interested in exploring the links between language and behaviour. This is of use when thinking about assessment and treatment for people who have suffered a brain injury. Little is currently known about the processes involved in specific aspects of language processing and particular behaviours, though after brain injury both of these areas can be affected.

Why have I been invited?

You are being asked to take part so that I can investigate how normal language processing occurs in healthy adults compared to people who have suffered a traumatic brain injury. You have been identified as being demographically similar in some way (e.g. gender, age, background) to the participants in the research who have suffered a brain injury.

Do I have to take part?

It is up to you to decide. I will describe the study and go through this information sheet, which I will then give to you. I will then ask you to sign a consent form to show you have agreed to take part. You are free to withdraw from the study during the experiment and for two weeks following your testing date, without giving a reason.

What will happen to me if I take part?

I will ask to meet you at a location of your choice and ask you to complete some questionnaires and a computer-based experiment. I should only need to see you once for approximately 1 hour.

Will my taking part in the study be kept confidential?

I will follow ethical and legal practice and all information about you will be handled in confidence. At no time will you be identified by name. No information that I keep will be able to be linked to you personally.

What are the possible benefits of taking part?

We hope that your taking part in the study will inform research into language and behaviour after brain injury which will be of benefit to services assessing and treating people who have suffered brain injury.

What will happen to the results of the research study?

The results will be written up for a doctoral thesis. In addition, the results may be published in psychological journals and disseminated at research seminars and conferences. Results from this project may be included in future projects. You will not be identified in any way in the thesis or in any published reports. If you would like me to send you a copy of any papers published, please let me know.

Who is organising the research?

The principle investigator for this study is Joanne Allen at the Leeds Institute of Health Sciences at the University of Leeds.

Who has reviewed the study?

The research has been reviewed by a panel organised by the University of Leeds as part of the requirements of the main researcher's doctoral training. It has been reviewed and approved through University of Leeds Institute of Psychological Sciences Research Ethics Committee, the Brain Injury Rehabilitation Trust Research Ethics Committee and the NHS Research Ethics Committee.

Where can I find out more information or report a problem/concern?

If you would like more information about taking part in this project, please contact the principal investigator, Joanne Allen, or the project supervisor, Dr Ekaterini Klepousniotou, on the details below. If you want to make a complaint please do so via Dr Ekaterini Klepousniotou.

Joanne Allen

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Thank you for thinking about taking part in this study.

Appendix 13: Control participant consent form



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Control participant consent form

Title of research: Sarcasm and aggression after traumatic brain injury

Name of researcher: Joanne Allen

Participant identification number:

	Add your initials next to the statement if you agree
I confirm I have read the information sheet dated 13.7.15 (Version 2). I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any time during the experiment, and for two weeks after that, without giving any reason, and without there being any negative consequences.	
I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.	
I understand that the information collected about me may be used to support other research in the future, and may be shared anonymously with other researchers.	
I agree to take part in the above research project.	

Name of Participant

Date

Signature

Name of Person taking consent

Date

Signature

Research script

Order

1. Information sheet
2. Consent form
3. Screening questionnaire
4. Handedness questionnaire
5. MoCA
6. BPAQ
7. E-prime experiments
 - i. Examples
 - ii. Practice
 - iii. Experiment
 - iv. Experiment
8. Sarcasm questions
9. Debrief sheet

Experiment instructions

The sections italicised and in speech marks below do not have to be read verbatim; this is more of a guide as to what you need to remind the participant of and when.

1. Examples

Set up the file. First screen = instructions screen.

“Have a read through this and let me know when you’ve read it, before pressing anything”

Participant reads instructions

“After you’ve been asked the questions, think about how you’d answer it, and if you think you know the answer tell me it out loud. You will be given the answers on the screen.”

Run file. You can talk throughout to clarify if needed. Explain you can press any key after you’ve read/heard the story to move on to the questions. In the examples only you (experimenter) should press any key to move quickly through the questions if the person is responding quickly and with no difficulty. If they are slow and need the time, leave each screen to time out and move onto the next.

If the participant needs this to be repeated, because they did not understand the task, or consistently made errors, run the example file again. If they still make mistakes are unsure how to respond talk through an example, e.g. *“When it is asked ‘Did Richard suggest a bad idea’, remember it says that ‘Richard made an unhelpful suggestion’. When it is asked ‘Did Richard’s wife think Richard suggested a bad idea’ although his wife says that he is ‘full of great ideas’, the way she says this suggests she doesn’t really mean this. Listen carefully to both the situation and the comment.”*

2. Practice

Set up the file. First screen = instructions screen.

“Have a read through this and let me know when you’ve read it, before pressing anything”.

Participant reads instructions

“As it says, this is a practice, but you won’t be told the correct answers this time. I want you to answer them yourself using the mouse. Please listen to the full story and answer the questions as quickly as you can”.

Make sure you look at how the participants are responding. If they make an error go back to this by running the practice file again – if they make mistakes again, talk through the vignettes e.g. *“When it asks ‘does Liz’s friend think Liz was playing tennis badly’, remember the story said that Liz was ‘hitting shots out of the court’, and although the friend said Liz was playing ‘really well’, the way she said this suggested she didn’t really mean this. Listen carefully to both the situation and the comment.”*

Remind them throughout that if they have finished listening to the story they can press any key to move onto the questions (to speed it up).

Ensure they are clear they know what to do.

3. Experiment (part 1 or 2 depending on order)

Set up the first experimental file. First screen = instructions screen.

“This is the first part of the real experiment now. I will leave the room and sit outside so that I don’t distract you. There is a programmed 1-minute break in the middle where I’ll ask you to stay in the room, and the test will restart. When it comes to an end the programme will close - please let me know and I’ll come and set up the next file.

“The format is the same as in the practice. There may be stories and questions that seem a bit more ambiguous (less obvious) than others, so please take a guess if you’re not sure. Remember to listen to the full story and respond as soon as you think you know the answer. Is that all clear?”

If not clarify anything as necessary.

Wait outside – good time to score the MoCA and BPAQ

4. Experiment (part 1 or 2 depending on order)

Check participant was happy with last bit/had any questions.

“This is just like before. I’ll sit outside whilst you are completing the task. Again there is a 1-minute break in the middle, please don’t leave the room. When it is finished the programme will close down – at this point please let me know when you are finished.

End.

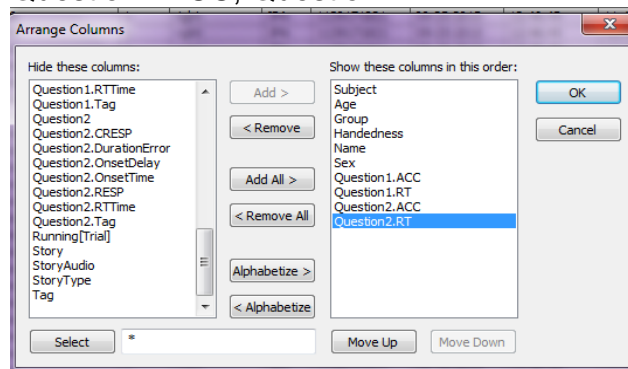
Appendix 15: Data preparation instructions

Instructions for Cleaning and Prepping Data for Analysis

For each participant there are 2 experimental files we are interested in; part 1 and part 2. Some people will have done part 1 first, and some part 2 – it is counterbalanced to control for potential confounds such as practice effects or fatigue. You want all of this experimental data (both part 1 and part 2) in the one spreadsheet.

Moving data from e-prime into the Excel spreadsheet:

1. Open whichever Edat.2 file the participant did first (this will be part 1 or part 2 depending on the counterbalancing order)
 - a. Rename that Edat.2 file appropriately – e.g.
C01_ALJ1987_Part 1
2. Open file. Tools > Arrange Columns. Remove all columns and then arrange in following order:
Subject, Age, Group, Handedness, Name, Sex, Question1.ACC, Question1.RT, Question2.ACC, Question2.RT



3. Re-save as – e.g. C01_ALJ1987_Part 1_ **analysed**
4. Export button (next to 'save' icon) > 'Excel' in drop down menu > save in folder (.txt file)
5. Open .txt file > Select all (Ctrl + A) > Copy
6. Open the template Excel spreadsheet and Paste into the sheet named "Raw data"
7. Highlight all the data in the first 6 columns (the demographic info), ignoring the top 2 rows (file name and column headings) > Copy

	A	B	C	D	E	F	G	H	I	J
1	C:\Jo Allen\Thesis\Experiment and data\Controls\C01\01. Experiment Part 1 V3-01-1.edat2									
2	Subject	Age	Group	Hanc Name	Sex		Question1.ACC	Question1.RT	Question2.ACC	Question2.RT
3	1	56	1	right JPA	male		1	1819	1	2259
4	1	56	1	right JPA	male		1	2160	1	2262
5	1	56	1	right JPA	male		1	2204	1	1397
6	1	56	1	right JPA	male		1	1141	0	4695
7	1	56	1	right JPA	male		1	2747	1	1495
8	1	56	1	right JPA	male		1	3017	1	1340
9	1	56	1	right JPA	male		1	1952	1	3075
10	1	56	1	right JPA	male		1	2476	1	1260
11	1	56	1	right JPA	male		1	1826	1	3699
12	1	56	1	right JPA	male		1	2524	1	1018
13	1	56	1	right JPA	male		1	2027	1	1747
14	1	56	1	right JPA	male		1	2282	1	1747
15	1	56	1	right JPA	male		1	2131	1	3117
16	1	56	1	right JPA	male		1	2529	1	2305
17	1	56	1	right JPA	male		1	2116	1	1003
18	1	56	1	right JPA	male		1	1720	1	1817
19	1	56	1	right JPA	male		1	1722	1	3423
20	1	56	1	right JPA	male		1	1145	1	1721
21	1	56	1	right JPA	male		1	1648	1	1262
22	1	56	1	right JPA	male		1	2463	1	1896
23	1	56	1	right JPA	male		1	1997	1	1924
24	1	56	1	right JPA	male		1	1968	1	1258
25	1	56	1	right JPA	male		1	1427	1	2192
26	1	56	1	right JPA	male		1	2212	1	2246
27	1	56	1	right JPA	male		1	1668	1	2353
28	1	56	1	right JPA	male		1	2827	1	1326
29	1	56	1	right JPA	male		0	3523	0	5615
30	1	56	1	right JPA	male		1	1752	1	1192

8. Open second sheet named “Data-check for factual errors” and paste into the demographics section (cell A3) and paste again underneath this (cell A33) so it repeats twice
 - a. This will no longer be blue so if you want it to be in colour (so easier to visually separate the sections) highlight cells and use the fill colour option to change colour
9. Go back to “Raw data” sheet > highlight the data in the last 4 columns (the accuracy and RT data), again ignoring the top 2 rows > Copy
10. Go to “Data-check for factual errors” sheet and paste into the red data section **for the corresponding experiment part** – cell T3 for Part 1, cell T33 for Part 2)
 - a. Again the colour will have changed so fill colour if wanted
11. Complete column H with the order the participant did the part, so if they did Part 1 first, the order for that section would say 1, but if they did Part 1 second the order would say 2 for that section, like below)

B	C	D	E	F	G	H	I	J	K
Demographics									
Age	Group	Handedness	Name	Sex	Part	Order	Story	StoryAudio	Q1 Text
21	1	right	21	female	1	1	Andre Vignette 20 : Was Anc		
21	1	right	21	female	1	1	Peter v Vignette 4 Ni Did Peter		
21	1	right	21	female	1	1	Zoe ar Vignette 19 : Did Zoe		
21	1	right	21	female	1	1	Sam c Vignette 6 Ni Was Sar		
21	1	right	21	female	1	1	Rob ar Vignette 9 Ni Did Jame		
21	1	right	21	female	1	1	Patrick Vignette 33 : Did Patric		
21	1	right	21	female	1	1	Helen v Vignette 12 : Was Hel		
21	1	right	21	female	1	1	Dennis Vignette 24 : Did Lisa		
21	1	right	21	female	1	1	Joan's Vignette 26 : Did Joan		
21	1	right	21	female	1	1	Jess v Vignette 28 : Did Jess		
21	1	right	21	female	1	1	Steve Vignette 18 : Did Stev		
21	1	right	21	female	1	1	Susan Vignette 14 : Did Vick		
21	1	right	21	female	1	1	Gary v Vignette 13 : Was Gar		
21	1	right	21	female	1	1	Matt ar Vignette 34 : Did John		
21	1	right	21	female	1	1	Joe ca Vignette 1 Ni Did Joe's		
21	1	right	21	female	1	1	Kate v Vignette 27 : Did Kate		
21	1	right	21	female	1	1	Nathar Vignette 15 : Was Nat		
21	1	right	21	female	1	1	Gemmi Vignette 25 : Was Ge		
21	1	right	21	female	1	1	Jen w Vignette 22 : Did Alic		
21	1	right	21	female	1	1	Chelse Vignette 32 : Did Chel		
21	1	right	21	female	1	1	Kenne Vignette 7 Si Had Ken		
21	1	right	21	female	1	1	Chloe v Vignette 16 : Did Chlo		
21	1	right	21	female	1	1	Claire v Vignette 3 Ni Was Clai		
21	1	right	21	female	1	1	Melani Vignette 21 : Did Melai		
21	1	right	21	female	1	1	On Tor Vignette 8 Ni Did Chris		
21	1	right	21	female	1	1	Mary v Vignette 5 Si Did Jane		
21	1	right	21	female	1	1	Laurer Vignette 10 : Did Laur		
21	1	right	21	female	1	1	Tina ar Vignette 11 : Did Tina		
21	1	right	21	female	1	1	Ian wa Vignette 23 : Had Ian c		
21	1	right	21	female	1	1	Simon Vignette 29 : Did Geof		
21	1	right	21	female	2	2	Sam c Vignette 6 Si Did Sam		
21	1	right	21	female	2	2	Susan Vignette 14 : Did Susa		
21	1	right	21	female	2	2	Jim Vignette 25 : Did Danik		
21	1	right	21	female	2	2	Kenne Vignette 7 Ni Did Kenn		

A	B	C	D	E	F	G	H	I	J	K
Demographics										
Subject	Age	Group	Handedness	Name	Sex	Part	Order	Story	StoryAudio	Q1 Text
21	1	21	1	right	21	female	1	2	Andre Vignette 20 : Was Au	
21	1	21	1	right	21	female	1	2	Peter v Vignette 4 Ni Did Peh	
21	1	21	1	right	21	female	1	2	Zoe ar Vignette 19 : Did Zoe	
21	1	21	1	right	21	female	1	2	Sam c Vignette 6 Ni Was Si	
21	1	21	1	right	21	female	1	2	Rob ar Vignette 9 Ni Did Jarr	
21	1	21	1	right	21	female	1	2	Patrick Vignette 33 : Did Pat	
21	1	21	1	right	21	female	1	2	Helen v Vignette 12 : Was Hel	
21	1	21	1	right	21	female	1	2	Dennis Vignette 24 : Did Lisr	
21	1	21	1	right	21	female	1	2	Joan's Vignette 26 : Did Joa	
21	1	21	1	right	21	female	1	2	Jess v Vignette 28 : Did Jes	
21	1	21	1	right	21	female	1	2	Steve Vignette 18 : Did Ste	
21	1	21	1	right	21	female	1	2	Susan Vignette 14 : Did Vic	
21	1	21	1	right	21	female	1	2	Gary v Vignette 13 : Was Gi	
21	1	21	1	right	21	female	1	2	Matt ar Vignette 34 : Did Joh	
21	1	21	1	right	21	female	1	2	Joe ca Vignette 1 Ni Did Joe	
21	1	21	1	right	21	female	1	2	Kate v Vignette 27 : Did Kat	
21	1	21	1	right	21	female	1	2	Nathar Vignette 15 : Was Ni	
21	1	21	1	right	21	female	1	2	Gemmi Vignette 25 : Was Gi	
21	1	21	1	right	21	female	1	2	Jen w Vignette 22 : Did Alic	
21	1	21	1	right	21	female	1	2	Chelse Vignette 32 : Did Che	
21	1	21	1	right	21	female	1	2	Kenne Vignette 7 Si Had Ke	
21	1	21	1	right	21	female	1	2	Chloe v Vignette 16 : Did Chl	
21	1	21	1	right	21	female	1	2	Claire v Vignette 3 Ni Was Cl	
21	1	21	1	right	21	female	1	2	Melani Vignette 21 : Did Mel	
21	1	21	1	right	21	female	1	2	On Tor Vignette 8 Ni Did Chr	
21	1	21	1	right	21	female	1	2	Mary v Vignette 5 Si Did Jan	
21	1	21	1	right	21	female	1	2	Laurer Vignette 10 : Did Lau	
21	1	21	1	right	21	female	1	2	Tina ar Vignette 11 : Did Tin	
21	1	21	1	right	21	female	1	2	Ian wa Vignette 23 : Had Ian	
21	1	21	1	right	21	female	1	2	Simon Vignette 29 : Did Ge	
21	1	21	1	right	21	female	2	2	Sam c Vignette 6 Si Did Sar	
21	1	21	1	right	21	female	2	2	Susan Vignette 14 : Did Sus	
21	1	21	1	right	21	female	2	2	Jim Vignette 25 : Did Dar	
21	1	21	1	right	21	female	2	2	Kenne Vignette 7 Ni Did Ken	

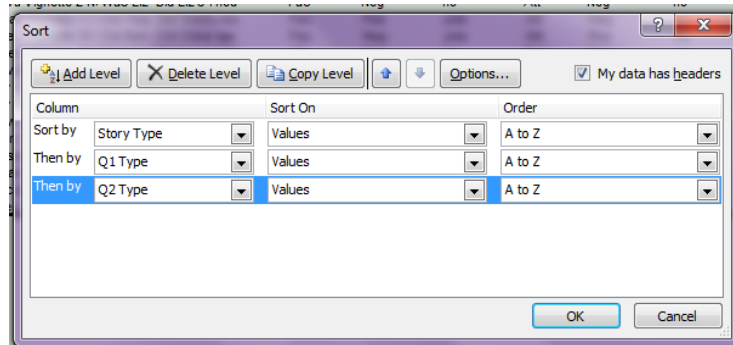
N.B. It's important to make sure the accuracy and RT data is pasted next to the correct story/question info (the green section) depending on the part number (i.e. which part was completed first – part 1 or part 2).

You will now need to be doing the same with the second Edat.2 file with the other set of experimental data from the other experimental part:

12. Open whichever Edat.2 file the participant did second (this will be part 1 or part 2 depending on the counterbalancing order)
 - a. Rename that Edat.2 file appropriately – e.g. C01_ALJ1987_Part 2
13. As above, Open file. Tools > Arrange Columns. Remove all columns and then arrange in following order:
Subject, Age, Group, Handedness, Name, Sex, Question1.ACC, Question1.RT, Question2.ACC, Question2.RT
14. Re-save as – e.g. C01_ALJ1987_Part 2_analysed
15. Export button (next to 'save' icon) > 'Excel' in drop down menu > save in folder (.txt file)
16. Open .txt file > Select all (Ctrl + A) > Copy
17. Open the Excel spreadsheet and Paste into "Raw data" underneath the other data from the other part (row 33)
18. Highlight the new accuracy and RT data in the last 4 columns that you've just pasted in > Copy
19. Go to "Data-check for factual errors" sheet and paste into the appropriate data section – again as in step 10 above this needs to correspond to the correct experiment Part – cell T3 for Part 1, cell T33 for Part 2)
 - a. Again the colour will have changed so fill colour if wanted

Removing errors and outliers:

20. Firstly you need to sort the data in “Data-check for factual errors” sheet. Highlight all data minus the first row > Data > Sort > Sort by “Story Type” > add level > Then by “Q1 Type” add level > Then by “Q2 Type”



21. Insert 3 blank rows between each of the 4 sorted sections (neu-att-fac, neu-fac-att, sar-att-fac, sar-fac-att), so it should look as follows:

Demographics						Story and question information									
Subj	Age	Group	Handed	Name	Sex	Part	Order	Story	Q2 Text	Story Type	Q1 Type	Q1 Pos-N	Q2 Type	Q2 Pos-N	Question
1	21	1	right	21	femal	1	2	Rob a V	was Rob neu	Att	Pos	yes	Fac	Neg	yes
3	1	21	1	right	21	femal	1	2	Jess v V	Was Jess neu	Att	Neg	no	Fac	Pos
4	1	21	1	right	21	femal	1	2	Susan Vignette 14	Did Susan neu	Att	Neg	no	Fac	Pos
5	1	21	1	right	21	femal	1	2	Joe c Vignette 14	Did Joe v neu	Att	Pos	yes	Fac	Pos
6	1	21	1	right	21	femal	1	2	Joe c Vignette 14	Did Joe v neu	Att	Neg	no	Fac	Neg
7	1	21	1	right	21	femal	1	2	Jen w Vignette 22	Did Jen t neu	Att	Pos	yes	Fac	Neg
8	1	21	1	right	21	femal	1	2	Chloe Vignette 16	Did Chic Did Ben c neu	Att	Neg	no	Fac	Neg
9	1	21	1	right	21	femal	1	2	On To Vignette 8	Did Chr: Was Torr neu	Att	Pos	yes	Fac	Neg
10	1	21	1	right	21	femal	1	2	Simor Vignette 29	Did Geo Was Sim neu	Att	Pos	yes	Fac	Pos
11	1	21	1	right	21	femal	2	1	Kenri Vignette 7	Did Ken Had Ken neu	Att	Pos	yes	Fac	Pos
12	1	21	1	right	21	femal	2	1	Melan Vignette 21	Did Mel Did Melai neu	Att	Pos	yes	Fac	Neg
13	1	21	1	right	21	femal	2	1	Matt a Vignette 34	Did Matt Did John neu	Att	Neg	no	Fac	Neg
14	1	21	1	right	21	femal	2	1	Andre Vignette 20	Did Pos: Was And neu	Att	Neg	no	Fac	Pos
15	1	21	1	right	21	femal	2	1	Joan: Vignette 26	Did Pau Did Joan neu	Att	Neg	no	Fac	Neg
16	1	21	1	right	21	femal	2	1	Laure Vignette 10	Did Lau Did Laur neu	Att	Neg	no	Fac	Neg
17	1	21	1	right	21	femal	2	1	Gary v Vignette 13	Did Gan Was Gar neu	Att	Pos	yes	Fac	Pos
18	1	21	1	right	21	femal	2	1	Natha Vignette 15	Did Jani Was Nat neu	Att	Pos	yes	Fac	Pos
19															
20															
21															
22	1	21	1	right	21	femal	1	2	Peter Vignette 4	Did Pete Did Rebe neu	Fac	Neg	no	Att	Pos
23	1	21	1	right	21	femal	1	2	Sam c Vignette 6	Was Sam Did Sam neu	Fac	Pos	yes	Att	Neg
24	1	21	1	right	21	femal	1	2	Helen Vignette 12	Was Hel Did Andy neu	Fac	Neg	no	Att	Neg
25	1	21	1	right	21	femal	1	2	Kate v Vignette 27	Did Kate Did Kate neu	Fac	Neg	no	Att	Pos
26	1	21	1	right	21	femal	1	2	Gemm Vignette 25	Was Ge Did Danir neu	Fac	Neg	no	Att	Pos
27	1	21	1	right	21	femal	1	2	Claire Vignette 31	Was Cla Did Claire neu	Fac	Neg	no	Att	Neg
28	1	21	1	right	21	femal	1	2	Ian v Vignette 23	Had Ian Did Ian's neu	Fac	Pos	yes	Att	Pos
29	1	21	1	right	21	femal	2	1	Steve Vignette 18	Was Ma Did Steve neu	Fac	Pos	yes	Att	Neg
30	1	21	1	right	21	femal	2	1	Zoe ai Vignette 13	Did Edw Did Zoe t neu	Fac	Pos	yes	Att	Neg
31	1	21	1	right	21	femal	2	1	Patric Vignette 33	Was Pai Did Patir neu	Fac	Neg	no	Att	Pos
32	1	21	1	right	21	femal	2	1	Liz wa Vignette 21	Was Liz Did Liz's neu	Fac	Neg	no	Att	Neg
33	1	21	1	right	21	femal	2	1	Tina a Vignette 11	Did Tina Did Tina neu	Fac	Pos	yes	Att	Neg
34	1	21	1	right	21	femal	2	1	Mary v Vignette 5	Was Ma Did Jane neu	Fac	Pos	yes	Att	Pos
35	1	21	1	right	21	femal	2	1	Chels Vignette 32	Did Sarz Did Chel neu	Fac	Neg	no	Att	Pos
36															
37															
38															
39	1	21	1	right	21	femal	1	2	Zoe ai Vignette 19	Did Zoe Did Edw s sar	Att	Pos	no	Fac	Pos

22. Next look for errors, as indicated by a '0', on factual (fac) questions.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
1	Demographics						Story and question information														
2	Subject	Age	Group	Handedness	Name	Sex	Part	Order	Story	StoryAudio	Q1 Text	Q2 Text	Story Type	Q1 Type	Q1 Pos-Neg	Q1 Answer	Q2 Type	Q2 Pos-Neg	Q2 Answer	Question	
3	1	21	1	right	21 fema	1	2	Rob a Vignette 9 N	Did Jam Was Roi neu	Att	Pos	yes	Fac	Neg	no						
4	1	21	1	right	21 fema	1	2	Jess v Vignette 28	Did Jes: Was Jes: neu	Att	Neg	no	Fac	Pos	yes						
5	1	21	1	right	21 fema	1	2	Susar Vignette 14	Did Vick: Did Sus: neu	Att	Neg	no	Fac	Neg	no						
6	1	21	1	right	21 fema	1	2	Joe c: Vignette 1 N	Did Joe: Did Joe: neu	Att	Pos	yes	Fac	Pos	yes						
7	1	21	1	right	21 fema	1	2	Jen w Vignette 22	Did Alice: Did Jen: neu	Att	Pos	yes	Fac	Neg	no						
8	1	21	1	right	21 fema	1	2	Chloe Vignette 16	Did Chic: Did Ben: neu	Att	Neg	no	Fac	Neg	no						
9	1	21	1	right	21 fema	1	2	On To Vignette 8 N	Did Chri: Was Tor: neu	Att	Pos	yes	Fac	Neg	no						
10	1	21	1	right	21 fema	1	2	Simor Vignette 29	Did Geo: Was Sin: neu	Att	Pos	yes	Fac	Pos	yes						
11	1	21	1	right	21 fema	2	1	Ken: Vignette 7 N	Did Ken: Had Ker: neu	Att	Pos	yes	Fac	Pos	yes						
12	1	21	1	right	21 fema	2	1	Melan Vignette 21	Did Meis: Did Meis: neu	Att	Pos	yes	Fac	Neg	no						
13	1	21	1	right	21 fema	2	1	Matt a Vignette 34	Did Matt: Did Johr: neu	Att	Neg	no	Fac	Pos	yes						
14	1	21	1	right	21 fema	2	1	Andre Vignette 20	Did Ros: Was Anc: neu	Att	Neg	no	Fac	Pos	yes						
15	1	21	1	right	21 fema	2	1	Joan v Vignette 26	Did Pau: Did Joar: neu	Att	Neg	no	Fac	Pos	yes						
16	1	21	1	right	21 fema	2	1	Laure Vignette 10	Did Lau: Did Laur: neu	Att	Neg	no	Fac	Pos	yes						
17	1	21	1	right	21 fema	2	1	Gary v Vignette 13	Did Gan: Was Gar: neu	Att	Pos	yes	Fac	Pos	yes						
18	1	21	1	right	21 fema	2	1	Natha Vignette 15	Did Jani: Was Nal: neu	Att	Pos	yes	Fac	Pos	yes						
19																					
20																					
21																					
22	1	21	1	right	21 fema	1	2	Peter Vignette 4 N	Did Pets: Did Reb: neu	Fac	N										
23	1	21	1	right	21 fema	1	2	Sam v Vignette 6 N	Was Sai: Did Sam: neu	Fac	P										
24	1	21	1	right	21 fema	1	2	Helen Vignette 12	Was He: Did And: neu	Fac	N										
25	1	21	1	right	21 fema	1	2	Kate v Vignette 27	Did Kate: Did Kate: neu	Fac	N										
26	1	21	1	right	21 fema	1	2	Gemr Vignette 25	Was Ge: Did Dan: neu	Fac	N										
27	1	21	1	right	21 fema	1	2	Claire Vignette 3 N	Was Clz: Did Clai: neu	Fac	N										
28	1	21	1	right	21 fema	1	2	Ian w: Vignette 23	Had Ian: Did Ian: neu	Fac	Pos	yes	Att	Pos	yes						
29	1	21	1	right	21 fema	2	1	Steve Vignette 18	Was Ma: Did Stev: neu	Fac	Pos	yes	Att	Neg	no						
30	1	21	1	right	21 fema	2	1	Zoe a Vignette 19	Did Edw: Did Zoe: neu	Fac	Pos	yes	Att	Neg	no						
31	1	21	1	right	21 fema	2	1	Patric Vignette 33	Was Pal: Did Patri: neu	Fac	Neg	no	Att	Pos	yes						
32	1	21	1	right	21 fema	2	1	Liz w: Vignette 2 N	Was Liz: Did Liz: neu	Fac	Neg	no	Att	Neg	no						
33	1	21	1	right	21 fema	2	1	Tina v Vignette 11	Did Tina: Did Tina: neu	Fac	Pos	yes	Att	Neg	no						
34	1	21	1	right	21 fema	2	1	Mar v Vignette 5 N	Was Ma: Did: Jane: neu	Fac	Pos	yes	Att	Neg	no						

Error on question 1.

Q1 type = 'fac'. Therefore this needs removing.

23. If there are any factual question errors the whole story needs removing (even if the attitude question is correct). Highlight the whole row with the factual error in, by clicking the row number on the left (in this case row 32) > Cut > Paste in “Errors & outliers” sheet under the **Factual errors** heading
24. Go back to the “Data-check for factual errors” sheet and delete this row by clicking on the row number to highlight it > right click > delete
25. If there are errors on both question 1 and question 2 (as in row 3 above), you know that one is definitely a factual question error so just cut this and paste it in the “Errors & outliers” sheet, again deleting the empty row where it came from (as in steps 23 & 24 above)
26. Once all factual errors are removed, highlight the data > copy > paste into the next sheet along “Data-check for attitude errors”
27. Now you’re looking for errors on attitude (att) questions only, but first the questions need separating out. Highlight the data (without the headings) > copy > paste below leaving 3 empty rows.
28. Delete the Q2 data in the first section, and the Q1 data in the second (newly pasted) section. Also, remove the 3 columns of information relating to the question you’ve just deleted (the green cells). It should look as follows in the 2 screenshots:

Demographics						Story and question information															
Subject	Age	Group	Handedness	Name	Sex	Part	Order	Story	Audio	Q1 Text	Q2 Text	Story Type	Q1 Type	Q1 Pos-Neg	Q1 Answer	Q2 Type	Q2 Pos-Neg	Q2 Answer	Question1_ACC	Question1	
1	21	1	right	21 fema	1	2	Jess	Vignette 28	Did Jess Was Jess neu	Att	Neg	no								1	17
2	21	1	right	21 fema	1	2	Susar	Vignette 14	Did Sus: Did Vick sar	Att	Neg	no								1	30
3	21	1	right	21 fema	1	2	Jess	Vignette 28	Did Jess Was Jess neu	Att	Neg	no								1	24
4	21	1	right	21 fema	1	2	Jen w	Vignette 22	Did Alic: Did Jen neu	Att	Pos	yes								1	24
5	21	1	right	21 fema	1	2	Chloe	Vignette 16	Did Chic: Did Ben neu	Att	Neg	no								1	16
6	21	1	right	21 fema	1	2	On To	Vignette 8	N Did Chr: Was Tor neu	Att	Pos	yes								1	27
7	21	1	right	21 fema	1	2	Simon	Vignette 29	Did Geo: Was Sin neu	Att	Pos	yes								1	16
8	21	1	right	21 fema	2	1	Ken	Vignette 7	N Did Ken: Had Ken neu	Att	Pos	yes								1	25
9	21	1	right	21 fema	2	1	Melan	Vignette 21	Did Mel: Did Mel neu	Att	Pos	yes								1	15
10	21	1	right	21 fema	2	1	Matt a	Vignette 34	Did Matt: Did John neu	Att	Neg	no								1	14
11	21	1	right	21 fema	2	1	Andre	Vignette 20	Did Ros: Was Ann neu	Att	Neg	no								1	25
12	21	1	right	21 fema	2	1	Joan	Vignette 26	Did Pau: Did Joan neu	Att	Neg	no								1	32
13	21	1	right	21 fema	2	1	Laure	Vignette 10	Did Laur: Did Laur neu	Att	Neg	no								1	17
14	21	1	right	21 fema	2	1	Gary	Vignette 13	Did Gan: Was Gain neu	Att	Pos	yes								1	12
15	21	1	right	21 fema	2	1	Natha	Vignette 15	Did Jan: Was Nat neu	Att	Pos	yes								1	12
16	21	1	right	21 fema	1	2	Peter	Vignette 4	N Did Pete: Did Reb neu	Fac	Neg	no								1	16
17	21	1	right	21 fema	1	2	Sam	Vignette 6	N Was Sa: Did Sam neu	Fac	Pos	yes								1	16
18	21	1	right	21 fema	1	2	Helen	Vignette 12	Was He: Did And neu	Fac	Neg	no								1	13
19	21	1	right	21 fema	1	2	Kate	Vignette 27	Did Kate: Did Kate neu	Fac	Neg	no								1	13
20	21	1	right	21 fema	1	2	Gemr	Vignette 25	Was Ge: Did Dan neu	Fac	Neg	no								1	10
21	21	1	right	21 fema	1	2	Claire	Vignette 3	N Was Cla: Did Clair neu	Fac	Neg	no								1	13
22	21	1	right	21 fema	1	2	Ian w	Vignette 23	Had Ian: Did Ian's neu	Fac	Pos	yes								1	11
23	21	1	right	21 fema	2	1	Steve	Vignette 18	Was Ma: Did Stev neu	Fac	Pos	yes								1	11
24	21	1	right	21 fema	2	1	Zoe a	Vignette 19	Did Zoe: Did Edw neu	Fac	Pos	yes								1	10
25	21	1	right	21 fema	2	1	Patric	Vignette 33	Was Pat: Did Patri neu	Fac	Neg	no								1	14
26	21	1	right	21 fema	2	1	Tina a	Vignette 11	Did Tina: Did Tina neu	Fac	Pos	yes								1	8
27	21	1	right	21 fema	2	1	Mary	Vignette 5	N Was Ma: Did Jane neu	Fac	Pos	yes								1	16
28	21	1	right	21 fema	2	1	Chels	Vignette 32	Did Sars: Did Che neu	Fac	Neg	no								1	12

60	21	1	right	21 fema	1	2	Laure	Vignette 10	Did Laur: Did Laur sar	Fac	Neg	yes								1	30	
61	21	1	right	21 fema	2	1	Susar	Vignette 14	Did Sus: Did Vick sar	Fac	Neg	yes									1	8
62	21	1	right	21 fema	2	1	Jess	Vignette 28	Was Jess: Did Jess sar	Fac	Pos	no									1	8
63	21	1	right	21 fema	2	1	On To	Vignette 8	S Was Tor: Did Chris sar	Fac	Pos	no									1	14
64	21	1	right	21 fema	2	1	Chloe	Vignette 16	Did Ben: Did Chlo sar	Fac	Neg	yes									1	10
65	21	1	right	21 fema	2	1	Jen w	Vignette 22	Did Jen: Did Alic sar	Fac	Neg	yes									1	11
66	21	1	right	21 fema	2	1	Simon	Vignette 29	Was Sin: Did Geo sar	Fac	Pos	no									1	15
67	21	1	right	21 fema	1	2	Jess	Vignette 28	Did Jess: Was Jess neu				Fac	Pos	yes							
68	21	1	right	21 fema	1	2	Susar	Vignette 14	Did Vick: Did Sus neu				Fac	Neg	no							
69	21	1	right	21 fema	1	2	Joe c	Vignette 1	N Did Joe: Did Joe neu				Fac	Pos	yes							
70	21	1	right	21 fema	1	2	Jen w	Vignette 22	Did Alic: Did Jen I neu				Fac	Neg	no							
71	21	1	right	21 fema	1	2	Chloe	Vignette 16	Did Chlo: Did Ben neu				Fac	Neg	no							
72	21	1	right	21 fema	1	2	On To	Vignette 8	N Did Chr: Was Tor neu				Fac	Neg	no							
73	21	1	right	21 fema	1	2	Simon	Vignette 29	Did Geo: Was Sin neu				Fac	Pos	yes							
74	21	1	right	21 fema	2	1	Ken	Vignette 7	N Did Ken: Had Ken neu				Fac	Pos	yes							
75	21	1	right	21 fema	2	1	Melan	Vignette 21	Did Mel: Did Mel neu				Fac	Neg	no							
76	21	1	right	21 fema	2	1	Matt a	Vignette 34	Did Matt: Did John neu				Fac	Neg	no							
77	21	1	right	21 fema	2	1	Andre	Vignette 20	Did Ros: Was Ann neu				Fac	Pos	yes							
78	21	1	right	21 fema	2	1	Joan	Vignette 26	Did Pau: Did Joan neu				Fac	Neg	no							
79	21	1	right	21 fema	2	1	Laure	Vignette 10	Did Laur: Did Laur neu				Fac	Neg	no							
80	21	1	right	21 fema	2	1	Gary	Vignette 13	Did Gan: Was Gain neu				Fac	Pos	yes							
81	21	1	right	21 fema	2	1	Natha	Vignette 15	Did Jan: Was Nat neu				Fac	Pos	yes							
82	21	1	right	21 fema	1	2	Peter	Vignette 4	N Did Pete: Did Reb neu				Att	Pos	yes							
83	21	1	right	21 fema	1	2	Sam	Vignette 6	N Was Sa: Did Sam neu				Att	Neg	no							
84	21	1	right	21 fema	1	2	Helen	Vignette 12	Was He: Did And neu				Att	Neg	no							
85	21	1	right	21 fema	1	2	Kate	Vignette 27	Did Kate: Did Kate neu				Att	Pos	yes							
86	21	1	right	21 fema	1	2	Gemr	Vignette 25	Was Ge: Did Dan neu				Att	Pos	yes							
87	21	1	right	21 fema	1	2	Claire	Vignette 3	N Was Cla: Did Clair neu				Att	Neg	no							
88	21	1	right	21 fema	1	2	Ian w	Vignette 23	Had Ian: Did Ian's neu				Att	Pos	yes							
89	21	1	right	21 fema	1	2	Steve	Vignette 18	Was Ma: Did Stev neu				Att	Neg	no							

29. Now look for errors on attitude questions:

1	21	1	right	21 fema	2	1	Patric	Vignette 33	Was Pat: Did Patri neu	Fac	Neg	no								1	1437	
2	21	1	right	21 fema	2	1	Tina a	Vignette 11	Did Tina: Did Tina neu	Fac	Pos	yes									1	867
3	21	1	right	21 fema	2	1	Mary	Vignette 5	N Was Ma: Did Jane neu	Fac	Pos	yes									1	1829
4	21	1	right	21 fema	2	1	Chels	Vignette 32	Did Sars: Did Chel neu	Fac	Neg	no									1	1215
5	21	1	right	21 fema	1	2	Zoe a	Vignette 19	Did Zoe: Did Edw sar	Att	Pos	no									1	2453
6	21	1	right	21 fema	1	2	Patric	Vignette 33	Did Patri: Was Pat sar	Att	Pos	no									1	3665
7	21	1	right	21 fema	1	2	Denni	Vignette 24	Did Lisa: Did Denr sar	Att	Neg	yes									1	1681
8	21	1	right	21 fema	1	2	Steve	Vignette 18	Did Stev: Was Ma sar	Att	Pos	no									1	3115
9	21	1	right	21 fema	1	2	Mary	Vignette 5	S Did Jane: Was Ma sar	Att	Pos	no									1	3086
10	21	1	right	21 fema	1	2	Tina a	Vignette 11	Did Tina: Did Tina sar	Att	Pos	no									1	1923
11	21	1	right	21 fema	2	1	Sam c	Vignette 6	S Did Sam: Was Sai sar	Att	Neg	yes									1	2187
12	21	1	right	21 fema	2	1	Gemr	Vignette 25	Did Dani: Was Ge sar	Att	Pos	no									1	1468
13	21	1	right	21 fema	2	1	Peter	Vignette 4	S Did Reb: Did Pete sar	Att	Neg	yes									1	1604
14	21	1	right	21 fema	2	1	Kate	Vignette 27	Did Kate: Did Kate sar	Att	Pos	no									1	2080
15	21	1	right	21 fema	2	1	Helen	Vignette 12	Did And: Was Hel sar	Att	Neg	yes									1	2131
16	21	1	right	21 fema	2	1	Ian w	Vignette 23	Did Ian: Was Ian sar	Att	Pos	no									1	1637
17	21	1	right	21 fema	2	1	Roger	Vignette 17	Did Brye: Did Root sar	Att	Neg	yes									0	2610
18	21	1	right	21 fema	1	2	Andre	Vignette 20	Was An: Did Ros sar	Fac	Neg	yes									1	1419
19	21	1	right	21 fema	1	2	Joan	Vignette 26	Did Joar: Did Paul sar	Fac	Neg	yes									1	1426
20	21	1	right	21 fema	1	2	Gary	Vignette 13	Was Ga: Did Gary sar	Fac	Neg	yes									1	2015
21	21	1	right	21 fema	1	2	Matt a	Vignette 34	Did John: Did Matt sar	Fac	Neg	yes									1	1816
22	21	1	right	21 fema	1	2	Natha	Vignette 15	Was Na: Did Janik sar	Fac	Pos	no									1	1257
23	21	1	right	21 fema	1	2	Ken	Vignette 7	S Had Ker: Did Kenr sar	Fac	Pos	no									1	1344
24	21	1	right	21 fema	1	2	Melan	Vignette 21	Did Mel: Did Mel sar	Fac	Neg	yes									1	1546
25	21	1	right	21 fema	1	2	Laure	Vignette 10	Did Laur: Did Laur sar	Fac	Neg	yes									1	3375
26	21	1	right	21 fema	2	1	Susar	Vignette 14	Did Sus: Did Vick sar	Fac	Neg	yes									1	966
27	21	1	right	21 fema	2	1	Jess	Vignette 28	Was Jess: Did Jess sar	Fac	Pos	no									1	906
28	21	1	right	21 fema	2	1	On To	Vignette 8	S Was Tor: Did Chris sar													

30. If there are any attitude question errors highlight the row with the attitude error in, by clicking the row number on the left > Cut > Paste in “Errors & outliers” sheet under the **Attitude errors** heading.
31. Go back to the “Data-check for attitude errors” sheet and delete this row by clicking on the row number to highlight it > right click > delete
32. **Next remove outliers.** Start by rank ordering each block of RT data. Highlight block, **always taking one row above the actual data** > Data > Sort > Sort by *select the last option in the list* – it will either be “Question1.RT”, “Column U” or “Column W” (see images below)

The screenshot shows an Excel spreadsheet with a 'Sort' dialog box open. The dialog box has the following settings:

- Column: Question1.RT
- Sort On: Values
- Order: Smallest to Largest
- My data has headers: checked

 The spreadsheet data includes columns for Demographics and Story and question information. The 'Sort' dialog box is positioned over the data, and the 'Question1.RT' column is selected in the 'Sort by' dropdown.

The screenshot shows an Excel spreadsheet with a 'Sort' dialog box open. The dialog box has the following settings:

- Column: (Column U)
- Sort On: Values
- Order: Smallest to Largest
- My data has headers: checked

 The spreadsheet data includes columns for Demographics and Story and question information. The '(Column U)' option is selected in the 'Sort by' dropdown.

Do this for all 8 blocks (4 question1, 4 question2).

33. Now calculate means and standard deviations of the RT data in each of the 8 blocks separately
- MEAN: fx button – choose AVERAGE from drop down menu – **make sure appropriate range of cells is chosen**
 - STDEV: fx button – choose STDEV (if using Excel 2007 or older) or STDEV.S (if using a newer than 2007 version of Excel) – **make sure appropriate range of cells is chosen**

The screenshot shows an Excel spreadsheet with a dialog box for the STDEV.P function. The dialog box displays the formula $=STDEV.P(U3:U17)$ and the result 667.0306007 . The spreadsheet data includes columns for Demographics (Subject, Age, Group, Handedness, Name, Sex) and Story and question information (Part, Order, Story, StoryAudio, Q1 Text, Q2 Text, Story Type, Q1 Type, Q1 Pos, Neg, Q1 Answer, Q2 Type, Q2 Pos, Neg, Q2 Answer). The spreadsheet shows a list of subjects and their responses to various vignettes.

34. Calculate 2 STDEV **above** the mean: use formula $=(\text{mean})+(\text{stdev}) * 2$ → enter appropriate cell for mean and stdev not the words!
35. Calculate 2 STDEV **below** the mean: formula $=(\text{mean})-(\text{stdev}) * 2$
36. Identify and remove any data that lies above or below the upper/lower limits just calculated. Cut and paste these outliers into the sheet named “Errors & outliers” under the heading **Outliers**

Story and question information										Data				
Story	Audir	Q1 Text	Q2 Text	Story Type	Q1 Type	Q1 Pos-Neg	Q1 Answer	Q2 Type	Q2 Pos-Neg	Q2 Answer	Question1.AC	Question1.R	Question2.AC	Question2.RT
Vignette 13	Did	Garj	Was	Ga	neu	Att	Pos	yes			1	1250		
Vignette 34	Did	Matt	Did	John	neu	Att	Neg	no			1	1429		
Vignette 21	Did	Mela	Did	Mela	neu	Att	Pos	yes			1	1578		
Vignette 29	Did	Geo	Was	Sim	neu	Att	Pos	yes			1	1649		
Vignette 28	Did	Jess	Was	Jes	neu	Att	Neg	no			1	1729		
Vignette 10	Did	Laur	Did	Laur	neu	Att	Neg	no			1	1740		
Vignette 15	Did	Jani	Was	Nal	neu	Att	Pos	yes			1	1809		
Vignette 16	Did	Chlo	Did	Ben	neu	Att	Neg	no			1	1812		
Vignette 22	Did	Alic	Did	Jen	neu	Att	Pos	yes			1	2447		
Vignette 1 h	Did	Joe	Did	Joe	neu	Att	Pos	yes			1	2496		
Vignette 7 h	Did	Keni	Had	Ken	neu	Att	Pos	yes			1	2518		
Vignette 8 h	Did	Chri	Was	Tor	neu	Att	Pos	yes			1	2792		
Vignette 20	Did	Ros	Was	An	neu	Att	Neg	no			1			
Vignette 14	Did	Vick	Did	Sus	neu	Att	Neg	no			1			
Vignette 26	Did	Paul	Did	Joan	neu	Att	Neg	no			1			
Mean:											214			
St Dev:											694			
Vignette 11	Did	Tina	Did	Tina	neu	Fac	Pos	yes						
Vignette 6 h	Was	Sa	Did	Sam	neu	Fac	Pos	yes						
Vignette 25	Was	Ge	Did	Dani	neu	Fac	Neg	no						
Vignette 19	Did	Edw	Did	Zoe	neu	Fac	Pos	yes						
Vignette 18	Was	Ma	Did	Stev	neu	Fac	Pos	yes						
Vignette 23	Had	Ian	Did	Ian's	neu	Fac	Pos	yes						
Vignette 32	Did	Sarz	Did	Chel	neu	Fac	Neg	no						
Vignette 3 h	Was	Cla	Did	Clair	neu	Fac	Neg	no						
Vignette 12	Was	He	Did	And	neu	Fac	Neg	no						
Vignette 27	Did	Kate	Did	Kate	neu	Fac	Neg	no						
Vignette 33	Was	Pal	Did	Patri	neu	Fac	Neg	no						
Vignette 4 h	Did	Pete	Did	Rebr	neu	Fac	Neg	no						
Vignette 5 h	Was	Ma	Did	Jane	neu	Fac	Pos	yes						
Mean:											1253.69231			
St Dev:											272.432372	1798.557052	708.8275632	

37. Copy and paste the formulas for means/StDevs to apply them to the second question, but **make sure the cell range is adjusted** to include all of the appropriate data. Similarly, identify and move outliers to “Errors & outliers” sheet
38. **ONCE OUTLIERS HAVE BEEN IDENTIFIED AND REMOVED, DO NOT CLEAN DATA AGAIN!**
39. Once all the data has been cleaned, copy this data from “Data-check for attitude errors” sheet and paste into the sheet named “Data cleaned”. Remove the gaps between groups where means and StDevs have been calculated
40. Copy and paste this cleaned data into the spreadsheet containing all data from all participants in the appropriate sheets: All cleaned data; factual errors; attitude errors; outliers.

Appendix 16: Sarcasm questions

Sarcasm questions

1. How often do you use sarcasm in your day to day conversations?

Extremely often, very often, often, not very often, rarely, extremely rarely, never.

2. How sarcastic would you say you are as a person, on a scale of 0-10, where 0 = Not at all sarcastic and 10 = extremely sarcastic?