Investigation into the frontal lobe functioning of young offenders with and without a head injury

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Abstract

Recent research has established a high prevalence of head injuries in both the adult and youth offending populations. Offenders often have difficulties with tasks that involve executive and frontal lobe functioning compared to non-offenders, but research has often not recorded or controlled for the effect of head injury. This research aimed to investigate whether young offenders in the community, with self-reported traumatic brain injury (TBI), perform differently to young offenders without a TBI on tasks that are associated with frontal lobe functioning. Participants completed a battery of assessment measures that related to four different areas of frontal lobe functioning. In addition measures of mood, socio-economic status (SES) and IQ were taken as possible confounding variables. A total of 20 participants were recruited in the TBI group and 15 in the non-TBI group. Participants were aged between 12-17 years old and had either past or current involvement with Youth Offending Services (YOS). The TBI group had significantly lower IQ and SES than the non-TBI group but similar levels of self-reported depression. The TBI group were more impulsive on an inhibition task and were poorer at intuitive and emotion-based decision making, and reading emotions from the eyes. There were no significant differences between the groups on reaction time tests. The study concluded that within this sample of young offenders, those with a self-reported head injury had poorer performance on some tasks associated with frontal lobe functioning, but not others. The findings are considered in the context of theoretical and clinical implications with suggestions for further research.

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Chapter 1: Introduction

1.1. Chapter Introduction

This chapter outlines the development of executive functioning and frontal lobe functioning and the associated neuroanatomy, with a description and critique of prominent theoretical stances. A definition of traumatic brain injury (TBI) is provided, in addition to a review of the neurological, cognitive and behavioural effects of injury. The chapter then presents the association between frontal lobe dysfunction and offending, with a discussion of both general theories of crime and neuropsychological theories. A review and critique of the existing research on the frontal lobe functioning of youth offenders is presented along with prevalence rates of head injuries in offending populations. A summary and critique of current research findings precedes the rationale for the current research and finally there is a description of the research questions for this study.

1.2. Neuroanatomy

1.2.1. Basic anatomy of the brain. The three main components of the brain are the cerebrum, the cerebellum and the brain stem. The cerebellum is associated with motor coordination and muscle tone control. The brain stem is a pathway between the cerebral structures and the spinal cord and is responsible for a range of autonomic functions e.g., heart rate, blood pressure, arousal, attention and respiration. The cerebrum/cerebral hemispheres are divided into the right and left hemisphere, and consist of pairs of frontal, parietal, occipital and temporal lobes (Darby & Walsh, 2005). The left hemisphere controls many of the functions of the right side of the body and vice versa. The cerebrum is covered by two layers, the outermost layer is called the cerebral cortex (grey matter) consisting of nerve cell connections and an internal white matter layer of cell fibres (Darby & Walsh, 2005).

1.2.2. Neuroanatomy of the frontal lobes. The frontal cortex is divided into the precentral cortex, prefrontal cortex and the limbic cortex (A. R. Damasio, Anderson, & Tranel, 2012). The precentral cortex functions as a primary motor area and is thus related to motor activity. The limbic cortex refers to the posterior parts of the orbitofrontal cortex and forms part of the limbic system for emotion and memories. The prefrontal cortex constitutes the largest area of the frontal cortex, which is subdivided into the mesial, dorsolateral and orbital cortices and comprises what most authors refer to as the frontal lobe (A. R. Damasio et al., 2012). The frontal lobes constitute one-fourth to one-third of the human brain and have functional connections to cortical, subcortical and brain stem areas (Alvarez & Emory, 2006; Stuss & Alexander, 2007). The frontal lobes are the most recently developed parts of the brain (Darby & Walsh, 2005), and are organised in a hierarchical manner (Fuster, 2000). The orbital frontal cortex is associated with medial temporal limbic systems for both long term memory and internal information for affect and motivation (E. Miller & Asad, 2002). The prefrontal cortex is connected to neocortical structures in the temporal, parietal and occipital lobes and receives sensory associations from the limbic and motor system (A. R. Damasio et al., 2012).

The historical case that led to the association of frontal lobes and complex behaviour was the case of Phineas Gage (A. R. Damasio et al., 2012). In 1848 Phineas Gage, a rail worker, had an iron rod penetrate his skull, but Gage remained conscious and able to talk and walk (H. Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). The seminal finding was that damage to the left and right prefrontal cortices can result in deficits in processing emotions, rational decision making, and socially suitable behaviour (H. Damasio et al., 1994). During the 1920s and 1930s the frontal lobes were defined as the 'seat' of intellectual functions (Reitan & Wolfson, 1994), and are now traditionally associated with 'executive processes' (Williams, 2012). The prefrontal cortex is utilised for complex tasks that require flexibility and the acquisition of new goals and behaviours (E. Miller & Asad, 2002). There are tentative links between executive functioning deficits and social problems such as peer relationships (Best & Miller, 2010).

There are multiple executive functions associated with the frontal lobes: flexibility in problem solving, organisation of behaviour, goal setting, self-regulation, learning from reward and punishment, cognitive flexibility, working memory, decision making, meta-cognition and inhibition (Diamond, 2013; Levin & Hanten, 2005). Meta-cognition is the method of monitoring and regulating cognitive function, and inhibition is the capacity to suppress an automatic response (Best, Miller, & Jones, 2009).

1.3. Executive Functioning

1.3.1. Executive function development. During late childhood, between 11-12 years of age in particular, there is an increase of cortical development and white matter in frontal areas (de Luca & Leventer, 2008). The adolescent brain experiences a number of fundamental changes with the increased myelination of axons in the frontal cortex, a reduction of synaptic density as a result of synaptic elimination and an overall increase in white brain matter and decrease in grey matter (Best & Miller, 2010; Blakemore & Choudhury, 2006; de Luca & Leventer, 2008). These changes increase the speed of neural information in the frontal cortex and are associated with increased performance on executive tasks such as inhibitory control, processing speed, working memory and decision making (Blakemore & Choudhury, 2006). Metabolic activity in the prefrontal cortex only reaches levels comparable to adults in late adolescence (Bennetto & Pennington, 2005). Best et al. (2009) highlight different developmental trajectories for executive function constructs, with inhibition improving in pre-school years, in contrast to the more gradual development of working memory and shifting abilities. The ability to link behaviour and consequence develops in conjunction with increased language skills from the ages of seven to 11 years (Williams, 2012). Some researchers claim that the frontal lobes have undergone much of their biological maturation by puberty (Stuss, 1992). Due to the maturation and development of the frontal lobes in childhood, a head injury during childhood can have a significant impact and affect developmental trajectories (Levin & Hanten, 2005). Despite the significant impact of a TBI in childhood, there are some preliminary research findings that suggest that executive function abilities can be improved in some children through computerised training programmes (Diamond, 2013). Further research is required in this field to investigate the efficacy of training programmes for executive functioning.

Traditionally, executive functioning was only associated with the frontal lobes, but more recent research has established reciprocal connections between the frontal lobes and other brain regions that are important in executive functioning (Stuss, Shallice, Alexander, & Picton, 1995). Current research is investigating which of the many executive functioning components are associated with different brain areas, including the frontal lobes.

1.3.2. Executive function theories. A large number of theoretical accounts of executive functioning and frontal lobe functioning have been developed and revised over the years, but most have faced continued critique.

1.3.2.1. Luria's three functional unit theory (1966). Luria's three functional unit theory (1966) proposed that the brain is divided into three functional units that are interactively linked. The first unit regulates and maintains arousal of the cortex and is located mainly in the brain stem. The second unit is associated with encoding, processing and storing information and is located in the temporal, parietal and occipital lobes (Chan, Shum, Toulopoulou, & Chen, 2008).

The final unit regulates behaviour and is located in the anterior region, known as the frontal lobes, with the prefrontal cortex acting as a 'superstructure' of regulation (Chan et al., 2008).

If damage occurs in the dorsolateral prefrontal cortex region, this then affects the internal mediating processes and the ability to regulate more complex behaviour of a higher order (Luria, 1973). As a result of this damage, patients often respond with stereotypical behavioural patterns or exhibit disinhibitory behaviours, as the internal processes that normally override the stereotypical response are less effective. Luria (1966) additionally proposed that speech was important for self-control of behaviour, as a consequence of parental verbal instructions and reinforcements being converted to internal, verbally based self-control mechanisms. Language is the foundation to direct and motivate internalisation of standards, so that over time one can make judgements on behaviour in relation to the environment and oneself. Auditory and verbal memory and verbal abstract reasoning are necessary mechanisms for the development of self-control.

Specific tests to assess this theory include motor tasks, such as the reciprocal motor programme (Chan et al., 2008) and the Luria-Nebraska Neuropsychological Battery (Golden, 2003). The theory has been criticised due to its limited general applicability, as the theory was developed from personal observations of the effects of brain damage associated with chronic, focal epileptic lesions (Reitan & Wolfson, 1994).

1.3.2.2. Baddeley and Hitch's (1974) working memory model. Alternatively, Baddeley and Hitch (1974) proposed a model of working memory. The model proposed three systems: phonological loop, visuospatial sketchpad and the central executive. The phonological loop constitutes a phonological store that holds information for approximately two seconds, which, if the information is subsequently rehearsed, can be maintained through the articulatory loop

(Baddeley, 1992). The central executive system controls and regulates cognitive processes through attentional control and is described as the executive function component (Jurado & Rosselli, 2007). An advantage of the model is that the frontal lobe is not the solitary component to the central executive and so the model does not constrict the functional description in terms of anatomical location but serves as a reminder of the role of working memory in the central executive (Baddeley, 1996).

The working memory model has become a pertinent cognitive model of executive functioning, but has been criticised for not encompassing functional relations between different executive functions such as planning and self-perception (Jurado & Rosselli, 2007). The model is not necessarily inconsistent with the proposal that the executive functions are fractioned and Baddeley (2002) concedes that the early model descriptions were too vague. Neuropsychological evidence disputes the claim that a single brain region is associated with executive function tasks as a unitary concept (Miyake et al., 2000; Parkin, 1998). Further criticism questions the validity of the central executive as neuropsychological tasks activate different areas within the frontal cortex. For example, retrieval memory tasks activate the right frontal cortex, and encoding memory tasks activate the left frontal cortex, which may lead one to question the concept of a central controlling resource (Parkin, 1998).

1.3.2.3. Norman and Shallice's (1986) supervisory attentional system. Norman and Shallice (1986) extended the three functional unit theory (Luria, 1966) to develop the supervisory attentional system theory. The theory proposed that there were four component systems involved in human actions and thoughts: cognitive units, schemata, contention scheduling and a supervisory attentional system (SAS; Chan et al., 2008). The schemata control the basic cognitive processes and are organised in a hierarchical structure (Stuss et al., 1995).

The contention scheduling system controls routine and automatic tasks through schemata, and the SAS is for novel and non-routine tasks. The SAS is based in the prefrontal cortex and is classified as the executive component. The theory has been criticised for the division between automatic and controlled processes not being adequate to explain executive functioning (Jurado & Rosselli, 2007). Recent research has suggested that the SAS is fractionated into more component processes than originally proposed (Stuss et al., 2005).

1.3.2.4. A.R. Damasio's (1995) somatic marker hypothesis. An alternative theory was presented by A. R Damasio (1995) who proposed the somatic marker hypothesis that emphasised the role of the frontal lobes in emotion and social behaviour in decision making. The hypothesis is based on the assumptions that decision making and reasoning rely on various levels of neural operations and knowledge of the situation, whilst cognitive operations depend on working memory, attention and emotion (Bechara, Damasio, & Damasio, 2000). Somatic markers are feelings that have been created from secondary emotions and connect to predict future outcomes by the process of learning (Bechara, Damasio, Tranel, & Damasio, 2005).

This theory is supported by lesions in adults in the ventromedial prefrontal cortex that were identified using brain scanning techniques (Bechara et al., 2000). The participants with lesions have impaired processing of somatic or emotional signals but cognitive functions are minimally affected, resulting in poor decision making, compared to healthy controls (Bechara et al., 2000). The Iowa Gambling Task (IGT) has been developed as a paradigm to measure this distinction of decision making and somatic marker signals (Dunn, Dalgleish, & Lawrence, 2006) with real life reward and punishment (Bechara et al., 2005). The IGT has been described as sensitive to these markers and as an ecologically valid measure of decision making (Dunn et al., 2006). Patients with ventromedial prefrontal cortex lesions lack the association between successful task completion and development of somatic markers (Dunn et al., 2006). The task demonstrates that decision making is guided by emotional signalling of somatic states and resembles real life decision making as participants cannot calculate the net gain or loss from each deck (Bechara, Tranel, & Damasio, 2002).

Critics argue that the suggestion that learning occurs through somatic markers is not supported by psychophysiology profiles and that some of the participants in the IGT have accurate knowledge of the task and so implicit learning is questioned (Dunn et al., 2006). The somatic marker hypothesis has made some progress in identifying the anatomical areas involved in decision making and emotion, but needs more clarification on how these interact at a psychological level (Dunn et al., 2006).

1.3.2.5.Stuss (2011a). The final theory to be presented is by Stuss (2011a). The theory proposes that executive functions are only one functional category within the frontal lobes. Stuss (2011a) states that the dispersed nature of frontal lobe injuries that compromise directional associations with frontal lobe functions, the size of the frontal lobes and the large array of frontal processes and reciprocal connections with other anatomical areas, support the theory that the frontal lobes have multiple functions. The theory is supported by diffusion tensor imaging research on brain injury (Zappala, Thiebaut de Schotten, & Eslinger, 2012). A direct result of the inadequately operationalised frontal lobe theories is that frontal lobe tests often do not correlate with lesions (Stuss et al., 1995). Instead, Stuss (2011a) proposes that there is no unitary executive function, that the frontal lobes are associated with the limbic system and therefore affect, and that different anatomical regions are associated with different functions (Stuss & Alexander, 2000). Stuss et al. (2005) propose an elaboration of Norman and Shallice's (1986) SAS model as described in section 1.3.2.3. However, in contrast to the original SAS conceptualisation, there is no central executive but the SAS is fractionated into components that are associated with attention. The energization, monitoring, and task setting processes, which are part of the frontal lobe functions, are associated with attention (Stuss, 2011a). This theory would thus propose that, as there is no central executive, there is no dysexecutive syndrome, a term employed by many researchers and clinicians (Stuss et al., 1995).

Evidence from developmental, anatomical connectivity and lesion studies suggest that the frontal lobes are divided into four functional domains (Cicerone, Levin, Malec, Stuss, & Whyte, 2006). The domains provide an explanation for frontal lobe functioning as the functional distinctions relate to anatomical distinctions, which is beneficial in understanding the effects of traumatic brain injury (TBI) and subsequent rehabilitation strategies (Cicerone et al., 2006). These functional distinctions and associated anatomical distinctions are presented below.

The cortex is developed from the lateral prefrontal cortical cortex (LPFC) which determines spatial and conceptual reasoning, and the ventral prefrontal cortex (VPFC), which is associated with emotional processing and stimulus-reward associations (Nauta, 1971; Rolls, 2000). These constitute two functional divisions of the frontal lobes, executive/cognitive associated with the lateral frontal areas, and behavioural/emotional self-regulatory associated with the ventral-medial/orbital areas (Stuss, 2011b). The third functional division is formed from the sensory, limbic and frontal output, combining with the medial frontal area for regulating energization of cognitive activities. The energization function is associated with the dorsomedial areas (Stuss, 2011b). The final category is the metacognitive function which is associated with damage to the frontopolar regions (Stuss, 2011b), which are in the anterior part of the prefrontal cortex (Dreher, Koechlin, Tierney, & Grafman, 2008). The model does not include a specific function for inhibition as this process can be explained by the regulation energization function and task setting (Stuss & Alexander, 2007).

The regulating energization function is a process of self-regulation to initiate and energise behaviour to attain goals and maintain concentration on tasks (Cicerone et al., 2006; Stuss & Alexander, 2007). Energization is required in the absence of external triggers or motivation to increase activation of lower level perceptual/motor schemata to subsequently select and sustain the required response (Stuss & Alexander, 2007). It is associated with the anterior cingulate and superior cingulate and is supported by evidence from lesions in the superior medial lobe (Stuss, 2011a; Stuss & Alexander, 2009). Demanding reaction time tests, such as simple and choice tests, are recommended to examine regulating energization due to their sensitivity to individual variability (Stuss et al., 2005). Superior medial deficits are shown using prolonged simple reaction time tests (Stuss & Alexander, 2007). Alternative tests such as the Stroop test (Golden, 1978) or verbal fluency assessment (Delis, Kaplan, & Kramer, 2001) do examine energization, but as they additionally involve executive cognitive functions, they are not the most effective tasks for assessment (Stuss, 2007).

The executive cognitive functions are higher level cognitive functions for control and direction of lower level automatic functions (Cicerone et al., 2006), otherwise known as executive functioning (Stuss, 2011b). This function is further divided into task setting and monitoring. Task monitoring involves the checking of task performance and adjustment of behaviour accordingly (Stuss & Alexander, 2007). Right lateral damage is associated with a disruption in task monitoring and an increase in the amount of errors on tasks (Stuss, 2011a). Task setting is required for the preliminary stages of learning to do an activity and involves the capacity to develop a stimulus-response relationship (Stuss & Alexander, 2007). Left lateral damage is said to be related to a disruption in task setting with more false positives on tasks such as the Stroop task or word list learning (Stuss, 2011a). Tests for this category include the Wisconsin Card Sorting Test, verbal fluency and the Stroop test (Cicerone et al., 2006). Research additionally suggests that the Stroop test activates the dorso-lateral regions (Phillips, MacPherson, & Sala, 2002). A caveat of the more real life tasks is that these can often employ multiple functional systems (Stuss, 2007).

Behavioural and emotional self-regulatory functions are associated with the VPFC with connections to the limbic nuclei (Stuss, 2011a). Damage to the inferior medial frontal cortex is associated with problems understanding emotional consequences of actions and in unstructured situations (Stuss, 2007). The function is associated with emotional and reward processing and decision making (Rolls, 2000), including the acquisition and reversal learning of stimulus reward associations (Cicerone et al., 2006). The behavioural self-regulation function is required when environmental cues and cognitive analysis are not adequate to determine the appropriate response (Cicerone et al., 2006). Damage to the VPFC can often be associated with normal performance on traditional executive function tests (Stuss, 2011a). Tests to evaluate this component include gambling tasks and the modified six elements task (Wilson, Emslie, Evans, Alderman, & Burgess, 1996), which examine the ability to regulate behaviour according to goals and constraints (Stuss, 2007).

The metacognitive function is associated with the frontal polar regions (Stuss, 2011a; Stuss, Gallup, & Alexander, 2001). Metacognitive function is involved in the awareness of one's own mental states, beliefs, experiences and attitudes and the capacity to understand the mental states of others (Stuss, 2007). The metacognitive function plays a pivotal role in integrating and co-ordinating energization, motivation, emotions and executive cognitive functions for complex tasks (Stuss, 2011a). The metacognitive functions are involved in social cognition, theory of mind, self-awareness and self-reflection (Stuss et al., 2001), which can be examined with perspective-taking tasks and putting yourself in the mind of others tasks e.g., Mind in the Eyes test (Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001), theory of mind and empathy measures (Stuss, 2007).

1.4. Traumatic Brain Injury

1.4.1. Definition. Acquired brain injury (ABI) is the umbrella term for brain injury caused after birth and can be caused by traumatic injury or non-traumatic injury. Non-traumatic brain injury can be caused from central nervous system tumours or infections, metabolic problems, toxins, or as a consequence of treatment (Middleton, 2005). Traumatic brain injury (TBI) is defined as an external force resulting in either an altered brain function or brain pathology (Menon, Schwab, Wright, & Maas, 2010). An altered brain function is further defined as: loss or decreased consciousness, loss of memory pre or post injury, neurological deficits or altered mental state at the time of the injury (Menon et al., 2010). TBI is the leading cause of death in the youth population and of long-term disability (Zappala et al., 2012) and thus has a significant burden on public health and social care (Kinnunen et al., 2011). Childhood injury could interrupt the maturational processes of the frontal lobe regions and thus interrupt the normal developmental trajectory and result in irreversible changes of brain structure (Anderson, Jacobs, & Anderson, 2008). Injury to the frontal lobes and wider anatomical areas through TBI are often associated with deficits in frontal and executive functioning (Anderson & Catroppa, 2005; Demery, Larson, Dixit, Bauer, & Perlstein, 2010; Konrad et al., 2011).

One example of TBI is diffuse axonal injury (traumatic axonal injury), which can result from a car accident or fall, as the deceleration and rotational forces result in shearing of white matter in the frontal lobes (Zappala et al., 2012). The white matter connects nodes in networks that are fundamental in connecting different anatomical areas of the brain (Kinnunen et al., 2011). This transfer of energy and damage to the white matter nodes (Kinnunen et al., 2011) can result in structural, physiological and/or functional changes in the brain (Jeter et al., 2013).

The traditional method for assessing brain injury used in the majority of clinical settings is the Glasgow Coma Scale (Teasdale & Jennett, 1974). The scale relies on independent observations of eye opening, motor responsiveness and verbal responsiveness, which provide an overall rating scale (Prasad, 1996). Alternatively, severity of TBI can be defined as mild, with loss of consciousness (LOC) for less than 10 minutes; moderate, with LOC from 10 minutes to 6 hours; and severe, with LOC of 6 hours or more (Williams, Cordan, Mewse, Tonks, & Burgess, 2010). The prevalence of mild TBI within the TBI estimates is approximately 70- 80% (Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006). Approximately 9% of concussed children experience loss of consciousness, but many cases, particularly those with mild TBI, do not seek medical attention (Gordon, 2006). Mild TBI damage is often not visible on traditional imaging techniques e.g., magnetic resonance imaging as the injury is so diffuse (Zappala et al., 2012), but can be detected on diffusion tensor imaging (Sharp & Ham, 2011).

1.4.2. Effects of TBI. The effects of TBI can be subdivided into neurological, cognitive and behavioural symptoms (Jeter et al., 2013).

1.4.2.1. Neurological effects. The neurological consequences of TBI can range from headaches, vomiting, dizziness, sleep disturbances, drowsiness, balance problems, dyspraxia, sensory problems, aphasia and nausea (Jeter et al., 2013; Menon et al., 2010). The neurological effects of TBI, in conjunction with cognitive and behavioural effects, are classified as post concussive syndrome (PCS) if symptoms last for more than a week, or persistent PCS, if they last for more than three months (Bigler, 2008). The majority of mild TBI PCS symptoms are largely resolved after two or three months (Carroll et al., 2004; Frencham, Fox, & Maybery, 2005), but the injury can cause white matter abnormalities (Kinnunen et al., 2011; Zappala et al., 2012).

1.4.2.2. Cognitive effects. Mild TBI can cause diffuse axonal injury resulting in white matter damage (Sharp & Ham, 2011), whilst moderate TBI can result in localised injury within the orbitofrontal cortex (OFC), amygdala and anterior hippocampus (Zappala et al., 2012). These regions are connected via the uncinate fasciculus, a bilateral white matter tract that connects the lateral orbitofrontal cortext with the anterior temporal lobes and is fundamental in memory, inhibition and emotional processing (Zappala et al., 2012). Damage to the dorsolateral frontal cortex is associated with deficits in executive functioning, working memory and insight (Zappala et al., 2012). Schretlen and Shapiro (2003) conducted a quantitative meta-analysis of 39 studies investigating the effects of TBI on cognitive functioning, and found an effect size of d = 0.74 for moderate to severe TBI and d = 0.24 for mild TBI. However, the authors of the review did not distinguish between different cognitive domains. Specific cognitive deficits included decision-making on gambling tasks compared to controls (Levine et al., 2005), cognitive flexibility and abstract thought (Anderson & Catroppa, 2005). Demery et al. (2010) found that those with moderate/severe TBI had impaired performance on the Stroop task, trail making A and B and digit span backwards. Both the trail making A and B represent poor processing speed. A caveat is that the aforementioned tasks additionally require attention and so are multi-faceted. Fenwick and Anderson (1999) additionally found that children with a TBI performed significantly worse on the Stroop interference task as a measure of attention, compared to non-injured controls.

Some findings have suggested that the age of injury may affect the outcomes, as a group of younger children (8-10 year olds) with TBI were not found to have significant cognitive difficulties, compared to a control non-injury group (Tonks, Williams, Yates, & Slater, 2011). This finding could be attributed to either the neuroplasticity capacity of a younger brain, or simply because the measures were less sensitive to the younger population.

A meta-analysis conducted by Belanger, Curtiss, Demery, Lebowitz, and Vanderploeg (2005) on cognitive outcomes following mild TBI revealed an overall effect size of d = 0.54, with greatest effects for delayed memory (d = 1.03) and fluency (d = .89). The meta-analysis had difficulties in defining mild TBI due to the lack of a standardised definition (Gordon, 2006) and the small number of studies in some of the cognitive domains weakened the effect size calculation. Konrad et al. (2011) found that even six years post mild TBI, there is a medium to large effect size for cognitive deficits (d = 0.2 - 1.3), particularly for word fluency.

1.4.2.3. Mood and behavioural effects. Konrad et al. (2011) found higher rates of depression symptoms and diagnosis six years post mild TBI, which could be associated with damage to the emotional regulation system, or alternatively as a result of an injury. This was supported by Kreutzer, Seel, and Gourley (2001), who found that, of a sample of adults who had experienced a TBI, 42% were experiencing depressive symptoms, with particular difficulties with fatigue, frustration and poor concentration. Children also report depressive symptoms following a TBI, with children with a lower socioeconomic status reporting more depressive symptoms (Kirkwood et al., 2000). Children with TBI additionally experience long term deficits in social problem solving skills (Janusz, Kirkwood, Yeates, & Taylor, 2002) and more wider negative social outcomes, that are aggravated by lower socioeconomic status (SES; Tonks, Yates, et al., 2011; Yeates et al., 2004). Furthermore, children with ABI were found to have more peer relationship difficulties and greater emotional distress that those without an ABI (Tonks, Yates, Williams, Frampton, & Slater, 2010).

There are, however, many research limitations for studies investigating the effects of TBI, particularly those with mild TBI. The poorly defined classification of head injury, especially mild TBI, the lack of, or poor control and matching of groups, the weak sensitivity of many neuropsychological measures and practice effects masking head injury are limitations that should be addressed in future research (Dikmen, Machamer, & Temkin, 2001).

1.5. Executive Function Deficits in Young Offenders

Offenders have similar profiles of executive function deficits as non-offenders with a head injury. Morgan and Lilienfeld (2000) conducted a meta-analysis on the relationship between antisocial behaviour and executive function and found a mean medium effect size (d = .57) between antisocial groups and comparison groups. A more recent meta-analysis found a similar effect size of d = .44 (Ogilvie, Stewart, Chan, & Shum, 2011). Moffitt and Henry (1989) established an early link between executive deficits and a subgroup of self-report delinquents who had childhood co-morbidity of antisocial behaviour.

The subsequent overview of the research and the current research study focuses on young offenders as adolescence is a pivotal time for entry to the custodial system (Williams, Cordan, et al., 2010). The research field, however, uses various terms to define this population. The terms juvenile offenders and young offenders, describe those individuals who have committed an offence and are aged between 10-17 years old. Juvenile offenders account for 13.6% of arrests in England and Wales with a re-offending rate of 35.5% (Ministry of Justice, 2014). The term juvenile delinquent is more commonly used in American research but it has the same definition as the English counterpart as it classifies those under the age of 18 years old who have committed a crime. Illegal acts and crimes that are committed by those who are under 18 years of age, are classified as delinquent behaviours (Shoemaker, 2005). The terms 'juvenile offenders', 'juvenile delinquents' and 'young offenders' will therefore be used interchangeably as they refer to the same population. In England, young offenders are either given measures or sentences in the community under a Youth Offending Service (YOS), or are sentenced to custody in a secure environment.

A report from the Children's Commissioner highlights the need to identify neurodisability within the youth justice system as it can pose challenges to engagement in treatment and with the legal process (Hughes, Williams, Chitsabesan, Davies, & Mounce, 2012). The following section will present some of the existing literature investigating the executive functioning of young offenders in the community and in institutions. A review and critique of the research studies will be presented, in addition to an overview of any theoretical or clinical implications.

1.5.1. Studies with a theoretical reference. The first section of the review will outline research that is specifically testing particular psychological theories, or has explicit reference to theories in the discussion of the research.

1.5.1.1. Studies involving community offenders. Syngelaki, Moore, Savage, Fairchild, and Van Goozen (2009) investigated the somatic marker hypothesis (see Section 1.3.2.4) in a group of male young offenders between 12 to 18 years old in Wales. The somatic marker hypothesis proposes that somatic processes are signals that facilitate decision-making (Bechara & Damasio, 2005) and was investigated in this study with a decision-making task and the Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition Ltd, 2014) executive function assessment. Reliability data for the CANTAB are only available for adults (Henry & Bettenay, 2010) but reported internal consistency coefficients for 4 to 12 year old children were high (.73-.95) (Luciana, 2003). A further weakness is that the CANTAB has poor ecological validity (Henry & Bettenay, 2010). The IQ measure was changed during testing, which meant uneven data between groups, and thereby it could have potentially compromised comparisons. Participants with below average IQ were excluded from some of the analyses, which could affect generalisation as offenders often have lower IQ than non-offenders and IQ is often cited as a factor in offending and violence (Koolhof, Loeber, Wei, Pardini, & D'Escury, 2007; Moffitt, 1990) . The results for all of the measures, except the decision-making task, were compared to norms, and thus there was no control for confounding variables, such as SES and IQ. The decision-making task results were compared to a comparison group from a deprived area to control for SES and so the results are more generalisable. Statistical analysis revealed that offenders had deficits in reversal learning, planning and elevated risk-taking, supporting the somatic marker hypothesis. A significant strength was that partial eta squared effect sizes were presented in addition to results based on clinical significance as well as statistical significance. The results suggest that young offenders do not have global prefrontal deficits but deficits confined to reversal learning and detecting altered contingencies associated with dorsolateral and ventromedial prefrontal cortex functioning (Syngelaki et al., 2009).

Enns, Reddon, Das, and Boukos (2007) used the Das-Naglieri Cognitive Assessment System (CAS; Naglieri & Das, 1997) on a large sample of adolescent males in Canada. The participants had been admitted to a psychiatric facility for assessment under the Young Offenders Act prior to trial or sentencing. A limitation of the research is the absence of a comparison non-offender group and comparisons were only made to test norms. The CAS is based on an early theory of executive functioning by Luria (1973). Participants completed an IQ and psychiatric diagnostic assessment and the CAS. The findings suggest that the participants had lower verbal, performance and full scale IQ (FSIQ) scores compared to norms. The authors found that the FSIQ for the adolescent-onset group were significantly lower than norm scores, which is contrary to the findings of Moffitt (1993). The participants had lower scores on the CAS measures of planning, attention and successive processing. Strengths of the research include the reporting of effect sizes, reference to multiple theories and the large sample size.

The aforementioned researchers extended the research described above on a group of female adolescents who had been admitted to a youth detention facility under the Young Offenders Act in Canada (Enns, Reddon, Das, & Boudreau, 2008). The studies had similar methodologies and measures. The findings suggested that the female participants had lower scores on the planning and successive processing CAS measures but not on the attention component. The replication of a study on both male and female participants is a significant strength as most research is on male only samples.

Cauffman, Steinberg, and Piquero (2005) investigated Gottfredson and Hirschi's (1990) theory of crime (see Section 1.7.1.1). The theory proposes that no independent effect for biological/psychological variables should exist if self-control is controlled for. An executive function battery (CANTAB), IQ test and heart rate measures were administered to participants. The CANTAB has been criticised for poor ecological validity and reliability estimates for the population. The study was moderately large, with an offender group consisting of 105 participants who were incarcerated in a Californian Youth Authority and a High School comparison group of 78. Despite the large sample size, no sample size calculations were presented to ensure adequate power. The comparison group were valuable as they had similar ethnic diversity and SES as the offenders and were randomly selected, thus reducing selection bias (Crombie, 1996). The IQ measure has previously been included in related studies with offenders and correlated highly with other IQ measures (Prewetf, 1992). The use of biological and psychological tasks associated with frontal lobe functioning was a strength as it linked neuropsychological deficits to self-control. Multiple statistical tests were performed, which could have contributed to Type I error and spuriously significant results (Crombie, 1996). The results showed that self-control is a predictor of offending, but both heart rate and spatial span could differentiate between offenders, which is contrary to the aforementioned theory of crime.

Kelly, Richardson, Hunter, and Knapp (2002) investigated executive function and attention in adolescent sex offenders and a comparison group matched on SES. The offender group consisted of males who had been referred to an Adolescent Forensic Service in England for assessment and treatment of sexual offending. The comparison group were recruited from an activity project in an area of social deprivation. The executive battery may not be reliable for the sample of 10 to 17 year olds in this study as it has previously been used on a younger sample. Matching groups on IQ was unsuccessful as the comparison group presented with low verbal IQ, and so may have confounded the results, as IQ can correlate with executive function (Lynam, Moffitt, & Stouthamer-Loeber, 1993). One of the strengths of the study was that it examined the role of a serious head injury, but it is also limited by the fact that it did not record those with mild or unreported injury, both of which are common in young offenders (Farrer, Frost, & Hedges, 2013). The results suggest that sex offenders have difficulties in processing salient information and encoding. The finding that IQ, attention and executive function abilities correlate, suggests the need to control for IQ in future studies. Neuropsychological deficits are related to the information processing theory with problems in processing salient information affecting encoding and thus decision making (Wallace, Schmitt, Vitale, & Newman, 2000). Due to the small sample size, subgroup analyses on specific offending behaviours cannot be calculated. The results should not be generalised to all offenders as the participants were adolescent sex offenders.

1.5.1.2. Studies involving institutionalised offenders. Hurt and Naglieri (1992) investigated the Planning, Attention, Simultaneous, Successive (PASS) model of cognitive processing (Naglieri & Das, 1988), which is an extension on Luria's theory (1966) (see Section 1.3.2.1). The PASS model includes planning and attention as the first and third functional units of Luria's (1966) model. The research aimed to investigate the relationships between the cognitive processes in delinquents. The offender group had been incarcerated for property offences in America, and there was also a comparison group who were matched on SES, age and gender. Multiple tests for each construct allowed for more comprehensive assessment. Statistical tests support the independence of the PASS constructs as the offenders only had significant deficits in selective attention. No effect sizes were presented and so the practical and theoretical importance of the effects are difficult to ascertain (Fritz, Morris, & Richler, 2012). A caveat to the findings is that there were group differences on non-verbal IQ, which is inconsistent with previous related research and therefore, the groups may not be representative.

Veneziano, Veneziano, LeGrand, and Richards (2004) investigated the executive functioning of adolescent sex offenders and non-sex offenders who had committed nonviolent property offences and had behavioural problems. The participants were drawn from the same American residential treatment centre, and so controlled for the possible effect of institutionalisation. A strength of the study was that the groups were matched on age, grade and handedness. The executive function measures included the Wisconsin Card Sorting Test, which is said to activate a distributed neural network (Alvarez & Emory, 2006), Trail Making and the Controlled Oral Word Association task. Not all of the participants had IQ scores and so the correlations between the measures and IQ were compromised. Group differences were examined using t-tests, which revealed no significant difference between groups on most measures. The participants scored below average on the Controlled Oral Word Association task and on the Trail Making task. The researchers proposed that there is a subgroup of offenders, who have committed either sexual or nonsexual offences, who have neuropsychological difficulties. The authors considered treatment implications that suggested offenders with neuropsychological dysfunction could engage with programmes to target impulsivity and executive difficulties before engaging in cognitive behavioural interventions.

Iselin and Decoster (2012) investigated the theory of context processing, which involves attention, memory and response inhibition to develop appropriate behavioural responses. Participants were adolescent and adult offenders, who were recruited from an American juvenile detention centre and a medium security prison respectively, and an adolescent and adult community comparison group, who were recruited from schools and a University respectively. The comparison of adolescent and adult participants was a strength of the research as was the measurement of potentially confounding variables of IQ, SES and drug and alcohol use. The Stroop test was used as a robust measure of selective attention (Alvarez & Emory, 2006). The researchers recorded and controlled for distractions during the Stroop task in the analysis. Statistical analysis found no effect of IQ, head trauma, SES, and drug and alcohol use on performance. Self-report data on the presence of a head trauma was collated, which is important due to the high prevalence of head injuries within youth offender populations (Farrer et al., 2013). The research found that both adolescent offenders and controls had difficulties engaging selective attention. The findings do not provide support for the proposal that delinquency is directly associated with context processing, which may have been a consequence of the heterogeneous sample. Clinical implications of the study findings were presented in the context of recommending training programmes to improve selective attention and cognitive control for offenders, which could prepare them for subsequent cognitive behavioural therapy (CBT).

1.5.2. Studies without a theoretical reference. The subsequent section will review research that has no explicit reference to psychological theories.

1.5.2.1. Studies involving community offenders. The sample from a large American youth study (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998) was investigated by Koolhof et al. (2007). The youth study was a longitudinal investigation of a group of boys from Pittsburgh's high schools who were assessed as being disruptive and delinquent (e.g., offending and aggressive behaviours) from a range of different sources (self, parent, school and court reports). The sample included 430 boys, and had low attrition rate. Furthermore, the researchers used multiple methods and informants to measure both behavioural and cognitive impulsivity. A further strength was a large number of confounding variables that were measured e.g., attention deficit hyperactivity disorder (ADHD), depression, substance use, parental factors and SES. Statistical analysis was limited due to the categorisation of low and high IQ groups, which led to large group differences. Some of the measures (impulsivity and empathy) were only completed at certain time points and thus comparisons with other variables (e.g., delinquency) are therefore limited. Appropriate statistical analyses were conducted, which included Pearson product-moment correlations, analysis of variance (ANOVA), and logistic regression. The findings suggested that delinquents with a lower IQ were more behaviourally and cognitively impulsive than delinquents with a higher IQ. Furthermore, there was an association between cognitive deficits and impulsive behaviour, which suggests a potential role for impulsivity reduction training in rehabilitation.

1.5.2.2. Studies involving institutionalised offenders. Fooks and Thomas (1957) used the Porteus Maze test (PMT) on a group of participants from an American institution for delinquents and a comparison group from a high school. The PMT is designed to measure planning and problem-solving ability. There was an equal amount of males and females in the delinquent group, which allows for greater generalisation to offending groups. Furthermore, most previous research has involved male offenders only. A further strength was that the comparison group of non-delinquent high school students were matched on age, gender and IQ, but not SES. A limitation of the research was that the statistical analyses were not clearly presented. The research found that the qualitative score of the PMT could differentiate between delinquents and non-delinquents. The research was conducted primarily to validate the PMT, and therefore was not concerned with behavioural or clinical implications. In addition there were no suggestions for further research.

The PMT assessment was also used by O'Keefe (1975), who sought to examine impulsivity. The sample consisted of a group of American boys who had been court ordered to an institution due to delinquent behaviour, and a comparison group from a children's home for neglected children. The comparison group controlled for the effect of institutionalisation and groups were matched on potentially confounding variables of age, race and IQ. The researchers divided the sample into high and low impulsive groups for analysis. Proxy measures of impulsivity were provided by teachers and social-workers. The analysis revealed that there was an association between low impulsive groups scoring higher on the PMT, although this failed to reach significance. There was a significant difference between groups, with non-delinquents scoring higher on the PMT, which is in contrast to some of the previous related research. The researchers propose that impulsivity could be as a result of a history of dependency in institutions and/or child neglect and thus recommend that is controlled for in future research.

Chretien and Persinger (2000) also used the PMT, in addition to multiple measures of executive function that infer prefrontal function. The offender group was recruited from a Canadian closed custody youth facility and there was a student comparison group. A weakness of the study was that tests were administered in the same order and thus could have been subject to order effects. The comparison group were matched on age, only and not on IQ or SES, and there were fewer student subjects so comparisons between the groups should be interpreted with caution. There were, however, no group differences found on IQ measures, which is contrary to previous related research (Syngelaki et al., 2009). Statistical analysis revealed that offenders demonstrated deficits in critical thinking, increased impulsivity and reduced ability for conceptual reasoning. The researchers attributed the findings to an over-activity of the anterior temporal regions, although it is recommended that this should be investigated using scanning and neuroimaging techniques in future research. The authors proposed that offenders have delayed prefrontal development but normal development of the caudal region due to their average intelligence.

Berman and Siegal (1976) used the Halstead-Reitan Battery to measure executive functioning. The battery includes the Category Test, Trail Making and Finger Tapping amongst other tests. The research involved two American groups. The offending group had been incarcerated at a juvenile correctional centre, where they were serving their first sentence. The comparison group were recruited from a high school. The groups were matched for age, race, and gender to control for potential confounding variables. Furthermore, both groups were recruited from the same school catchment area, which was deemed as an approximate control for SES. The research assessments were conducted in the first week of intake of participants, which would control for potential effects of institutionalisation. Furthermore, the participants were randomly selected as part of routine assessments, which would have controlled for selection bias (Crombie, 1996). A further strength is that descriptive statistics and the results of appropriate statistical analysis were presented, although there is an absence of effect sizes (Fritz et al., 2012). The analysis found that offenders performed worse on all tasks on the IQ scales and Halstead-Reitan battery (with the exception of the Rhythm and Finger Oscillation Tests), with deficits in comprehension, manipulation and use of conceptual material. The authors proposed clinical implications that included recommending a thorough neuropsychological assessment of sensory and perceptual skills and formulation at intake to services.

Yeudall, Fromm-Auch, and Davies (1982) also used the Halstead-Reitan Battery, in addition to 12 other tests which were classified by the authors according to hemisphere dysfunction. The researchers aimed to investigate biological and neurological factors. There was an offender group that consisted of 99 male and female adolescents who had been admitted to a residential treatment centre for persistent delinquent behaviour and a comparison group of 47 high school students in America. The groups were matched on age, gender and handedness, but no further confounding variables were measured, which is a weakness. Alcohol and drug use were assessed and reported in the offender group, but not explicitly for the comparison group. The statistical analysis revealed that the offender group were significantly impaired on 74% of the neuropsychological variables, which the researchers classified as greater anterior non-dominant hemisphere dysfunction. The authors relate their findings to the prevalence of head injuries in the population but have not controlled or measured this within their own research. The results are consistent with the hypothesis that offenders have difficulties with planning actions and perceiving consequences. A caveat to the brain-behaviour links made by the researchers, is that dysfunction in one area may affect many different tasks and the tasks may involve wider functional areas and networks, so it is recommended that neuroimaging should be used to examine this further. Further limitations are that the participants were self-selected and there were IQ and educational differences between the groups that were not controlled for.

An early study by Wolff, Waber, Bauermeister, Cohen, and Ferber (1982) investigated neurological status, language, psychomotor and cognitive functions in offenders and two comparison groups. The offender group were detained in an American Youth Service and the comparison groups were recruited from a local school and community, with one lower middle class group and one upper middle class group. A further strength is that the groups were matched for age, gender and race. The study included both a neurological and neuropsychological assessment, that included word naming and Stroop measures, unlike previous research that has often focused on them individually. Neurological assessment included examination of minor neuropathological signs e.g., tremors, balance, clumsiness, and movement abnormalities. Statistical analysis controlled for the confounding effect of non-verbal intelligence on outcome measures. The statistical analysis revealed that the offender group were only impaired in language function and had more minor neurological signs than either comparison group. The cross-sectional nature of the design restricts the conclusions, as evidence of a causal link between neuropsychological impairment and offending cannot be proposed.

Tung and Chhabra (2011) conducted a study in India to investigate the neuropsychological status of delinquent boys in an institution and a comparison group of non-delinquent boys from a mainstream school. The authors state that the groups were comparable on the potentially confounding variables of education, age and gender, but do not provide data on these variables. Groups were not matched for SES or IQ and thus results may be confounded. The test battery included culture-free test of intelligence, visuo-spatial and motor tasks and the Stroop task. Descriptive statistics and appropriate statistical analysis with significance values were clearly presented. The statistical analysis revealed that delinquents have lower IQ than controls, which supports previous related research (Lynam et al., 1993). Furthermore, the delinquent group had additional impairments in visual and perceptual motor spheres and more reading impairment on the Stroop task, but with little interference. The study is a positive addition to the literature as it demonstrates similar deficits in young offenders cross-culturally.

1.5.3. Summary of findings. The aforementioned research proposes that young offenders have a multitude of deficits relating to executive functioning in comparison to non-offending groups. The offending groups had specific deficits on tasks that required reversal learning, attention, planning with further deficits in impulsivity, language and processing salient information. In addition, in most of the studies, the offender group had a significantly lower IQ than non-offender groups and it has been demonstrated that IQ correlates with executive function. In relation to the standard neuropsychological batteries, further deficits were found for offender groups with a lower resting heart rate, right hemisphere anterior cerebral dysfunction and more minor neurological signs than non-offender comparisons. Some of the research controlled for the potential effect of institutionalisation, and subsequently found no differences between offending and non-offending groups. These researchers suggest that institutionalisation should be controlled for in future research and propose that some of the deficits illustrated in previous research could be related to the experience of institutionalisation per se.

In relation to the clinical implications of the research, researchers have recommended that offenders have an IQ and executive functioning assessment on admission to secure facilities. Furthermore, some of the research has recommended that offenders could potentially benefit from engaging in treatments to improve selective-attention, impulsivity and problem-solving. These intervention recommendations complement the current utilisation of CBT for offenders and were often recommended to be implemented before CBT (Wikstrom & Treiber, 2008). It would be beneficial for the aforementioned recommendations to be assessed for efficacy in relation to the specific crime committed e.g., whether the crime was premeditated, or whether it was an impulsive act, or whether it was a violent or non-violent crime.

The theoretical implications from the aforementioned research are more tentative due to many of the studies not investigating or referencing any theories, which is a significant weakness in the research field. Research that did reference theory, included the support for the self-control theory of crime, information processing theory, the somatic marker hypothesis and PASS theories.

1.5.4. Research quality. There have been significant improvements in this field since the early studies in the 1970s and 1980s, with larger samples, more measures and brain-behaviour links being inferred, which is associated with technological development and the use of scanning techniques. Despite these improvements, the many methodological limitations remain and these include either no control or poor control of potentially confounding variables such as IQ and SES. Both IQ and SES have been found to be related to offending and executive function (Farrington, 1990; Heimer, 1997; Lynam et al., 1993). Therefore, any relationships could also be due to these variables, and not the variable of interest; offending (Crombie, 1996).

A significant weakness in the research field is the poorly specified nature of executive function in addition to poorly specified and classified measures (Crombie, 1996; Enns et al., 2008; Ogilvie et al., 2011). Furthermore, as studies used a variety of measures, most of which were not ecologically valid, comparisons across research were limited. Furthermore, due to the cross-sectional nature of most of the research, developmental effects cannot be ascertained. Many of the studies did not obtain corroboration of offending status provided by the young offenders from the prison services to confirm the accuracy of self-report (Williams, Cordan, et al., 2010). There is also a large variation in the definition of the offending population, so it may not be a homogenous population. A further weakness is that none of the aforementioned studies reported *a priori* power calculations (J. Cohen, 1988). These calculations would have computed the sample size required to detect an effect, if one were there, and so reduce the risk of Type II error (Crombie, 1996). In addition, effect size calculations were not presented, and so only statistical significance can be ascertained, which is a limitation in the research (Fritz et al., 2012).

A very small amount of previous research has either recorded or controlled for TBI when investigating executive functioning in young offenders, and those that did, have focused on severe TBI only (Kelly et al., 2002). Researchers suggest the need for further investigations into the neurocognitive deficits among young offenders with TBI to investigate possible frontal lobe deficits (Farrer et al., 2013; Kenny & Lennings, 2007; Williams, Cordan, et al., 2010). The research field investigating the prevalence and effects of TBI and offending is limited and in its infancy compared to research on mental health and substance abuse in the offending population (Hendrix, Carney, & Aalsma, 2012).

1.6. Head Injuries, Frontal Lobe Dysfunction and Offending

A caveat to the research and discussion of frontal lobe dysfunction is the complex nature of frontal lobe injuries and syndromes. As discussed in section 1.3.2., there are a multitude of theories of executive functioning and frontal syndromes that cover different frontal areas and constructs. Furthermore, the frontal lobes have reciprocal connections to numerous other brain areas and so damage to one area could affect these connections and subsequently affect areas other than the frontal lobes (Stuss, 2011b). This complexity of frontal lobe anatomy, connectivity and the subsequent impact on the theoretical basis of frontal syndromes should be considered whilst reviewing the association between frontal lobe dysfunction and offending.

The preceding sections have highlighted the neurological, behavioural and cognitive effects of TBI and frontal lobe dysfunction and the executive functioning deficits of young offenders. Frontal lobe dysfunction and injury have additionally been associated with an increase in aggressive and antisocial behaviour (Brower & Price, 2001). In particular, a review of the research established the strongest evidence for a link between focal prefrontal damage and an impulsive type of aggression (Brower & Price, 2001).

The neuropsychology of offending is a somewhat controversial research area and so a caveat to this research area will first be presented: the research on frontal lobe dysfunction does not predict aggression or crime; it suggests that these variables are merely associated and does not establish causality. The association between neuropsychology and anti-social behaviour is not a new phenomenon. The infamous case of Phineas Gage (A. R. Damasio et al., 2012), as described in section 1.2.2., highlighted the effect a head injury can have on personality change and anti-social behaviour.

One of the earliest studies investigating the link between head injuries and offending was by Gibbens, Pond, and Stafford- Clark (1959). The authors investigated and followed-up two groups of English adult offenders in prison. Participants in one group had been diagnosed as "psychopaths" and there was a comparison group of non-psychopathic prisoners. The study followed the criminal records of the participants and measured the amount of reconvictions in addition to conducting electroencephalographs (EEG). It was reported that 40% of the psychopathic criminals had received a head injury and that those with a head injury had a higher number of convictions for violent offences and more convictions in total than those without (Gibbens et al., 1959).

E. Miller (1999b) conducted a review of the literature and concluded that structural damage to the frontal brain can cause psychological changes that include a lack of foresight, and an increase in impulsivity, aggression and irritability (E. Miller, 1999a). These aforementioned psychological changes may predispose an individual to offending behaviours, but it is unclear which is the prominent mediating factor (E. Miller, 1999a). Alternatively, it is possible that the head injury itself is not directly linked to offending, and other factors such as social and environmental influences (e.g. parenting), are more closely associated with offending.

Research evidence in this area is however limited by poor definitions of TBI, unrepresentative samples, an overreliance on cross-sectional research, a lack of longitudinal research and a lack of control for intelligence and SES (Brower & Price, 2001; E. Miller, 1999a).

1.6.1. Prevalence of TBI in offender populations.

1.6.1.1. Adult offenders. Recent research has highlighted the high prevalence of a history of TBI within adult offending populations (Ferguson, Pickelsimer, Corrigan, Bogner, & Wald, 2012; Schofield et al., 2006; Williams, Mewse, et al., 2010). A recent meta-analysis estimated the overall prevalence of TBI in adult offenders to be 60.25% (Shiroma, Ferguson, & Pickelsimer, 2012). Most studies indicate a prevalence rate of approximately 60-65% of offenders reporting a history of TBI (Williams, Mewse, et al., 2010). A history of TBI was also associated with chemical dependency, aggression, and problem-solving difficulties (Shiroma et al., 2012). Schofield et al. (2006) investigated Australian prisoners and found that 45% of those with a history of TBI continued to experience neurological effects such as headaches, in addition to symptoms of anxiety and depression. Adult offenders who reported a history of TBI were also younger at entry to the custodial system, had higher recidivism rates and had spent more time in prison the preceding five years (Williams, Mewse, et al., 2010). Prevalence studies alone cannot elucidate whether the injury occurred before or after a conviction, although Timonen et al. (2002) followed up a large Finnish birth cohort prospectively up to 31 years, and found TBI to be associated with later mental disorder with coexisting criminality in males.

1.6.1.2. Young offenders. Prevalence rates of at least one self-reported head injury in young offenders range from 18% (Perron & Howard, 2008) to at least 70% (Davies, Williams, Hinder, Burgess, & Mounce, 2012). In the normal population, at 25 years old, 30% of the population would have experienced a TBI (McKinlay, Grace, Horwood, Fergusson, & MacFarlane, 2010). Schofield, Butler, Hollis, and D'Este (2011) compared prisoners' self-report data of TBI against hospital medical records and found that self-reporting was an accurate form of measurement for research. Williams, Cordan, et al. (2010) found 16% of the offenders reported moderate TBI , defined as loss of consciousness (LOC) between ten minutes to six hours to severe TBI (LOC more than six hours), whilst 29.6% reported mild TBI (LOC less than ten minutes), with those reporting TBI having more convictions than other offenders and a higher severity of violence. A meta-analysis on young offenders with TBI compared to controls without TBI, suggested TBI may be an important risk factor for young offending as young offenders had 3.38 times higher odds of having a head injury than controls (Farrer et al., 2013).

Young offenders with a reported TBI have higher impulsivity, negative emotionality and are more likely to have been subjected to violence and abuse themselves (Vaughn, Salas-Wright, DeLisi, & Perron, 2014). In an Australian sample of juvenile offenders, those who reported a TBI, were significantly more likely to have a diagnosis of a mental health disorder, with a higher history of bullying, substance use and offending behaviours (Moore, Indig, & Haysom, 2014). Furthermore, those who reported more TBIs (more than two), were more likely meet criteria for psychological disorders and substance use. Davies et al. (2012) investigated the prevalence of self-reported TBI within a youth offending institute and found a dose response relationship, as the amount of PCS increased with an increase in the severity and frequency of TBI. The findings from prevalence studies have prompted the validation of a new Comprehensive Health Assessment Tool in young offending services that also screens for TBI (Hughes et al., 2012).

As in the adult offender prevalence studies, cause and effect cannot be ascertained and it is unclear whether there is a causal relationship between head injury and offending, or whether the TBI interacts with biological and social factors (Kenny & Lennings, 2007). Kenny and Lennings (2007) found a significant association between self-reported head injury and severe violent offending among juvenile offenders and proposed that a head injury may increase vulnerability to offending with the threshold effect theory. The threshold effect theory proposes that obtaining a head injury lowers the threshold for violent behaviour with activating conditions such as alcohol in those who are already predisposed to violent behaviour due to biological and social risk factors (Kenny & Lennings, 2007).

1.6.2. Impact of TBI on offenders in the justice system. Research has established the high prevalence of TBI in both adult and young offender populations and is beginning to shed light on what consequences this may have on these populations. Shiroma et al. (2010) examined an American state prison population and found that prisoners with a TBI had increased rates of prisoner code violations. Merbitz, Jain, Good, and Jain (1995) supported this finding, as they found that those prisoners with a head injury were involved in nearly twice as many disciplinary actions due to infractions. Without successful intervention, prisoners with TBI could pose a threat to themselves and others, have difficulties adjusting to prison regimes, and develop co-existing health conditions (Ferguson et al., 2012). Offenders with a TBI may have additional difficulties in the community, such as planning and remembering appointments and engaging in rehabilitation programmes and so a thorough understanding of the potential deficits related to the injury could help services to plan and support the offender.

Williams (2012) argues that TBI is a largely neglected area of concern within the criminal justice system, which has led to a lack of appropriate provisions and services for those in need. Offenders are also typically poor at engaging with services, particularly health and mental health care, and so it is important to engage effectively with them within the justice system.

If research can establish not only the prevalence of TBI in the offending population, but also whether this is associated with neuropsychological deficits, then this could influence treatment and rehabilitation programmes. Ross and Hoaken (2010) suggest that offenders and those with acquired brain injury have similar deficits and thus could benefit from similar training programmes to improve executive functioning. Rehabilitation treatment could therefore include computer cognitive training programs and more functional problem solving skills development

(Ross & Hoaken, 2010). Fishbein and Sheppard (2006) have suggested a similar approach of applying brain injury rehabilitation to the prison population and found that specific deficits impacted on treatment outcomes. Poor cognitive flexibility in the Stroop task was significantly related to poorer treatment outcomes, as was risky decision making (Fishbein & Sheppard, 2006).

1.7. Theories of Crime and Offending

The preceding sections have highlighted the executive functioning deficits of offenders and the high frequency of offenders with a history of TBI. Theories of executive functioning have been presented in section 1.3.2, and the following section will present an overview and critique of some of the prominent theories of crime. The section will provide examples of both general theories of crime and neuropsychological theories and will discuss the limited integration between the neuropsychological theories of executive functioning and of crime.

1.7.1. General theories of crime.

1.7.1.1. Gottfredson and Hirschi's (1990) general theory of crime. Gottfredson and Hirschi (1990) propose that crime is explained purely by low self-control and opportunity. The theory proposes that a lack of self-control results in someone possessing little tolerance, a lack of interest in long-term goals and insensitivity to the needs of others. Self-control is established in early childhood due to parental socialisation and is a dynamic variable up to the age of ten years (Gottfredson & Hirschi, 1990). The theory proposes that crime is easy to commit, often involves minimal planning and skills and can provide immediate gratification. The theory disputes the claims that biological or psychological factors influence criminal behaviour. Pratt and Cullen (2000) conducted a meta-analysis to examine the empirical status of the general theory of crime and found that the proposal that low self-control increases engagement in criminal behaviour was empirically supported, but was less supported in longitudinal studies. Grasmick, Tittle, Bursik, and Arneklev (1993) further critiqued the theory, as they found that criminal opportunity has a main effect on self-reported crime and the majority of variance in crime is not explained by the self-control theory. The theory has been criticised for not recognising individual, biological and psychological factors that may influence and interact with self-control and is said to over-simplify personality dispositions within criminal behaviour (Cauffman et al., 2005). Curran and Renzetti (1994) critique the theory as research suggests that there are certain crimes such as white collar crime and murder that are not explained by this theory and important factors such as poverty, homelessness and unemployment that are not incorporated into the theory.

1.7.1.2. A three-dimensional, cumulative developmental model of delinquency. Loeber, Slot, and Stouthamer-Loeber (2006) have proposed a life course model of delinquency that integrates the development and accrual of risk and promotive factors. Promotive factors in the general population predict low probability of later offending, and within an offending population they predict desistance from offending (Loeber, Pardini, Stouthamer-Loeber, & Raine, 2007). They criticise other theories for not incorporating promotive factors and for their limited linear developmental pathways. Risk factors for delinquency are divided into domains: peers, school, individual, family and neighbourhood and differentiate the time of exposure. For instance, IQ and low SES, can be risk factors from birth and attentional deficits and poor executive functions can be risk factors from early childhood (Loeber et al., 2006). The model, incorporating a dose-response relationship among risk factors, suggests the higher number of risk factors, the greater likelihood of delinquency. A strength of the model is its three dimensional nature, which can represent the development of a multitude of factors to show a progression from minor to serious delinquency.

1.7.2. Theories of the neuropsychology of juvenile delinquency. Moffitt (1990) presents a thorough review of the evidence base and theoretical understanding of the neuropsychology of juvenile delinquency. Moffitt (1990) distinguishes between two theoretical accounts: social delinquency theories and neuropsychological theories. The social delinquency theories postulate that any individual differences, particularly of cognitive abilities, have an indirect effect on delinquency, which is actually mediated through a social variable (Moffitt, 1990). The neuropsychological theories assume that cognitive factors have a direct effect on deviant behaviours and combine developmental, personality and neurobehavioural variables (Moffitt, 1990).

1.7.2.1. Social delinquency theories (mediated effects). One such social theory is the status frustration theory (A. K. Cohen, 1955). The theory states that poor cognitive ability affects the capability of children to meet middle-class school achievement and they therefore find school aversive and thus rebel against middle-class values. The 'delinquent boy' is said to have internalised the value system and so stands ambivalent about his own 'deviant behaviour' (A. K. Cohen & Short, 1958). In a critique of this theory, Polk, Frease, and Richmond (1974) found no significant differences between classes on rates of delinquency and found that delinquency is related to academic ability regardless of class. Empirical evidence supports the association between lower class youths performing badly at school but the theory does not conceptualise how school failure results in delinquent behaviour (Shoemaker, 2005). This theory does not consider any other risk factors aside from SES and thus is not comprehensive and the totality of the theory has not been empirically validated (Shoemaker, 2005).

An alternative theory is that of the social control theory (Hirschi, 1969), which predicts that cognitive ability affects how children engage with school. The engagement with school is the key social factor as cognitively able children will receive reinforcement at school and those with difficulties will have a negative experience and thus be unable to form attachments that can prevent delinquent behaviour. The model proposes that a bond between an individual and society is formed through four factors: attachment with others, commitment and aspiration for the future, involvement in conventional activities and belief and acceptance of moral validity (Wiatrowski, Griswold, & Roberts, 1981). Social control theory is generally well supported by cross-sectional data, although longitudinal research finds a reduced amount of support as social control accounts for only 1-2% of the variance in future delinquency (Agnew, 1985). Research does generally find a consistent relationship between the type of parenting and delinquency, but the specific nature of this association is not defined by the theory which has limited utility (Curran & Renzetti, 1994). In addition, the theory has a limited view of IQ as a unidimensional concept of general intellectual ability and does not acknowledge strengths and weaknesses that may interact (Moffitt, 1990).

A fundamental criticism of both theories, is that the majority of children with cognitive difficulties do not become delinquents and that there is no acknowledgement of early developmental processes in the pre-school years (Moffitt, 1990).

1.7.2.2. Neuropsychological delinquency theories (direct effects).

1.7.2.2.1. Luria (1966). A description of the theories of frontal lobe functioning (Luria, 1966) and inner speech (Luria, 1961) are described in section 1.3.2.1. Although Luria did not discuss delinquency and the theory was from a purely neuropsychological perspective, it has been subsequently applied to delinquency. Moffitt and Henry (1991) propose that there is some support for the application of this theory to delinquency, as they suggest that delinquents perform worse on tests using language skills compared to non-language tests and demonstrate overall weaker verbal than visuo-spatial abilities. Gorenstein (1990) also argues that the theories can be applied to delinquency, as patients with prefrontal cortical damage exhibit similar characteristics to 'unsocialised delinquents' with impairments in cognitive and social development. In addition, the theory suggests that those with prefrontal deficits, may be more responsive to needs and desires that most others can override with higher order internal processes (Gorenstein, 1990). The application of the theory to delinquency has important clinical implications, as it suggests that punishment is unlikely to prevent re-offending and young people may give the perception of insight, but the ability to sustain higher order representations is in fact weak, increasing the probability of re-offending (Gorenstein, 1990).

1.7.2.2.2. Gorenstein (1990). Gorenstein (1990) proposes that juvenile delinquents have deficits in the inhibitory function of the prefrontal cortex (PFC), the septal and the hippocampus, which contributes to their delinquency. Gorenstein (1990) likens the brain injury population to the delinquent population and postulates that delinquents have an 'anomaly' of the central nervous system. The term 'anomaly' of the CNS, is not necessarily derived from a trauma and that there may not be qualitative differences from normal brain development (Gorenstein, 1990). The model is most readily applied to "under socialised" delinquents who engage in persistent, impulsive antisocial behaviour from an early age and have difficulties maintaining attachment relationships. The theory would predict that affected individuals are driven by impulse and their desire, rather than by plans or aspirations, which would predict poor response to punishment (Gorenstein, 1990).

Animal models of brain damage to the septum, hippocampus and frontal cortex (SHF system) resulted in what Gorenstein (1990) described as antisocial conduct with avoidance of punishment, stimulation seeking, responsiveness to rewards and anticipation of aversive events.

The avoidance of incidental punishment is demonstrated in animals with SHF lesions who are unable to inhibit their learned response to a food dish despite an electric shock. The anticipation of aversive events is observed in animals with lesions who have reduced fear to an imminent aversive stimulus and offenders who are ambivalent to a remote negative outcome. Overall, these deficits can be interpreted as deficits in mediating of temporal intervals, as autonomic arousal can maintain internal representation of future events over time. A further consequence of lesions is a heightened responsiveness to rewards demonstrated in higher response rates to positive reinforcement and that offenders are more likely to prefer an immediate reward (Gorenstein, 1990).

The theory was supported by animal models that used brain damaged animals to demonstrate similar behaviour to juvenile delinquents: stimulation seeking, decreased fear of aversive events and disinhibition (Gorenstein & Newman, 1980). A caveat to animal research is that the research cannot always be generalised to humans due to differences in brain structures. The theory is supported by empirical evidence such as the case of Phineas Gage discussed in section 1.2.2. (H. Damasio et al., 1994). Review papers (L. Miller, 1988) provide supplementary empirical support for the theory of PFC deficits in young offenders.

1.7.2.2.3. Moffitt's (1993) developmental taxonomy theory. The developmental taxonomy theory postulates that offenders have neuropsychological and/or biological deficits. The theory differentiates between adolescence-limited offenders and life-course persistent offenders. Adolescence-limited offenders originates from puberty with the emergence of the maturity gap between biological maturity and responsibility and so these offenders try to show autonomy from their parents and seek attention from peers often with group offending (Moffitt, 1993). These offenders will progress to lead a more conventional normative life and away from persistent offending (Moffitt & Caspi, 2001). Life-course persistent offenders have inherited or acquired neuropsychological variation, which is confounded by environmental factors e.g., impoverished environments and poor parenting. The offending behaviour of life-course offenders is more persistent and pathological as a result of this neuropsychological variation and the presence of additional environmental factors (Moffitt & Caspi, 2001). Piquero (2001) supports Moffitt's (1993) hypothesis of a relationship between poor neuropsychological test scores and life-course offending using data from a national collaborative perinatal project. One limitation of the aforementioned research is that only proxy measures of neuropsychological functioning were taken, which may not be representative of actual deficits. Barnes and Beaver (2010) provide further support for the theory, especially in male offenders.

The neuropsychological theories are often not constructed to explain delinquency and the delinquency theories have been primarily developed since the development of neuropsychological research (Moffitt, 1990). Subsequently, there is minimal integration of neuropsychological research and theories into criminological models of delinquency. Both theoretical standpoints have also neglected to include the correlation between children and their parents' cognitive abilities and predict solely unidirectional effects (Moffitt, 1990). It is plausible for reciprocal effects, e.g., poor verbal skills and cognitive ability could lead to parental rejection and thus a less supportive environment, which could affect subsequent learning and the social groups a young person engages in, that could lead to substance abuse and violence and further adverse effects on neurological development (Moffitt, 1990).

In addition to the reciprocal effects with parents' abilities, there are alternative components that could be associated with executive functioning difficulties. For example, DePrince, Weinzierl, and Combs (2009) found an association between familial trauma and poor executive functioning on tasks of working memory, inhibition, attention and processing speed in children. A history of emotional abuse or neglect in foster children has also been found to be negatively correlated with executive functioning ability (Pears & Fisher, 2005). Furthermore, Bernier, Carlson, Deschenes, and Matt-Gagne (2012) suggest that higher-quality parenting and attachment security are associated with the development of executive functioning and control.

1.8. Research Rationale

The preceding sections (1.4 and 1.5) have highlighted a similarity between executive function deficits of patients with a head injury and those within the youth offending population. In addition, prevalence studies have been presented (see section 1.6.1) emphasising the high rates of TBI within the adult and young offending populations and the impact injury could have on their engagement with the justice system. Information should be gathered on head injuries, due to the high prevalence of brain injury in young offenders (Farrer et al., 2013) and the association with executive function deficits (Schretlen & Shapiro, 2003). Research should also investigate the neuropsychological dysfunction of offenders with a brain injury (Williams, Cordan, et al., 2010). Williams (2012) highlights the need for further research into the association between brain injury and offending, which could develop a better understanding of the role of the frontal systems. Both offenders and individuals with a TBI exhibit frontal lobe deficits. There is, however, limited research to investigate whether offenders with a history of TBI present with more severe deficits than those offenders without a history of TBI, or whether they present with different deficits. The high rates of TBI in the offending population reinforces the importance of investigating the effect of TBI on an offending population.

The current research aims to compare the frontal lobe functioning of young offenders with and without a TBI, using the Stuss (2011a) neuropsychological model of frontal lobe functioning to characterise differences and as the theoretical basis for the study. The Stuss (2011a) neuropsychological model was examined as the functional approach may be more sensitive to highlighting deficits than traditional executive functioning measures and it provides both functional and anatomical associations (Stuss, 2007). The theory also provides a more comprehensive view of frontal lobe functioning in comparison to previous research that has focused on specific executive functioning abilities and thus may be more sensitive to highlighting differences. As discussed in section (1.7.2), the criminological theories have not been well integrated within the body of neuropsychological theories. The current research is therefore, not directly examining a criminological theory. However, if young offenders with a head injury are shown to have more severe deficits than those without, it could support the general corpus neuropsychological theories of crime and support the concept that offenders might have neuropsychological deficits. In addition, it could help establish whether these were associated with pre-existing deficits or acquired from injury. It could also be argued that a TBI could act as an individual risk factor in the developmental model of delinquency (Loeber et al., 2006).

Many of the offender groups studied are recruited from discrete populations e.g. special units or minority subgroups, which may not be representative of the more general population of young offenders in the wider community (E. Miller, 2002). Previous research (see section 1.5) suggests that there may be an effect of institutionalisation on research findings, and so research on young offenders in the community could reduce this effect and focus on an area of earlier intervention than those already institutionalised due to offending behaviours. Accordingly, this research used a sample of community young offenders and multiple sources to corroborate information e.g., parents, youth offending records (Moffitt, 1990).

1.8.1. Confounding variables. The preceding sections have highlighted that IQ and SES have often been poorly controlled in previous research. A further confounding variable of mood will also be proposed. A brief summary of the confounding variables controlled for in this research will be presented.

1.8.1.1. IQ. Research on the executive functioning of young offenders has highlighted that those with a lower IQ have more behavioural and cognitive impulsivity deficits than those with a higher IQ (Koolhof et al., 2007). Furthermore, IQ has been found to correlate with both attention and executive functioning (Kelly et al., 2002). Both the status frustration theory (A. K. Cohen, 1955) and social control theory of delinquency (Hirschi, 1969) presented in section 1.7.2.1., propose the association with low IQ and subsequent school attainment with juvenile violence (Farrington, 1990). In sum, IQ correlates both with attention, behavioural and executive functioning and is proposed to be a risk factor in juvenile violence and so was controlled for in this research. A caveat to this variable is that IQ can be affected by a TBI, with a dose-response relationship between the severity of the TBI and performance on IQ tests post-injury (Catroppa & Anderson, 2003).

1.8.1.2. SES. The Status Frustration theory (A. K. Cohen, 1955) proposes that SES is the foundation of the development of delinquency (see section 1.7.2.1). Despite the criticisms for not incorporating many other important risk factors, there is support for the concept of SES as one contributory risk factor for delinquency and violence (Farrington, 1990; Heimer, 1997). Furthermore, social outcomes as a result of TBI are found to be aggravated by SES (Tonks, Yates, et al., 2011; Yeates et al., 2004). In sum, and similarly to IQ, SES is found to be a risk factor in the development of delinquency and to be associated with poorer outcomes after TBI and so was controlled for in this research.

1.8.1.3. Depression. A further potentially confounding variable could be mood, as young offenders report significant depressive symptoms (Chitsabesan et al., 2006) and fluctuations in mood influences neural activation and cognition (R. L. Mitchell & Phillips, 2007). Furthermore, there is an increase in depressive symptoms after TBI (1.4.2.3). Research has found that an increased severity of depression is significantly associated with reduced cognitive ability, particularly in episodic memory, executive functioning and processing speed (McDermott & Ebmeier, 2009). The impact mood has on cognition is associated with neural activation and it is postulated that the PFC is the likely site of interaction between mood and executive functions (R. L. Mitchell & Phillips, 2007). This is particularly pertinent to this research due to the prevalence of depressive symptoms in young offender populations. Young offenders' mental health and depression are seen as unmet needs, partly due to the poor screening of internalising problems by institutions (P. Mitchell & Shaw, 2011). There is increasing evidence of the prevalence of depression in young offenders as Chitsabesan et al. (2006) conducted a cross-sectional survey of young offenders in custody and the community across England and Wales, which revealed that almost one in five young offenders had significant depressive symptoms. Research suggests that female young offenders are more likely to be diagnosed with major depression (29.2%) than male young offenders (10.6%) (Fazel, Doll, & Långström, 2008).

The research could therefore highlight specific frontal lobe deficits in young offenders with and without a head injury and these deficits could suggest whether additional services or adaptation to existing services are required. The research will aim to control, albeit statistically for the potentially confounding variables of IQ, SES and depression. The results could additionally recommend whether interventions for the TBI population could be effectively applied to young offenders.

1.9. Research Questions

This study aims to compare the frontal lobe functioning of young offenders with and without a TBI using the (Stuss, 2011a) neuropsychological model of frontal lobe functioning to characterise differences.

The research questions are defined as:

1. Do young offenders with a self-reported TBI have poorer energization frontal lobe functioning than young offenders without a self-reported TBI?
    - Hypothesis 1: Young offenders with a self-reported TBI will have slower reaction times on the detection and identification tasks than young offenders without a self-reported TBI (Cogstate task; Westerman, Darby, Maruff, & Collie, 2001).
2. Do young offenders with a self-reported TBI have poorer executive cognitive frontal lobe functioning than young offenders without a self-reported TBI?
    - Hypothesis 2: Young offenders with a self-reported TBI will have lower scaled scores on the colour-word interference task than young offenders without a self-reported TBI (Delis Kaplan Executive Functions Systems [DKEFS]; Delis et al., 2001).
3. Do young offenders with a self-reported TBI have poorer self-regulatory frontal lobe functioning than young offenders without a self-reported TBI?
    - Hypothesis 3: Young offenders with a self-reported TBI will have lower scores on the Intuitive Reasoning Task (IRT; Dunn et al., 2010) than young offenders without a TBI.

4. Do young offenders with a self-reported TBI have poorer metacognitive functioning than young offenders without a self-reported TBI?

    - Hypothesis 4: Young offenders with a self-reported TBI will have lower scores on the Mind in the Eyes task (Baron-Cohen et al., 2001) than young offenders without a self-reported TBI.

Chapter 2: Methodology

2.1. Chapter Introduction

This chapter outlines the research methods used to conduct this research study. An outline of the research design will be followed by a description of the inclusion and exclusion criteria, and demographic characteristics of the participants. The recruitment process and procedure will be discussed, including the measures that were employed to assess frontal lobe functioning. The ethical considerations of conducting research with young people, with and without a head injury, will also be presented. The section will conclude with a plan of analysis.

2.2. Design

The main aim of this study is to investigate whether young offenders with a self-reported TBI and young offenders without a TBI differ in their performance on tests of frontal lobe functioning. To investigate this, the study employed a between-groups, cross-sectional study design to compare the performance of young offenders who have sustained a TBI with a comparison group of age and gender matched young offenders without a TBI. Both groups were assessed at a single time point. Both groups were recruited from the same age range of 12 to 17 years 11 months. The primary outcome variables were as follows: i) the energization function assessed by detection (simple) and identification (choice) reaction time tests; ii) the executive cognitive function assessed by colour-word inhibition; iii) emotional self-regulatory function assessed by the intuitive reasoning task; and iv) metacognitive function assessed by the Mind in the Eyes test.

Both IQ and SES have been poorly controlled as confounding variables in previous research (Farrington, 1990; Heimer, 1997). A further potentially confounding variable could be depression, as young offenders report significant depressive symptoms (Chitsabesan et al., 2006), and both adults and children report depressive symptoms after a TBI, although not always at a clinical diagnostic level (Kirkwood et al., 2000; Kreutzer et al., 2001). Furthermore, fluctuations in mood can influence neural activation and cognition (R. L. Mitchell & Phillips, 2007). Lower SES has additionally been found to be associated with higher reported depressive symptoms in children following TBI (Kirkwood et al., 2000). In order to control for variables that may affect the primary outcome variables, a number of confounding variables were measured including i) SES, ii) depression, and iii) IQ.

2.2.1. Rationale for design. A cross-sectional design was utilised to determine group differences and identify associations between TBI and frontal lobe functioning. The research question could then be more rigorously tested with cohort or longitudinal studies in the future (Mann, 2003).

2.3. Participants

Participants were recruited from Youth Offending Services (YOS), educational provisions and social services throughout Cambridgeshire, Peterborough, Suffolk and Norfolk and Educational Centres (see section 2.3.3.).

2.3.1. Inclusion and exclusion criteria. Individuals were recruited if they had a current or previous Youth Offending Order. Juvenile offenders/young offenders are classified as those between 10-17 years old and subject to a Youth Offending Order or legislation (Youth Justice Board, 2013). The initial inclusion criteria specified participants aged between 12 and 16 years 11 months. As a result of recruitment difficulties and following discussion with Supervisors the inclusion criteria for age was increased to 17 years 11 months part way through the research.

Participants were required to have normal/normal-corrected vision due to the visual nature of some of the assessments.

Exclusion criteria were established to minimise possible effects of confounding variables that could affect differences between the groups. Due to the nature of the assessments, individuals were excluded if English was not their first language. Individuals that were colour blind were excluded due to the nature of the colour-inhibition task. This was established by either a known diagnosis by the service or if it was not known, then the case workers/referrers asked the participants whether they were colour-blind. To reduce the possible effect of cognitive impairment, other than an impairment attributable to a TBI as a confounding variable, individuals with an identified learning disability by the YOS or Educational service were excluded. An individual with a learning disability is defined as having a significant impairment of both intellectual functioning and social functioning, with an age of onset before adulthood (British Psychological Society, 2000).

Participants were recruited into the TBI group if they reported having sustained a head injury in the past (see section 2.4.1 below for details on how this was assessed), and those who reported no head injury were recruited into the no head injury (comparison) group.

2.3.2. Estimated sample size. Sample sizes were calculated using G* Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009), assuming probability of p = .05 and power .80 (J. Cohen, 1988). Previous research has not compared frontal lobe functioning of community young offenders with and without a head injury ranging from mild-severe, and therefore similar research with similar tasks was used to calculate effect sizes. If the research did not cite an effect size, these were calculated on G*Power (Faul et al., 2009). The effect size calculation for

Cohen's *d* is the difference between the TBI and non-TBI group means divided by the pooled standard deviation (J. Cohen, 1988).

2.3.2.1. Hypothesis one. It was hypothesised that young offenders with TBI will have poorer energization frontal lobe functioning, as measured by simple and choice reaction time tasks. A similar task of continuous performance, a sustained attention based task, was utilised in order to calculate an effect size based on previous research (Fenwick & Anderson, 1999). The participants in the research were aged between 8 and 14 years old, with a moderate-severe TBI group and age matched comparisons. The effect size of *d* = 1.07 was determined from the task using the means and standard deviations for adolescents with a TBI (*M* = 43.17, *SD* = 28.7) and controls (*M* = 19.33, *SD* = 12.71) (Fenwick & Anderson, 1999). This effect size requires a minimum sample size of 12 in each group to reach significance in an independent t-test.

2.3.2.2. Hypothesis two. It was hypothesised that young offenders with a head injury will have poorer executive cognitive functioning, measured by the colour-word interference task. Research by Fenwick and Anderson (1999) was used as a comparison as they utilised the traditional Stroop Colour Word Interference test (Golden, 1978) on the aforementioned sample. The effect size of *d* = 1.24 was determined from the Stroop test using the means and standard deviations for adolescents with a TBI (*M* = 18.78, *SD* = 6.04) and controls (*M* = 28.5, *SD* = 9.27) (Fenwick & Anderson, 1999). This effect size requires a sample size of 12 in each group.

2.3.2.3. Hypothesis three. For the third hypothesis, it was hypothesised that young offenders with a TBI had poorer self-regulatory function than those without a TBI, using the IRT task (Dunn et al., 2010). As previously mentioned, there is no published research using this task on a TBI population. Therefore, a comparable computerised decision making task called the Risky Choice Task (Rogers et al., 2003) was examined. The task is a measure of decision making and of the effects of reward and punishment (Syngelaki et al., 2009), which is comparable to the IRT task. Syngelaki et al. (2009) used the task on a sample of 104 12-18 year old male young offenders. Syngelaki et al. (2009) found an effect size of d = 0.88 of young offenders gambling significantly more than a control group on a decision-making task, which would require a sample size of 17 in each group.

2.3.2.4. Hypothesis four. It was hypothesised that young offenders with TBI had poorer metacognitive functioning than those without, using the Mind in Eyes task (Baron-Cohen et al., 2001). The task has been used in a study investigating reading emotions in a sample of 18 children aged between 9- 17 year olds with acquired brain injuries in comparison to normative data of matched health controls. The effect size of d = 0.87 was determined from the Mind in the Eyes test using the means and standard deviations for children with a brain injury (M = 55.5, SD = 17.8) and controls (M = 69.1, SD = 13.2) (Tonks, Williams, Frampton, Yates, & Slater, 2007b). This effect size requires a sample size of 18 in each group.

Therefore, taking the most conservative sample size estimate from the aforementioned hypotheses, a total sample size of 36 (18 in each group) was required to reach statistical significance for a between-groups t-test analysis.

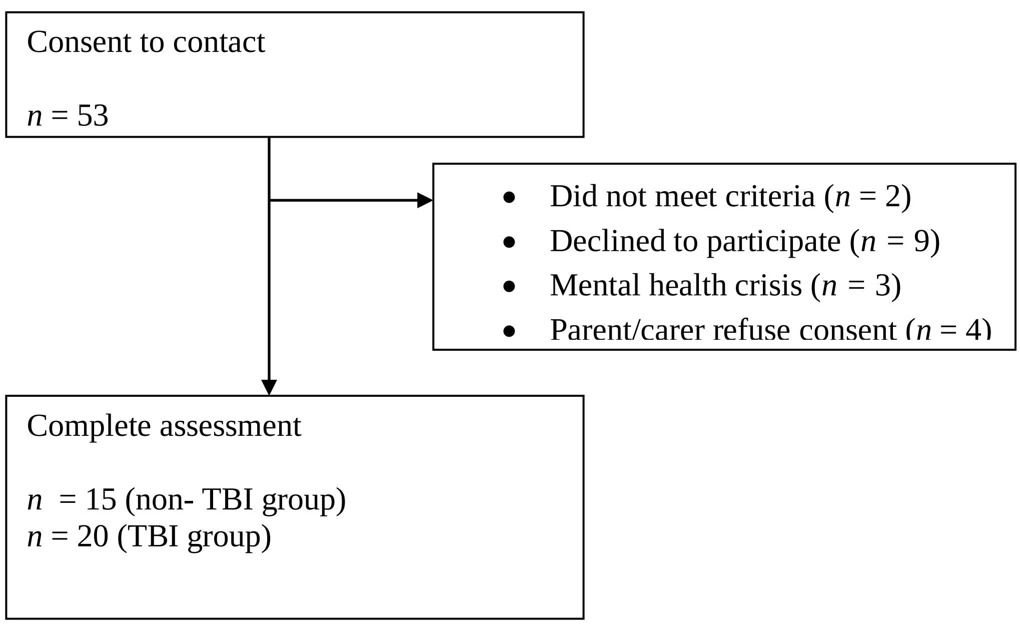
2.3.3. Recruitment. The researcher initially liaised with clinical psychologists from the Cambridgeshire YOS, an Educational Centre in Norfolk and the Head of Youth Offending and Integrated Youth Support Services in Suffolk. Consultation with the aforementioned contacts assisted in assessing the feasibility and acceptability of the research. The researcher then sought ethical approval, approval from the Association of Directors of Children's Services Ltd (ADCS) and individual research governance if required. Research governance was additionally required in Norfolk, Suffolk and Cambridgeshire County Councils. A total of five county YOS were involved in the research: Cambridgeshire, Peterborough, Norfolk, Suffolk and Essex. In addition, Norfolk Short Stay Schools, City Academy, Norwich; Bramfield House School, Suffolk; a Pupil Referral Unit in Cambridgeshire, a solicitors firm in Cambridge and Children's Social Services in Cambridgeshire were involved in recruitment. A further nine services, mostly charities, were approached but declined to participate. Despite multiple sources from which to recruit participants, recruitment of the study population was extremely challenging.

The team members were asked to identify potential participants from their case-load. If the young person met the study criteria, the worker was asked to discuss the research with the young person, and their parent/guardian if under 16 years old, and distribute the relevant information sheets (Appendix A for 12- 15 year olds, Appendix B for 16-17 year olds). Potential participants who were under 16 years of age were provided with information sheets for their parent/guardian (Appendix C). The information sheets were checked using the website Gunning Fox Index (Bond, 2012) to estimate the education level required to read them. The participant information sheets can be understood by someone who left full-time education at a later age than 8 years, and 9 years for the parent/guardian information sheet.

If the young person was interested in the research they were asked to complete a consent form to be screened and contacted (Appendix D). Alternatively, a shorter consent form to be screened and contacted was included on a compliment slip (Appendix E) that was attached to the front of the information packs. The compliment slip was designed to be a user-friendly version and included a photograph of the researcher so that the young person knew who to expect for assessments. The service then completed the initial TBI screen (Appendix F) with those who had consented. The screen question was "Have you ever had an injury to the head, which knocked you out and/or left you dazed and confused? e.g., from a fall, accident, hit to the head". The service was then asked to feedback the screening outcome to the researcher.

2.3.4. Sample obtained. A total of 20 individuals were recruited to the TBI group and 15 to the control group. The total number of individuals who were approached about the research, but declined to be contacted or participate in the research was difficult to ascertain as case workers did not report these figures as requested by the researcher. See Figure 1 for a consort diagram of participants. The sample was recruited from Cambridgeshire YOT (*n* = 9); Norfolk YOT (*n* = 4); Suffolk YOT (*n* = 4); Peterborough YOT (*n* = 3), Essex YOT (*n* = 2); Norfolk Short Stay Schools (*n* = 5); Bramfield House School, Suffolk (*n* = 1); Cambridgeshire Children's Social Care (*n* = 2); solicitors in Cambridge (*n* = 2); Wisbech PRU (*n* = 1); City Academy (*n*= 2).

Figure 1: Consort diagram



2.3.4.1. Participant characteristics**.** Basic demographic information was collated for both groups, including age and gender (Table 1). When possible, self-report data were corroborated with parental/guardian report. This was only possible for nine of the participants. The mean age for both groups is comparable to previous related research on young offenders at 15.7 years old, (Williams, Cordan, et al., 2010).

Table 1

Sample Demographic Characteristics for Both Groups

Group	*N*	Mean age (*SD*)	Sex (M : F)
TBI	20	14.6 (1.8)	18:2
Non-TBI	15	15.3 (1.3)	10:5

Information was collected from both groups on their offending history. The groups (TBI and Non-TBI) were similar in their current involvement with YOT (Table 2).

Table 2

Percentage of Participants Currently Involved with YOT for Both Groups

Group	Currently under YOT (%)
TBI (*n* = 20)	70
Non- TBI (*n* = 15)	73.3

For those who were not currently involved in YOT, the time since they were last involved with YOT differed between the groups as the non-TBI group had more recent contact than the TBI group (Table 3).

Table 3

Most Recent Conviction, if Not Currently with YOT for Both Groups.

	Non-TBI Group (*n* = 4)		TBI Group (*n* = 6)	
Time Frame	Frequency (*n*)	Percentage (%)	Frequency (*n*)	Percentage (%)
One month ago	0	0	0	0
Two-five months ago	1	6.7	1	5
Six-twelve months	3	20	1	5
One-two years ago	0	0	2	10
Two-three years ago	0	0	1	5
More than three years	0	0	0	0
Don't know	0	0	1	5

The groups differed on the cause of their most recent conviction, with the most frequent conviction for burglary for the non-TBI group and violence for the TBI group (Table 4).

Table 4

Most Recent Conviction for Both Groups

	Non-TBI (*n* = 15)		TBI Group (*n* = 20)	
Conviction	Frequency (*n*)	Percentage (%)	Frequency (*n*)	Percentage (%)
Burglary	6	40	4	20
Violence	4	26.7	9	45
Arson	1	6.7	0	0
Sexual	0	0	1	5
Drug	1	6.7	1	5
Other	3	20	5	25

The TBI group reported more previous convictions than the non-TBI group. A total of 60% of the TBI group reported up to four previous convictions, in comparison to the 80% of the non-TBI group reporting two or less convictions. See Table 5 for the frequency values.

Table 5

Frequency of Previous Convictions for Both Groups

	Non-TBI Group (*n* = 15)		TBI Group (*n* = 20)	
Number	Frequency (*n*)	Percentage (%)	Frequency (*n*)	Percentage (%)
None	6	40	3	15
One	5	33.3	3	15
Two	1	6.7	6	30
Three	0	0	0	0
Four	0	0	1	5
Five or more	3	20	7	35

The groups differed on their most current youth offending (YO) order (Table 6). The most common YO order for the non-TBI group was for a referral order, and for the TBI group, it was 'other' followed by a youth rehabilitation order with intensive support and surveillance.

Table 6

Record of YO Orders for Both Groups

	Non-TBI Group (*n* = 15)		TBI Group (*n* = 20)	
YO order	Frequency (*n*)	Percentage (%)	Frequency (*n*)	Percentage (%)
Reprimand	2	13.3	1	5
Final Warning	1	6.7	1	5
YRO	3	20	1	5
YRO with ISS	1	6.7	4	20
Referral Order	5	33	2	10
Reparation Order	1	6.7	2	10
Other	1	6.7	7	35
Don't know	1	6.7	2	10

Note. YRO= Youth Rehabilitation Order; ISS= Intensive Support and Surveillance.

Information on the characteristics of the TBI in the TBI group were collated (see Table 7). The percentage of those who had more than one self-reported TBI was 40%, which is slightly higher than previous research on young offenders that found a rate of 32% (Williams, Cordan, et al., 2010).

Table 7

Frequency of TBI in the TBI Group

Frequency of TBI	Frequency (*n*)	Percentage (%)
1	12	60
2	2	10
3	1	5
4	1	5
More than 4	4	20

Williams, Cordan, et al. (2010) utilised similar criteria for establishing severity of TBI, with less than 10 minutes classified as mild, 10 minutes to six hours as moderate and more than six hours as severe. These criteria would suggest that 10 % of the sample did not report LOC, 60% of the sample reported a mild TBI, 5% a moderate TBI and 5% a severe TBI, with 20% of the sample not knowing whether they experienced any LOC (Table 8).

Table 8

Duration of LOC in the TBI Group

Duration	Frequency (*n*)	Percentage (%)
No LOC	2	10
Less than 5 minutes	9	45
5-10 minutes	3	15
10-30 minutes	1	5
30-60 minutes	0	0
1-6 hours	0	0
More than 6 hours	1	5
Don't know	4	20

Within the TBI group, more participants reported that their TBI was sustained prior to their first conviction than after their first conviction (Table 9).

Table 9

Time of First Conviction in Relation to TBI for TBI Group

	Frequency (*n*)	Percentage (%)
Before	10	50
After	8	40
During the crime that led to the conviction	1	5
Don't know	1	5

2.4. Measures

2.4.1. Demographics. Basic information regarding each participant's age and gender was collected. Participants were asked if they have ever been 'knocked out/dazed/confused' after a blow to the head and asked to estimate the length of time of any loss of consciousness (LOC) in addition to the frequency of TBI (Appendix F). Although the aforementioned question constituted the screen question, it was repeated at the assessment in case of an interim head injury. The self-report questioning determining the presence, frequency and severity of a TBI, has been widely used in previous research (Davies et al., 2012; Williams, Cordan, et al., 2010). More recently, the questions have been introduced on the CHAT for young people in secure estates and in youth offending teams as part of their initial assessment to screen for TBI (Offender Health Research Network, 2013). Further validation of self-report data for TBI has been provided by Schofield et al. (2011) who found that self-report history of TBI was a reliable source of information compared to medical records in a prisoner population for research purposes.

Information on LOC was important as it could assist in establishing the severity of TBI, in addition to frequency, to determine a possible 'dosage' effect of TBI, that previous research on TBI in young offenders has failed to establish (Farrer et al., 2013). Parental/ guardian proxy report about TBI was collected when possible (Appendix G), which acted as a proxy measure for corroborative purposes. Parental/guardian report could also highlight any TBI that occurred at a young age that the participant may not have been able to recall. Medical records were not checked as only an estimated 25% of mild TBI cases are brought to clinical attention (Perron & Howard, 2008).

Participants were asked what their current conviction was for, or, if not currently under the YOS, then their previous conviction, the number of previous convictions and whether their first conviction was prior to their first TBI (Appendix H). The aforementioned questions on TBI history and offending history are taken from previous research (Williams, Cordan, et al., 2010). Self-report for youth offending has been validated in previous research (Jolliffe et al., 2003). The researcher sought confirmation of the young person's current youth offending record from the service, which can help to establish the accuracy of the young person's self-report. This is important as a limitation of previous research is the lack of corroboration with offender services on the accuracy of self-report crime history (Williams, Cordan, et al., 2010).

2.4.2. Confounding variables.

2.4.2.1. SES. Many traditional measures of SES are inappropriate for use with adolescents, as they are often unable to report accurately their parents' occupation or education (Currie, Elton, Todd, & Platt, 1997). The Family Affluence Scale II (FAS II; Boyce, Torsheim, Currie, & Zambon, 2006) was therefore used as an objective measure of family wealth, which consists of four self-report questions about material and housing deprivation (Appendix H). The scale has good criterion validity, strong correlations with national health indicators of gross national product (r = .87) and high correlations between individual indicators (Boyce et al 2006). The questions are 'Does your family own a car, van or truck?' with responses classified as no (0), one (1), two or more (2), 'Do you have your own bedroom for yourself?' with responses as no (0), yes (1), 'During the past 12 months, how many times did you travel away on holiday with your family?', with responses as none (0), once (1), twice (2), more than twice (3) and 'How many computers does your family own?' as none (0), one (1), two (2), more than two (3). The SES questions are presented in the demographics questionnaire (Appendix F). A three point ordinal scale is utilised, whereby FAS low (score = 0, 1, 2) indicates low affluence, FAS medium (scores = 3, 4, 5) suggests middle affluence and FAS high (scores = 6 ,7, 8, 9) indicates high affluence.

The FAS II (Boyce et al., 2006) has been used in the large scale Health Behaviour in School-Aged Children: WHO Collaborative Cross-National study research and was demonstrated to be sensitive in differentiating levels of child material affluence in both research and policy contexts.

2.4.2.2. Depression. A measure of depression as a confounding variable was collected due to previous research suggesting the impact mood has on cognitive and executive functioning (McDermott & Ebmeier, 2009) and the high prevalence of depressive symptoms in youth offenders (Chitsabesan et al., 2006). The Short Mood and Feelings Questionnaire (SMFQ; Angold et al., 1993; Messer et al., 1995) is a self-report measure consisting of 13 questions with answers on a 3-point scale (true, sometimes, not true). The measure has previously been used on 6- 17 year olds and has high internal reliability, coefficient alpha 0.85 (Angold et al., 1993). The SMFQ is a considered as a brief and reliable measure of depression in children and adolescents (Messer et al., 1995).

The SMFQ is described as a supplemental measure of psychiatric functioning in paediatric TBI (McCauley et al., 2012). Thapar and McGuffin (1998) have found that a score of 8 on the SMFQ represents the 'caseness' cut-off for depression as defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R; American Psychiatric Association, 1987). The SMFQ has also been validated in offending populations (Hewitt, Perry, Adams, & Gilbody, 2011) with a sensitivity of 1.00 and specificity of 0.72. The researcher was granted permission from the authors to use the measure. The administration time of the SMFQ is 5 minutes (Hewitt et al., 2011).

2.4.2.3. Intelligence. Two subtests (Matrix Reasoning and Vocabulary) from the Wechsler Intelligence Scales for Children version four (WISC-IV; Wechsler, 2004) were administered. This two subtest version yields an estimated Full Scale IQ (FSIQ), with a correlation with the full WISC-IV of .876 and reliability of .926 (Crawford et al., 2013). The Vocabulary subtest comprises both pictorial and verbal items. The matrix reasoning subtest involves the young person looking at an incomplete matrix of pictures and selecting the missing portion from five responses. Matrix reasoning is a culture-fair and language-free measure of fluid reasoning. The administration time for both subtests is approximately 15 minutes (Ryan, Glass, & Brown, 2007).

The WISC-IV has been used in previous research with children with TBI from 6- 16 year olds, which revealed relative deficits on all subtests and indexes for the TBI group (Allen, Thaler, Donohue, & Mayfield, 2010). A possible confound for using the two subtest version is that it has yet to be validated on a clinical population, including those with TBI, and so may not be sensitive to deficits in this population. However, as IQ was not used as a clinical measure in this research, but instead to control for a potential confounding variable, it was deemed appropriate.

As a result of the increased age limit part way through the recruitment, an additional measure of IQ was also utilised. The Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011) is a two subtest measure of intelligence for individuals from 6-89 years old. The test consists of two subtests: vocabulary and matrix reasoning to yield a FSIQ. The WASI-II was only administered to the five participants who were 17 years old, as the participants between 12- 16 years of age were all administered the WISC-IV. The administration time is approximately 15 minutes. The split half reliability coefficient for the two subtests is .89, with a test-retest stability of .91 (corrected for variability), and has a high correlation with the WISC-IV *r* = .85 (Wechsler, 2011). The matrix reasoning subtest for the WASI-II has a correlation with the WISC-IV matrix subtest of .72 and the vocabulary WASI-II subtest correlated .73 with the WISC-IV version (Wechsler, 2011). Scaled scores are derived from both subtests and due to the correlations between the subtests and the use of the age-corrected standard scaled scores, test scores can be substituted from the WASI-II to the WISC-IV, that suggests the scaled scores are to some extent comparable (Zhou & Raiford, 2011).

2.4.3. Outcome measures.

2.4.3.1. Energization function (Detection and identification tasks). Simple and choice reaction time tests are proposed to evaluate the energization component of frontal lobe functioning, and alternative forms of the tests have been used in the Rotman-Baycrest Battery to investigate attention (ROBBIA; Stuss et al., 2005). Two reaction time subtests from the Cogstate (Westerman et al., 2001) computer-assisted cognitive function assessment were thus selected. The detection task is a measure of simple reaction time and the identification task is a measure of choice reaction time, both described as sustained attention tasks (Betts, McKay, Maruff, & Anderson, 2006). The software was chosen due to the acceptability and familiarity of the test stimuli of playing cards that can be used with individuals from more diverse cultural and social groups (Maruff et al., 2009). The Cogstate software has been validated on adults with TBI to detect subtle mild TBI deficits (Maruff et al., 2009) and tested on children from 5 years old (Betts et al., 2006; Mollica, Maruff, Collie, & Vance, 2005). The assessment can additionally be used as a measure of cognitive change in children (Mollica et al., 2005). The assessments were conducted on software downloaded on a Dell laptop (screen resolution 1440 x 900, and 33cm screen size).

In the detection task, participants are required to attend to the centre of the screen and respond to the rule 'Has the card turned face up?' Participants are required to press the 'K' key if the answer is yes. In the identification task, participants are presented with the rule 'Is the face-up card red?' and if the answer is yes then they are required to press the 'K' key and 'D' key for no. The practice test for both tasks takes one and a half minutes and a further four minutes to complete the full version of both tests. Both tests yield a primary outcome of speed of correct responses in milliseconds. The researcher had permission to use this test from Cogstate.

2.4.3.2. Executive cognitive function (Colour-word interference task). Stuss and Alexander (2007) propose that deficits in executive cognitive functioning, and more specifically, task setting, would be highlighted on tasks that require suppression of salient responses. The Colour-word interference evaluates the inhibition component process and involves suppression of responses, with possible dorsolateral anatomical basis (Stuss et al., 1995). Therefore, the colour-word interference task is used in this research as a measure of executive cognitive function (Stuss, 2007).

The task is a subtest from the Delis Kaplan Executive Function System (DKEFS; Delis et al., 2001), which involves individuals naming the colour of the ink on written names of colours. The task involves verbal inhibition, simultaneous processing and cognitive flexibility and has good internal consistency .75 - .82 (Delis et al., 2001). The task also has moderately high split-half reliabilities .62 - .86 (Homack, Lee, & Riccio, 2005) and good to high test-retest reliabilities of .77-.90 (Henry & Bettenay, 2010).

The measure is based on the Stroop task (Golden, 1978) procedure and is used to assess the ability to inhibit an over learned response (reading a word), to name the dissonant ink colour in which the words are printed. The DKEFS version includes four conditions: condition one involves naming colour patches (naming); condition two, reading colour-words printed in black (reading); condition three, inhibiting reading the words but naming the dissonant ink colours that the words are printed in (inhibition), and condition four when the participant is asked to switch between naming the dissonant ink colours and reading the words (inhibition/switching). This final condition evaluates both inhibition and cognitive flexibility. The primary outcome measures are completion-time scores for each of the four conditions, which are converted to scaled scores for the relevant age group. The scaled scores for the number of errors will additionally be calculated. Furthermore, contrast scores can be computed with the inhibition versus colour naming contrast score in which the naming is factored out from the inhibition task, and the inhibition/switching versus combined naming plus reading contrast score. These additional control conditions are beneficial for those who may have difficulties with speed of word naming or reading (Henry & Bettenay, 2010). The scaled scores do not incorporate errors made on the task and so these will be additionally analysed.

2.4.3.3. Emotional self-regulation (IRT; Dunn et al., 2010). Tasks to assess the emotional self-regulation function are those that involve reward and risk processing, such as gambling tasks (Stuss, 2011a). The Intuitive Reasoning Task (IRT; Dunn et al., 2010) is a computerised task to measure intuitive decision making, evolved from the Iowa Gambling task (Bechara, Damasio, Damasio, & Anderson, 1994). The task was selected to measure the emotional self-regulation function as an example of a decision making, gambling task. The task was displayed using Microsoft Visual Basics (Microsoft Corporation, 2010) on a Dell laptop (screen resolution 1440 x 900, size 33cm).

The task begins with the presentation of four decks of cards towards the top of the screen, with contemplation time before buttons appear under each deck for the participant to select a deck. Following the selection, an upturned card appears in the centre of the screen and participants have to guess if the card from the chosen deck would be the same or different colour to the central card. Participants are given feedback on their responses, with money increasing and decreasing for correct or incorrect responses, respectively. Sounds accompany the feedback, with a melodic flourish sound accompanying a correct guess and a buzzer with an incorrect choice. The length of time that the cards were presented on the screen, and time between presentations of the cards were reduced following the administration of the task with the first two participants. All participants still completed 100 trials. Feedback from the participants was that the task was too long and was subsequently affecting their engagement on the task and one participant refused to complete the task. Data was analysed for the participants with the shorter presentation time only, all of which were presented with 100 trials.

Participants are unaware that the outcomes of each deck are predetermined by the computer. Participants are required to learn over 100 trials to choose from the two profitable decks (Decks A and B) and avoid the two unprofitable decks (Decks C and D). The intuitive reasoning score is calculated by subtracting the total selections from the unprofitable decks from the total selections from the profitable decks. Scores range from +100 (entirely profitable decks) to -100 (all from unprofitable decks). Higher scores suggest better intuitive decision making. The novel paradigm has been used on healthy adults (Dunn et al., 2010) that showed intuitive learning with minimal awareness of the reinforcement procedure. In addition, Dunn et al. (2010) demonstrated that presence of bodily responses (heart rate and skin conductance) distinguished between profitable and unprofitable decks, much like the somatic marker hypothesis and IGT (Bechara et al., 2005). The researcher had permission to use this test from the designer.

The confounding variable of the task is that there is no published research on the validation of the task with adolescents or on a brain injury population. The task, however, was deemed appropriate for this research as it was a more accessible task than others such as the Iowa gambling task (Bechara et al., 1994). The task has been used as an alternative to the Iowa Gambling task (Bechara et al., 1994) as a more ecologically valid task, in which the visual aspects appear more like cards. The position of the cards and the cards themselves were counterbalanced to control for bias and as profitability could be distinguished, reversal learning was not required.

2.4.3.4. Metacognitive (Mind in the Eyes task; Baron-Cohen et al., 2001). The metacognitive function is a higher order processing that involves the ability to empathise (Stuss, 2011b), theory of mind and awareness of self and others' mental states (Cicerone et al., 2006). The Mind in the Eyes task (Baron-Cohen et al., 2001) assesses each participant's ability to read emotion from eyes presented on pictures and is classified as an advanced theory of mind task (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). Therefore, the task was selected to measure the metacognitive function.

Participants are required to pick one of four words that describes what the person is thinking or feeling from 28 photos of the eye region of the face. Some of the words are basic emotions (Ekman, 1992) (happy, sad, angry, afraid) while others are more complex states (reflective, arrogant, scheming, planning). Three of the four words are foil mental state terms and the position of the words are randomised for each item.

The original task was designed for adults as an advanced theory of mind task (Baron-Cohen et al., 1997). The results also mirrored that of the standard theory of mind task (Happé, 1994). In addition, the poor performance on the task by individuals with autism or

Asperger syndrome was shown to demonstrate poor theory of mind and not due to difficulties in subtracting social information from limited cues, or to deficits in basic emotion recognition (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997).

The task has been used on children from 6-12 years old (Baron-Cohen et al., 2001). It has been demonstrated as a reliable measure in 9-17 year olds (Tonks, Williams, Frampton, Yates, & Slater, 2007a) and on children with brain injury (Tonks et al., 2007b). The Mind in the Eyes task is used to measure metacognitive functioning (Stuss, 2007), as it tests the ability to understand mental states of others, which includes both affect and non affective (cognitive) mental state terms (Baron-Cohen et al., 2001). Research suggests that the Mind in the Eyes task activates the posterior superior temporal sulcus, with early adolescents showing additional involvement of medial PFC, inferior frontal gyrus and the temporal lobe (Moor et al., 2012).

A limitation of the task is that the demand is simpler than real social situations, particularly as the stimuli are presented as static (Baron-Cohen et al., 2001). In addition, the task is considered as an 'emerging' measure, as there is currently no published normative or standardised data on children and adolescents (McCauley et al., 2012).

2.5. Ethical Considerations

The protocol design followed guidelines from the British Psychological Society (Cooper, Turpin, Bucks, & Kent, 2005), the Medical Research Council (2007) guidelines on research involving children, and the National Children's Bureau (NCB) guidelines for research with children and young people (Shaw, Brady, & Davey, 2011).

The researcher sought advice from the Youth Justice Board (YJB) for England and Wales research office in relation to the level of ethical approval required for recruiting from youth offending services (YOS) in the community. The YJB advised that the individual YOS grant approval and that YJB and National Offender Management Service (NOMS) approval was not required.

Following research proposal peer review approval from the University of East Anglia's (UEA) Doctorate in Clinical Psychology's academic staff, approval was sought from the UEA's Research Enterprise and Engagement department to secure the required insurance and indemnity cover for the research project (Appendix I). The researcher subsequently obtained ethical approval from the UEA's Faculty of Medicine and Health Sciences Research Ethics Committee (reference 2012/2013-53; Appendix J). Due to the involvement of five YOS covering five children's services, approval was sought from the Association of Directors of Children's Services Ltd (ADCS; reference: RGE130314, Appendix K). Only some of the areas (Cambridge, Norfolk and Suffolk) required further individual county council research governance approval (Appendix L).

2.5.1. Consent. Individuals who met inclusion criteria in the services, were given an information sheet for themselves and their parents if under 16 years old (Appendices A and B). If individuals were interested in participating then they were asked by their worker to consent to complete an initial screen and for the researcher to be informed of their screen (Appendix D) or alternatively the compliment slip (Appendix E). They were then given the information packs and the researcher's study contact details if they had any further questions. At the assessment session, individuals were fully informed about the research study, they had the opportunity to ask any questions and were given the opportunity to opt in to the research (Shaw et al., 2011). Adolescents under 16 years of age provided assent agreeing to participate in the study (Appendix M) in addition to consent from either their parent/ guardian (Appendix N). If the young person was in the care of the Local Authority (subject to a Care Order), the researcher sought consent from the Local Authority via the young person's social worker. Written consent was sought from adolescents 16 years and over (Appendix O).

The study intended to recruit people aged 16 or 17 years who have capacity to consent, as defined in the Mental Capacity Act (HM Government, 2005). In line with the Act, all 16 and 17 year olds were assumed to have capacity to consent. If it was decided that the young person did not have that capacity then they would have been excluded from the research. This was not the case for any of the participants.

2.5.2. Deception and coercion. No deception was involved in this research project. Participants were fully informed of the purpose of the investigation before they consented to participate. To protect against possible coercion, individuals were initially informed about the study by their case workers and not the researcher.

The information sheets explained the purpose of the research, procedure, confidentiality, dissemination and stated that they can withdraw from the research at any point without any adverse consequences and it would not affect their involvement with the referring service (Shaw et al., 2011). Participants were entered into a prize draw to win a £30 shopping voucher.

2.5.3. Confidentiality and data protection. Confidentiality was preserved throughout, in line with Data Protection Act (HM Government, 1998). Once participants had consented to the research they were assigned a participant number, which was used on all of the assessment data. The participant number information was stored separately from the assessment data. The paper format data were stored in a locked filing cabinet. Participants were informed that, if they withdrew from the research, they could have their data destroyed up to the point of the results being analysed.

Electronic data were anonymised and password protected. To follow Good Practice Guidelines (Cooper et al., 2005) after the completion of the study, data will be stored for a minimum of 5 years with an archived company that the UEA Medical School use off-site from the UEA.

The researcher followed guidance from the Royal College of Psychiatrists College Report guidelines on Confidentiality and Information Sharing (Royal College of Psychiatrists, 2010). The guidance discusses the rule of proportionality that considers the terms of specificity and imminence and defines the definition of a serious crime, which warrants breaking confidentiality. The researcher adhered to these guidelines and thus was obliged only to report disclosed crimes after considering proportionality and seriousness through a discussion with the research supervisor. Reporting of disclosed crimes was not required in this study.

2.5.4. Protection from harm. The researcher followed an incident reporting procedure that stated in the improbable event that a participant was exposed to physical or psychological harm during the study and/or appeared distressed, the assessment would be discontinued and the participant debriefed. If the participant was under 16 years old, then the parents/guardian would be contacted and the team member who referred him/her for assessment would be notified. An incident record log was created to record any such events. No incidents occurred during the research study.

In addition, a procedure was designed so that if the research assessment indicated that a participant who had self-reported a TBI had significant deficits on the tasks associated with frontal lobe functioning compared to other participants and these were not known by the referring service, then the researcher would discuss the results with the research supervisor. The task performance would also be considered in light of the participant's engagement with the task.

If necessary, the participant would be provided with a letter to take to his/her GP (Appendix P). This was procedure was not required to be implemented for any of the participants.

A protocol regarding the researcher's personal security during the data collection process was established and adhered to throughout.

2.5.5. **Debriefing.** Participants were given a debrief sheet after the assessment (Appendix Q), and were given the opportunity to opt in to receive an overview of the research and results once the research had been completed.

2.6. Procedure

The assessments were conducted in either the YOS, education centre or the participant's home and lasted approximately an hour with breaks. The researcher completed the full informed consent procedure at the start of the assessment session (see Section 2.5.1).

To reduce the possibility of an interaction between test order and fatigue, each participant was given the assessments in a different random order (Coolican, 2004). The order of assessments was randomised by using a Microsoft Excel worksheet to establish all of the possible permutations for the order of the seven assessments, which was calculated as 5040 variations. Each permutation was then assigned a random number between 0 - 5040 and the permutations and random numbers were then sorted and the lowest 36 random numbers were selected.

Previous research recognises that there are certain challenges in engaging young offenders in research, and in particular, research assessments (Holt & Pamment, 2011). Young offenders often have difficulties maintaining attention and concentration, with a recommended research interview time of up to 20 minutes before a break (Holt & Pamment, 2011). However, as this research was using a combination of tasks, including engaging computer-based tasks, a

60-70 minute session was deemed appropriate with the inclusion of a break of 5 to 10 minutes if required. Service leads and clinicians concurred with the appropriateness of the session time.

The approximate time of the assessment session was 70 minutes and included a break to prevent fatigue: demographic data collection (5 minutes), SMFQ (5 minutes) WISC-IV (15 minutes), colour-word interference (5 minutes), Mind in the Eyes (10 minutes), IRT (25 minutes) and detection and identification reaction time tests (5 minutes).

2.7. Analysis Plan

2.7.1. Demographics data. All analyses were conducted on SPSS 19 (IBM Corperation, 2010). Data on mean age, IQ, SES, and SMFQ scores were visually inspected in SPSS 19 (IBM, 2010) for missing data, incorrect inputted data, and outlier scores using histogram and box plot outputs.

Data were examined to investigate whether they met the assumptions required for parametric analysis. One such assumption is that the data are normally distributed, which is examined using skewness and kurtosis z scores, and the Shapiro-Wilk test. Further assumptions of parametric data is that the data should be measured on at least the interval level, and have homogeneity of variance, with equal variances between the groups and the participants in each group should be independent of each other (Field, 2005).

2.7.2. Main analysis. The aforementioned data inspection, descriptive statistics and parametric assumption tests (Section 2.7.1) were additionally conducted on the main outcome measures. See Appendix S for a summary of results. The mean scores of each group (TBI and non-TBI) were then compared for each of the four tests of frontal lobe functioning: detection and identification tasks (Cogstate task; Westerman et al., 2001), colour-word interference task (DKEFS; Delis et al., 2001), the Intuitive Reasoning Task (IRT; Dunn et al., 2010) and the Mind in Eyes task (Baron-Cohen et al., 2001) to test for significance. Due to clear a priori hypotheses and only four comparisons, corrections for multiple comparisons were not required.

Data were additionally examined to investigate whether it was appropriate to conduct analyses of covariance (ANCOVA). These assumptions include those for parametric analysis, such as that the data are interval scaled, normally distributed and there is homogeneity of variance across the different groups (see section 2.7.1). The additional assumptions for an ANCOVA analysis include that there should be a 'reasonable' correlation between the dependent variable and the covariate, within the range of 0.30 and 0.90 (Mayers, 2013). Further examination should indicate whether the covariate is independent of the independent variable. If covariates do not significantly vary between the groups, then they can be used to reduce error variance. Alternatively, if there are significant differences between the groups, then the potential impact of the confounding variables can be examined (Mayers, 2013). It is worth noting that some authors claim that when the independent variable is observed and not manipulated, as in this study, then the aforementioned assumption of the independence of the covariate and independent variable is not pertinent (Grace-Martin, n.d.).

A further assumption is homogeneity of regression slopes, which assumes that the relationship is true for both groups of participants and so the correlation between the dependent variable and covariate is similar across the independent variable groups (Field, 2005; Mayers, 2013). When multiple covariates are examined, these should not be correlated with each other. If these assumptions are not met then it is not appropriate to conduct an ANCOVA, particularly as the groups sizes are unequal, as the analysis is not robust to violations (Field, 2005).

2.7.2.1. Hypothesis one. The main outcome variable for the detection and identification task on the Cogstate task (Westerman et al., 2001) is the speed of performance for correct answers, with lower scores indicating better performance. As the data for the TBI group for both the tasks were non-parametric, they were visually inspected for outliers on the box plots. The same participant was an outlier for both tasks and had been distracted throughout the task. Removal of this outlier produced normally distributed data and so independent t-tests were conducted to compare group means. As there were clear directional hypotheses (see section 1.9), then one-tailed tests were employed, so the SPSS standard two-tailed output was divided by two (Field, 2005). To establish effect sizes, the t-score and degrees of freedom were utilised to calculate *r*-values (Field & Hole, 2012). Standard parameters of effect sizes were adhered to: small effect ($r = .10$), medium effect ($r = .30$) and large effect ($r = .50$) (J. Cohen, 1988).

2.7.2.2. Hypothesis two. The main outcome measure for the colour-word interference task is the completion time scores that are converted to age equivalent scaled scores. The participants completed all of the four conditions on the DKEFS task (Delis et al., 2001). The traditional colour-word interference is condition three, which is a measure of inhibition, but additional exploratory analysis will examine the inhibition/switching task that measures inhibition and cognitive flexibility. The colour-word interference inhibition data for both groups met parametric assumptions and therefore an independent t-test was conducted to compare group means. Further exploratory analysis investigated mean error frequency scores and, as these data were non-parametric, a Mann-Whitney U test was conducted. The inhibition/switching task scaled score data were non-parametric and a further Mann-Whitney U test was employed. The inhibition/scaled error means were parametric and so an independent t-test was conducted.

Further exploratory analysis revealed that the inhibition vs naming contrast score data were normally distributed but had a significant Levene's score, but the inhibition/switching vs combined naming plus reading contrast scores were parametric. Two tailed test statistics were utilised for the exploratory analysis as there were no directional hypotheses for these analyses.

2.7.2.3. Hypothesis three. The main outcome measure for the IRT task is the total profitable deck selections minus the total unprofitable deck selections. The IRT scores were non-parametric and so a Mann-Whitney analysis was again employed to compare groups on this dependent variable. An effect size estimate of *r* was calculated by dividing the z score by the square root of the total number of observations (Field, 2005).

2.7.2.4. Hypothesis four. The main outcome measure for the Mind in the Eyes test (Baron-Cohen et al., 2001) is the amount of correct answers. The Mind in the Eyes mean correct score was parametric and an independent t-test was conducted to compare for group differences.

Chapter 3: Results

3.1 Introduction

This chapter outlines the results of the study. An outline of the data preparation, including testing for parametric assumptions, reliability of some of the measures and matching of the groups are presented first. The results from each of the research question will then be presented followed by a summary of the research findings.

3.2 Data Preparation

Data were entered on a database on SPSS 19 statistical package (IBM Corperation, 2010).

3.2.1. Missing data. The data base was visually inspected for missing data and incorrectly inputted data. Each participant completed the Mind in the Eyes task. One participant in the TBI group declined to complete the SES questions, SMFQ, IRT, detection and identification tasks, colour-word interference and vocabulary test, and so a FSIQ could not be calculated. One other participant from the TBI group declined to complete the colour-word interference task. All the participants in the non-TBI group completed every task and measure.

3.2.2. Testing parametric assumptions. Histograms and box plots were initially visually inspected for outliers and the form of the distributions (Appendix R). The data were also examined to see if parametric data assumptions were met (Appendix S). Central to this is the assumption of a normal distribution, which was examined by calculating the value of skewness and kurtosis and converting the scores to z scores (Field, 2005). These values were converted to z scores by subtracting the mean of each distribution by the standard deviation of each distribution, to examine if the data were significantly different to normally distributed data (Field, 2005). If a z score is greater than 1.96 then the data is significantly different than what would be expected in a normal distribution at $p < .05$. The Shapiro-Wilk test was conducted to further examine whether the data were normally distributed. The test compares the scores in the sample to a set of normally distributed scores with the same mean and standard deviation (Field & Hole, 2012). The Shapiro-Wilk test is more accurate than the Kolmogorov-Smirnov test of normality, with a significant value suggesting deviation from normality (Field, 2005). Results that were non-significant suggested that the data were normally distributed, at least within the limits of acceptability for parametric analysis.

Homogeneity of variance was examined using the Levene's test on SPSS (Jones, 2010). Non-significant scores indicated that the difference between the variances was approximately zero and that the assumptions of homogeneity of variance has not been violated. If Levene's test result was significant, then the data were reported from the SPSS output stating 'equal variances not assumed'.

3.2.2.1. Examination of distributions for potential confounding variables. The distribution for age, gender, SES, IQ and SMFQ scores were examined to determine the appropriate analysis to be conducted to ascertain whether the groups were matched on these variables. An error by the researcher on the scaling of the first SES question was identified. The first question "Does your family own a car, van or truck?" was designed to have three responses: no (0), one (1), two or more (2). The question provided to participants only had the choices no (0) or yes (1) and so the total score participants could receive was eight, not nine as in the original measure. The original measure then used an ordinal scale to classify SES into categories. As the scoring differs from the original, categorical classifications of SES based on total score were not made. Instead, the total SES scores were compared across groups and classifications were not distinguished. The age, SES total score, and SMFQ score for the TBI group had a significant Shapiro-Wilk score, and the SMFQ additionally had a significant z skewness score and therefore were not normally distributed. The scores for both groups met the parametric assumptions for FSIQ.

The confounding variable of gender was categorical in nature and thus was examined using a Chi-Square test. As one of the frequencies for the gender analysis fell below five, which violates an assumption of the Chi-Squared test, the Fisher exact probability test statistic was utilised (Howitt & Cramer, 2014).

In summary, age, SES, and SMFQ data were not normally distributed, whereas IQ was normally distributed. A summary of the parametric analysis results are presented in Appendix S.

3.2.2.2. Examination of distributions for dependent variables. Analysis of the TBI group's data for both the detection and identification tasks showed significant z scores for kurtosis, skewness, Shapiro-Wilk and Levene's. Histograms and box plots were inspected for outliers and the same participant was an outlier in both results (Participant one). Researcher observation from the assessment noted that the participant was distracted throughout the task. When this outlier was removed, both the simple and choice reaction time test data met parametric assumptions and subsequently parametric tests were employed.

The data for both the TBI and non-TBI group for the colour-word interference inhibition scaled score met the parametric assumptions and thus parametric tests were conducted. The inhibition error scaled scores for the non-TBI group were not normally distributed with a significant Shapiro-Wilk score. The contrast score inhibition versus colour naming data for both groups met parametric assumptions.

The additional outcome of the inhibition/switching condition scaled score of the colour-word interference task had a significant Shapiro-Wilk score for both the TBI and non-TBI groups. A log10 transformation was employed in an attempt to correct for distributional problems (Field, 2005), but this was unsuccessful and thus non-parametric tests were employed. The inhibition/switching errors data for both groups were parametric. The contrast score for the inhibition/switching versus combined naming plus reading data met parametric assumptions for both groups.

The IRT data for the TBI group did not meet parametric assumptions as it violated normality with a significant z skewness score and Shapiro-Wilk score. The Mind in the Eyes data met parametric assumptions for both groups.

In summary, the following data met the assumptions to conduct parametric analyses; detection and identification reaction times, colour-word interference inhibition scaled score, inhibition/switching versus combined naming plus reading data, inhibition/switching errors and the Mind in the Eyes. A summary table of the parametric analyses for the main variables is presented in Appendix S.

3.2.3. Group equivalence. The age of the TBI group (*Mdn* = 14.5) did not significantly differ from the age of the non-TBI group (*Mdn* = 15), *U* = 120, z = -1.02, *p* = .31. There was no significant difference between the groups for gender between the TBI group (2 females, 18 males) and non TBI group (5 females, 10 males), χ^2 (1, *N* = 35) = 2.92, exact *p* = .2, two tailed. The aforementioned findings suggest that the groups were matched on age and gender.

3.2.4. Confounding variables. The literature and previous research recommended consideration of IQ, SES and depression as possible confounding variables (see section 1.8.1). With respect to depression, a Mann-Whitney U test revealed that the SMFQ depression score for the TBI group (*Mdn* = 5) did not differ significantly from the non-TBI group (*Mdn* = 6), *U* = 124, *z* = -.64, *p* = .53 (two tailed test). Both of these scores are below the clinically significant cut off for depression, which is a score of 8 or more (Thapar and McGuffin, 1998).

A Mann-Whitney U test indicated that the SES total scores for the non-TBI group were significantly higher (*Mdn* = 6) than for the TBI group (*Mdn* = 3.5), *U* = 75.5, *z* = -2.53, *p* = .01 (two tailed). Caution is required, however, when interpreting the SES scores due to the aforementioned error in the scoring system, which is why the scores have not been categorically classified.

An independent t-test revealed that the FSIQ of the TBI group (*M* = 80.16, *SD* = 12.66) was significantly lower than the FSIQ of the non-TBI group (*M* = 90.27 , *SD* = 14.87), *t*(32) = 2.14, *p* =.04. A total of 6.7% of the non-TBI group had a FSIQ less than 70, while 26% of the TBI were so classified.

3.2.5. Examining assumptions for ANCOVA analysis. Data were preliminarily examined to investigate whether the assumptions for an ANCOVA test were met. A full description of these assumptions is provided in the Methods section (2.7.2).

3.2.5.1. Examining the ANCOVA assumptions. The first assumption is that the data met criteria for parametric analysis. The dependent variables that meet these criteria are the detection and identification tasks, Mind in the Eyes task and the colour-word interference inhibition scaled score (see section 3.2.2). The following exploratory variables also meet parametric assumptions: inhibition/switching errors, inhibition vs naming contrast scores and inhibition/switching vs combined naming and reading contrast score. The only covariate that meets parametric assumptions is IQ.

The next assumption is that the covariate and dependent variable are correlated. The correlations between each parametric variable and FSIQ are presented in Table 10 . The only dependent variable that meets the aforementioned criteria is the colour-word interference inhibition scaled score.

Table 10

Pearson Product Moment Correlation Coefficients and Significance Values Between Each Parametric Dependent Variable and FSIQ

Dependent Variable	Correlation
Detection task	-.22
Identification task	-.19
Mind in the Eyes task	.10
Colour-word interference inhibition scaled	.46**
Inhibition/switching errors scaled score	-.39*
Inhibition vs naming contrast score	-.09
Inhibition/switching combined naming and reading contrast score	-.11

Note. *p<.05; ** p <.01.

The independence of the covariate is examined next. As previously mentioned (see section 3.2.4) there were significant differences between the groups on the covariate of IQ. Some authors claim that despite this significant difference, the extent to which the covariate confounds the outcome can still be investigated (Mayers, 2013). Furthermore, some researchers argue that in designs such as this, in which the main independent variable is observed and not manipulated as in an experimental study, then the assumption of the independence of the covariate and independent variable is not applicable (Grace-Martin, n.d.).

The next assumption is that of the homogeneity of regression of slopes, which states that correlations between the covariates and the dependent variables should not significantly differ across groups. The covariate of IQ was examined individually for the two dependent variables that met the previous assumptions (inhibition scaled and inhibition/switching errors scaled score). Neither variable violated the assumption of homogeneity of regression of slopes.

3.2.5.2. ANCOVA assumptions summary. The preceding section has indicated that due to violations of assumptions, only two ANCOVAs could be computed in the analysis, which were the colour-word interference inhibition scaled score and inhibition/switching error scaled scores, both with IQ as the covariate.

3.2.6. Reliability. Reliability tests for the SMFQ were computed using Cronbach's alpha on SPSS (IBM Corperation, 2010) .The SMFQ total score had a high reliability coefficient for both groups, at Cronbach's $\alpha = .869$ for the TBI group and $\alpha = .892$ for the non-TBI group.

3.3. Main Analysis

3.3.1. Hypothesis one. The first hypothesis was that young offenders with a TBI will have slower reaction times on the detection and identification tasks than young offenders without a TBI (Cogstate task; Westerman et al., 2001).

3.3.1.1. Detection task. The primary outcome for the task is the speed of correct responses in milliseconds, which met parametric assumptions after the removal of the outlier in the TBI group. The mean reaction time for the TBI group ($M = 2.46$, $SD = 0.06$) did not significantly differ from the non-TBI group ($M = 2.43$, $SD = 0.05$), $t(31) = -1.62$, $p = .06$.

3.3.1.2. Identification task. The primary outcome for the task is the speed of correct responses in milliseconds, which met parametric assumptions when the outlier was removed from the TBI group. The mean reaction time for the TBI group (*M* = 2.7, *SD* = 0.07), did not differ significantly from the non-TBI group (*M* = 2.65, *SD* = 0.09), *t*(31), = -1.56, *p* = .07.

3.3.2. Hypothesis two.

3.3.2.1. Inhibition task. The second hypothesis is that young offenders with a TBI will have lower scaled scores on the colour-word interference task than young offenders without a TBI (DKEFS; Delis et al., 2001). The inhibition colour-word interference task met parametric assumptions for both groups. The TBI group had a lower mean inhibition scaled score (*M* = 8.89, *SD* = 3.23) than the non-TBI group (*M* = 10.2, *SD* = 2.96). An independent t-test indicated that this difference was not significant, *t*(31) = 1.21, *p* =.12. This finding is not changed when IQ has been applied as a covariate, *F*(1,30) = .08, *p* = .77. The error scaled scores were compared between the groups and did not meet parametric assumptions. The non-TBI group's inhibition error scaled score was significantly higher (*Mdn* = 11) than the TBI group (*Mdn = 7*), *U* =84, *z* = -1.86, *p* =.03, *r* =- .32.

The contrast score inhibition vs colour naming was additionally examined as this factors out the naming ability on the inhibition task. Both groups had a significant Levene's statistic and therefore the 'equal variances not assumed' statistics were utilised. There was no significant difference between the non-TBI group's mean inhibition vs naming contrast score (*M* = 9.93, *SD* = 1.33) and the TBI group (*M* = 10.72, *SD* = 3.34), *t*(23) = -.92, *p* = .37 (two tailed). Furthermore, the means of both groups are between the threshold of 8 to 12, which would suggest equivalent performance on the inhibition and the naming score (Delis et al., 2001).

3.3.2.2. Inhibition/switching task. Further analysis was conducted to investigate whether there were group differences on the inhibition/switching condition of the task, which investigates cognitive flexibility and verbal inhibition. The data did not meet parametric assumptions. The inhibition/switching scaled score for the TBI group (*Mdn* = 8.5) did not differ significantly from the scaled for the non-TBI group (*Mdn* = 10), *U* = 106, *z* = -1.06, *p* = .3 (two tailed).

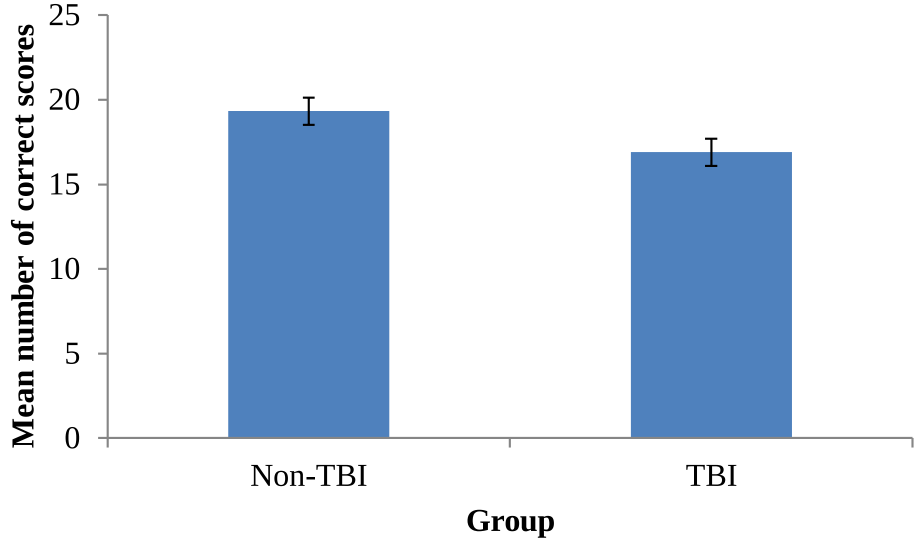
Further analysis was conducted to investigate whether there were differences between the groups in errors made as this was not included in the other scaled scores. These data met the parametric assumptions. There was no significant difference between the error scaled score in the non-TBI group (*M* = 9.73, *SD*= 2.58) and the TBI group (*M* = 8.17, *SD* = 3.03), *t*(31) = 1.58, *p* = .12 (two tailed). This finding is not changed when IQ has been applied as a covariate, *F*(1,30) = .72, *p* = .40 (two tailed).

The inhibition/switching versus combined naming plus reading contrast measure was examined as this factors out the performance of naming and reading on the inhibition/switching task. The data met the parametric assumptions. There was no significant difference between the mean contrast scores for the non- TBI group (*M* = 8.27, *SD* = 2.91) and TBI group (*M* = 9.56, *SD* = 2.75), *t*(31) = -1.31, *p* = .21 (two tailed). Both groups were in the range of contrast scores that suggested that their performance was equivalent on the lower level reading and naming tasks to the higher level inhibition/switching.

3.3.3. Hypothesis three. The third hypothesis is that young offenders with a self-reported TBI will have lower scores on the Intuitive Reasoning Task (IRT; Dunn et al., 2010) than young offenders without a TBI. The scores for the TBI group were not normally distributed with a significant z skewness score and Shapiro-Wilk test. There were too many outliers to remove as this could have affected the validity of the results. Instead, a log10 transformation was employed to correct for distributional problems (Field, 2005). The transformation was unable to correct for the distributional problems and so the original scores were used. A non-parametric one-tailed Mann-Whitney U test revealed that the IRT scores for the TBI group (*Mdn* = 3) were significantly lower than for the non-TBI group (*Mdn* = 28), $U = 87$, $z = -1.74$, $p = .04$, $r = -.3$.

3.3.4. Hypothesis four. The fourth hypothesis is that young offenders with a self-reported TBI will have lower scores on the Mind in the Eyes task (Baron-Cohen et al., 2001) than young offenders without a TBI. The data for both groups met the parametric assumptions. The participants in the TBI group had a lower mean score (16.9, $SD = 3.63$) on the Mind in the Eyes task than the non-TBI group ($M = 19.3$, $SD = 2.97$). An independent t-test revealed that this difference was significant, $t(33) = 2.12$, $p = .02$, $r = .35$. The means are presented in Figure 2.

Figure 2. Means and standard error of mean bars on the Mind in the Eyes task for both groups.



3.4. Summary of findings

The findings suggest that the TBI and non-TBI groups were matched on age and gender. There were no significant differences in SMFQ scores, which suggest that both groups were self-reporting similar levels of sub-clinical depressive symptoms.

The non-TBI group had significantly higher FSIQ than the TBI group, with the non-TBI group's mean classified in the 'average' range, whilst the rounded mean for the TBI group is within the 'low average range'. Both groups included participants with a FSIQ less than 70, which could suggest they meet the criteria for a learning disability but had not been excluded from the research as this had not been formally diagnosed prior to the research. A caveat to this finding is that there were limitations to the IQ subtests and statistical difficulties in controlling for IQ. The matrix reasoning subtest scores can be affected by level of impulsivity as participants who are more impulsive may chose the distracter answer quickly (Wechsler, 2011). Furthermore, the vocabulary subtest could be affected by engagement in education, which may have been limited in the sample recruited in this research. The non-parametric data and distribution of the data additionally restricted the statistical analysis and the opportunities to co-vary IQ with the dependent variables.

The non-TBI group also had significantly higher SES scores. As previously mentioned, the SES scores have not been classified into low, medium, high SES, as initially intended, due to a scoring error, but nonetheless, the non-TBI group scored significantly higher than the TBI group.

The first hypothesis was that young offenders with a self-reported TBI will have slower reaction times on the detection and identification tasks than young offenders without a self-reported TBI (Cogstate task; Westerman et al., 2001). This hypothesis was not supported by the results as no significant differences were found between the groups on either tasks.

The second hypothesis was that young offenders with a self-reported TBI will have lower scores on the colour-word interference task than young offenders without a self-reported TBI (DKEFS; Delis et al., 2001). This hypothesis was not supported by the findings as there were no significant differences between the groups on the colour-word interference inhibition task. The inclusion of IQ as a covariate did not alter this finding. Further analysis did reveal that the non-TBI group had significantly higher error scaled scores for the colour-word interference inhibition task than the TBI group. Additional analysis revealed that there were no significant differences on the inhibition/switching task scaled score or number of errors between the groups. Exploratory analysis on the contrast measures indicated that the colour-word interference and inhibition/switching task scores were not affected by either the colour naming or word reading for either of the groups.

The third hypothesis was that young offenders with a self-reported TBI will have lower scores on the IRT (Dunn et al., 2010) than young offenders without a TBI. The results supported this hypothesis as the TBI group had significantly lower scores, indicative of lower intuitive reasoning, compared to the non-TBI group.

The fourth hypothesis was that young offenders with a self-reported TBI will have lower scores on the Mind in the Eyes task (Baron-Cohen et al., 2001) than young offenders without a self-reported TBI. The findings supported this hypothesis, as the TBI group had significantly lower scores on this task than the non-TBI group.

Chapter Four: Discussion

4.1. Chapter Introduction

Previous research evidence suggests that young offenders have similar executive functioning deficits to the non-offending TBI population. A major criticism of this previous research, however, is that often the presence of a TBI is neither recorded nor examined when assessing executive functioning in offenders. Of the studies that do investigate TBI, most only consider moderate to severe TBI that involved medical care and not the plethora of mild TBI cases that may not have sought medical attention. Epidemiological studies have established the high prevalence of TBI within both the adult and young offending populations. There is, however, still a case for further investigation as there is limited research on the neuropsychological and frontal lobe dysfunction of young offenders with TBI and it has been recommended that research should investigate this dysfunction (Williams, 2012; Williams, Cordan, et al., 2010). Therefore, the current study aimed to investigate whether young offenders with a self-reported TBI were found to show poorer executive frontal lobe functioning than young offenders without a self-reported TBI. The participants were assessed on a battery of tasks that are associated with the four domains of frontal lobe functioning established by Stuss (2011a). The research was conducted on a community sample of young offenders due to the limited research in this area for this population.

Previous research has often failed to control for possible confounding variables of IQ, SES and depression. All of the aforementioned variables have been associated with executive and frontal lobe functioning.

The four main dependent variables aimed to investigate the four domains of the model of frontal lobe functioning (Stuss, 2011a): energization, executive cognitive, self-regulatory, and metacognitive functions. It was hypothesised that young offenders with a self-reported TBI will have poorer functioning in each of the four domains than young offenders without a self-reported TBI.

This chapter will first outline the main findings for each of the hypotheses and whether these results support previous research findings. Theoretical and clinical implications will then be presented, followed by a summary of the strengths and limitations of the study. The chapter will end with conclusions, recommendations for future research and an overall summary of the chapter.

4.2. Summary of the Results

The research compared 20 offenders with a self-reported TBI with 15 offenders with no self-reported TBI as a comparison group. The aim was to investigate whether those with a self-reported TBI differed on measures of frontal lobe functioning that included the detection and identification reaction time tests, the colour-word interference task, the IRT task to measure intuitive reasoning and the Mind in the Eyes task.

The results of the study should be interpreted tentatively as the significant findings were from the hypotheses that were underpowered. Furthermore, there were limitations with the control of confounding variables due to the nature of the data and so SES and depression scores were not included in ANCOVAs, and IQ was only included as a covariate for two dependent variables.

4.2.1. Participant characteristics. The sample obtained in this study was of a similar age to those in previous research in which the prevalence rates of TBI within a young offending population has been established (Williams, Cordan, et al., 2010). The percentage of participants in each group in this research, who were currently involved in YOS, were comparable. The non-

TBI group's most frequent recent conviction for this sample was burglary, whereas it was violence f/or the TBI group. There has been varied findings with the association of violence and a history of TBI in previous research. Some researchers have found that with three or more self-reported TBIs, there is an increase in the severity of violent offending (Williams, Cordan, et al., 2010), whereas, in other research there was no such effect (Davies et al., 2012).

The TBI group had a higher amount of previous convictions than the non-TBI group. This finding is similar to previous research that found those with a self-reported TBI had more convictions than other offenders (Williams, Cordan, et al., 2010).

The research used the same screening question and classifications for severity of TBI as previous research, to allow for direct comparisons (Williams, Cordan, et al., 2010). The screen and classifications are additionally being used nationally on the CHAT assessment for both secure and youth offending services (Chitsabesan et al., 2014). The percentage of the TBI group that reported more than one TBI (40%) was similar to previous research on young offenders that found a slightly lower frequency of 32% (Williams, Cordan, et al., 2010). This research found that 10% of the TBI group did not experience LOC, 60% reported a mild TBI, with 10% reporting a moderate to severe TBI and 20% of the group being unable to classify. The prevalence rates were compared to previous research that used the same screening question (Williams, Cordan, et al., 2010). The prevalence of mild TBI in this research (60%) was lower than previous research (74%). The rates of moderate-severe TBI (10%) in this research were lower than previous research (26%), although it is worth noting that 20% of this sample were unable to report the duration of their LOC.

4.2.2. Demographics. The non-TBI group had a significantly higher mean IQ than the TBI group. Despite the study excluding participants who had a diagnosed learning disability, 6.7% of the non-TBI group and 26% of the TBI group had a FSIQ less than 70. The research aimed to measure IQ, as lower IQ has been associated with higher impulsivity (Koolhof et al., 2007), and correlates with attention and executive functioning (Kelly et al., 2002). As the research is cross-sectional, it cannot ascertain cause and effect for the relationship between IQ and TBI, but previous research has suggested that low IQ can be a predictor of violence (Farrington, 1990). As previously mentioned, caution should be employed when interpreting the IQ scores due to the potential confounds of the subtests administered and the limited statistical control of the variable.

The non-TBI group, additionally, had a significantly higher total SES score than the TBI group. It is worth noting that the SES measure was less valid for those who were in care as the answers would not have been representative for their birth families and this could have contributed to the difference. Previous research has proposed that SES is a contributory factor for delinquency and violence (Farrington, 1990; Heimer, 1997), which could suggest that those with lower SES could experience more violent situations, that could have resulted in a TBI.

There were no significant differences between the groups on self-reported depression with both mean scores below the cut off of eight. Scores of eight or above are associated with clinically significant symptoms of depression (Thapar & McGuffin, 1998). This does not support previous research, which has found high rates of depression in the TBI population (Konrad et al., 2011; Kreutzer et al., 2001) and within the young offending population (Chitsabesan et al., 2006; Fazel et al., 2008). One explanation for this could be that as the participants had to volunteer to participate, those with depression may not have wanted to engage with the research and so the sample is not representative of the wider offending population. As noted in the consort diagram (see section 2.3.3), some young people consented to participate but then, due to a deterioration in their mental health, it was deemed inappropriate for them to participate by their case workers.

Four of the participants were under the care of the Local Authority, two participants were in the TBI group, and two from the non-TBI group.

4.2.3. Hypothesis one. The first hypothesis was that young offenders with a TBI would have slower reaction times on the detection and identification task than young offenders without a TBI (Cogstate task; Westerman et al., 2001). This hypothesis was not supported as there were no significant differences between the groups on either of the tasks. The finding would suggest that the presence of TBI in this sample does not impact on the regulating energization component, or potentially that the tasks were not sensitive enough to detect any differences.

4.2.4. Hypothesis two. The second hypothesis was that young offenders with a TBI would have lower scores on the colour-word interference inhibition task than young offenders without a TBI (Delis et al., 2001). There were no significant group differences on the colour-word interference task scaled score and the finding was not changed when IQ was included as a potential covariate. This finding does not support previous research that has reported that those participants with moderate to severe TBI had impaired performance on the Stroop task (Demery et al., 2010; Fenwick & Anderson, 1999). This result may be associated with the lower percentage of participants with a moderate to severe TBI in this sample.

The scaled scores, however, do not consider the error rate during the task, only the speed of completion. Therefore, the error rate was investigated and the current study found that the TBI group demonstrated significantly lower error scaled scores than the non-TBI group on the inhibition task. This could be associated with an increased impulsivity in the TBI group as there were no differences in completion time (Delis et al., 2001). Previous research has found that young offenders with TBI have higher levels of impulsivity (Vaughn et al., 2014). The inhibition vs naming score was additionally analysed to investigate whether performance on the colour-word interference inhibition task was affected by naming ability. There were no significant differences between the groups and the mean score for both groups fell within the range that suggested that their performance was equivalent on the higher level inhibition task relative to the naming task.

The inhibition/switching task score was additionally analysed to investigate both inhibition and cognitive flexibility between the groups. There were no significant group differences on the inhibition/switching task for the scaled score or the error scaled score. This finding is also inconsistent with results from previous research, which has found that individuals with a TBI had impaired cognitive flexibility and inhibition (Anderson & Catroppa, 2005). The inhibition/switching versus combined naming plus reading contrast score was analysed to factor out the performance on the naming and reading on the inhibition/switching task. There were no significant group differences, although, both groups' scores fell within the range that suggested their performance on the inhibition/switching task was not affected by their reading or naming ability.

4.2.5. Hypothesis three. The third hypothesis investigated whether young offenders with a self-reported TBI would have lower scores on the IRT (Dunn et al., 2010) than young offenders without a TBI. The non-TBI group had significantly higher scores on the IRT task than the TBI group, which is suggestive of higher intuitive reasoning. This finding is supportive of previous research that has found those with a TBI have impaired performance on decision-making and gambling tasks (Levine et al., 2005). As the measure has not been formally validated yet, it is not possible to compare the groups' performance against those of a normative sample to determine whether the young offending sample differs from the general population of the same age range.

4.2.6. Hypothesis four. The fourth hypothesis was that young offenders with a self-reported TBI would achieve lower scores on the Mind in the Eyes task (Baron-Cohen et al., 2001) compared to young offenders without a TBI. The non-TBI group had significantly higher scores than the TBI group on the task. This finding supports previous research that has found that children with ABI are poorer at reading emotions than same aged peers (Tonks et al., 2007b). The mean scores for this research study were converted to mean percentage scores and compared to a study that assessed emotion recognition in 9-15 year olds (Tonks et al., 2007a). Tonks et al. (2007a) found that participants who were between 14 and 15 years old had a mean percentage score of 68.2%. This was comparable to the non-TBI group in this study, which had a mean percentage of 68.9%, but was higher than the TBI group, which had a mean of 60%. This would suggest that the non-TBI offending group performed similarly on the task to the normative sample of healthy controls, but that those with a TBI had poorer performance.

4.3. Theoretical Implications

4.3.1. Theory of frontal lobe functioning (Stuss, 2011a). The four main dependent variables in the study were examined to measure the four functional domains of frontal lobe functioning. Stuss and Alexander (2000) proposed that anatomical regions are associated with different functions. The four functional divisions are as follows, regulating energization, executive cognitive functions, behavioural and emotional self-regulatory functions and metacognitive functions. Each of these domains will be considered in turn. A caveat to the following theoretical implications is that each functional domain was examined by one test in this research and therefore may be limited in its ability to assess each domain entirely.

Furthermore, the measures may have involved different abilities that were not captured by the domains e.g., attention, working memory and thus may have additionally affected participant performance. Furthermore, some of the measures used have not been validated in the population from this research and thus caution should be employed when interpreting the results.

4.3.1.1. Regulating energization. This function is associated with the process of self-regulation that can provide initiation to attain goals and maintain concentration (Cicerone et al., 2006). The anterior and superior cingulate have been associated with this particular function (Stuss & Alexander, 2009). The current research used the detection and identification tasks, which are simple and choice reaction time tests, to measure this construct. Simple and choice reaction time tests are recommended by Stuss et al. (2005) and Stuss and Alexander (2007) to measure the regulating energization function. The research found no significant differences between the TBI and non-TBI groups on the two reaction time measures. One possible explanation for this null finding could be that the anterior and superior cingulate areas may not have been affected by the TBI in the TBI population to cause a deficit on the task. Alternatively, the small sample size and range of severity of TBI may have contributed to the null finding or that the task was not sensitive to changes in functioning.

4.3.1.2. Executive cognitive functions. The executive cognitive functions are described as higher level cognitive functions that control lower level automatic functions and are divided into task setting and monitoring (Cicerone et al., 2006). The function is associated with the LPFC. This research study used the colour-word interference task to assess this domain as recommended by previous research (Stuss, 2011a; Stuss & Alexander, 2007). Stuss (2011a) proposed that monitoring and task setting, the components of executive functions, can be assessed by the Stroop task, with an increased amount of errors and false positives with right and left damage respectively. There were no group differences on the colour-word interference inhibition task on their scaled scores. The TBI group, however, had significantly lower error scaled scores than the non-TBI group, which could be associated with difficulties with impulsivity due to the higher frequency of errors. There were no group differences on the inhibition/switching task for either the scaled score or error scaled score. The contrast measures suggested that the scores for both groups on the more complex inhibition and inhibition/switching task were not affected by reading or naming ability.

The findings suggest that young offenders with a TBI completed the inhibition task in comparable times to those without a TBI, but had significantly lower error scaled scores, thus potentially demonstrating more impulsivity. This could suggest that young offenders with a TBI have poorer executive cognitive functions than those without a TBI. The task activates dorsolateral regions (Phillips et al., 2002), and so those with a TBI could have potentially sustained damage to these regions. This would need to be confirmed with neuroimaging research and this damage cannot be definitively ascertained by this study as damage to other areas could contribute to this finding. Furthermore, as the participants on this study were not assessed for ADHD, those who demonstrated more impulsivity could have symptoms of ADHD. A caveat to these findings is that there were no group differences on the more complex task of inhibition/switching that involved inhibition and cognitive flexibility, and the reasons for this are unknown.

4.3.1.3. Behavioural and emotional self-regulatory functions. The behavioural and emotional self-regulatory functions are involved in decision-making and emotional and reward processing (Rolls, 2000). The function is associated with the VPFC area. This research used the IRT to assess this domain as gambling tasks are the recommended to assess difficulties in this function (Stuss, 2011a). Young offenders with a TBI demonstrated lower intuitive reasoning on this measure than those without a TBI, which could suggest that they have poorer behavioural self-regulation functioning and possible VPFC damage.

A caveat to the aforementioned conclusion is the validity of the IRT measure used to assess this domain. As mentioned in section 2.4.3.3, there are no published norms or validity tests for this measure for either adolescents or the brain injury population. Furthermore, the task lacks ecological validity to real life decision making. The participants in this research were not playing the game with real money from which they could win or lose, and so the incentive was less than in some of the previous research.

4.3.1.4. Metacognitive function. The metacognitive function involves the integration of executive cognitive functions and involves self-awareness of the mental states of one-self and others (Stuss et al., 2001). This function is associated with the frontal polar regions. This research used the Mind in the Eyes task to assess this domain as Stuss (2007) described the function as the ability to understand the mental state of others. The TBI group had significantly lower scores on the task than the non-TBI group, suggesting that they had difficulties in reading emotions and thus poor awareness of the mental states of others, that is suggestive of deficits in the metacognitive function.

4.3.1.5. Summary. In summary, young offenders with a self-reported TBI, had poorer performance on tasks that required behavioural and emotional-self regulatory functions, and metacognitive function, with some differences on executive cognitive functions. These findings would suggest that the theory of frontal lobe functioning can be used to distinguish particular deficits in both the young offending population in addition to those with TBI ranging from mild to severe. This current study is not able to make definitive claims on potential areas of damage and only suggests areas of potential damage that have been associated with the tasks in previous research. Furthermore, due to the large amount of reciprocal connections between the frontal areas and wider neuroanatomy (Stuss, 2011a), it would be difficult to associate damage to one area to difficulties on one particular domain. Brain injuries are likely to be more diffuse in nature and affect a wider anatomical area in addition to disrupting the connectivity between anatomical divisions.

One limitation is that there were no group differences on the regulating energization component, which could be due to task specificity, the severity of the TBI, or small sample sizes. It is acknowledged that due to the limited statistical control of the effect of SES, depression and IQ as covariates, caution is required when interpreting between group differences. This will be discussed in more detail section 4.5.5.2 later.

4.3.2. Additional theoretical implications. The main theoretical basis for the research was the aforementioned model of frontal lobe functioning. A brief summary of other theoretical implications will be now presented.

4.3.2.1. Somatic marker hypothesis (A. R Damasio, 1995). This theory has been outlined in more detail in section 1.3.2.4. The IRT in this research is a comparable task to the IGT as they both measure decision making with rewards and punishments. The theory proposes that emotional signalling of somatic states guides decision making and that those with VMPFC lesions do not have the successful development of these somatic markers (Dunn et al., 2006). The study found that those with a TBI had poorer intuitive reasoning and therefore decision making, which could suggest that they have not been appropriately guided by emotional signalling. As this study included those with mild TBIs, the findings support the IRT's sensitivity to these differences in a wide range of severity of TBIs and in this youth offending population.

4.3.2.2. Further theoretical perspectives. The research has not explicitly investigated neuropsychological theories of crime. However, the finding that young offenders with a TBI demonstrate more deficits than those without a TBI on a task of intuitive reasoning and the Mind in the Eyes task, could be considered consistent with the general neuropsychological theories of crime which suggest that offenders have neuropsychological deficits. This association is only tentative and would require more explicit brain behaviour links from additional imaging studies.

Tonks et al. (2008) propose that emotional processing occurs over three levels; intrinsic emotional arousal and control system, sensory/spatial analysis and executive system synthesis. The Mind in the Eyes task involves emotion recognition skills, that are related to the sensory/spatial analysis level. Emotion recognitions skills are said to improve around 11 years of age (Tonks et al., 2007a), but are impaired after an acquired brain injury (Tonks et al., 2007b). The findings in this study suggest that offenders without a TBI have similar ability on the sensory/spatial analysis system level to non-offenders (Tonks et al., 2007a), but those with a self-reported TBI have deficits on this level.

A model proposed by Joliffe and Farrington (2004) suggests that low IQ and low empathy could be caused by executive functioning deficits and that these deficits are linked to offending. For example, executive function deficits could contribute to difficulties in understanding the mental states of others. The findings of this research suggest that those participants with a TBI are assessed to have lower IQ, score lower on a measure of empathy (Mind in the Eyes) and report a higher number of convictions, and thus could provide some support for this model. Any form of causal relationships cannot be inferred from this research and would require further investigation with longitudinal research.

4.4. Clinical Implications

First and foremost, this research has raised general awareness in the services that took part in this research of the high frequency of young offenders with a TBI. Through the use of the screening question, the services identified many more young people who had often experienced multiple TBIs than had been anticipated by these services. The screening question has been incorporated into the CHAT assessment for secure settings and is now being rolled out to YOS (Chitsabesan et al., 2014). Further training and resources should be provided to services working with young offenders to enhance the recognition of and knowledge about TBI and advice on providing the best support for the young person.

The findings of the current study suggest that some young offenders have lower IQ and that this was not always identified by the referring service. This finding is very tentative due to the limitations of the IQ tests used in this research and the limited statistical analysis with IQ as a covariate. Despite these limitations, McKenzie et al. (2012) have additionally found that there is a high proportion of young offenders with unidentified learning disabilities and are developing a screening questionnaire for use within the UK forensic setting.

The research has additionally demonstrated that young offenders with a TBI may have additional potential difficulties with impulsivity, in intuitive emotion-based reasoning and decision making and reading emotional states of others as assessed by the measures used in the current study. These difficulties are additional to any pre-existing difficulties that the young offending population may exhibit. These are important deficits that can potentially impact on their rehabilitation. For example, poorer cognitive flexibility, and decision making are associated with poorer correctional treatment outcomes (Fishbein & Sheppard, 2006). Higher levels of impulsivity are associated with poor executive function and subsequent adolescent risk taking and problem behaviours (Romer, 2010). In relation to impulsivity, there are a range of cognitive behavioural treatments (CBT) for children that include reinforcement contingencies, modelling, problem-solving training and self-statement modification (Bear & Nietzel, 1991). These treatment options could be included in a young person's rehabilitation programme if they were identified as having a TBI and high impulsivity. The aforementioned conclusions should be considered in relation to the limitations of the current research as discussed in section 4.5 and are only preliminary findings in suggesting potential areas of difficulties for young offenders with a TBI.

An emerging evidence base is developing with the use of mindfulness training to improve executive functioning, and in particular attentional functioning. Mindfulness involves an increased focus on one's own thoughts, emotions and actions (Tang, Yang, Leve, & Harold, 2012). It increases top-down reflection and incorporates both the cognitive level of attention, and emotional level, or evaluation to interrupt automatic emotional responses (Zelazo & Lyons, 2012). There is some evidence to suggest that mindfulness training can improve specific aspects of executive functioning e.g., attention, emotional regulation and cognitive control (Tang et al., 2012) in addition to a reduction of behavioural problems in children and adolescents (van de Weijer-Bergsma, Formsma, de Bruin, & Bögels, 2012). Further research in this field, particularly with young offenders would be beneficial.

The finding that young offenders with a TBI performed less well at reading emotions from the eyes of others has important clinical implications. These difficulties could enhance peer and social problems, that may not be managed appropriately by services (Tonks et al., 2008). The evidence base on interventions for individuals with autism spectrum disorder could inform possible interventions for this population. Golan and Baron-Cohen (2006) have designed a Mind

Reading programme for adults to improve recognition of complex emotions, which has shown some promising improvements despite restrictions on generalisation. There is evidence that video modelling can also improve perspective taking skills (Charlop-Christy & Daneshvar, 2003; Reichow & Volkmar, 2010). Goldstein and Winner (2011) proposed that acting training that involves role-playing, can improve empathy and theory of mind in children and adolescents.

The Mind in the Eyes task can additionally be viewed as a measure of empathy (Auyeung et al., 2009), and more specifically, cognitive empathy (Wood & Williams, 2008). As discussed in section 4.3.2.2, Joliffe and Farrington (2004) proposed a model that suggested that deficits in executive functioning are linked to an increase in offending, low IQ and low empathy. The current research provides some evidence for this model as it has demonstrated that individuals with a TBI have some executive frontal lobe difficulties, low IQ, low levels of empathy and an increased amount of convictions. The model proposed by Joliffe and Farrington (2004) would suggest that empathy training would not be associated with reduced offending. Alternatively, interventions that included general CBT skills training that could improve executive functioning, could increase empathy and decrease future offending (Joliffe & Farrington, 2004).

This study has provided preliminary evidence that suggests young offenders with a self-reported TBI potentially have significantly more deficits in some domains than those without a TBI. When considering any possible interventions for children and young people, it is vital to consider the developmental needs of the young person in the context of the development of their brain (Limond, Adlam, & Cormack, 2014). The current research was not able to distinguish between age groups, but has considered the developmental impact having sustained a TBI can have on 12 to 17 year olds. The findings of this study promote the routine screening of TBI within the young offending population, and if a history of TBI is indicated, then, when resources allow, further neuropsychological assessment should be conducted to examine and identify any particular deficits. An individually tailored psychological formulation and intervention can then be developed and implemented for the young person to give them the most appropriate support.

There is an increasing amount of literature and movement towards legal cases seeking to establish a causal relationship between TBI and criminal behaviour, particularly violence, as a defence (Wortzel & Archiniegas, 2013). It is therefore important to note that this research has not aimed to provide any causal explanations for offending behaviour and that the variables measured in this study are only some of a range of factors that could be contributing to offending behaviours. Previous research has found that TBI is linked to offending and more specifically to being in custody at a younger age, to longer sentences, higher recidivism rates and to more violent crimes (Williams, 2012).

4.5. Strengths and Limitations

The strengths and limitations of the study will be evaluated in terms of its methodological characteristics.

4.5.1. Design.

4.5.1.1. Strengths. The advantages of the cross-sectional study design include the ability to investigate multiple outcome variables and low attrition rates (Coolican, 2004; Mann, 2003). Attrition rates are particularly important to consider when researching a difficult to engage sample such as young offenders (Holt & Pamment, 2011). The two offending groups were matched on age and gender.

4.5.1.2. Limitations. There are, however, some disadvantages to cross-sectional designs, as groups may differ on a number of factors other than the specific variables of interest, in this case TBI (Coolican, 2004). In addition, cross-sectional designs cannot differentiate between cause and effect (Mann, 2003). This methodological limitation has been highlighted as a common limitation in the expanding research area of TBI and young offenders, as research cannot ascertain whether TBI preceded offending behaviour (Farrer et al., 2013). Farrer et al. (2013) recommended the research field expand to use cohort studies or case-control studies, and Williams, Cordan, et al. (2010) have recommended longitudinal designs. The researcher considered these alternative designs, but a longitudinal study was not feasible due to the time-constraints of this research project, and it was deemed more appropriate to conduct a smaller cross-sectional study to identify any differences, before a larger cohort study was undertaken.

A between-groups design was employed. However, the design can be less sensitive to detecting significant effects of the independent variable (TBI) due to participant confounding variables and differences (Field & Hole, 2012).

Due to a limited sample size, within group analyses examining type of offence were not feasible, but this could be an area for further research.

4.5.2. Participants.

4.5.2.1. Strengths. A strength of the study was that a priori power calculations (J. Cohen, 1988) were presented to establish appropriate sample sizes, which are absent from most published research. The sample being obtained from community YOS is also a strength of the study as this group is particularly difficult to engage in research (Holt & Pamment, 2011). Conducting research with this population is particularly important as the frontal lobe and executive demands placed on offenders may be particularly high e.g., attending regular statutory contacts, court appearances, engaging in rehabilitation programmes, and meetings with professionals. In addition, previous research (see section 1.5) has concluded institutionalisation can also adversely impact on executive functioning, which is avoided or minimised with the choice to recruit a community sample. The exclusion criteria of having an identified learning disability, being colour-blind or having uncorrected vision was also beneficial in reducing possible further confounding variables on group differences.

The participants were recruited from each YOS in East Anglia, in addition to schools, solicitors, Social Services, and charities. This wide catchment area in terms of locality and service provision is advantageous, as it provides a more representative sample of community young offenders across the region, but at the same time results in a heterogeneous sample.

The study included a roughly equivalent number of female participants in both offending groups, which did not significantly differ across groups. This is a further strength as most of the previous research is with male only samples. However, the sample size was not large enough in this study to compare functioning across gender.

The criteria for a TBI included an injury from mild to severe, and subsequently did not rely on this information from medical records. This is advantageous for this population as the prevalence studies (Williams, Cordan, et al., 2010) have established a high prevalence of this range of injury which would have been missed if medical records were specified as inclusion criteria. Furthermore, many of the participants in the current sample had not received medical care after their injury and thus would not have been included were this criterion imposed.

4.5.2.2. Limitations. As the participants voluntarily consented to participate in the research, they were a self-selected sample as many approached chose not to participate. This could have led to a selection-bias and thus the sample may not be entirely representative of the community youth offending population.

Despite the exclusion criteria of having an identified learning disability, 6.7% of the non-TBI group and 26% of the TBI group had a FSIQ less than 70. Some caution should be implemented in interpreting the full scale IQ due to it being derived from only two subtests, which included a vocabulary test that may have been affected by their poor educational engagement. The participants may have not been previously formally identified as having a learning disability due to limited or sporadic engagement with the educational system and it thus highlights that the needs of some of the population have not been appropriately identified.

Due to recruitment difficulties, the sample size of the non-TBI group was three less than required for some of the hypotheses. The sample size was adequate for hypothesis one investigating energization with the reaction time tests and hypothesis two investigating the executive cognitive function with the colour-word interference task. The sample size was underpowered for hypothesis three assessing the self-regulatory function with the IRT task and hypothesis four investigating metacognitive function with the Mind in the Eyes task. Power is described as the capacity of a test to reject the null hypothesis when it is false (Howitt & Cramer, 2014) and so with underpowered research, there is an increased risk of Type II error of not detecting a difference between groups when one exists (Field, 2005).

4.5.2.3. *Recruitment difficulties.* A range of strategies were implemented to enhance recruitment, including liaising with clinicians during the protocol development, attending team meetings, and regular phone and e-mail liaison with the services (Appendix T). To enhance recruitment, the number of recruitment sites and services were increased, in addition to increasing the age criteria to include 17 year olds. However, the sample recruited was three less than the target calculated in the power analysis in the non-TBI group (see section 2.3.2). One of the explanations for this difficulty was that many of the services were experiencing either service redesign or financial and time constraints. The case workers and educational staff reported that many of their case-load were excluded due to the learning disability exclusion criterion or were in care and they did not have easy access to those with parental responsibility for consent. In addition, the YOS reported their lowest referral rates for some time. Such data is reinforced by recent statistics of a reduction in the numbers of young people entering the youth justice system in addition to a decrease in re-offending rates (Youth Justice Board, 2014).

The most widely reported difficulty from case workers was that the young people did not want to engage in the research and that they often had difficulties in engaging with them themselves. This lack of engagement is common in the population as many find the appointments threatening or can feel suspicious of professionals (Holt & Pamment, 2011). A total of eight appointments were cancelled by the participants, but subsequent appointments were booked, a further three additional participants cancelled their appointment and then later declined to participate. Two participants did not attend their appointments but attended a subsequent appointment, with a further five young people not attending their booked appointment and not wanting a further appointment.

4.5.3. Measures

4.5.3.1. Strengths. As noted in section 1.8.1 previous research often neglects to measure and control for confounding variables such as IQ, SES and mood, which this research aimed to do. A further strength is that when possible, multiple sources were used to corroborate information (e.g., parents and YOS), which was recommended by Moffitt (1990) and Williams, Cordan, et al. (2010). This was not always possible when the young people were either in care or not living with their parents. The TBI screening question has been employed in previous research (section 2.4.1), which is a strength as it allows for comparisons across studies (Dikmen et al., 2001).

The remaining measures were chosen to assess a specific component of frontal lobe functioning as recommended by previous research (Cicerone et al., 2006; Stuss, 2011a), and when possible, were well validated and reliable. The SMFQ had high reliability for both groups in this sample (section 3.2.6).

4.5.3.2. Limitations. There was an error on the SES measure on the demographics form regarding the number of cars in the household. Therefore, SES classifications were not identified and the scale was used with the total score. Furthermore, the measure was less valid in calculating SES for those children in care, as they were often unable to complete the measure for their family of origin.

There are a number of limitations associated with the measure of IQ. The two subtest version of the WISC-IV (Wechsler, 2004) and WASI (Wechsler, 2011) were employed to reduce burden on the participants. The participants may have found the vocabulary subtest more difficult due to a limited educational engagement and thus this may have compromised their overall score.

As with many tests of executive and frontal lobe functioning, the tests employed in this study lacked ecological validity, and thus lack generalisability to real life situations (Coolican, 2004). However, more ecologically valid tests often require multiple executive functions and thus it can be difficult to isolate specific deficits (Ogilvie et al., 2011).

4.5.4. Procedure

4.5.4.1. Strengths. Due to the difficulties with engaging young offenders (Holt & Pamment, 2011), the researcher ensured that, when safe and appropriate, the appointment was conducted where the young person felt most comfortable e.g., at home or at their service/school. This could have had a positive impact on their engagement with the tasks. Furthermore, the order of the administration of the tasks was counterbalanced to ensure the effects of fatigue had less of an impact on results.

4.5.4.2. Limitations. Despite requesting a quiet space for testing, this was not always feasible for home assessments, and so there were sometimes distractions for the participants. Although this could be more representative of real life scenarios, as this was not controlled for across all participants, this could have affected the internal reliability and consistency of the results.

4.5.5. Data analysis

4.5.5.1. Strengths. As previously mentioned, a priori power calculations were conducted and presented to provide transparency about the required sample size for the research. Furthermore, effect sizes were calculated and presented to illustrate the practical and theoretical importance of the results (Fritz et al., 2012). There was a minimal amount of missing data.

4.5.5.2. Limitations.

A number of the confounding variables (age, SES, and SMFQ) and the dependent variables (colour-word interference inhibition scaled score, IRT reasoning score, and inhibition errors) did not meet the requirements for parametric analysis. Therefore, non-parametric analyses were conducted for these data, which have less power than their parametric equivalents (Field, 2005). Due to the number of variables that did not meet parametric assumptions in addition to ANCOVA assumptions, only two ANCOVAs, controlling for a potential confounding variable were calculated. This meant it was not statistically appropriate to include SES and depression as potential confounding variables in the analysis and IQ was only included for two dependent variables. This is a weakness of the analysis, as the results may have been attributed to the differences in SES or IQ between the groups and not to the TBI. A larger sample size is likely to have more of an equal distribution and equal sample sizes would have meant that the ANCOVA would have been more robust to any violations of normality.

4.6. Future Research Recommendations

Future research should be conducted on larger sample sizes, with sufficient power to detect differences between groups and more thorough statistical analysis. A larger sample size could allow for more sub-group analyses that could investigate different offending types e.g., violent or sexual offences. A lot of the previous research on the executive functioning deficits of offenders has been conducted on violent offenders and so it would be interesting to see whether violent and sexual offenders have different deficits.

This study used two groups of young offenders, as it aimed to investigate differences within the sample for those with and without a TBI. Future research could additionally include non-offender matched groups with and without a TBI. This could help distinguish between deficits that young offenders have compared to non-offenders and provide a more accurate comparison than to the published task norms. Many of the previous research studies have only recruited males, whereas this study recruited both genders. It would be interesting to see, in a larger sample, whether there were any gender differences in performance.

The study aimed not to have a long assessment battery to maximise engagement with the study, however, a consequence of this was that, certain other confounding variables were not able to be investigated. For example, alcohol and drug use has been found to be related to greater TBI severity (Davies et al., 2012). High alcohol and drug use could have impacted on performance in this research and it would therefore be beneficial to include as a variable of interest. Williams (2012) also highlights other areas of need for the youth offending population that includes ADHD and post-traumatic stress disorder (PTSD). There is a high prevalence of both of these conditions within the young offending population and particularly the presence of ADHD within the study participants could have impacted on task performance.

As previously mentioned, this study was not designed to determine cause and effect. This is more appropriately investigated in cohort and longitudinal studies (Mann, 2003) that could examine the development of frontal lobe functioning and whether the presence of a TBI during development changes or alters the trajectory of the brain's development.

The evidence base is currently developing in the area that examines the impact a TBI has on young offenders' frontal lobe functioning. Once these research findings further develop, it will be of value to investigate the efficacy of various treatment or skills training programmes for young offenders with a TBI. This research is vital as young offenders often do not access primary health care or mental health services (Williams, 2012) and so the treatment or rehabilitation they receive as part of their order could be one of the few opportunities to provide treatment and support.

4.7. Conclusions and Summary

This study aimed to investigate the frontal lobe functioning of young offenders in the community, both with and without a self-reported TBI. The research sought to examine whether a TBI was associated with increased deficits on a range of tasks. The main outcome measures used in the research were associated with four domains of the frontal lobe model of frontal lobe functioning (Stuss, 2011b). These included energization, executive cognitive, self-regulatory and metacognitive function. The findings of the study should be considered in the context of the methodological weaknesses as discussed in section 4.5. Furthermore, the constructs that were examined are complex and multifaceted and the measures used to assess these may not have been able to assess them entirely.

The study revealed that young offenders with a TBI have significantly lower IQ and SES than those without a TBI. There were no differences on self-report levels of depression between both groups. The TBI group did not differ on reaction times for a simple and choice reaction time test for the energization domain. The TBI group also had comparable scaled scores on the executive cognitive domain assessment using colour-word interference inhibition and inhibition/switching tasks to the non-TBI group, but the TBI group made significantly more errors on the inhibition tasks. The TBI group additionally had poorer intuitive and emotion based reasoning that assessed the behavioural and emotional self-regulatory function on the IRT task and performed less well at reading emotions from eyes on the metacognitive domain compared to the non-TBI group.

The main theoretical implications from the study are in relation to the four domain model of frontal lobe functioning (Stuss, 2011a). Young offenders with a self-reported TBI demonstrated more deficits on tasks that involved the behavioural and emotional, self-regulatory components, executive cognitive and metacognitive functions. The findings have highlighted that the model of frontal lobe functioning is sensitive to a range of TBI severity within a young offending population. The study could potentially provide support for the somatic marker hypothesis (A. R Damasio, 1995) as the young offenders with a TBI were poorer at the IRT task compared to young offenders without a TBI. The IRT measure has been previously associated with the somatic marker hypothesis with bodily responses distinguishing between profitable and unprofitable decks (Dunn et al. (2010).

From a clinical and service perspective, the study highlights the needs of young offenders with a self-reported TBI which may go unrecognised. The specific problems with impulsivity, emotional-decision making and lower levels of empathy could potentially be targeted in an individually developed formulation and rehabilitation programme for young people.

In summary, the findings of this research suggest that young offenders with a self-reported TBI have lower SES, lower IQ, poorer intuitive reasoning, higher impulsivity and are poorer at reading emotions from the eyes of others compared to young offenders without a self-reported TBI. There were no differences between the groups on a self-report measure of depression, on reaction time tests or the time scaled scores of the inhibition or inhibition/switching task.

The conclusions from this study are to some degree influenced by the methodological weaknesses. These limitations include a small sample size, with unequal group sizes, the high proportion of the sample with an IQ less than 70, and the difficulties with examining the effect of confounding variables. Future research should address these limitations and could be extended to include non-offending matched groups for TBI and non-TBI with a greater number of confounding variables being examined. Future evaluation of the efficacy of executive functioning and problem skills training within the context of young offenders with TBI will also be beneficial.

References

Agnew, R. (1985). Social Control Theory and Delinquency: A Longitudinal Test. *Criminology, 23*(1), 47-61. doi: 10.1111/j.1745-9125.1985.tb00325.x

Allen, D. N., Thaler, N. S., Donohue, B., & Mayfield, J. (2010). WISC-IV Profiles in Children With Traumatic Brain Injury: Similarities to and Differences From the WISC-III. *Psychological Assessment, 22*(1), 57-64. doi: 10.1037/a0016056

Alvarez, J. A., & Emory, E. (2006). Executive Function and the Frontal Lobes: A Meta-Analytic Review. *Neuropsychology Review, 16*(1), 17-42. doi: 10.1007/s11065-006-9002-x

American Psychiatric Association. (1987). *Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R)*. Washington, DC: Author.

Anderson, V., & Catroppa, C. (2005). Recovery of executive skills following paediatric traumatic brain injury (TBI): A 2 year follow-up. *Brain Injury, 19*(6), 459-470. doi: 10.1080/02699050400004823

Anderson, V., Jacobs, R., & Anderson, P. J. (2008). *Executive Functions and the the Frontal Lobes. A Lifespan Perspective*. East Sussex: Taylor and Francis Group.

Angold, A., Costello, E. J., Messer, S. C., Pickles, A., Winder, F., & Silver, D. (1993). Development of a short questionnaire for use in epidemiological studies of depression in children and adolescents. *International Journal of Methods in Psychiatric Research, 5*, 237-249.

Auyeung, B., Wheelwright, S., Allison, C., Atkinson, M., Samarawickrema, N., & Baron-Cohen, S. (2009). The Children's Empathy Quotient and Systemizing Quotient: Sex Differences in Typical Development and in Autism Spectrum Conditions. *Journal of Autism and Developmental Disorders, 39*(11), 1509-1521. doi: 10.1007/s10803-009-0772-x

Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559. doi: 10.1126/science.1736359

Baddeley, A. (1996). Exploring the Central Executive. *The Quarterly Journal of Experimental Psychology Section A, 49*(1), 5-28. doi: 10.1080/713755608

Baddeley, A. (2002). Is working memory still working? *European psychologist, 7*(2), 85-97. doi: 10.1027//1016-9040.7.2.85

Baddeley, A., & Hitch, G. (1974). Working Memory. In G. H. Bower (Ed.), *Recent Advances of Learning and Motivation* (pp. 47-89). New York: Academic Press.

Barnes, J. C., & Beaver, K. M. (2010). An empirical examination of adolescence-limited offending: A direct test of Moffitt's maturity gap thesis. *Journal of Criminal Justice, 38*, 1176-1185.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another Advanced Test of Theory of Mind: Evidence from Very High Functioning Adults with Autism or Asperger Syndrome. *Journal of Child Psychology and Psychiatry, 38*(7), 813-822. doi: 10.1111/j.1469-7610.1997.tb01599.x

Baron-Cohen, S., Wheelwright, S., Spong, A., Scahill, V., & Lawson, J. (2001). Are intuitive physics and intuitive psychology independent? A test with children with Asperger Syndrome. *Journal of Developmental and Learning Disorders, 5*(1), 47-78.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry, 38*(7), 813-822. doi: 10.1111/j.1469-7610.1997.tb01599.x

Bear, R. A., & Nietzel, M. T. (1991). Cognitive and Behavioral Treatment of Impulsivity in Children: A Meta-Analytic Review of the Outcome Literature. *Journal of Clinical Child Psychology, 20*(4), 400-412. doi: 10.1207/s15374424jccp2004_9

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior, 52*(2), 336-372. doi: 10.1016/j.geb.2004.06.010

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*(1), 7-15.

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, Decision Making and the Orbitofrontal Cortex. *Cerebral Cortex, 10,* 295-307. doi: 10.10170S1355617705050277

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. (2005). The Iowa Gambling Task and the somatic marker hypothesis: Some questions and answers. *Trends in Cognitive Sciences, 9*(4), 159-162. doi: 10.1016/j.tics.2005.02.002

Bechara, A., Tranel, D., & Damasio, A. R. (2002). The somatic marker hypothesis and decision-making. In F. Boller & J. Grafman (Eds.), *Handbook of Neuropsychology: The Frontal Lobes* (Vol. 7, pp. 117-143). Amsterdam: Elsevier Science.

Belanger, H., Curtiss, G., Demery, J. A., Lebowitz, B. K., & Vanderploeg, R. D. (2005). Factors moderating neuropsychological outcomes following mild traumatic brain injury: A meta-analysis. *Journal of the International Neuropsychological Society, 11*(3), 215-227.

Bennetto, L., & Pennington, B. F. (2005). Executive Functioning in Normal and Abnormal Development. In S. Segalowitz & I. Rapin (Eds.), *Handbook of Neuropsychology: Child Neuropsychology* (Vol. 8, pp. 785-802). Amsterdam: Elsevier Science.

Berman, A., & Siegal, A. W. (1976). Adaptive and Learning Skills in Juvenile Delinquents. A Neuropsychological Analysis. *Journal of Learning Disabilities, 9*(9), 583-590. doi: 10.1177/002221947600900909

Bernier, A., Carlson, S. M., Deschenes, M., & Matte-Gagne, C. (2012). Social factors in the development of early executive functioning: A closer look at the caregiving environment. *Developmental Science, 15*(1), 12-24. doi: 10.1111/j.1467-7687.2011.01093.x

Best, J. R., & Miller, P. H. (2010). A Developmental Perspective on Executive Function. *Child Development, 81*(6), 1641-1660. doi: 10.1111/j.1467-8624.2010.01499.x

Best, J. R., Miller, P. H., & Jones, L. L. (2009). Executive Functions after Age 5: Changes and Correlates. *Developmental Review, 29*(3), 180-200. doi: 10.1016/j.dr.2009.05.002

Betts, J., McKay, J., Maruff, P., & Anderson, V. (2006). The Development of Sustained Attention in Children: The Effect of Age and Task Load. *Child Neuropsychology, 12*(3), 205-221. doi: 10.1080/09297040500488522

Bigler, E. D. (2008). Neuropsychology and clinical neuroscience of persistent post-concussive syndrome. *Journal of the International Neuropsychological Society, 14*(1), 1-22. doi: 10.1017/S135561770808017X

Blakemore, S. J., & Choudhury, S. (2006). Development of the adolescent brain: Implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry, 47*(3-4), 296-312. doi: 10.1111/j.1469-7610.2006.01611.x

Bond, S. (2012). *Gunning Fog Index*. Retrieved from http://gunning-fog-index.com/

Boyce, W., Torsheim, T., Currie, C., & Zambon, A. (2006). The Family Affluence Scale as a Measure of National Wealth: Validation of an Adolescent Self-Report Measure. *Social Indicators Research, 78*(3), 473-487. doi: 10.1007/s11205-005-1607-6

British Psychological Society (2000). *Learning Disability: Definitions and Contexts.* Retrieved from http://www.bps.org.uk/system/files/documents/ppb_learning.pdf

Brower, M. C., & Price, B. H. (2001). Neuropsychiatry of frontal lobe dysfunction in violent and criminal behaviour: A critical review. *Journal of Neurology, Neurosurgery & Psychiatry, 71*, 720-726. doi: 10.1136/jnnp.71.6.720

Cambridge Cognition Ltd. (2014). CANTAB. Cambridge: Author.

Carroll, L., Cassidy, J. D., Peloso, P., Borg, J., von Holst, H., Holm, L., . . . Pepin, M. (2004). Prognosis for Mild Traumatic Brain Injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 43*, 84-105. doi: 10.1080/16501960410023859

Catroppa, C., & Anderson, V. (2003). Recovery and predictors of intellectual ability two years following paediatric traumatic brain injury. *Neuropsychological Rehabilitation: An International Journal, 13*(5), 517-536. doi: 10.1080/09602010343000084

Cauffman, E., Steinberg, L., & Piquero, A. R. (2005). Psychological, Neuropsychological and Physiological Correlates of Serious Antisocial Behavior in Adolescence: The Role of Self-Control. *Criminology, 43*(1), 133-176. doi: 10.1111/j.0011-1348.2005.00005.x

Chan, R. C., Shum, D., Toulopoulou, T., & Chen, E. Y. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology, 23*(2), 201-216. doi: 10.1016/j.acn.2007.08.010

Charlop-Christy, M. H., & Daneshvar, S. (2003). Using Video Modeling to Teach Perspective Taking to Children with Autism. *Journal of Positive Behavior Interventions, 5*(1), 12-21. doi: 10.1177/10983007030050010101

Chitsabesan, P., Kroll, L., Bailey, S., Kenning, C., Sneider, S., MacDonald, W., & Theodosiou, L. (2006). Mental health needs of young offenders in custody and in the community. *The British Journal of Psychiatry, 188,* 534-540. doi: 10.1192/bjp.bp.105.010116

Chitsabesan, P., Lennox, C., Theodosiou, L., Law, H., Bailey, S., & Shaw, J. (2014). The development of the comprehensive health assessment tool for young offenders within the secure estate. *The Journal of Forensic Psychiatry & Psychology, 25*(1), 1-25. doi: 10.1080/14789949.2014.882387

Chretien, R., & Persinger, M. (2000). Prefrontal deficits discriminate young offenders from age-matched cohorts: Juvenile delinquency as an expected feature of the normal distribution of prefrontal cerebral development. *Psychological Reports, 87,* 1196-1202. doi: 10.2466/pr0.2000.87.3f.1196

Cicerone, K., Levin, H., Malec, J., Stuss, D., & Whyte, J. (2006). Cognitive Rehabilitation Interventions for Executive Function: Moving from Bench to Bedside in Patients with Traumatic Brain Injury. *Journal of Cognitive Neuroscience, 18*(7), 1212-1222.

Cohen, A. K. (1955). *Delinquent Boys: The Culture of the Gang*. New York: Free Press.

Cohen, A. K., & Short, J. F. (1958). Research in Delinquent Subcultures. *Journal of Social Issues, 14*(3), 20-37. doi: 10.1111/j.1540-4560.1958.tb01414.x

Cohen, J. (1988). *Statistical Power Analysis for the Behavioural Sciences*. Hillsdale: Erlbaum.

Coolican, H. (2004). *Research Methods and Statistics in Psychology*. Bristol, England: Hodder Arnold.

Cooper, M., Turpin, G., Bucks, R., & Kent, G. (2005). *Good Practive Guidelines for the Conduct of Psychological Research within the NHS*. Retrieved from http://www.psy.ed.ac.uk/psy_research/documents/BPS%20Guidelines%20for%20the%20Conduct%20of%20Research%20within%20the%20NHS.pdf

Crawford, J. R., Gates, S. J., Corral, S., Horn, S., Kooij, A., Tressoldi, P. E., & Vannier, L.-C. (2013). *Formation, scoring and analysis of flexibile short-forms for European versions of the Wechsler Intelligence Scales for Children*. Manuscript in preparation.

Crombie, I. (1996). *The Pocket Guide to Critical Appraisal*. London: BMJ Publishing Group.

Curran, D. J., & Renzetti, C. M. (1994). *Theories of Crime*. MA, USA: Allyn & Bacon.

Currie, C. E., Elton, R. A., Todd, J., & Platt, S. (1997). Indicators of socioeconomic status for adolescents: The WHO Health Behaviour in School-aged Children Survey. *Health Education Research, 12*(3), 385-397. doi: 10.1093/her/12.3.385

Damasio, A. R. (1995). REVIEW: Toward a Neurobiology of Emotion and Feeling: Operational Concepts and Hypotheses. *The Neuroscientist, 1*(1), 19-25. doi: 10.1177/107385849500100104

Damasio, A. R., Anderson, S. W., & Tranel, D. (2012). The Frontal Lobes. In K. M. Heilman & E. Valenstein (Eds.), *Clinical Neuropsychology* (pp. 404-446). Oxford: Oxford University Press.

Damasio, H., Grabowski, T., Frank, R., Galaburda, A. M., & Damasio, A. (1994). The Return of Phineas Gage: Clues About the Brain from The Skull of a Famous Patient. *Science, 264*(5162), 1102-1105.

Darby, D., & Walsh, K. (2005). *Walsh's Neuropsychology. A Clinical Approach*. London: Elsevier.

Davies, R. C., Williams, W. H., Hinder, D., Burgess, C. N. W., & Mounce, L. T. A. (2012). Self-Reported Traumatic Brain Injury and Postconcussion Symptoms in Incarcerated Youth.

The Journal of Head Trauma Rehabilitation, 27(3), E21-E27 doi: 10.1097/HTR.0b013e31825360da

de Luca, C. R., & Leventer, R. J. (2008). Developmental Trajectories of Executive Functions across the Lifespan. In V. Anderson, R. Jacobs & P. J. Anderson (Eds.), *Executive Functions and the Frontal Lobes*. London: Taylor & Francis.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis Kaplan Executive Function System*. San Antonio, TX: The Psychological Corporation.

Demery, J. A., Larson, M. J., Dixit, N. K., Bauer, R. M., & Perlstein, W. M. (2010). Operating Characteristics of Executive Functioning Tests Following Traumatic Brain Injury. *The Clinical Neuropsychologist, 24*(8), 1292-1308. doi: 10.1080/13854046.2010.528452

DePrince, A. P., Weinzierl, K. M., & Combs, M. D. (2009). Executive function performance and trauma exposure in a community sample of children. *Child Abuse & Neglect, 33*, 353-361. doi: 10.1016/j.chiabu.2008.08.002

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64*, 135-168. doi: 10.1146/annurev-psych-113011-143750

Dikmen, S., Machamer, J., & Temkin, N. (2001). Mild Head Injury: Facts and Artifacts. *Journal of Clinical Experimental Neuropsychology, 23*(6), 729-738. doi: 10.1076/jcen.23.6.729.1019

Dreher, J.-C., Koechlin, E., Tierney, M., & Grafman, J. (2008). Damage to the Fronto-Polar Cortex Is Associated with Impaired Multitasking. *PLoS ONE, 3*(9), e3227. doi: 10.1371/journal.pone.0003227

Dunn, B. D., Dalgleish, T., & Lawrence, A. D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience Biobehavioral Review, 30*(2), 239-271. doi: 10.1016/j.neubiorev.2005.07.001

Dunn, B. D., Galton, H. C., Morgan, R., Evans, D., Oliver, C., Meyer, M., . . . Dalgleish, T. (2010). Listening to Your Heart. How Interoception Shapes Emotion Experience and Intuitive Decision Making. *Psychological Science, 21*(12), 1835-1844. doi: 10.1177/0956797610389191

Ekman, P. (1992). Facial Expressions of Emotion: New Findings, New Questions. *Psychological Science, 3*(1), 34-38. doi: 10.1111/j.1467-9280.1992.tb00253.x

Enns, R. A., Reddon, J. R., Das, J. P., & Boudreau, A. (2008). Measuring Executive Functions in Female Delinquents Using the Cognitive Assessment System. *Journal of Offender Rehabilitation, 47*(1-2), 3-23. doi: 10.1080/10509670801940326

Enns, R. A., Reddon, J. R., Das, J. P., & Boukos, H. (2007). Measuring Executive Function Deficits in Male Delinquents Using the Cognitive Assessment System. *Journal of Offender Rehabilitation, 44*(4), 43-63. doi: 10.1300/J076v44n04_04

Farrer, T. J., Frost, R. B., & Hedges, D. W. (2013). Prevalence of traumatic brain injury in juvenile offenders: A meta-analysis. *Child Neuropsychology, 19*(3), 225-234. doi: 10.1080/09297049.2011.647901

Farrington, D. P. (1990). Implications of criminal career research for the prevention of offending. *Journal of Adolescence, 13*(2), 93-113. doi: 10.1016/0140-1971(90)90001-N

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160. doi: 10.3758/BRM.41.4.1149

Fazel, S., Doll, H., & Långström, N. (2008). Mental Disorders Among Adolescents in Juvenile Detention and Correctional Facilities: A Systematic Review and Metaregression Analysis of 25 Surveys. *Journal of the American Academy of Child & Adolescent Psychiatry, 47*(9), 1010-1019. doi: 10.1097/CHI.ObO13e31817eecf3

Fenwick, T., & Anderson, V. (1999). Impairments of Attention Following Childhood Traumatic Brain Injury. *Child Neuropsychology (Neuropsychology, Development and Cognition: Section C), 5*(4), 213-223. doi: 10.1076/0929-7049(199912)05:04;1-r;ft213

Ferguson, P. L., Pickelsimer, E. E., Corrigan, J. D., Bogner, J. A., & Wald, M. (2012). Prevalence of Traumatic Brain Injury Among Prisoners in South Carolina. *Journal of Head Trauma Rehabilitation, 27*(3), E11-20. doi: 10.1097/HTR.0b013e31824e5f47

Field, A. (2005). *Discovering Statistics Using SPSS*. London: SAGE Publications.

Field, A., & Hole, G. (2012). *How to Design and Report Experiments*. London: SAGE Publications Ltd.

Fishbein, D., & Sheppard, M. (2006). *Assessing the Role of Neuropsychological Functioning in Inmates' Treatment Response*. Retrieved from http://ccpoa.org/files/216303_1.pdf

Fooks, G., & Thomas, R. R. (1957). Differential Qualitative Performance of Delinquents on the Porteus Maze. *Journal of Consulting Psychology, 21*(4), 351-353. doi: 10.1037/h0046741

Frencham, K. A., Fox, A. M., & Maybery, M. T. (2005). Neuropsychological Studies of Mild Traumatic Brain Injury: A Meta-Analytic Review of Research Since 1995. *Journal of Clinical Experimental Neuropsychology, 27*(3), 334-351. doi: 10.1080/13803390490520328

Fritz, C. O., Morris, P. E., & Richler, J. L. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology*, *14*(1). doi: 10.1037/a0024338

Fuster, J. (2000). Executive frontal functions. *Experimental Brain Research*, *133*(1), 66-70. doi: 10.1007/s002210000401

Gibbens, T. C. N., Pond, D. A., & Stafford- Clark, D. (1959). A Follow-up Study of Criminal Psychopaths. *The British Journal of Psychiatry*, *105*, 108-115. doi: 10.1192/bjp.105.438.108

Golan, O., & Baron-Cohen, S. (2006). Systemizing empathy: Teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Development and Psychopathology*, *18*(02), 591-617. doi: doi:10.1017/S0954579406060305

Golden, C. (1978). *Stroop Color and Word Test*. Chicago, IL: Stoelting.

Golden, C. (2003). The Adult Luria-Nebraska Neuropsychological Battery. In G. Goldstein, S. R. Beers & M. Herson (Eds.), *Comprehensive Handbook of Psychological Assessment* (pp. 133-146). Hoboken, NJ: John Wiley & Sons, Inc.

Goldstein, T. R., & Winner, E. (2011). Enhancing Empathy and Theory of Mind. *Journal of Cognition and Development*, *13*(1), 19-37. doi: 10.1080/15248372.2011.573514

Gordon, K. E. (2006). Pediatric Minor Traumatic Brain Injury. *Seminars in Pediatric Neurology, 13*(4), 243-255. doi: 10.1016/j.spen.2006.09.005

Gorenstein, E. E. (1990). Neuropsychology of juvenile delinquency. *Forensic Reports, 3*(1), 15-48.

Gorenstein, E. E., & Newman, J. P. (1980). Disinhibitory psychopathology: A new perspective and a model for research. *Psychological Review, 87*(3), 301-315. doi: 10.1037/0033-295X.87.3.301

Gottfredson, M. R., & Hirschi, T. (1990). *A General Theory of Crime*. Stanford, CA: Stanford University Press.

Grace-Martin, K. (n.d.). *When Assumptions of ANCOVA are Irrelevant.* Retrieved from http://www.theanalysisfactor.com/assumptions-of-ancova/

Grasmick, H. G., Tittle, C. R., Bursik, R. J., & Arneklev, B. J. (1993). Testing the Core Empirical Implications of Gottfredson and Hirschi's General Theory of Crime. *Journal of Research in Crime and Delinquency, 30*(1), 5-29. doi: 10.1177/0022427893030001002

Happé, F. G. E. (1994). An Advanced Test of Theory of Mind: Understanding of Story Characters' Thoughts and Feelings by Able Autistic, Mentally Handicapped, and Normal Children and Adults. *Journal of Autism and Developmental Disorders, 24*(2), 129-154. doi: 10.1007/BF02172093

Heimer, K. (1997). Socioeconomic Status, Subcultural Definitions, and Violent Delinquency. *Social Forces, 75*(3), 799-833. doi: 10.1093/sf/75.3.799

Hendrix, K. S., Carney, C. D., & Aalsma, M. C. (2012). Psychological and neuropsychological assessment in the juvenile justice system: Recommendations for protocols. *Criminal Justice Studies, 25*(3), 239-249. doi: 10.1080/1478601X.2012.705530

Henry, L. A., & Bettenay, C. (2010). The Assessment of Executive Functioning in Children. *Child and Adolescent Mental Health, 15*(2), 110-119. doi: 10.1111/j.1475-3588.2010.00557.x

Hewitt, C. E., Perry, A. E., Adams, B., & Gilbody, S. M. (2011). Screening and case finding for depression in offender populations: A systematic review of diagnostic properties. *Journal of Affective Disorders, 128*(1-2), 72-82. doi: 10.1016/j.jad.2010.06.029

Hirschi, T. (1969). *Causes of Delinquency*. Berkeley: University of California Press.

HM Government. (1998). *Data Protection Act.* Retrieved from http://www.legislation.gov.uk/ukpga/1998/29/contents

HM Government. (2005). *Mental Capacity Act.* Retrieved from http://www.legislation.gov.uk/ukpga/2005/9/contents

Holt, A., & Pamment, N. (2011). Overcoming the challenges of researching 'young offenders': Using assisted questionnaires– a research note. *International Journal of Social Research Methodology, 14*(2), 125-133. doi: 10.1080/13645579.2010.507366

Homack, S., Lee, D., & Riccio, C. A. (2005). Test Review: Delis-Kaplan Executive Function System. *Journal of Clinical Experimental Neuropsychology, 27*(5), 599-609. doi: 10.1080/13803390490918444

Howitt, D., & Cramer, D. (2014). *Introduction to Statistics in Psychology*. Great Britain: Pearson Education Limited.

Hughes, N., Williams, H., Chitsabesan, P., Davies, R., & Mounce, L. (2012). *Nobody made the connection: The prevalence of neurodisability in young people who offend*. Retrieved from http://www.childrenscommissioner.gov.uk/content/publications/content_633

Hurt, J., & Naglieri, J. A. (1992). Performance of Delinquent and Nondelinquent Males on Planning, Attention, Simultaneous, and Successive Cognitive Processing Tasks. *Journal of Clinical Psychology, 48*(1), 120-128. doi: 10.1002/1097-4679(199201)48:1<120::AID-JCLP2270480117>3.0.CO;2-5

IBM Corperation. (2010). *IBM Statistics for Windows Version 19.0.* Armonk, NY: IBM Corp.

Iselin, A. M., & Decoster, J. (2012). Unique relations of age and delinquency with cognitive control. *Journal of Adolescence, 35*(2), 367-379. doi: 10.1016/j.adolescence.2011.08.004

Janusz, J. A., Kirkwood, M. W., Yeates, K. O., & Taylor, H. G. (2002). Social Problem-Solving Skills in Children with Traumatic Brain Injury: Long-Term Outcomes and Prediction of Social Competence. *Child Neuropsychology, 8*(3), 179-194. doi: 10.1076/chin.8.3.179.13499

Jeter, C. B., Hergenroeder, G. W., Hylin, M. J., Redell, J. B., Moore, A. N., & Dash, P. K. (2013). Biomarkers for the Diagnosis and Prognosis of Mild Traumatic Brain Injury/Concussion. *Journal of Neurotrauma, 30*(8), 657-670. doi: 10.1089/neu.2012.2439

Joliffe, D., & Farrington, D. (2004). Empathy and offending: A systematic review and meta-analysis. *Aggression and Violent Behavior, 9*(5), 441-476. doi: 10.1016/j.avb.2003.03.001

Jolliffe, D., Farrington, D. P., Hawkins, J. D., Catalano, R. F., Hill, K. G., & Kosterman, R. (2003). Predictive, concurrent, prospective and retrospective validity of self-reported delinquency. *Criminal Behaviour and Mental Health, 13*(3), 179-197. doi: 10.1002/cbm.541

Jones, S. (2010). *Statistics in Psychology, explanations without equations*. Hampshire: Palgrave Macmillan.

Jurado, M. B., & Rosselli, M. (2007). The Elusive Nature of Executive Functions: A Review of our Current Understanding. *Neuropsychology Review, 17*(3), 213-233. doi: 10.1007/s11065-007-9040-z

Kelly, T., Richardson, G., Hunter, R., & Knapp, M. (2002). Attention and Executive Function Deficits in Adolescent Sex Offenders. *Child Neuropsychology, 8*(2), 138-143. doi: 10.1076/chin.8.2.138.8722

Kenny, D. T., & Lennings, C. J. (2007). *The relationship between head injury and violent offending in juvenile detainees.* Retrieved from http://www.bocsar.nsw.gov.au/agdbasev7wr/bocsar/documents/pdf/cjb107.pdf#xml=http://search.lawlink.nsw.gov.au/isysquery/e8227436-88cc-4372-9468-b12fd3238140/1/hilite/

Kinnunen, K. M., Greenwood, R., Powell, J. H., Leech, R., Hawkins, P. C., Bonnelle, V., . . . Sharp, D. J. (2011). White matter damage and cognitive impairment after traumatic brain injury. *Brain, 134*(Pt 2), 449-463. doi: 10.1093/brain/awq347

Kirkwood, M., Janusz, J., Yeates, K. O., Taylor, H. G., Wade, S. L., Stancin, T., & Drotar, D. (2000). Prevalence and Correlates of Depressive Symptoms Following Traumatic Brain Injuries in Children. *Child Neuropsychology, 6*(3), 195-208. doi: 10.1076/chin.6.3.195.3157

Konrad, C., Geburek, A. J., Rist, F., Blumenroth, H., Fischer, B., Husstedt, I., . . . Lohmann, H. (2011). Long-term cognitive and emotional consequences of mild traumatic brain injury. *Psychological Medicine, 41*(6), 1197-1211. doi: 10.1017/S0033291710001728

Koolhof, R., Loeber, R., Wei, E. H., Pardini, D., & D'Escury, A. C. (2007). Inhibition deficits of serious delinquent boys of low intelligence. *Criminal Behaviour and Mental Health, 17*(5), 274-292. doi: 10.1002/cbm.661

Kreutzer, J. S., Seel, R. T., & Gourley, E. (2001). The prevalence and symptom rates of depression after traumatic brain injury: A comprehensive examination. *Brain Injury, 15*(7), 563-576. doi: 10.1080/02699050010009108

Levin, H., & Hanten, G. (2005). Executive Functions after Traumatic Brain Injury in Children. *Pediatric Neurology, 33*(2), 79-93. doi: 10.1016/j.pediatrneurol.2005.02.002

Levine, B., Black, S. E., Cheung, G., Campbell, A., O'Toole, C., & Schwartz, M. L. (2005). Gambling Task Performance in Traumatic Brain Injury: Relationships to Injury Severity, Atrophy, Lesion Location, and Cognitive and Psychosocial Outcome. *Cognitive and Behavioral Neurology, 18*(1), 45-54.

Limond, J., Adlam, A. L. R., & Cormack, M. (2014). A Model for Pediatric Neurocognitive Interventions: Considering the Role of Development and Maturation in Rehabilitation Planning. *The Clinical Neuropsychologist, 28*(2), 181-198. doi: 10.1080/13854046.2013.873083

Loeber, R., Farrington, D. P., Stouthamer-Loeber, M., & Van Kammen, W. B. (1998). *Antisocial Behaviour and Mental Health Problems. Explanatory Factors in Childhood and Adolesence*. Mahwah, NJ: Lawrence Erlbaum.

Loeber, R., Pardini, D. A., Stouthamer-Loeber, M., & Raine, A. (2007). Do cognitive, physiological, and psychosocial risk and promotive factors predict desistance from delinquency in males? *Development and Psychopathology, 19*(3), 867-887. doi: 10.1017/S0954579407000429

Loeber, R., Slot, N. W., & Stouthamer-Loeber, M. (2006). A three-dimensional, cumulative developmental model of serious delinquency. In P. Wikstrom & R. J. Sampson (Eds.), *The Explanation of Crime. Context, Mechanisms and Development* (pp. 153-194). Cambridge: Cambridge University Press.

Luciana, M. (2003). Practitioner Review: Computerized assessment of neuropsychological function in children: Clinical and research applications of the Cambridge

Neuropsychological Testing Automated Battery (CANTAB). *Journal of Child Psychology and Psychiatry, 44*(5), 649-663. doi: 10.1111/1469-7610.00152

Luria, A. R. (1961). *The Role of Speech in the Regulation of Normal and Abnormal Behavior*. Oxford: Pergamon Press.

Luria, A. R. (1966). *Higher Cortical Functions in Man*. Oxford: Basic Books.

Luria, A. R. (1973). *The Working Brain: An Introduction to Neuropsychology*. New York: Basic Books.

Lynam, D., Moffitt, T. E., & Stouthamer-Loeber, M. (1993). Explaining the relation between IQ and delinquency: Class, race, test motivation, school failure, or self-control? *Journal of Abnormal Psychology, 102*(2), 187-196. doi: 10.1037/0021-843X.102.2.187

Mann, C. J. (2003). Observational research methods. Research design II: Cohort, cross sectional, and case-control studies. *Emergency Medicine Journal, 20*, 54-60. doi: R10.1136/emj.20.1.54

Maruff, P., Thomas, E., Cysique, L., Brew, B., Collie, A., Snyder, P., & Pietrzak, R. H. (2009). Validity of the CogState brief battery: Relationship to standardized tests and sensitivity to cognitive impairment in mild traumatic brain injury, schizophrenia, and AIDS dementia complex. *Archives of Clinical Neuropsychology, 24*(2), 165-178. doi: 10.1093/arclin/acp010

Mayers, A. (2013). *Introduction to Statistics and SPSS in Psychology*. Harlow, England: Pearson Education Limited.

McCauley, S. R., Wilde, E. A., Anderson, V. A., Bedell, G., Beers, S. R., Campbell, T. F., . . . Pediatric, T. B. I. O. W. (2012). Recommendations for the Use of Common Outcome

Measures in Pediatric Traumatic Brain Injury Research. *Journal of Neurotrauma*, *29*(4), 678-705. doi: 10.1089/neu.2011.1838

McDermott, L. M., & Ebmeier, K. P. (2009). A meta-analysis of depression severity and cognitive function. *Journal of Affective Disorders, 119*(1-3), 1-8. doi: 10.1016/j.jad.2009.04.022

McKenzie, K., Paxton, D., Michie, A., Murray, G., Murray, A., & Curtis, J. (2012). Screening with young offenders with an intellectual disability. *The Journal of Forensic Psychiatry & Psychology, 23*(5-6), 676-688. doi: 10.1080/14789949.2012.733723

McKinlay, A., Grace, R. C., Horwood, L. J., Fergusson, D. M., & MacFarlane, M. R. (2010). Long-term behavioural outcomes of pre-school mild traumatic brain injury. *Child Care Health and Development*, *36*(1), 22-30. doi: 10.1111/j.1365-2214.2009.00947.x

Medical Research Council. (2007). *MRC Ethics Guide. Medical research involving children*. Retrieved from http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC002430

Menon, D. K., Schwab, K., Wright, D. W., & Maas, A. I. (2010). Position Statement: Definition of Traumatic Brain Injury. *Archives of Physical Medicine Rehabilitation*, *91*(11), 1637-1640. doi: 10.1016/j.apmr.2010.05.017

Merbitz, C., Jain, S., Good, G. L., & Jain, A. (1995). Reported Head Injury and Disciplinary Rule Infractions in Prison. *Journal of Offender Rehabilitation, 22*(3-4), 11-19. doi: 10.1300/J076v22n03_02

Messer, S. C., Angold, A., Costello, J., Loeber, R., van Kammen, W., & Stouthamer-Loeber, M. (1995). Development of a short questionnaire for use in epidemiological studies of depression in children and adolescents: Factor composition and strucutre across development. *International Journal of Methods in Psychiatric Research, 5*, 251-262.

Microsoft Corporation. (2010). *Microsoft Visual Basics.* Retrieved from http://www.visualstudio.com/downloads/download-visual-studio-vs#DownloadFamilies_4

Middleton, J. A. (2005). Acquired brain injury. *Psychiatry, 4*(7), 61-64. doi: http://dx.doi.org/10.1383/psyt.2005.4.7.61

Miller, E. (1999a). Head injury and offending. *The Journal of Forensic Psychiatry, 10*(1), 157-166. doi: 10.1080/09585189908402146

Miller, E. (1999b). The Neuropsychology of Offending. *Psychology, Crime & Law, 5*(4), 297-318. doi: 10.1080/10683169908401774

Miller, E. (2002). Brain Injury as a Contributory Factor in Offending. In J. Glicksohn (Ed.), *The Neurobiology of Criminal Behavior* (pp. 137-153). The Netherlands: Kluwer Academic Publishers Group.

Miller, E., & Asad, W. F. (2002). The Prefrontal Cortex: Conjuction and Cognition. In F. Boller & J. Grafman (Eds.), *Handbook of Neuropsychology: The Frontal Lobes* (second ed., pp. 29-55). Amsterdam: Elsevier Science.

Miller, L. (1988). Neuropsychological Perspectives on Delinquency. *Behavioral Sciences & the Law, 6*(3), 409-428. doi: 10.1002/bsl.2370060309

Ministry of Justice. (2014). *Youth Justice Statistics.* Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/276098/youth-justice-stats-exec_summary.pdf

Mitchell, P., & Shaw, J. (2011). Factors affecting the recognition of mental health problems among adolescent offenders in custody. *Journal of Forensic Psychiatry & Psychology, 22*(3), 381-394. doi: 10.1080/14789949.2011.564644

Mitchell, R. L., & Phillips, L. H. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. *Neuropsychologia, 45*(4), 617-629. doi: 10.1016/j.neuropsychologia.2006.06.030

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" tasks: A Latent Variable Analysis. *Cognitive Psychology, 41*(1), 49-100. doi: 10.1006/cogp.1999.0734

Moffitt, T. E. (1990). The Neuropsychology of Juvenile Delinquency: A Critical Review. *Crime & Justice, 12*, 99.

Moffitt, T. E. (1993). The neuropsychology of conduct disorder. *Developmental Psychopathology, 5*(1-2), 135-151. doi: 10.1017/S0954579400004302

Moffitt, T. E., & Caspi, A. (2001). Childhood predictors differentiate life-course persistent and adolesence-limited antisocial pathways among males and females. *Development and Psychopathology, 13*(2), 355-375.

Moffitt, T. E., & Henry, B. (1989). Neuropsychological assessment of executive functions in self-reported delinquents. *Developmental Psychopathology, 1*, 105-118.

Moffitt, T. E., & Henry, B. (1991). Neuropsychological studies of juvenile delinquency and juvenile violence. In J. S. Milner (Ed.), *Neuropsychology of Aggression* (pp. 67-91). Boston: Kluwer.

Mollica, C. M., Maruff, P., Collie, A., & Vance, A. (2005). Repeated Assessment of Cognition in Children and the Measurement of Performance Change. *Child Neuropsychology*, *11*(3), 303-310. doi: 10.1080/092970490911306

Moor, B. G., Macks, Z. A., Guroglu, B., Rombouts, S. A., Molen, M. W., & Crone, E. A. (2012). Neurodevelopmental changes of reading the mind in the eyes. *Social Cognitive and Affective Neuroscience*, *7*(1), 44-52. doi: 10.1093/scan/nsr020

Moore, E., Indig, D., & Haysom, L. (2014). Traumatic Brain Injury, Mental Health, Substance Use, and Offending Among Incarcerated Young People. *The Journal of Head Trauma Rehabilitation*, *29*(3), 239-247 doi: 10.1097/HTR.0b013e31828f9876

Morgan, A. B., & Lilienfeld, S. O. (2000). A Meta-Analytic Review of the Relation Between Antisocial Behavior and Neuropsychological Measures of Executive Function. *Clinical Psychology Review*, *20*(1), 113-136. doi: 10.1016/S0272-7358(98)00096-8

Naglieri, J. A., & Das, J. P. (1988). Planning-arousal-simultaneous-successive (PASS): A model for assessment. *Journal of School Psychology*, *26*(1), 35-48. doi: 10.1016/0022-4405(88)90030-1

Naglieri, J. A., & Das, J. P. (1997). *Cognitive Assessment System*. Itasca, IL: Riverside.

Nauta, W. J. H. (1971). The Problem of the Frontal Lobe: A Reinterpretation. *Journal of Psychiatric Research, 8*, 167-187.

Norman, D. A., & Shallice, T. (1986). Attention to Action: Willed and Automatic Control of Behaviour. In R. J. Davidson, G. E. Schwartz & D. Shapiro (Eds.), *Consciousness and Self-Regulation: Advances in Research and Theory* (pp. 1-18). New York: Plenum.

O'Keefe, E. J. (1975). Porteus Maze Q Score as a Measure of Impulsivity. *Perceptual and Motor Skills, 41*(2), 675-678. doi: 10.2466/pms.1975.41.2.675

Offender Health Research Network. (2013). *Comprehensive Health Assessment Tool (CHAT): Young People in contact with the Youth Offending Service.* Retrieved from http://www.ohrn.nhs.uk/OHRNResearch/CHATToolYOS.pdf

Ogilvie, J. M., Stewart, A. L., Chan, R. C. K., & Shum, D. H. K. (2011). Neuropsychological Measures of Executive Function and Antisocial Behavior: A Meta-Analysis*. *Criminology, 49*(4), 1063-1107. doi: 10.1111/j.1745-9125.2011.00252.x

Parkin, A. J. (1998). The central executive does not exist. *Journal of the International Neuropsychological Society, 4*, 518-522.

Pears, K., & Fisher, P. A. (2005). Developmental, Cognitive, and Neuropsychological Functioning in Preschool-aged Foster Children: Associations with Prior Maltreatment and Placement History. *Journal of Developmental & Behavioral Pediatrics, 26*(2), 112-122.

Perron, B. E., & Howard, M. O. (2008). Prevalence and correlates of traumatic brain injury among delinquent youths. *Criminal Behaviour and Mental Health, 18*(4), 243-255. doi: 10.1002/cbm.702

Phillips, L., MacPherson, S., & Sala, S. D. (2002). Age, cognition and emotion: The role of anatomical segregation in the frontal lobes. In F. Boller & J. Grafman (Eds.), *Handbook of Neuropsychology: The Frontal Lobes* (pp. 73-97). Amsterdam: Elsevier Science.

Piquero, A. (2001). Testing Moffitt's Neuropsychological Variation Hypothesis for the Prediction of Life-Course Persistent Offending. *Psychology, Crime & Law, 7*(1-4), 193-215. doi: 10.1080/10683160108401794

Polk, K., Frease, D., & Richmond, F. L. (1974). Social Class, School Experience, and Delinquency. *Criminology, 12*(1), 84-96. doi: 10.1111/j.1745-9125.1974.tb00622.x

Prasad, K. (1996). The Glasgow Coma Scale: A Critical Appraisal of Its Clinimetric Properties. *Journal of Clinical Epidemiology, 49*(7), 755-763. doi: 10.1016/0895-4356(96)00013-3

Pratt, T. C., & Cullen, T. (2000). The Empirical Status of Gottfredson and Hirschi's General Theory of Crime: A Meta-Analysis. *Criminology, 38*(3), 931-964. doi: 10.1111/j.1745-9125.2000.tb00911.x

Prewetf, P. N. (1992). The Relationship Between the Kaufman Brief Intelligence Test (K-BIT) and the WISC—R with Incarcerated Juvenile Delinquents. *Educational and Psychological Measurement, 52*, 977-982. doi: 10.1177/0013164492052004022

Reichow, B., & Volkmar, F. (2010). Social Skills Interventions for Individuals with Autism: Evaluation for Evidence-Based Practices within a Best Evidence Synthesis Framework. *Journal of Autism and Developmental Disorders, 40*(2), 149-166. doi: 10.1007/s10803-009-0842-0

Reitan, R. M., & Wolfson, D. (1994). A Selective and Critical Review of Neuropsychological Deficits and the Frontal Lobes. *Neuropsychology Review, 4*(3), 161-198. doi: 10.1007/BF01874891

Rogers, R. D., Tunbridge, E. M., Bhagwagar, Z., Drevets, W. C., Sahakian, B. J., & Carter, C. S. (2003). Tryptophan depletion alters the decision-making of healthy volunteers through altered processing of reward cues. *Neuropsychopharmacology*, *28*(1), 153-162. doi: 10.1038/sj.npp.1300001

Rolls, E. T. (2000). The Orbitofrontal Cortex and Reward. *Cerebral Cortex, 10*(3), 284-294. doi: 10.1093/cercor/10.3.284

Romer, D. (2010). Adolescent Risk Taking, Impulsivity, and Brain Development: Implications for Prevention. *Developmental Psychobiology, 52*(3), 263-276. doi: 10.1002/dev.20442

Ross, E. H., & Hoaken, P. N. S. (2010). Correctional Remediation Meets Neuropsychological Rehabilitation: How Brain Injury and Schizophrenia Research Can Improve Offender Programming. *Criminal Justice and Behavior, 37*(6), 656-677. doi: 10.1177/0093854810363104

Royal College of Psychiatrists. (2010). *Good Psychiatric Practice: Confidentiality and Information Sharing.* Retrieved from http://www.ncb.org.uk/media/434791/guidelines_for_research_with_cyp.pdf

Ryan, J. J., Glass, L. A., & Brown, C. N. (2007). Administration Time Estimates for Wechsler Intelligence Scale for Children-IV Subtests, Composites, and Short Forms. *Journal of Clinical Psychology, 63*(4), 309-318. doi: 10.1002/jclp.20343

Schofield, P., Butler, T., Hollis, S., & D'Este, C. (2011). Are prisoners reliable survey respondents? A validation of self-reported traumatic brain injury (TBI) against hospital medical records. *Brain Injury, 25*(1), 74-82. doi: 10.3109/02699052.2010.531690

Schofield, P., Butler, T. G., Hollis, S. J., Smith, N. E., Lee, S. J., & Kelso, W. M. (2006). Traumatic brain injury among Australian prisoners: Rates, recurrence and sequelae. *Brain Injury, 20*(5), 499-506. doi: 10.1080/02699050600664749

Schretlen, D. J., & Shapiro, A. M. (2003). A quantitative review of the effects of traumatic brain injury on cognitive functioning. *International Review of Psychiatry, 15*(4), 341-349. doi: 10.1080/09540260310001606728

Sharp, D. J., & Ham, T. E. (2011). Investigating white matter injury after mild traumatic brain injury. *Current Opinion in Neurology, 24*(6), 558-563. doi: 10.1097/WCO.0b013e32834cd523

Shaw, C., Brady, L.-M., & Davey, C. (2011). *Guidelines for Research with Children and Young People*. Retrieved from http://www.ncb.org.uk/media/434791/guidelines_for_research_with_cyp.pdf

Shiroma, E. J., Ferguson, P. L., & Pickelsimer, E. E. (2012). Prevalence of Traumatic Brain Injury in an Offender Population: A Meta-Analysis. *Journal of Head Trauma Rehabilitation*, *27*(3), E1-10. doi: 10.1097/HTR.0b013e3182571c14

Shiroma, E. J., Pickelsimer, E. E., Ferguson, P. L., Gebregziabher, M., Lattimore, P. K., Nicholas, J. S., . . . Hunt, K. J. (2010). Association of Medically Attended Traumatic Brain Injury and In-Prison Behavioral Infractions: A Statewide Longitudinal Study. *Journal of Correctional Health Care, 16*(4), 273-286. doi: 10.1177/1078345810378253

Shoemaker, D. J. (2005). *Theories of Delinquency. An Examination of Explanations of Delinquent Behaviour*. Oxford: Oxford University Press.

Stuss, D. T. (1992). Biological and Psychological Development of Executive Functions. *Brain and Cognition*, *20*(1), 8-23. doi: 10.1016/0278-2626(92)90059-U

Stuss, D. T. (2007). New approaches to prefrontal lobe testing. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders* (Vol. 2, pp. 292-305). New York: The Guilford Press.

Stuss, D. T. (2011a). Functions of the frontal lobes: Relation to executive functions. *Journal of International Neuropsychology Society, 17*(5), 759-765. doi: 10.1017/S1355617711000695

Stuss, D. T. (2011b). Traumatic brain injury: Relation to executive dysfunction and the frontal lobes. *Current Opinion in Neurology, 24*(6), 584-589. doi: 10.1097/WCO.0b013e32834c7eb9

Stuss, D. T., & Alexander, M., P. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research, 63*(3-4), 289-298.

Stuss, D. T., & Alexander, M. P. (2007). Is there a dysexecutive syndrome? *Philosophical Transactions of The Royal Society Biological Sciences, 362*(1481), 901-915. doi: 10.1098/rstb.2007.2096

Stuss, D. T., & Alexander, M. P. (2009). Frontal Lobe Syndrome. In L. R. Squire (Ed.), *Encyclopedia of Neuroscience* (Vol. 4, pp. 375-381). Oxford: Academic Press.

Stuss, D. T., Alexander, M. P., Shallice, T., Picton, T. W., Binns, M. A., Macdonald, R., . . . Katz, D. I. (2005). Multiple frontal systems controlling response speed. *Neuropsychologia, 43*(3), 396-417. doi: 10.1016/j.neuropsychologia.2004.06.010

Stuss, D. T., Gallup, G. G., & Alexander, M. P. (2001). The frontal lobes are necessary for theory of mind. *Brain, 124*(2), 279-286. doi: 10.1093/brain/124.2.279

Stuss, D. T., Shallice, T., Alexander, M., & Picton, T. (1995). A Multidisciplinary Approach to Anterior Attentional Functions. *Annals of the New York Academy of Sciences, 769*(1), 191-212. doi: 10.1111/j.1749-6632.1995.tb38140.x

Syngelaki, E. M., Moore, S. C., Savage, J. C., Fairchild, G., & Van Goozen, S. H. M. (2009). Executive Functioning and Risky Decision Making in Young Male Offenders. *Criminal Justice and Behavior, 36*(11), 1213-1227. doi: 10.1177/0093854809343095

Tagliaferri, F., Compagnone, C., Korsic, M., Servadei, F., & Kraus, J. (2006). A systematic review of brain injury epidemiology in Europe. *Acta Neurochirurgica, 148*(3), 255-268. doi: 10.1007/s00701-005-0651-y

Tang, Y.-Y., Yang, L., Leve, L. D., & Harold, G. T. (2012). Improving Executive Function and Its Neurobiological Mechanisms Through a Mindfulness-Based Intervention: Advances

Within the Field of Developmental Neuroscience. *Child Development Perspectives, 6*(4), 361-366. doi: 10.1111/j.1750-8606.2012.00250.x

Teasdale, G., & Jennett, B. (1974). Assessment of Coma and Impaired Consciousness: A Practical Scale. *The Lancet*, *304*(7872), 81-84. doi: 10.1016/S0140-6736(74)91639-0

Thapar, A., & McGuffin, P. (1998). Validity of the Shortened Mood and Feelings Questionnaire in a Community Sample of Children and Adolescents: A Preliminary Research Note. *Psychiatry Research*, *81*(2), 259-268. doi: 10.1016/S0165-1781(98)00073-0

Timonen, M., Miettunen, J., Hakko, H., Zitting, P., Veijola, J., von Wendt, L., & Räsänen, P. (2002). The association of preceding traumatic brain injury with mental disorders, alcoholism and criminality: The Northern Finland 1966 Birth Cohort Study. *Psychiatry Research, 113*(3), 217-226. doi: 10.1016/S0165-1781(02)00269-X

Tonks, J., Slater, A., Frampton, I., Wall, S. E., Yates, P., & Williams, W. H. (2008). The development of emotion and empathy skills after childhood brain injury. *Developmental Medicine & Child Neurology, 51*(1), 8-16. doi: 10.1111/j.1469-8749.2008.03219.x

Tonks, J., Williams, W. H., Frampton, I., Yates, P., & Slater, A. (2007a). Assessing emotion recognition in 9-15-years olds: Preliminary analysis of abilities in reading emotion from faces, voices and eyes. *Brain Injury, 21*(6), 623-629. doi: 10.1080/02699050701426865

Tonks, J., Williams, W. H., Frampton, I., Yates, P., & Slater, A. (2007b). Reading emotions after child brain injury: A comparison between children with brain injury and non-injured controls. *Brain Injury, 21*(7), 731-739. doi: 10.1080/02699050701426899

Tonks, J., Williams, W. H., Yates, P., & Slater, A. (2011). Cognitive correlates of psychosocial outcome following traumatic brain injury in early childhood: Comparisons between groups of children aged under and over 10 years of age. *Clinical Child Psychology and Psychiatry, 16*(2), 185-194. doi: 10.1177/1359104511403583

Tonks, J., Yates, P., Frampton, I., Williams, W. H., Harris, D., & Slater, A. (2011). Resilience and the mediating effects of executive dysfunction after childhood brain injury: A comparison between children aged 9-15 years with brain injury and non-injured controls. *Brain Injury, 25*(9), 870-881. doi: 10.3109/02699052.2011.581641

Tonks, J., Yates, P., Williams, W. H., Frampton, I., & Slater, A. (2010). Peer-relationship difficulties in children with brain injuries: Comparisons with children in mental health services and healthy controls. *Neuropsychological Rehabilitation, 20*(6), 922-935. doi: 10.1080/09602011.2010.519209

Tung, S., & Chhabra, N. (2011). A comparative study on the neuropsychological status of delinquent and non-delinquent boys. *International Journal of Culture and Mental Health, 4*(2), 121-127. doi: 10.1080/17542863.2010.530772

van de Weijer-Bergsma, E., Formsma, A., de Bruin, E., & Bögels, S. (2012). The Effectiveness of Mindfulness Training on Behavioral Problems and Attentional Functioning in Adolescents with ADHD. *Journal of Child and Family Studies, 21*(5), 775-787. doi: 10.1007/s10826-011-9531-7

Vaughn, M. G., Salas-Wright, C. P., DeLisi, M., & Perron, B. (2014). Correlates of traumatic brain injury among juvenile offenders: A multi-site study. *Criminal Behaviour and Mental Health, 3,* 188-203. doi: 10.1002/cbm.1900

Veneziano, C., Veneziano, L., LeGrand, S., & Richards, L. (2004). Neuropsychological Executive Functions of Adolescent Sex Offenders and Nonsex Offenders. *Perceptual and Motor Skills, 98*(2), 661-674. doi: 10.2466/pms.98.2.661-674

Wallace, J. F., Schmitt, W. A., Vitale, J. E., & Newman, J. P. (2000). Experimental investigations of information-processing deficiencies in psychopaths. Implications for diagnosis and treatment. In C. B. Gacono (Ed.), *The Clinical and Forensic Assessment of Psychopathy: A Practioner's Guide* (pp. 87-109). Mahway, NJ: Lawrence Erlbaum Associates.

Wechsler, D. (2004). *The Wechsler Intelligence Scale for Children- Fourth Edition*. London: Pearson Assessment.

Wechsler, D. (2011). *Wechsler Abbreviated Scale of Intelligence Second Edition (WASI-II)*. USA: Pearson.

Westerman, R., Darby, D. G., Maruff, P., & Collie, A. (2001). Computer-assisted cognitive function assessment of pilots. *Australian Defence Force, 2*, 29-36.

Wiatrowski, M. D., Griswold, D. B., & Roberts, M. K. (1981). Social Control Theory and Delinquency. *American Sociological Review, 46*(5), 525-541. doi: 10.2307/2094936

Wikstrom, P., & Treiber, K. (2008). *Youth Justice Board. Offending Behaviour Programmes.* Retrieved from http://www.insidetime.org/resources/Publications/Off-Beh-Progs_YJB-2008.pdf

Williams, W. H. (2012). *Repairing Shattered Lives: Brain injury and its implications for criminal justice.* Retrieved from http://www.t2a.org.uk/wp-content/uploads/2012/10/Repairing-Shattered-Lives_Report.pdf

Williams, W. H., Cordan, G., Mewse, A. J., Tonks, J., & Burgess, C. N. (2010). Self-reported traumatic brain injury in male young offenders: A risk factor for re-offending, poor mental health and violence? *Neuropsychological Rehabilitation: An International Journal, 20*(6), 801-812. doi: 10.1080/09602011.2010.519613

Williams, W. H., Mewse, A. J., Tonks, J., Mills, S., Burgess, C. N., & Cordan, G. (2010). Traumatic brain injury in a prison population: Prevalence and risk for re-offending. *Brain Injury, 24*(10), 1184-1188. doi: 10.3109/02699052.2010.495697

Wilson, B., Emslie, H., Evans, J., Alderman, N., & Burgess, P. (1996). *Behavioural Assessment of the Dysexecutive Syndrome (BADS)*. Bury St. Edmunds: Thames Valley Test Company.

Wolff, P., Waber, D., Bauermeister, M., Cohen, C., & Ferber, R. (1982). The neuropsychological status of adolescent delinquent boys. *Journal of Child Psychology and Psychiatry, 23*(3), 267-279. doi: 10.1111/j.1469-7610.1982.tb00072.x

Wood, R. L. L., & Williams, C. (2008). Inability to empathize following traumatic brain injury. *Journal of the International Neuropsychological Society, 14*(02), 289-296. doi: doi:10.1017/S1355617708080326

Wortzel, H. S., & Archiniegas, D. B. (2013). A Forensic Neuropsychiatric Approach to Traumatic Brain Injury, Aggression, and Suicide. *The Journal of the American Academy of Psychiatry and the Law, 41*, 274-286.

Yeates, K. O., Swift, E., Taylor, H. G., Wade, S. L., Drotar, D., Stancin, T., & Minich, N. (2004). Short- and long-term social outcomes following pediatric traumatic brain injury. *Journal of the International Neuropsychological Society, 10*(3), 412-426. doi: 10.1017/S1355617704103093

Yeudall, L. T., Fromm-Auch, D., & Davies, P. (1982). Neuropsychological impairment of persistent delinquency. *The Journal of Nervous and Mental Disease, 170*(5), 257-265.

Youth Justice Board. (2013). *Youth Justice Statistics 2011/12. Executive Summary*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/279906/yjb-stats-2011-12-exec-summary.pdf

Youth Justice Board. (2014). *Youth Justice Statistics 2012/13*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/276098/youth-justice-stats-exec_summary.pdf

Zappala, G., Thiebaut de Schotten, M., & Eslinger, P. J. (2012). Traumatic brain injury and the frontal lobes: What can we gain with diffusion tensor imaging? *Cortex, 48*(2), 156-165. doi: 10.1016/j.cortex.2011.06.020

Zelazo, P. D., & Lyons, K. E. (2012). The Potential Benefits of Mindfulness Training in Early Childhood: A Developmental Social Cognitive Neuroscience Perspective. *Child Development Perspectives, 6*(2), 154-160. doi: 10.1111/j.1750-8606.2012.00241.x

Zhou, X., & Raiford, S. E. (2011). *Using the WASI-II with the WISC-IV: Substituting WASI-II Subtest Scores When Deriving WISC-IV Composite Scores.* Retrieved from http://images.pearsonclinical.com/images/ca/webinars/wasi-ii-wisc-iv-editorial-lr.pdf

Appendix A Participant information sheet (12-15 years old)

Title: Investigation into the frontal lobe functioning of young offenders with and without a head injury.

My name is Ruth Payne  and I am a Trainee Clinical Psychologist based at the University of East Anglia (UEA). I am asking if you would like to join a research study, which is trying to find out whether having a knock on the head or being knocked out affects the way you complete tasks. I am looking at young people who are, or who have been part of a youth offending service. My research supervisors at the UEA are Dr Mike Dow, Clinical Psychologist and Dr Siân Coker, Clinical Psychologist and Deputy Programme Director.

Please read this information sheet carefully to see whether you want to be involved in the study. If anything is not clear, then please contact me, Ruth Payne via e-mail at ruth.payne@uea.ac.uk.

Why are we doing this research? 

- We want to see how young people who have had a knock to the head or have been knocked out do on some tasks and see whether they do any differently to those who have not had a knock to the head.

Why have I been invited to take part? 

- You have been asked to take part as you have been involved with the Youth Offending Services in the past or at the moment.
- There will be around 40 other people involved in the study.

Do I have to take part?

- No. You only have to take part if you want to and if you chose not to take part, then this will not affect you in anyway.

What will happen to me if I take part? 

- If you consent to being asked a question about whether you have ever had a knock to the head, then someone in the team will ask you this.
- You will be asked whether the team can pass on this answer to the researcher, called Ruth Payne and if you say yes then Ruth Payne may contact you to discuss any questions you have. Not everyone is asked to do anything more.
- If you want to take part then an appointment will be made between you and Ruth Payne, when you can ask any more questions you have.
- If you still want to take part then you will be asked to sign a form called an assent form, to say you agree. Your parent/guardian will also be asked to sign a consent form to say they agree too.
- It is okay to change your mind about taking part at any point up until your results are analysed. If you do not want to take part then either you or your parent/guardian should contact Ruth Payne.

What will I be asked to do? 

- A one-off appointment will be arranged with you and Ruth Payne.
- The appointment will be somewhere which is convenient for yourself and will be agreed with Ruth Payne.
- The appointment will take up to approximately 70 minutes and you can have a break if you need to.
- During the appointment, you will be asked to complete some tasks. The tasks involve you completing some card games on the computer, guessing how people are feeling from photos, reading some simple words. You will also be asked to complete a task involving naming and describing words and visual puzzles.
- The tasks are not a test that you can pass or fail as we are looking for the answers which seem right to you.
- You can stop the tasks at any point during the appointment if you want to.

Is there anything to be worried about by taking part? 

- There are no risks of taking part in the study.
- You have to be happy to take part in the tasks for about an hour, but nothing else is involved in the study.
- In the unlikely event that you become distressed in the session, the researcher will stop the session and inform your parent/guardian and the team member that referred you.

What are the possible benefits of taking part? 

- There are no direct benefits of taking part for you, however, you will be entered into a prize draw to win a £30 voucher.
- The information we gather from the research, can help people like you in the future as it can give us some more information about if having a knock on the head affects the way you can do some things.
- All your answers will be kept in a locked cabinet and will not have your name on them.

Who will see my answers?

- Your answers will be kept confidentially. This means that only people who need to know will be able to see them.
  If you tell the researcher anything that makes them concerned about the safety of you or others, they may have to report this, but they will discuss this with you first and then speak with the appropriate person e.g., YOT worker or the Police.
- All your answers will be kept in a locked cabinet and will not have your name on them.

Who has reviewed this study? 

- All research at the University of East Anglia is looked at by an independent group of people, called a Research Ethics Committee. This group of people make sure that the study is done properly. This study has been approved by the University of East Anglia's Faculty of Medicine and Health Sciences Research Ethics Committee.

What will happen to the results of the research? 

- The results will be part of a study involving other young people and will be submitted to the University of East Anglia as they are part of the researcher's thesis as part of her Doctorate in Clinical Psychology.

What happens next? 

- It may help you decide whether you want to take part by talking to people who are close to you.
- You can also contact Ruth Payne by email to answer any questions you may have. If you sign the form saying that you are happy for her to contact you, then she can speak to you to and answer any more questions you have. You can also phone her on 07851753515 (please leave a message and she will get back to you).

Who should I contact if I want to complain?

- If you would like to complain about any part of the research then please contact either the researcher (Ruth Payne, ruth.payne@uea.ac.uk, 07851753515), the research supervisor (Dr Mike Dow, email: mikedowuea@btinternet.com) or a member of the University staff not connected with the project (Professor Kenneth Laidlaw, email: K.Laidlaw@uea.ac.uk).).

Further information and contact details

- To ask any more questions about the study then please contact Ruth Payne, ruth.payne@uea.ac.uk. You can contact her at any stage of the study.

University of East Anglia

Appendix B Participant information sheet (16-17 year olds)

Title: Investigation into the frontal lobe functioning of young offenders with and without a head injury.

My name is Ruth Payne  and I am a Trainee Clinical Psychologist based at the University of East Anglia (UEA). I am asking if you would like to join a research study, which is trying to find out whether having a knock on the head or being knocked out affects the way you complete tasks. I am looking at young people who are, or who have been part of a youth offending service. My research supervisors at the UEA are Dr Mike Dow, Clinical Psychologist and Dr Siân Coker, Clinical Psychologist and Deputy Programme Director..

Please read this information sheet carefully to see whether you want to be involved in the study. If anything is not clear, then please contact me, Ruth Payne via e-mail at ruth.payne@uea.ac.uk.

Why are we doing this research?

- We want to see how young people who have had a knock to the head or have been knocked out do on some tasks and see whether they do any differently to those who have not had a knock to the head.

Why have I been invited to take part?

- You have been asked to take part as you have been involved with the Youth Offending Services in the past or at the moment.
- There will be around 40 other people involved in the study.

Do I have to take part?

- No. You only have to take part if you want to and if you chose not to take part, then this will not affect you in anyway.

What will happen to me if I take part?

- If you consent to being asked a question about whether you have ever had a knock to the head, then someone in the team will ask you this.
- You will be asked whether the team can pass on this answer to the researcher, called Ruth Payne and if you say yes then Ruth Payne may contact you to discuss any questions you have. Not everyone is asked to do anything more.
- If you want to take part then an appointment will be made between you and Ruth Payne, when you can ask any more questions you have.
- If you still want to take part then you will be asked to sign a form called a consent form, to say you agree. Your parent/guardian will also be asked to sign a consent form to say they agree too.
- It is okay to change your mind about taking part at any point up until your results are analysed. If you don't want to take part then either you or your parent/guardian can contact Ruth Payne.

What will I be asked to do?

- A one-off appointment will be arranged with you and Ruth Payne.
- The appointment will be somewhere which is convenient for yourself and will be agreed with Ruth Payne.

- The appointment will take up to approximately 70 minutes and you can have a break if you need to.
- During the appointment, you will be asked to complete some tasks. The tasks involve you completing some card games on the computer, guessing how people are feeling from photos, reading some simple words. You will also be asked to complete a task involving naming and describing words and visual puzzles.
- The tasks are not a test that you can pass or fail as we are looking for the answers which seem right to you.
- You can stop the tasks at any point during the appointment if you want to.

Is there anything to be worried about by taking part?

- There are no risks of taking part in the study.
- You have to be happy to take part in the tasks for about an hour, but nothing else is involved in the study.
- In the unlikely event that you become distressed in the session, the researcher will stop the session and inform your parent/guardian and the team member that referred you.

What are the possible benefits of taking part?

- There are no direct benefits of taking part for you, however, you will be entered into a prize draw to win a £30 voucher.
- The information we gather from the research, can help people like you in the future as it can give us some more information about if having a knock on the head affects the way you can do some things.

Who will see my answers?

- Your answers will be kept confidentially. This means that only people who need to know will be able to see them.
- If you tell the researcher anything that makes them concerned about the safety of you or others, they may have to report this, but they will discuss this with you first and then speak with the appropriate person e.g., YOT worker or the Police. All your answers will be kept in a locked cabinet and will not have your name on them.

Who has reviewed this study?

- All research at the University of East Anglia is looked at by an independent group of people, called a Research Ethics Committee. This group of people make sure that the study is done properly. This study has been approved by the of University of East Anglia's Faculty of Medicine and Health Sciences Research Ethics Committee.

What will happen to the results of the research?

- The results will be part of a study involving other young people and will be submitted to the University of East Anglia as they are part of the researcher's thesis as part of her Doctorate in Clinical Psychology.

What happens next?

- It may help you decide whether you want to take part by talking to people who are close to you, so that you can make an informed decision about whether or not you wish to take part in this study.
- We are only able to include people in the study who are able to make an informed decision about whether they wish to take part after considering the information about

the study and letting the researcher know their decision. Some people may not be able to make an informed decision to take part, and unfortunately, if this is the case they will not be able to take part in the study.

- You can also contact Ruth Payne by email to answer any questions you may have. If you sign the form saying that you are happy for her to contact you, then she can speak to you to answer any more questions you have.

Who should I contact if I want to complain?

- If you would like to complain about any part of the research then please contact either the researcher (Ruth Payne, ruth.payne@uea.ac.uk, 07851753515), the research supervisor (Dr Mike Dow, email: mikedowuea@btinternet.com) or a member of the University staff not connected with the project (Professor Kenneth Laidlaw, email: K.Laidlaw@uea.ac.uk).

Further information and contact details

- To ask any more questions about the study then please contact Ruth Payne on email, ruth.payne@uea.ac.uk or by phone on 07851753515 (please leave a message and she will get back to you). You can contact her at any stage of the study.

Appendix C Parental/guardian information sheet

Title: Investigation into the frontal lobe functioning of young offenders with and without a head injury.

My name is Ruth Payne and I am a Trainee Clinical Psychologist based at the University of East Anglia (UEA). I am asking if you would like to join a research study, which is trying to find out whether having a knock on the head or being knocked out affects the way you complete tasks. I am looking at young people who are, or who have been part of a youth offending service. My research supervisors at the UEA are Dr Mike Dow, Clinical Psychologist and Dr Sian Coker, Clinical Psychologist and Deputy Programme Director. Please read this information sheet carefully to see whether you want your child to be involved in the study. If anything is not clear, then please contact me, Ruth Payne via e-mail at ruth.payne@uea.ac.uk.

What is the purpose of the project?

- We want to see how young people who have had a knock to the head or have been knocked out do on some tasks and see whether they do them any differently to those who have not had a knock to the head.

Why has my child been invited to take part in the study?

- Your child has been asked to take part in the study as they are between 12-16 years old and are currently, or have been in the past, involved with the Youth Offending Services.
- There will be around 40 other people involved in the study.

Does my child have to take part?

- No. If you decide that you do not wish your child to take part, then this will not affect them in any way.

What will happen if I decide to give consent for my child to take part?

- Your child will first be asked whether they have ever had a knock to the head and become dazed or confused.
- Due to the study design, not everyone who completes the screen will be asked to complete a full assessment. If they are, your child will be asked to complete a one-off appointment which will last approximately 70 minutes.
- The appointment will involve your child completing some tasks on the computer and answering some questions, including whether they have had a knock to the head in the past.
- The tasks involve young people completing some card games on the computer, guessing how people are feeling from photos, reading some simple words. Young people will also be asked to complete a task involving naming and describing words and visual puzzles.
- It will be made clear to your child that the tasks are not a test, and there are no right or wrong answers, but I am interested in how they complete the tasks.
- Your child can stop the tasks at anytime if they do not want to continue.
- The information used in the research will be collected from the initial question asked by the service about whether your child has ever had a knock to the head and from the assessment session with the researcher. If you and your child provide consent, then the team will pass on your contact details to the researcher to arrange the assessment. The researcher will ask the service for your child's current YOT record of their conviction details.

What do I have to do if I am happy for my child to take part?

- If you decide that you are happy for your child to take part in the project, or would like to find out more about the study, then please complete the form consenting for the researcher, Ruth Payne to contact you and to answer the first question.
- As your child is under 16 years old, I will ask you to provide written consent for their involvement. I will also ask your child to sign a form called an assent form, agreeing that they are happy to take part.
- At any stage of the study, up until the results are analysed, you and your child can decide for their results not to be included in the report. If you decide this, then please contact Ruth Payne.

What are the disadvantages of my child taking part?

- There are no risks for your child from taking part in the study.
- In the unlikely event that they become distressed when completing the tasks, then the appointment will be stopped.
- Both you and your child have to be happy for your child to complete approximately a one hour appointment.
- In the unlikely event that your child becomes distressed in the session, the researcher will stop the session and inform you and the team member that referred your child to the research.

Are there any possible benefits of my child taking part?

- There is little direct benefit for your child taking part in the study, however, all participants are included into a prize draw to win a £30 voucher.
- The results from this study will help improve assessment and support for young people involved with Youth Offending Services.

Will information be kept confidentially?

- All the data collected will be kept confidentially. This means that only people who are granted access will be able to see the information. All data will be stored in a locked filing cabinet and will not have your child's name on them.
- If your child tells the researcher anything that makes them concerned about the safety of your child or others, they may have to report this, but they will discuss this with you and your child first and then speak with the appropriate person e.g., YOT worker or the Police.

What will happen to the results of the research?

- The results will be part of a study involving other young people and will be submitted to the University of East Anglia as they are part of the researcher's thesis as part of her Doctorate in Clinical Psychology.

Who has reviewed the study?

- All research at the University of East Anglia is looked at by an independent group of people, called a Research Ethics Committee. This group of people make sure that the study is done properly. This study has been approved by the University of East Anglia's Faculty of Medicine and Health Sciences Research Ethics Committee.

Who should I contact if I want to complain?

If you would like to complain about any part of the research then please contact either the researcher (Ruth Payne, ruth.payne@uea.ac.uk, 07851753515), the research supervisor (Dr Mike Dow, email: mikedowuea@btinternet.com) or a member of the University staff not connected with the project (Professor Kenneth Laidlaw, email: K.Laidlaw@uea.ac.uk).

Further information and contact details.

- To ask any more questions about the study then please contact Ruth Payne by email, ruth.payne@uea.ac.uk, or by phone on 07851753515. You can contact her at any stage of the study.

Appendix D Consent to be screened and contacted

Patient Identification Number for this trial:

CONSENT TO BE SCREENED AND CONTACTED

Title of Project: **Investigation into the frontal lobe functioning of young offenders with and without a head injury.**

Name of Researcher: Ruth Payne

Please initial all boxes

1. I confirm that I have been given an information sheet dated 07.08.13 (version 4) for the above study. ☐
2. I give consent for someone from my team to ask me a question about whether I have ever had a knock to the head. ☐
3. I give consent for my team to tell Ruth Payne, Trainee Clinical Psychologist at the University of East Anglia my answer. ☐
4. I give consent for Ruth Payne, Trainee Clinical Psychologist at the University of East Anglia to contact me about this study. I understand that she will contact me to discuss being involved in the study and will answer any questions I may have. ☐
5. I understand that by consenting to be contacted it does not mean that I have to participate. ☐

________________	________________	________________
Name of Participant	Date	Signature
________________	________________	________________
Name of Person taking consent.	Date	Signature

Address...

Telephone Number...

Preferred time to be contacted ....

Appendix E Compliment slip for consent to screen and contact

<u>Compliment Slip for Consent to Screen and Contact</u>

University of East Anglia

If you have the read the information sheet but do not have time to complete the form then you can put your initials in the box if:

- you are happy to be asked one question from the team for the research ☐
- you are happy for Ruth Payne  to contact you about the research ☐
- you are happy for the team to pass on your contact details to Ruth Payne ☐

PLEASE TURN OVER

Compliment slip. Version 1 (17.02.13). Pg 1/1.

(Other side)

<u>To be completed by team member</u>

If the young person has agreed on the reverse side, please complete the following:

- Have they had a head injury? YES ☐ NO ☐
- Your contact details (staff): NAME ______________________________________

  EMAIL ____

  CONTACT NUMBER ____________________________

Appendix F Screen question

Screen question

1. Have you ever had an injury to the head, which knocked you out and/or left you dazed and confused? E.g. from a fall, accident, hit to the head.

Yes	
No	

Appendix G Demographics form (proxy report)

Demographics Form (proxy report) ID ________

Date __________

1. Is your child currently under the Youth Offending Services?

Yes	
No	

2. If you answered no, what was their most recent conviction?

One month ago	
Two-five months ago	
Six-twelve months ago	
One year- two years ago	
Two- three years ago	
More than three years ago	

3. What is their current, or most recent conviction of if they are not currently under Youth Offending Services?

Burglary	
Violence	
Arson	
Sexual offence	
Drug offence	
Joyriding	
Other	

4. How many previous convictions has your child received?

One	
Two	
Three	
Four	
Five	
Five or more	

5. What is their current or most recent disposal (Youth Offending Order)?

Reprimand	
Final warning	
Youth Rehabilitation Order (YRO)	
YRO with Intensive support and surveillance	
Referral Order	
Reparation Order	
Fine	
Conditional Discharge	
Absolute Discharge	
Drinking Banning Order	
Other. Please state	

6. Has your child ever had an injury to the head, which caused them to be knocked out and/or left them dazed and confused? E.g. from a fall, accident, hit to the head.

Yes	
No	

If you answered Yes, please answer questions 7-9. If you answered no, then please go to question 10.

7. How many times have they been knocked out/confused/dazed? (Please tick the box which applies)

1	
2	
3	
4	
More than 4	

8. How long were they unconscious/knocked out for after their worst injury?

5 minutes	
5-10 minutes	
10-30 minutes	
30-60 minutes	
1- 6 hours	
More than 6 hours (please write how many)	

Appendix H Demographics form (participant)

Demographics form (self-report)

ID ________

Date __________

1. Are you male or female?

Male	
Female	

2. How old are you?

____

3. Are you currently under the Youth Offending Services?

Yes	
No	

4. If you answered no, when was your most recent conviction?

One month ago	
Two-five months ago	
Six-twelve months ago	
One - two years ago	
Two-three years ago	
More than three years ago	

5. What is your current, or most recent conviction of if you are not currently under Youth Offending Services?

Burglary	
Violence	
Arson	
Sexual offence	
Drug offence	
Joyriding	
Other	

6. How many previous convictions have you had?

One	
Two	
Three	
Four	
Five	
Five or more	

7. What is your current or most recent disposal (Youth Offending Order)?

Reprimand	
Final warning	
Youth Rehabilitation Order (YRO)	
YRO with Intensive support and surveillance	
Referral Order	
Reparation Order	
Fine	
Conditional Discharge	
Absolute Discharge	
Drinking Banning Order	
Other. Please state	

8. Have you ever had an injury to the head, which caused you to be knocked out and/or left you dazed and confused? E.g. from a fall, accident, hit to the head.

Yes	
No	

If you answered Yes, please answer questions 9-11. If you answered no, then please go to question 12.

9. How many times have you been knocked out/confused/dazed? (Please tick the box which applies to you) .

1	
2	
3	
4	
More than 4	

10. How long were you unconscious/knocked out for after your worst injury?

5 minutes	
5-10 minutes	
10-30 minutes	
30-60 minutes	
1- 6 hours	
More than 6 hours (please write how many)	

11. Was your first conviction before or after you had a knock to the head?

Before	
After	

12. Does your family own a car, van or truck?

Yes	
No	

13. Do you have your own bedroom for yourself?

Yes	
No	

14. During the past 12 months, how many times did you travel away on holiday with your family?

Not at all	
Once	
Twice	
More than twice	

15. How many computers does your family own?

None	
One	
Two	
More than two	

Appendix I University of East Anglia indemnity and insurance letter

University of East Anglia

Research & Enterprise Services
West Office (Science Building)
University of East Anglia
Norwich Research Park
Norwich, NR4 7TJ

Telephone: +44 (0)1603 591486
Email: sue.steel@uea.ac.uk

Web: www.uea.ac.uk/researchandenterprise

TO WHOM IT MAY CONCERN

22nd February 2013

Study: *Investigation into the frontal lobe functioning of young offenders with and without a head injury.*
Chief Investigator: *Payne, Ruth*

This is to confirm that the University of East Anglia and Subsidiary Companies have arranged insurance cover as detailed on the attached certificate.

The cover is subject to the terms and conditions of the policy. If you require further details, please contact the undersigned.

Yours faithfully

Sue Steel
Research Contracts Manager

ZURICH MUNICIPAL

To Whom It May Concern

Our ref: BM/IND 15 May, 2012

Zurich Municipal Customer: University of East Anglia and wholly owned subsidiary companies

This is to confirm that University of East Anglia and wholly owned subsidiary companies have in force with this Company until the policy expiry on 31 May 2013 Insurance incorporating the following essential features:

Policy Number: NHE-09CA01-0013

Limit of Indemnity:

Public Liability:	£25,000,000	any one event
Products Liability:	£25,000,000	for all claims in the aggregate during any one period of insurance
Pollution:		
Employers' Liability:	£25,000,000	any one event inclusive of costs

Excess:

Public Liability/Products Liability/Pollution:	£1,000 any one event
Employers' Liability:	Nil any one claim

Indemnity to Principals:
Covers include a standard Indemnity to Principals Clause in respect of contractual obligations.

Full Policy:
The policy documents should be referred to for details of full cover.

Yours faithfully

Underwriting Services
Zurich Municipal
Farnborough

Zurich Municipal
Zurich House
2 Gladiator Way
Farnborough
Hampshire
GU14 6GB

Telephone 0870 2418050
Direct Phone: 01252 387846
Direct Fax: 01252 375893
E-mail nicola.pilsbury@zurich.com

Appendix J UEA ethical approval

Faculty of Medicine and Health Sciences Research Ethics Committee

University of East Anglia

Ruth Payne
Department of Psychological Sciences
Norwich Medical School
University of East Anglia
Norwich
NR4 7TJ

Research & Enterprise Services
West Office (Science Building)
University of East Anglia
Norwich Research Park
Norwich, NR4 7TJ

Telephone: +44 (0) 1603 591566
Email: fmh.ethics@uea.ac.uk

Web: www.uea.ac.uk/researchandenterprise

10th April 2013

Dear Ruth,

Project title: Investigation into the frontal lobe functioning of young offenders with and without a head injury. Reference: 2012/2013-53

The amendments to your above proposal have been considered by the Chair of the Faculty Research Ethics Committee and we can confirm that your proposal has been approved.

Please could you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance and also that any adverse events which occur during your project are reported to the Committee. Please could you also arrange to send us a report once your project is completed.

The Committee would like to wish you good luck with your project.

Yours sincerely,

pp P. Cole

Yvonne Kirkham
Project Officer

Appendix K ADCS approval

ADCS
Leading Children's Services

Ruth Payne
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich, Norfolk
NR47TJ

By email

25 March 2013

Dear Ruth,

Request for ADCS research approval – University of East Anglia - Investigation into the frontal lobe functioning of young offenders with and without a head injury

ADCS ref: RGE130314

I write on behalf of Sue Wald, Chair of the ADCS Research Group regarding your request for research approval for the above named project.

The Research Group has considered your request and given its approval believing that the results of the project will be useful to local authorities. We would be grateful if when contacting local authorities you would quote the reference above.

The Group's encouragement to respond to the survey will be communicated to ADCS members in local authorities in England in the next edition of the ADCS weekly e-bulletin which is produced and circulated on Friday afternoons. A list of approved research projects can be found on the ADCS website. The Research Group wishes you well with the project.

As mentioned in the ADCS Guidelines for Research Approvals, please send the Research Group a copy of the full report and the summary of your main findings when the research is complete.

If you have any queries about this feedback, please contact me in the first instance.

Yours sincerely

Gary Dumbarton, **on behalf of Sue Wald, Chair of the ADCS Research Group**

The Association of Directors of Children's Services
Research Group, The ADCS Ltd, 3rd Floor – The Triangle, Exchange Square, Manchester, M4 3TR
Tel: 0161 838 5762 Fax: 0161 838 5756 Email: research@adcs.org.uk Website: www.adcs.org.uk/research
Registered in England & Wales. Company Number: 06801922. VAT registration number: 948814381.

Appendix L County Council research governance approval

Approval was additionally granted by the following professionals following research governance applications:

-Sessional Chair of Suffolk Research Governance panel

- Strategic Research Analyst (Norfolk County Council)

- Head of Youth Support Services (Cambridgeshire County Council)

-RGF Co-ordinator for Children's Services (Cambridgeshire County Council)

Appendix M Assent

Patient Identification Number:

PARTICIPANT ASSENT FORM

Title of Project: **Investigation into the frontal lobe functioning of young offenders with and without a head injury.**

Name of Researcher: Ruth Payne

Please initial all boxes

1. I confirm that I have read and understand the information sheet dated 07.08.13 (version 4) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2.I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, and this will not affect me. ☐

3. I understand that any of my data collected during the study, may be looked at by individuals from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐

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

5. I agree for my contact details, date of birth, sex, and nature/date of injury to be kept on a secure volunteer research participant register, hosted by UEA and Dr Anna Adlam, so that I can be contacted about future research studies conducted by Dr Anna Adlam's research team ☐

____________________ ____________________ ____________________

Name of Participant Date Signature

____________________ ____________________ ____________________

Name of Person taking consent Date Signature

University of East Anglia

Appendix N Parental consent

Patient Identification Number:

PARENTAL CONSENT FORM

Title of Project: **Investigation into the frontal lobe functioning of young offenders with and without a head injury.**

Name of Researcher: Ruth Payne

Please initial all boxes

1. I confirm that I have read and understand the information sheet dated 07.08.13 (version 4) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my child's participation is voluntary and that they are free to withdraw at any time without giving any reason, and this will not affect them. ☐

3. I understand that any of my child's data collected during the study, may be looked at by individuals from regulatory authorities or from the NHS Trust, where it is relevant to them taking part in this research. I give permission for these individuals to have access to my child's records. ☐

4. I agree that the child named below can take part in the above study and confirm that I have parental responsibility for them. ☐

5. I agree for my child's contact details, date of birth, sex, and nature/date of injury to be kept on a secure volunteer research participant register, hosted by UEA and Dr Anna Adlam, so that I can be contacted about future research studies conducted by Dr Anna Adlam's research team ☐

Name of Participant	Relationship to young person	
Name of Parent/guardian	Date	Signature
Name of Person taking consent	Date	Signature

Appendix O Participant consent form

Patient Identification Number:

PARTICIPANT CONSENT FORM (OVER 16 YEARS OLD)

Title of Project **: Investigation into the frontal lobe functioning of young offenders with and without a head injury.**

Name of Researcher: Ruth Payne
Please initial all boxes

1. I confirm that I have read and understand the information sheet dated 07.08.13 (version 4) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, and this will not affect me.

3. I understand that any of my data collected during the study, may be looked at by individuals from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐

☐

4. I agree to take part in the above study.

5. I agree for my contact details, date of birth, sex, and nature/date of injury to be kept on a secure volunteer research participant register, hosted by UEA and Dr Anna Adlam, so that I can be contacted about future research studies conducted by Dr Anna Adlam's research team ☐

________________	________________	________________
Name of Participant	Date	Signature
________________	________________	________________
Name of Person taking consent	Date	Signature

Appendix P GP letter

Ruth Payne
Department of Psychological Sciences
Norwich Medical School
University of East Anglia
Norwich
NR47TJ

Dear (Name of GP)

(Insert name of participant) has recently taken part in a research project conducted as part of Ruth Payne's Clinical Psychology Doctorate thesis at the University of East Anglia. The research was investigating the effects of a head injury on a young person's ability to engage in certain tasks, which are linked to functioning of the frontal lobes in the brain, compared to young people without a head injury. The research involved young people with and without a head injury.

(Insert name of participant) completed an assessment as part of the research project. The research assessment has highlighted that (Insert name of participant) may have some difficulties in certain tasks, which may be associated with lasting damage due to their head injury. The researcher has sought advice from her supervisor at the University of East Anglia, Dr Mike Dow and has advised (Insert name of participant) to contact their GP for further assessment and investigation in to their head injury.

If you have any queries, please contact either the researcher, Ruth Payne (email:ruth.payne@uea.ac.uk, or telephone 07851753515) , or the research supervisor (Dr Mike Dow, mikedowuea@btinternet.com.

Yours sincerely

Ruth Payne

Trainee Clinical Psychologist

Ruth.payne@uea.ac.uk

Appendix Q debrief form

University of East Anglia

PARTICIPANT DEBRIEF SHEET

Title: Investigation into the frontal lobe functioning of young offenders with and without a head injury.

Thank you for taking part in this study.

If you have any questions about the study, please ask me now, or email me later on ruth.payne@uea.ac.uk.

Would you like to receive a summary of the study and the findings? If you do, then please let me know.

If you would like your answers removed from the report, then please contact me on ruth.payne@uea.ac.uk. This will not affect you in anyway.

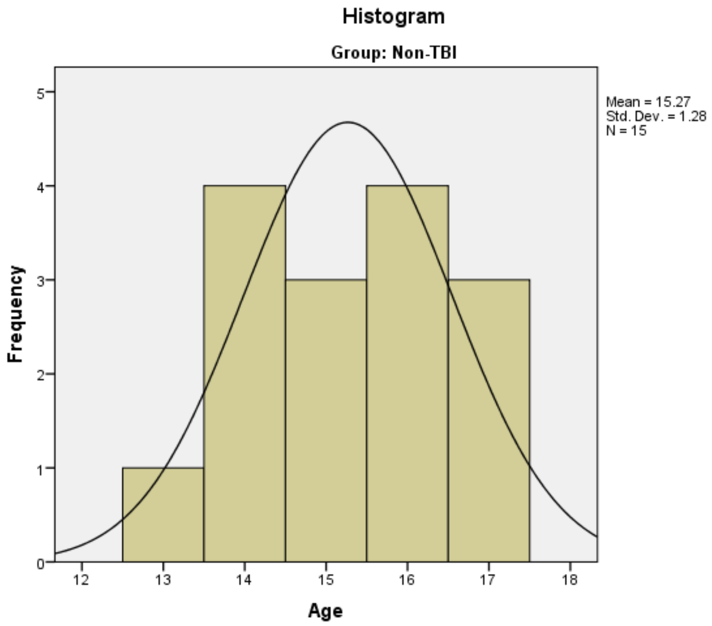
Thank you again for taking part in the study.

Ruth Payne

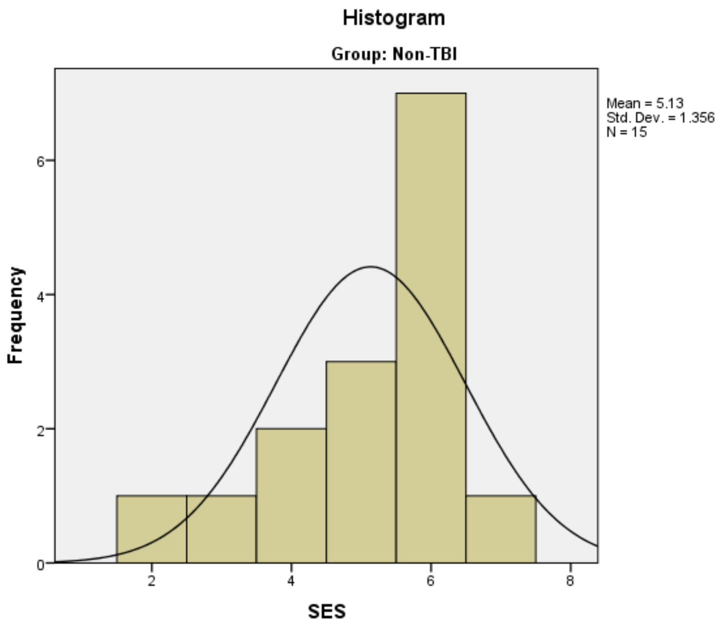
Trainee Clinical Psychologist

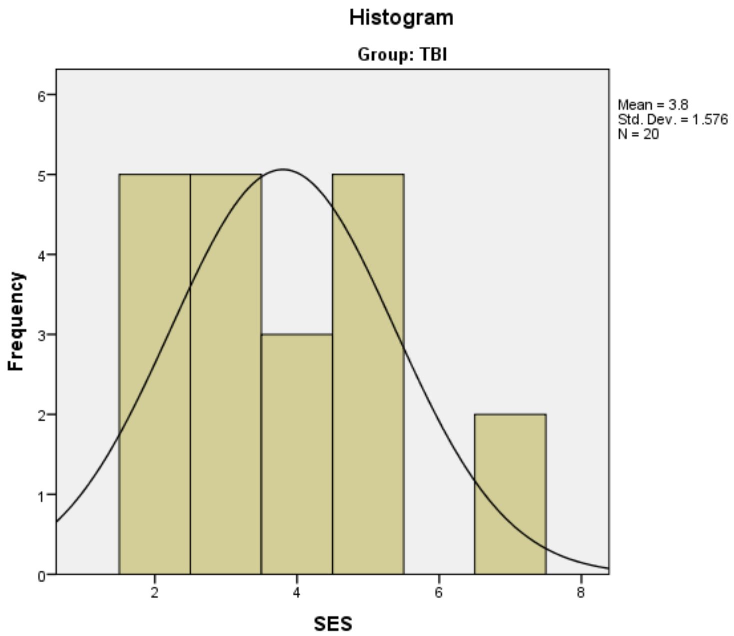
Appendix R Histograms

Age

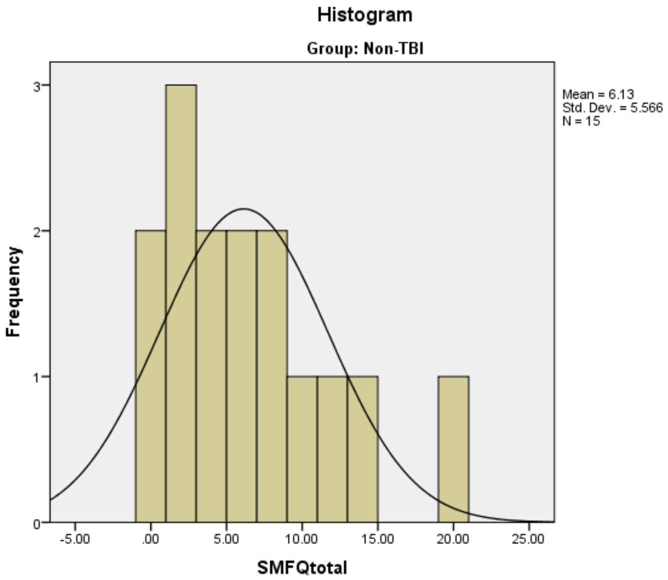


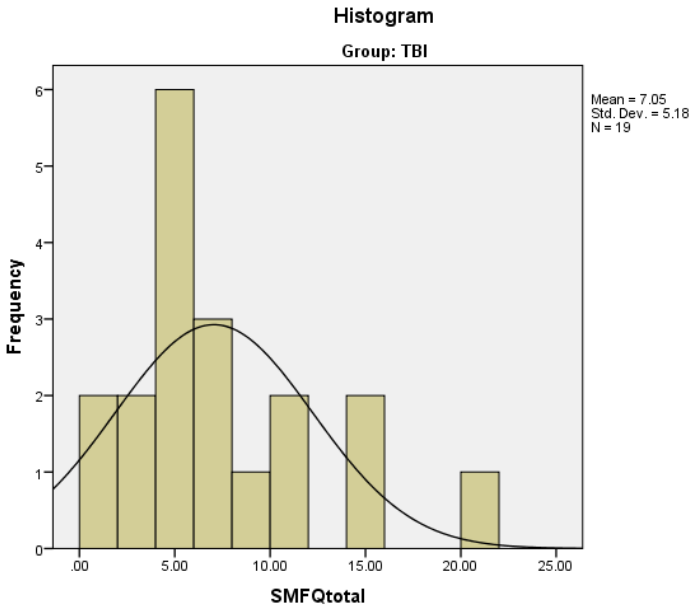
SES


Histogram
Group: Non-TBI
Mean = 5.13
Std. Dev. = 1.356
N = 15
Frequency
SES
0
2
4
6
8

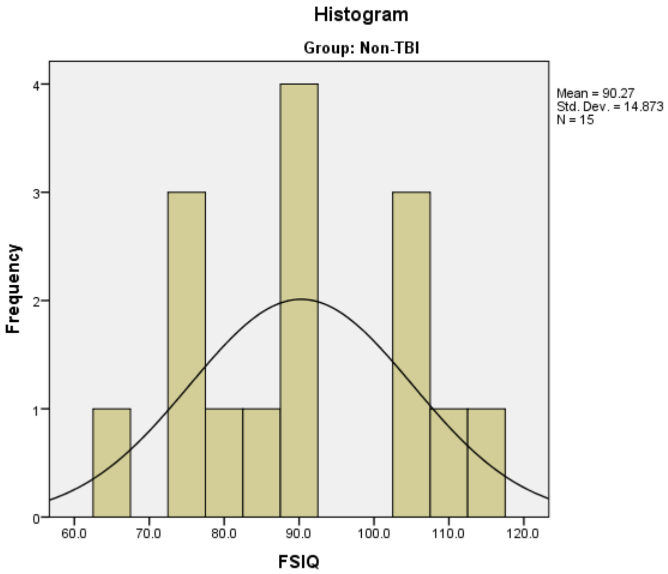

Histogram
Group: TBI
Mean = 3.8
Std. Dev. = 1.576
N = 20
Frequency
SES
0
1
2
3
4
5
6
8

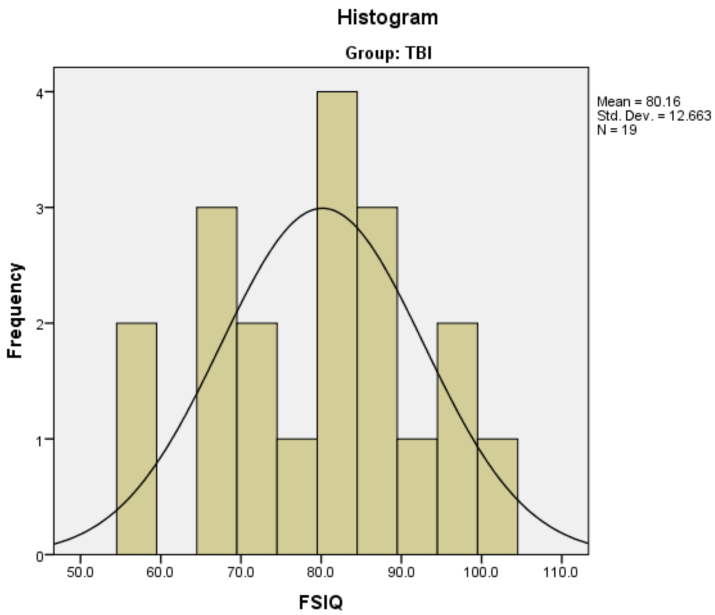
SMFQ


Histogram
Group: Non-TBI
Mean = 6.13
Std. Dev. = 5.566
N = 15
Frequency
SMFQtotal
-5.00
.00
5.00
10.00
15.00
20.00
25.00

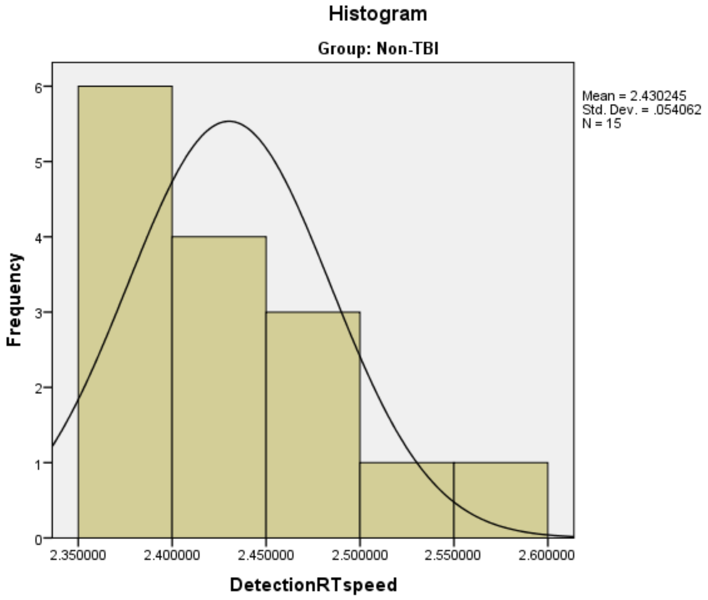

Histogram
Group: TBI
Mean = 7.05
Std. Dev. = 5.18
N = 19
Frequency
SMFQtotal
.00
5.00
10.00
15.00
20.00
25.00

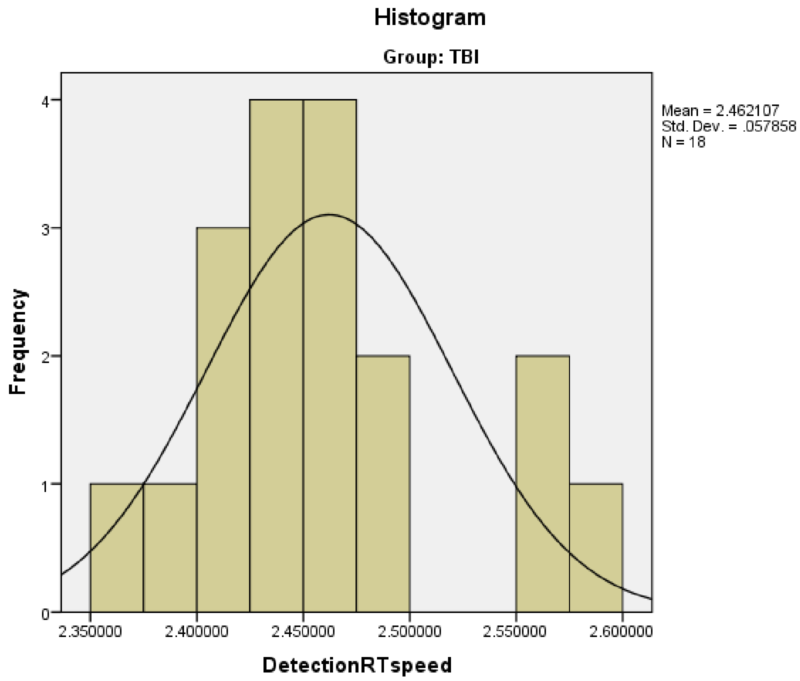
FSIQ


Histogram
Group: Non-TBI
Mean = 90.27
Std. Dev. = 14.873
N = 15
Frequency
0
1
2
3
4
60.0
70.0
80.0
90.0
100.0
110.0
120.0
FSIQ

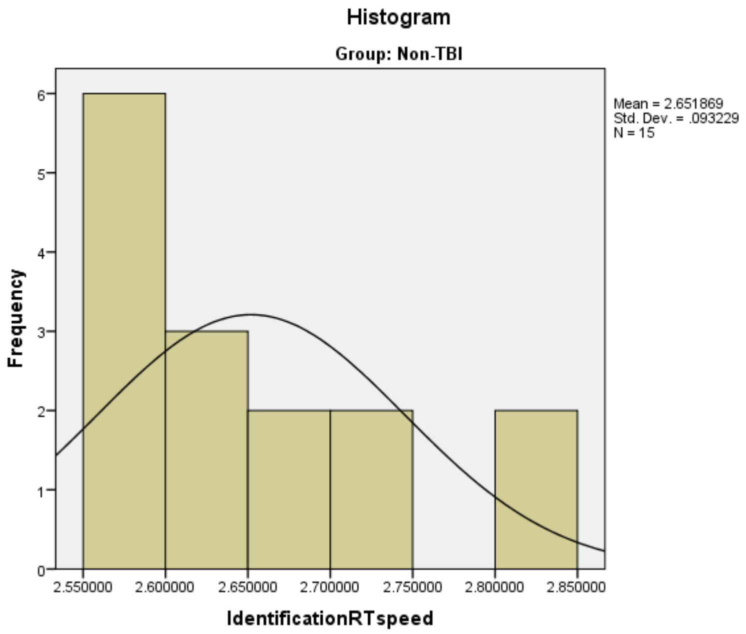

Histogram
Group: TBI
Mean = 80.16
Std. Dev. = 12.663
N = 19
Frequency
0
1
2
3
4
50.0
60.0
70.0
80.0
90.0
100.0
110.0
FSIQ

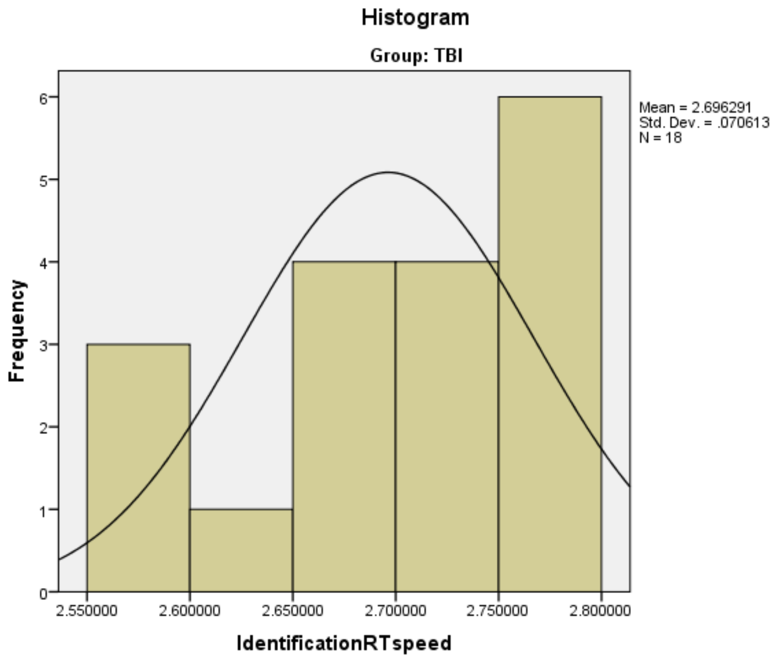
Detection


Histogram
Group: Non-TBI
Mean = 2.430245
Std. Dev. = .054062
N = 15
Frequency
0
1
2
3
4
5
6
2.350000
2.400000
2.450000
2.500000
2.550000
2.600000
DetectionRTspeed

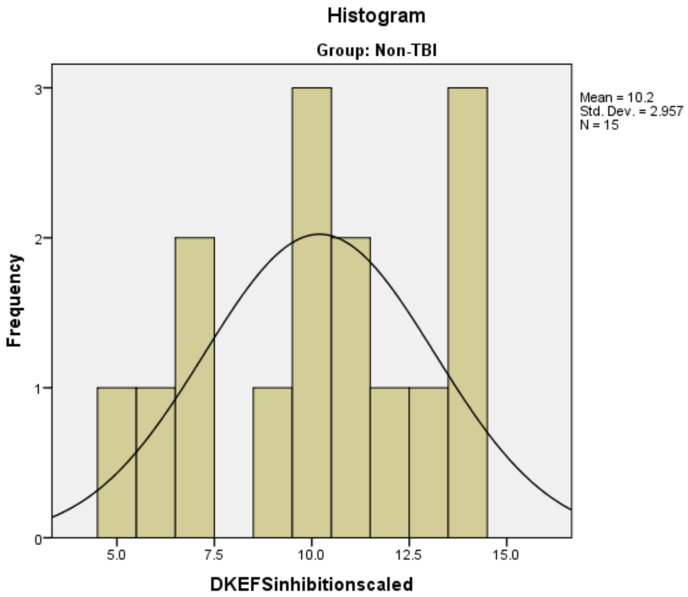

Histogram
Group: TBI
Mean = 2.462107
Std. Dev. = .057858
N = 18
Frequency
0
1
2
3
4
2.350000
2.400000
2.450000
2.500000
2.550000
2.600000
DetectionRTspeed

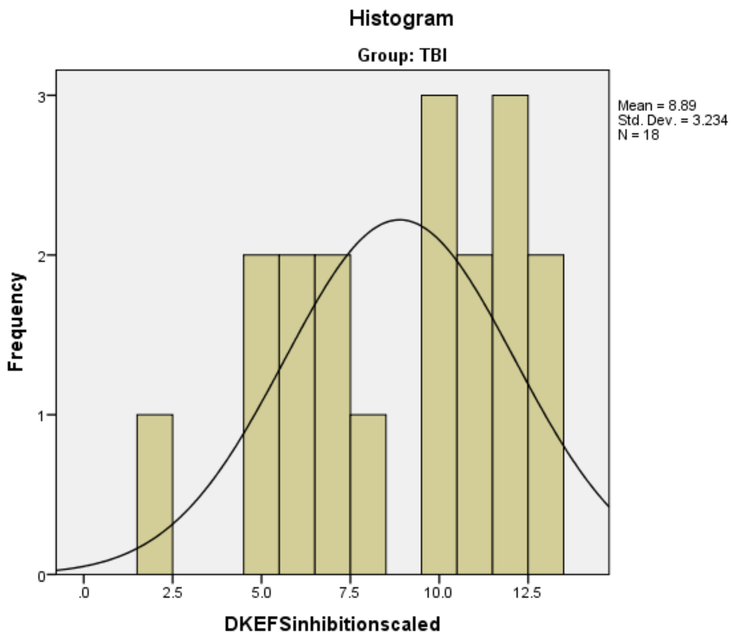
Identification



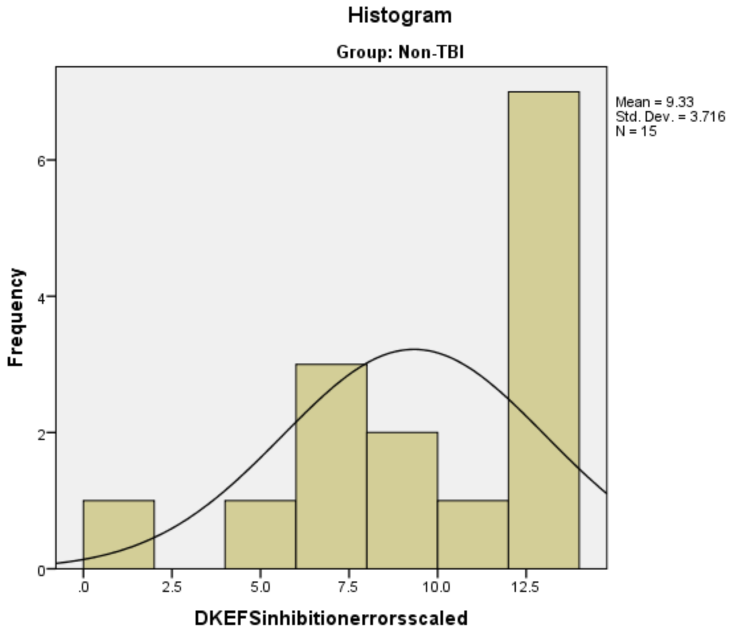


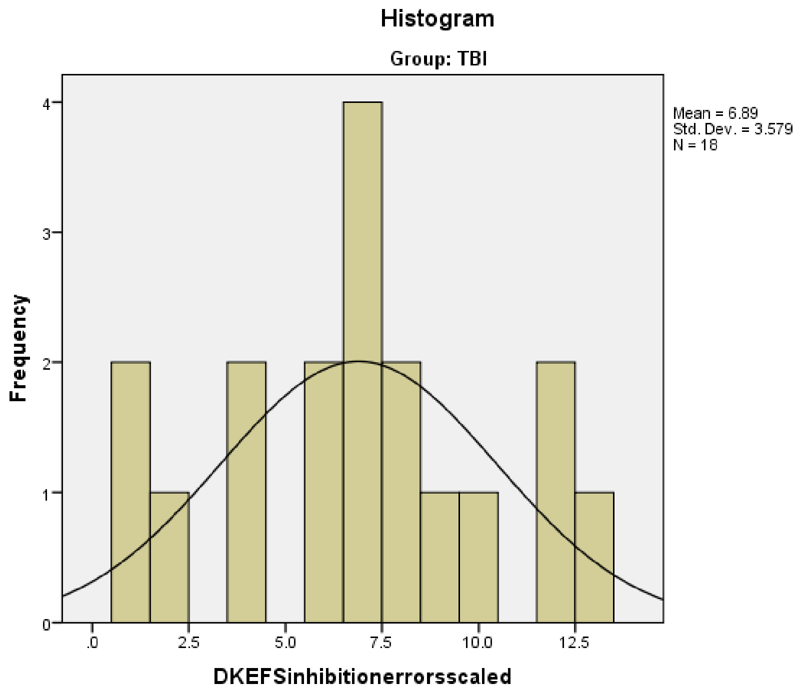
Inhibition scaled



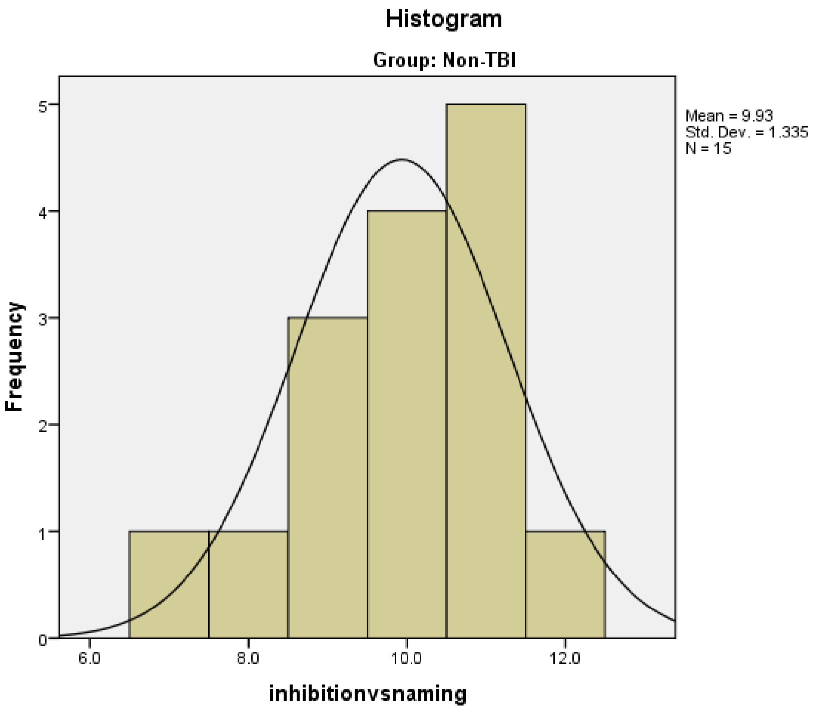


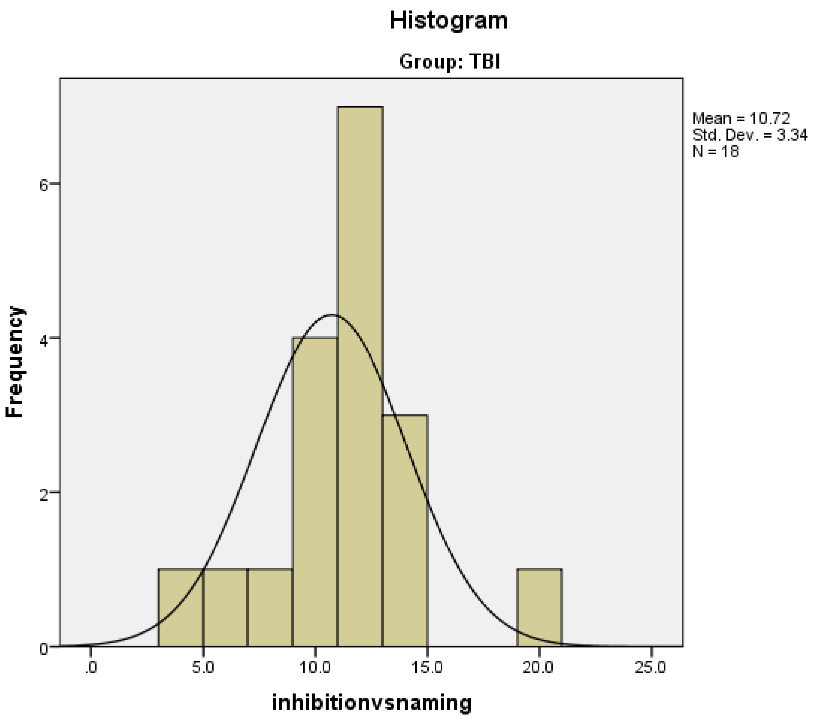
Inhibition errors scaled



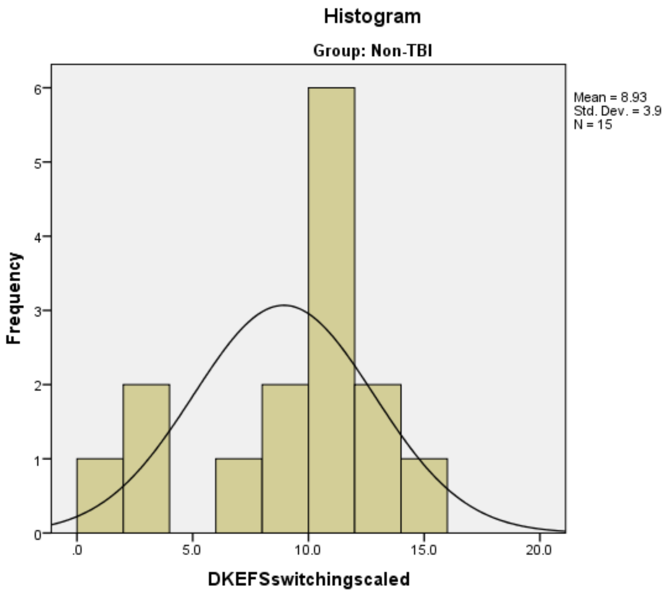


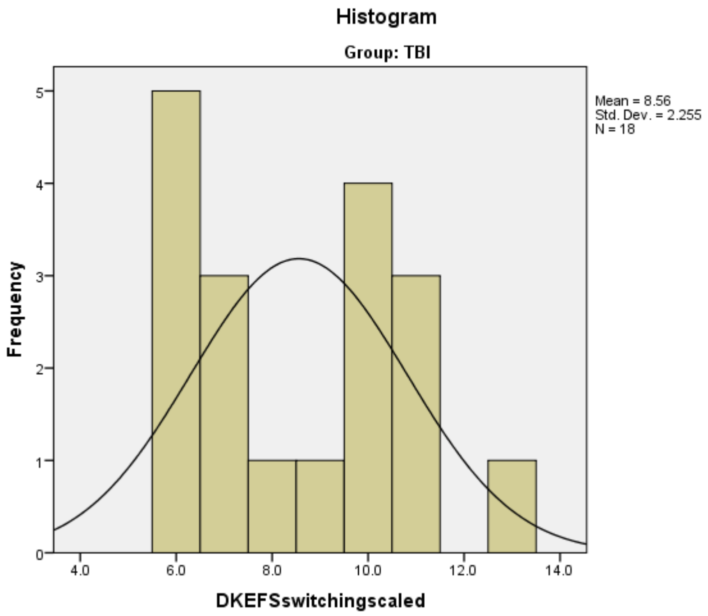
Inhibition vs naming



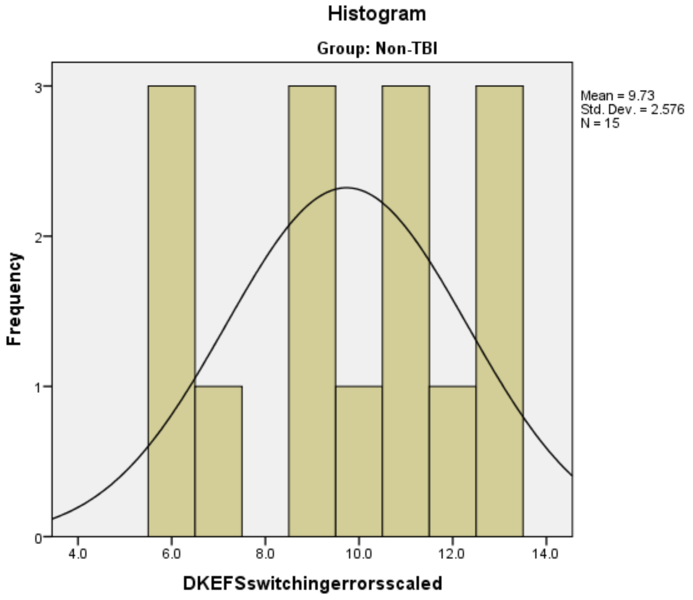


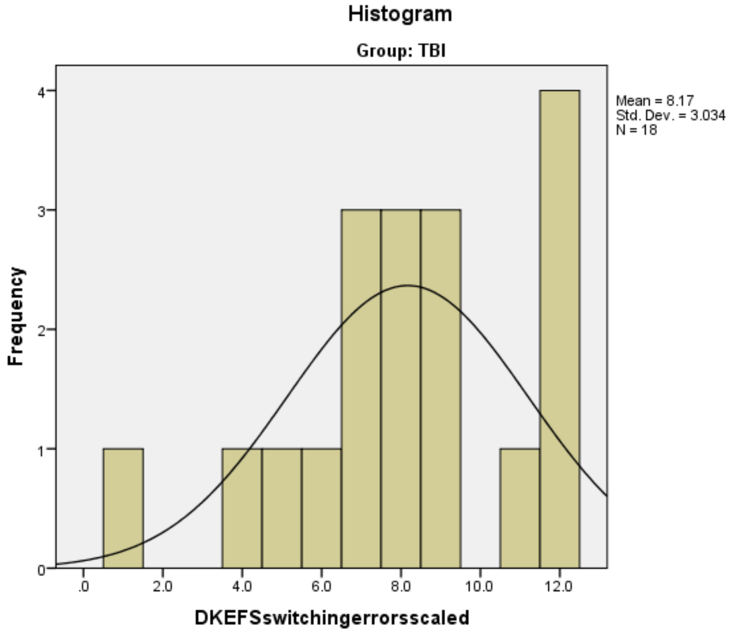
Inhibition/switching scaled



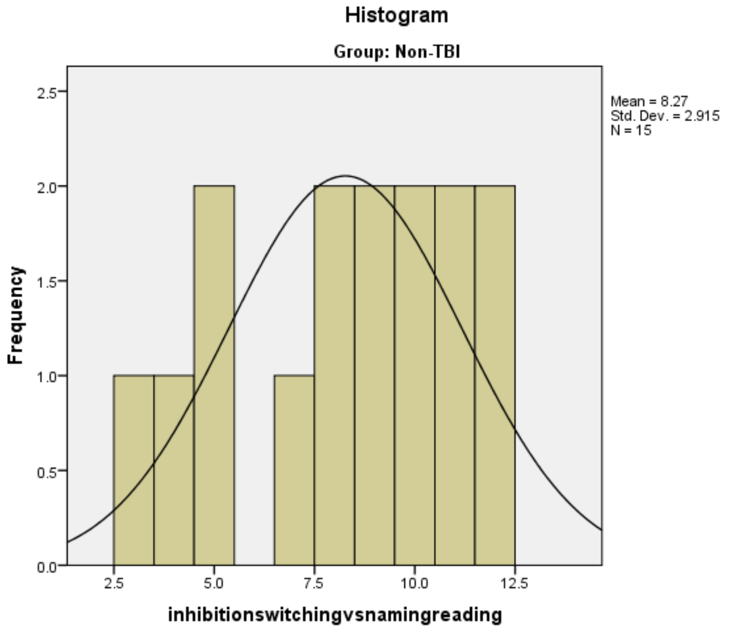


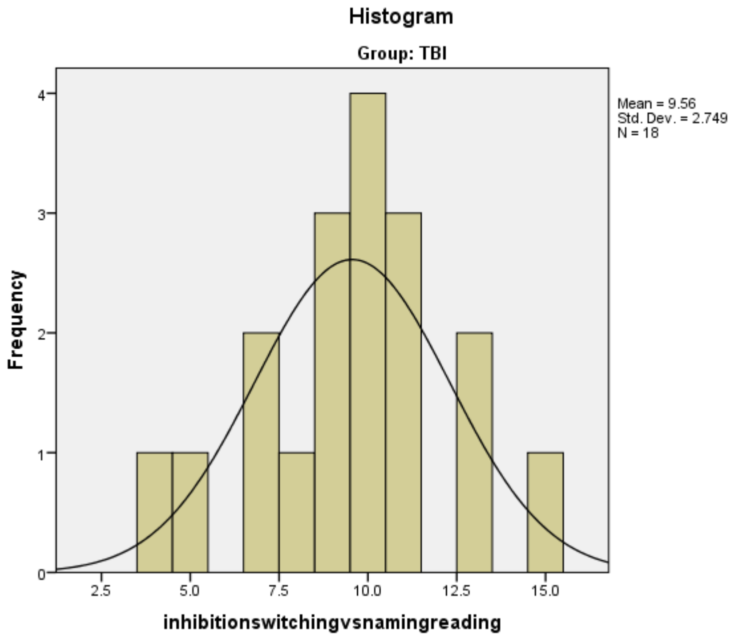
Inhibition/switching errors scaled



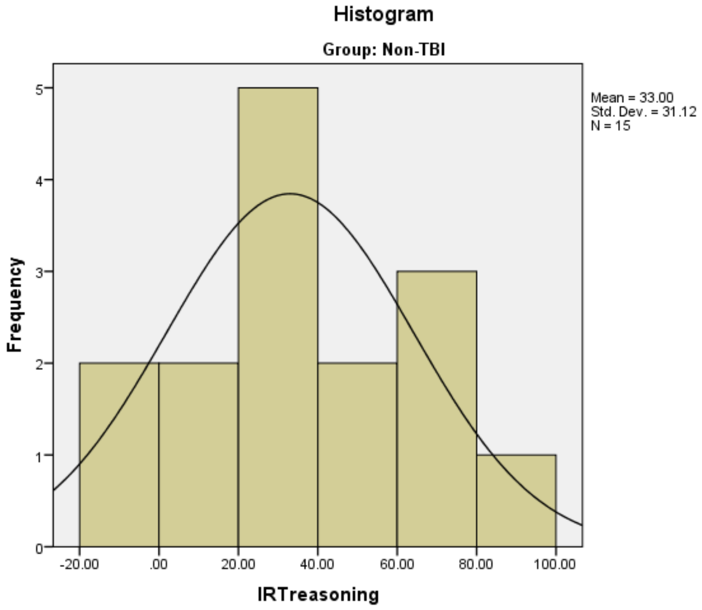


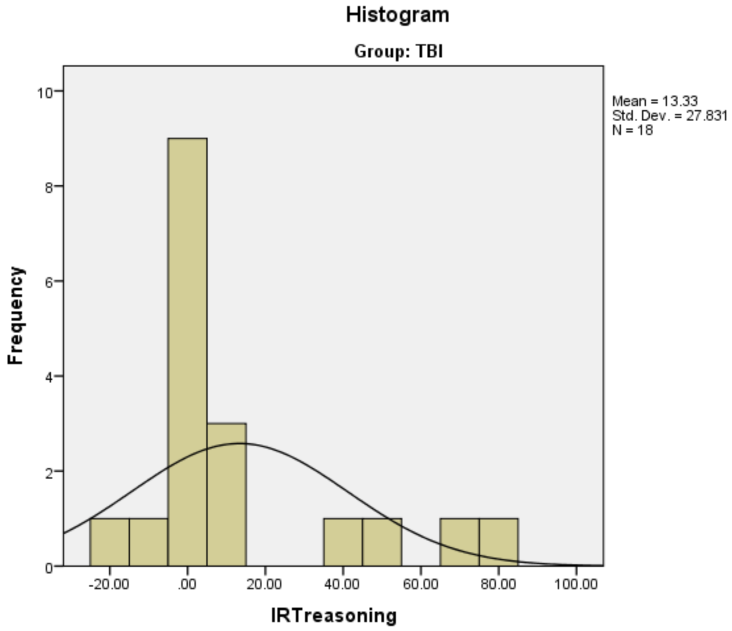
Inhibition/switching combined naming vs reading





IRT Reasoning





Appendix S Parametric assumptions

	Age		SMFQ		FSIQ		SES	
	TBI (n = 20)	Non-TBI (n = 15)	TBI (n = 19)	Non-TBI (n = 15)	TBI (n = 19)	Non-TBI (n = 15)	TBI (n = 20)	Non-TBI (n = 15)
Skewness z score	-0.67	-0.18	2.52*	1.65	-0.37	0.39	1.24	-1.84
Kurtosis z score	-1.37	-0.99	1.58	0.43	-0.79	-0.69	-0.33	0.6
Shapiro-Wilk score	0.87*	0.91	0.88*	0.91	0.96	0.96	0.89*	0.86*
Parametric	No	Yes	No	Yes	Yes	Yes	No	No

Note. *p <.05.

	Detection task		Identification task		Inhibition scaled		IRT		Mind in the Eyes	
	TBI (*n* =15)	Non-TBI (*n* = 18)	TBI (*n* = 18)	Non-TBI (*n* = 15)	TBI (*n* =18)	Non-TBI (*n* =15)	TBI (*n* =20)	Non-TBI (*n* = 15)	TBI (*n* =20)	Non-TBI (*n* =15)
Skewness z score	1.34	1.71	-0.89	1.58	-0.93	-0.49	2.69*	0.32	-0.23	-0.09
Kurtosis z score	0.11	0.49	-0.52	-0.11	-0.7	-0.86	1.05	-0.81	-1.46	-0.11
Shapiro-Wilk score	0.94	0.91	0.96	0.89	0.93	0.93	0.77*	0.96	0.91	0.98
Parametric data	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

Note. $*p < .05$.

	Inhibition error scaled		Inhibition vs naming		Inhibition/switching scaled		Inhibition/switching error scaled		Inhibition/switching vs naming plus reading	
	TBI (n =18)	Non-TBI (n = 15)	TBI (n = 18)	Non-TBI (n = 15)	TBI (n =18)	Non-TBI (n =15)	TBI (n =18)	Non-TBI (n = 15)	TBI (n =18)	Non-TBI (n =15)
Skewness z score	-0.1	-1.57	0.51	-1.2	0.53	-1.63	-1.05	-0.46	-0.3	-0.8
Kurtosis z score	-0.53	.0.02	1.48	0.19	-1.15	-0.14	0.33	-1.1	0.27	-0.85
Shapiro-Wilk score	0.95	0.87*	0.95	0.92	0.89*	0.88*	0.89	0.93	0.97	0.93
Parametric data	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes

Note. *p <.05.

Appendix T Recruitment service log

Team/Service	Recruitment time	Number of emails/phone calls (approximately)	Number of meetings at service	Number of team meetings attended
Cambridge YOT	July 2013- June 2014	100	3	2
Huntingdon YOT	July 2013-June 2014	21	1	1
Wisbech YOT	July 2013-June 2014	28	1	1
Norfolk YOT	July 2013- June 2014	48	4	0
Suffolk YOT	July 2013- June 2014		3	2
Peterborough YOT	August 2013- June 2014	55	1	2
Essex YOT	November 2013- June 2014	33	1	0
Norfolk Short Stay Schools	September 2013- June 2014	47	5	0
Cambridgeshire County Council Social Services	January 2014- June 2014	35	4	3
Shelly and Co. Solicitors	November 2013- June 2014	17	2	0
County Schools	November 2013- June 2014	32	4	0
Bramfield House	March 2014- June 2014	31	2	0
City Academy	November 2013- June 2014	14	1	0
Other services not included in recruitment		54		