Cognitive Functioning in UK-based Football (Soccer) Players, with emphasis on Social Cognition

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ABSTRACT

Introduction: An area of growing interest, the neuropsychological impact of sporting traumatic brain injuries has received considerable attention. Research has centred on boxing and the National Football League, with associations between sporting concussions and cognitive functioning widely acknowledged. The cumulative effect of mild sporting head injuries remains largely neglected. As the only sport incorporating head impacts (heading) as an integral part of the game, the world's most popular sport, football (soccer), has received limited research. To date, social cognition remains entirely neglected in the footballing literature, despite recent media attention regarding the potential long-term neuropsychological impacts.

Aims: To explore associations between football-related behaviours, cognitive functioning, and the novel addition of social cognition, in a UK-based sample.

Method: A quantitative cross-sectional design, enabled twenty-five male footballers to complete a neuropsychological assessment battery of premorbid functioning, cognitive functioning, and social cognition.

Results: Weaknesses relative to the norm were revealed for cognitive measures of visual attention, verbal functioning, and verbal memory, and social cognitive measures of theory of mind (ToM) and affective empathy. Results emerged in a highly educated sample, with above average optimal functioning. Associations between football-related behaviours, verbal memory, visual attention, and all measures of social cognition were revealed. Associations between quantified and cumulative career football-related concussions, verbal memory, ToM, and emotion recognition are highlighted.

Discussion: Findings indicate precautionary adjustments in assessment, monitoring, and management processes where football head-impacts are apparent. Deficits in verbal memory and social cognition should be held in mind, with future confirmatory research and preventative care recommended.

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LIST OF ACRONYMS

ACS	*Advanced Clinical Solutions*
ANT	*Affect Naming Task*
ASD	*Autism Spectrum Disorder*
AD	*Alzheimer's Disease*
bvFTD	*behavioural-variant Frontotemporal Dementia*
COVID-19	*Coronavirus Disease of 2019*
CTE	*Chronic Traumatic Encephalopathy*
DAI	*Diffuse Axonal Injury*
DAT	*Dementia Alzheimer's Type*
D-KEFS	*Delis-Kaplan Executive Functioning System*
dmPFC	*dorsomedial Prefrontal Cortex*
FA	*Football Association*
FIELD	*Football's Influence on Lifelong health and Dementia risk*
FIFA	*Federation Internationale de Football Association*
FTD	*Frontotemporal Dementia*
FTLD	*Frontotemporal Lobar Degeneration*
fMRI	*functional Magnetic Resonance Imaging*
GCS	*Glasgow Coma Scale*
HD	*Huntington's Disease*
IFAB	*International Football Association Board*
ImPACT	*Immediate Post-Concussion Assessment and Cognitive Testing*
LOC	*Loss of Consciousness*
MFC	*Medial Frontal Cortex*
mTBI	*mild Traumatic Brain Injury*
mPFC	*Medial Prefrontal Cortex*

NFL *National Football League*

NHS *National Health Service*

PCS *Post-Concussive Syndrome*

PFA *Professional Footballers' Association*

PFC *Prefrontal Cortex*

PTA *Post-Traumatic Amnesia*

QCAE *Questionnaire of Cognitive and Affective Empathy*

QoL *Quality of Life*

SDMT *Symbol Digit Modality Test*

SIS *Second Impact Syndrome*

SSQ *Social Stories Questionnaire*

TBI *Traumatic Brain Injury*

ToM *Theory of Mind*

TOPF-UK *Test of Premorbid Functioning UK*

UK *United Kingdom*

WAIS-IV *Wechsler Adult Intelligence Scale – Fourth Edition*

WMS-IV *Wechsler Memory Scale – Fourth Edition*

1. INTRODUCTION

1.1 Overview

Within the traumatic brain injury (TBI) literature, cognitive, behavioural, emotional, and social impairments have been widely acknowledged. Over the past two decades, the impact of TBI in sport has received considerable attention, particularly in boxing and the National Football League (NFL). Whilst we have witnessed a rapid transformation in how the scientific community, sporting organisations, athletes, legislative bodies, and the public view sporting concussions (McAllister & McCrea, 2017), an area of more recent interest is the impact of mild TBI (mTBI). Athletes participating in contact sports appear at significant risk, due to exposure to repeated mTBI throughout their career. However, the cumulative effect of mTBI in the most popular contact-sport worldwide, football (soccer), has received limited research. The limited studies available regarding the impact of football-related behaviours and head injuries on cognitive functioning have yielded conflicting results, which is often attributed to methodological short-comings.

Growing media attention regarding the long-term impact and possible association with neurodegenerative conditions suggests this area requires further consideration. Thus far, no research has been conducted exploring the impact of football-related behaviours on social cognition, even though concussive and subconcussive impacts have been shown to be associated with altered prefrontal cortex (PFC) functionality (Slobounov & Sebastianelli, 2006), a key regulator in social cognition (Bicks et al., 2015). With this in mind, a systematic review of the literature using search terms displayed in Appendix A was attempted. This however yielded no results across four databases (*Cinahl*, *PsychInfo*, *Science Direct* and *PubMed)*, indicating a lack of research in this area. As such, a narrative review was conducted, which subsequently informed a systematic approach to the literature and provided the rationale for the current study.

1.2 Traumatic Brain Injury

1.2.1 Definitions

Over the past 50 years, there has been a shift in the field away from terms such as “head injury” and “concussion”, concerned with trauma induced transient disturbance of brain function, and complex pathophysiological processes, that result in loss of consciousness and permanent brain damage (Bailes & Cantu, 2001; Harmon et al., 2013; Kutcher & Eckner, 2010; Richardson, 2000). The field of neuropsychology has shifted towards the more precise term “traumatic brain injury” (TBI). This umbrella term for all neurological sequalae, reflects the improved understanding of damage to brain matter as opposed to injury to the skull (Menon et al., 2010).

Defined as *“an alteration in brain function or brain pathology caused by an external force”* (Menon et al., 2010, p.1637), TBI has been shown to have short-term effects resulting in physiological symptoms and long-term impacts on cognition (i.e. language, memory) behaviour, sensation, personality, and emotion (Bailes & Cantu, 2001; National Institute of Health [NIH], 2020). How a person is impacted is dependent on several factors including history, location, severity, and number of previous TBIs (Harmon et al., 2013). Individual contributing factors, such as age, further impact duration and severity of deficits seen within hours, days, or weeks, with TBI exacerbating the natural cognitive decline associated with the ageing process (Moretti et al., 2012). The current view of TBI has thus broadened to understand the effects of injury across the life span, not simply during acute injury and recovery (McAllister & McCrea, 2017).

TBI results in one million patients attending accident and emergency departments in the United Kingdom (UK) each year and remains a leading cause of disability and mortality worldwide (Goldstein & McNeil, 2012). A leading charity in the field (Headway, 2017), highlight the ten-fold increase in associated hospital admissions across the past decade, with men one and a half times more likely to be admitted than women. Validation of such numbers is however hindered by accuracy of diagnoses, in the ever-changing definition of TBI, and the range of injuries this encompasses. In particular, mTBI are often overlooked, as people affected may not present at hospital. This may therefore result in this group experiencing mTBI being missed in the statistics.

1.2.2 Classification of Traumatic Brain Injury

Historically, road-traffic accidents, falls, and assaults have been reported as major causes of TBI (Goldstein & McNeil, 2012), whilst the last 20 years has highlighted the added significance of sporting injuries. TBI are often categorised into either, penetrating or closed. Penetrating head injuries involve a tearing of dura mater and subsequent exposure and damage of the skull, such as that seen in the famous case of Phineas Gage (Damasio et al., 1994; Richardson, 2000). This results in a lack of protection of the brain and damage localised to the area of penetration, that is often fatal. Closed head injuries refer to injuries that do not expose the contents of the skull, with the primary mechanism of damage a blunt impact to the head (Levin et al., 1976). Closed head injuries are the most common type, often impacting consciousness and resulting in diffuse cerebral damage (Richardson, 2000). Such injuries align with those most often seen in sporting TBI.

1.2.2.1 Primary and secondary damage

The mechanisms that cause TBI are multiple and complex, thus are often divided into primary and secondary forms of damage (Goldstein & McNeil, 2012). Primary brain damage occurs at the time of injury and includes haemorrhagic abrasions, lacerations, and contusions. Haemorrhagic contusions occur due to the biomechanical forces and dynamics that produce coup (point of impact damage) versus contra coup (directly opposite) injuries, most often to the frontal and temporal lobes (Cantu, 1992). Primary brain damage typically produces an immediate loss of consciousness, while secondary changes produce enduring coma and focal neurological signs, depending on the site and extent of injury. Secondary brain damage can occur in both extracranial and intracranial form, caused by extra and intradural haemorrhage and oedema, with cerebral ischaemia and intracranial hypertension most sensitive to therapeutic interventions (Werner & Engelhard, 2007). Most haemorrhages occur in, or near, the dura, in association with skull fracture, and constitute 3% of head injuries, with the highest incidence seen between ages 10 to 30 (Goldstein & McNeil, 2012).

1.2.2.2 Measuring severity of traumatic brain injury

TBI range in severity from “mild” (i.e. a brief change in mental status or consciousness) to “severe” (i.e. an extended period of unconsciousness or amnesia after the injury) (Centers for Disease Control and Prevention [CDC], 2020). To address issues around ambiguous definition of severity and to enable professionals to communicate effectively, three measures of TBI severity are commonly used. Firstly, the Glasgow Coma Scale (GCS) was originally devised by Teasdale and Jennett (1974) and updated by Sternbach (2000) to rate the length of time and complexity of altered consciousness, as soon as possible following a TBI. The GCS combines motor responses, verbal response, and eye opening, to score an individual from mild (15) to severe (3) TBI. Whilst often used for clinical interpretation, one may note that the GCS can be difficult to administer, is often time-consuming, and may fail to acknowledge the role of verbal comprehension.

Secondly, Loss of Consciousness (LOC), is often utilised to categorise severity of TBI, by focusing on the duration of time taken for the individual to regain consciousness (Kelly, 2001). Mild TBI are categorised as LOC lasting 30 minutes or under, whereas moderate TBI exceeds this time, with individuals regaining consciousness within 24 hours. TBI is categorised as severe when LOC exceeds 24 hours.

Thirdly, the Post-Traumatic Amnesia measure (PTA) (Richardson, 2000; Werner & Engelhard, 2007), focuses on the severity of memory alteration or period of confusion following TBI. Mild TBI are categorised as PTA lasting under one hour; moderate TBI exceeds one, but is less than 24 hours, and severe TBI is categorised when PTA exceeds 24 hours. While one may critique the arbitrary nature of these cut-offs, such measures exist due to a lack a of universally accepted definition of TBI in the field. Such measures are therefore necessary to aid the clinical classification of severity, when used in combination.

Clinically, severe TBI are often seen to result in physical, neuropsychological, behavioural, and emotional deficits, with impairment across all cognitive domains impacting across an individual's life (McDonald, 2013). Severe TBI is a rare injury in which the pathology often centres in the ventrolateral and orbital frontal lobes. Damage to the ventromedial temporal lobes can also be seen, due to abrasion against the anterior and middle fossa of the skull (Bigler, 2007; Courville, 1945; Gentry et al., 1988; Hadley et al., 1988). Additional medial frontal damage arises, as these surfaces are compressed against the dorsal bone and collide with the cerebral falx (Bigler, 2007). Whilst a rare occurrence, those who survive a severe TBI, can often remain comatised (Teasdale, 1995). Moderate TBI are often characterised by physical symptoms including headaches, alongside difficulties with memory, planning, thinking, attention, and concentration (Bailes & Cantu, 2001; NIH, 2020). Alternatively, mTBI, is often referred to as a 'silent epidemic', with symptoms rarely reported and thus resulting in limited research identifying acute effects (Karr, et al., 2014; McCauley et al., 2014).

1.2.3 Mild Traumatic Brain Injury

Now recognised as a major public health concern, mTBI has gained considerable attention in recent years. Accounting for around 75% of TBI that occur each year (CDC, 2003), mTBI exerts both primary and secondary effects on individual nerve cells (neurons), connected networks (neural networks) and cognition (NIH, 2020). This results in immediate and long-term effects including acute neuropsychological deficits in memory, verbal retrieval, and attention (Binder et al., 1997; Cicerone, 1997; Esselman & Uomoto 1995; Karr et al., 2014; McCauley et al., 2014). Early symptoms of headaches, dizziness, nausea, diplopia, tinnitus, irritability, fatigue, and disrupted sleep are often underestimated and underreported (Ponsford et al., 2000).

While the literature suggests children have a good prognosis post-mTBI, with a quick resolution of symptoms, adults reportedly experienced cognitive deficits and symptoms in the acute stage, with recovery ranging from 3-12 months, or sometimes longer (Carroll et al., 2004). This may result in persisting post-concussive syndrome (PCS), the aetiology of which remains controversial (Binder et al., 1997; Broglio et al., 2011). PCS can be defined as a cluster of physical, cognitive, and emotional symptoms, linked to measurable neuropsychological deficits (Ingebrigtsen et al., 1998; Leininger et al., 1990;

World Health Organisation [WHO], 2020), alongside neurobehavioural symptoms (i.e. emotional disturbances); (Levin & Robertson, 2012).

Sporting athletes are not only at risk of PCS, but those who return to play following a sustained head injury are at further risk of second impact syndrome (SIS) (American Psychiatric Association [APA], 2013; Saunders & Harbaugh, 1984). This rare yet, fatal condition is characterised by a second head injury sustained following return to play, which results in brain herniation, cerebral swelling, and subsequent death (APA, 2013; Bey & Ostick, 2009). This was recently demonstrated by Matser et al. (2004), who reported the case of a junior footballer in the Netherlands who had died after heading a ball when returning to play, following a previous head collision with another player. Alongside this, athletes who survive mTBI, are often at an increased long-term risk of neurodegenerative conditions, such as Alzheimer's disease (AD), Parkinsonism, and other brain disorders (CDC, 2003). As such, it has recently become apparent that the repetitive nature of mTBI that the sporting population are subjected to, may be a potential causal factor and thus result in long-term emotional and cognitive impairment.

1.2.3.1 Cumulative traumatic brain injury

Attention thus turns to the potential long-term cognitive, emotional, and subsequent economic consequences of cumulative TBI which, at present, lacks sufficient research (Barth et al., 1983; Brooks et al., 2016; Rimel et al., 1981; Ruchinshas et al., 1997). Whilst TBI is the most common cause of death in athletes, it remains one of the least understood sporting injuries (Cantu, 2003; Slobounov & Sebastianelli, 2006). Research suggests mTBI commonly occur during contact sports, where severe symptoms of neurological dysfunction may not develop. This is in addition to athletes often being exposed to repeated TBI, which may accumulate to produce chronic neuropsychological sequelae (Gronwall & Wrightson, 1975). Together, this results in a cumulative burden over the course of an athlete's career (Bailes et al., 2013), with many now stressing the cumulative effect of subtle yet, permanent damage in those exposed to repeated mTBI.

This is supported by functional impairment, neuropsychological deficits, and abnormalities of brain function, often observed through functional magnetic resonance imaging (fMRI), in the absence of observable symptoms (Bailes et al., 2013; Richardson, 2000). Impairment on tests of visual spatial attention and short-term memory suggest mechanisms contributing to cognitive performance are affected by multiple TBI, even in low-conflict situations (De Beaumont et al., 2013; Thériault et al., 2011). The limited data available thus indicate repetitive subconcussive impacts in sport have the potential to increase the long-term risk for cognitive decline, neurobehavioural changes, and neurodegenerative conditions (Bailes et al., 2013; McAllister & McCrea, 2017).

1.3 Sporting Traumatic Brain Injury

Over the past two decades, there has been a rapid transformation in how the scientific community, sporting organisations, athletes themselves, legislative bodies, and the public view sporting concussions (McAllister & McCrea, 2017). Sporting concussions refer to any TBI occurring in a sporting context, with the potential for head injury existing in almost all sports (Daneshvar et al., 2011; Nelson et al., 1984). Sporting TBI that result in a loss of consciousness have been widely studied in the NFL and boxing (Spiotta et al., 2011). Such studies suggest that the sporting population are at a heightened risk of chronic traumatic encephalopathy (CTE) (Mez et al., 2017; Omalu et al., 2005).

First highlighted in the boxing population in the 1920s, CTE was historically referred to as ‘punch drunk syndrome’ (Martland, 1928) or ‘dementia pugilistica’, translating to ‘boxer’s dementia’. A form of CTE involving impairment of cognitive and motor functioning, ‘dementia pugilistica’ is specific to boxing-related head impacts (Caron & Bush, 2015; McCrory, 2002). It was not until the 1940s that the now favoured term in the literature ‘CTE’ was coined (Montenigro et al., 2015), due to an improved understanding that exposure to any sporting TBI, may increase the risk of neurodegenerative disease.

A progressive degenerative disease, CTE is characterised by topographic and cellular patterns of tau neurofibrillary pathology (Montenigro et al., 2015; Stein et al., 2014). Recent evidence suggests CTE to be caused by cumulative repetitive impacts to the head, sustained over a period of years (Martland, 1928; McAllister & McCrea, 2017; McKee et al., 2015; Mez et al., 2017; Omalu et al., 2005; Slobounov et al., 2017). This implies that repetitive subconcussive impacts that are common in some sports, are a main causal factor of CTE. Neuropsychological alterations have been displayed including altered executive functioning, memory, speech, mood, behaviour, personality and gait, with CTE frequently resulting in dementia (Karr et al., 2014; Ling et al., 2015; Manley et al., 2017; Spiotta, et al., 2011; Stein et al., 2014; Stern et al., 2013).

Whilst CTE remains most commonly associated with boxing and more recently the NFL, an inquest following the death of Jeff Astle (a former England footballer), implied repeated ‘heading’ to have contributed to a diagnosis of dementia and subsequently, CTE-related death (BBC News, 2016). As detailed later, recent media interest in such football-related deaths has led to recent research which suggests footballers may experience a higher mortality rate from neurodegenerative disease, than the general population (Mackay et al., 2019). Whilst such research sheds light on the potential clinical implications of sporting TBI, cases of mTBI are estimated to account for 95% of sporting TBIs and do not result in loss of consciousness (McCrory et al., 2013). Although mTBI evidently account for the vast majority of sporting head injuries, they continue to be vastly overlooked in the literature. Furthermore, the impact of cumulative mTBI on cognitive functioning remains debated. The most popular sport worldwide, football (soccer) (Spiotta et al., 2012), appears widely neglected in the literature, with a scarce number of studies investigating mTBI in this population. Furthermore, of the limited studies conducted to date, the methodology and underreporting of symptoms has resulted in the field being critiqued (Hobbs et al., 2016; McMillan et al., 2017; Meier et al., 2015; Rutherford et al., 2005).

1.3.1 Definitions

The terms TBI, head-impacts and concussion are often used interchangeably in the literature, due to a lack of standardised definition. Throughout the past three decades, the field has begun to view sporting concussions as a form of TBI in its own right, with clinicians and scientists beginning to distinguish sporting concussions from other causes of concussion and mTBI (Ling et al., 2015). This is largely driven by sporting bodies, who highlight the need for clear and practical guidelines to determine recovery, and subsequently the safe return to play, of athletes experiencing sporting concussions (Ling et al., 2015). Sporting concussions thus refers to any TBI occurring in a sporting context, with a clinical diagnosis following sporting head trauma (Feddermann-Demont et al., 2017).

Inconsistency remains regarding appropriate assessment of sporting concussions, with altered mood, behaviour, personality, executive functioning, speech, memory, and gait frequently reported (Ling et al., 2015). Assessment thus focus largely on symptom-scores, neurocognitive functioning, and postural stability (Feddermann-Demont et al., 2017). The physiological impact of sporting concussions appears aligned with mTBI, with the frontal and temporal lobes most implicated (Manley et al., 2017). While the vast majority of research has focused on the acute consequences of sporting concussions that typically resolve within 7–10 days, much less is known about the long-term consequences of mTBI experienced in the sporting population (Johnston et al., 2001; McCrory et al., 2005).

Due to the recent surge in interest regarding sporting TBI and CTE, there has been increasing interest in the potential neuropsychological impact of sporting concussions (Belanger & Vanderploeg, 2005). However, the ambiguous definition of sporting concussions has led to a gap in the literature, whereby it is often assumed that sporting concussions must result in loss of consciousness. As such, repetitive mTBI common in the sporting population are often overlooked yet, have been suggested to have significant neuropsychological effects (Carroll et al., 2004). This lack of universal definition of the neurological symptoms of sporting concussions, thus results in a lack of consideration of the long-term impact of cumulative mTBI in the sporting population, limiting clinical assessment, diagnosis, and management (McCrory et al., 2017).

1.3.2 Subconcussive Sporting Injuries

Subconcussive sporting injuries occur frequently and can be defined as a mTBI that does not result in LOC (Kelly & Rosenberg, 1997). Such injuries are characterised by head impacts causing damaged axons and altered neuronal integrity yet, lacking sufficient force to result in symptoms of concussion (Bailes et al., 2013). As such, there is often a discrepancy; between individuals not reporting symptoms, yet still experiencing neuronal damage. Due to what may be described as a ‘silent epidemic’, the narrative around sporting concussion has witnessed a major shift over the past decade, in light of the somewhat hidden impact of subconcussive sporting injuries. Attention has recently turned to multiple repetitive subconcussive injuries and the potential risks associated with cumulative head-impact exposure (McAllister & McCrea, 2017). These concerns are particularly relevant in the setting of contact sports, given the incidence of concussion and exposure to repetitive head impacts, throughout an athlete’s career (McAllister & McCrea, 2017). It is therefore necessary to measure head impact exposure to understand the mechanisms involved in mTBI, including effects of repeated subconcussive impacts (Crisco et al., 2010), enabling a move towards preventative action.

However, concussive symptoms are often underreported across contact-sports (Stuart et al., 2018). Speculated reasons for underreporting include cultural pressures of not wanting to let the team down and to display bravery in playing on through injury, a lack of injury education (Sye et al., 2006), and external pressures from the fans and wider team (Kroshus et al., 2015). The fact that subconcussive impacts frequently occur without clinical symptoms, must be acknowledged. Whilst we have gained clearer understanding of the overall epidemiology of concussion across sports at various levels, we know little about the incidence of recurrent concussion and associated risks.

In rugby, it has been shown that accumulated and recent match exposure substantially influences current injury risk (Williams et al., 2017), with more than 25 matches per season increasing the risk of sustaining concussion, particularly for amateur athletes (Gardner et al., 2014; Rafferty et al., 2018). Nevertheless, the long-term effects of football-related behaviours remain largely neglected and require investigation (Rutherford et al., 2003). This may be due to the large-scale efforts necessary to determine the population-based frequency of repeated concussion, and lack of technological resources to reliably quantify head-impact exposure (McAllister & McCrea, 2017). Nonetheless, concerns remain regarding the measurement and subsequent understanding of the cumulative effect of subconcussive sporting-impacts.

As noted previously, TBI and repetitive head-impacts increase risk for neurodegenerative disorders later in life, with CTE developing specifically following repeated sporting head impacts (Martland, 1928; McAllister & McCrea, 2017; McKee et al., 2015; Mez et al., 2017; Omalu et al., 2005; Slobounov et al., 2017). Montenigro et al. (2017) highlight a potential dose-response effect of cumulative head impacts, with subconcussive exposure reliably predicting later life impairment in cognitive functioning, depression, and apathy. While an indication that sporting subconcussive injuries have the potential to impact brain structure and functioning later in life, associations with mTBI in football remain unclear, despite advances in technology (McAllister & McCrea, 2017).

1.3.3 Football-Related Behaviours

Association football, referred to as football or soccer, is the most popular sport in the world, with more than 265 million players in 204 countries (Bunc et al., 2017; Federation Internationale de Football Association [FIFA], 2006; Rodrigues et al., 2016). Football is unique in that it is the only sport in which participants actively engage in head impacts. Heading is an integral part of the game and a complex skill in which player's unprotected head is used to deliberately impact the ball for offensive and defensive play (Kirkendall & Garrett, 2001; Rodrigues et al., 2016). It is estimated that 4-22% of injuries sustained in football are reported to be head injuries, with an incidence of 1.7 injuries per 1000 football playing hours (Bunc et al., 2017; Tysvaer, 1992). A footballer can be subjected to an average of 6–16 incidents of heading per competitive game and more in training, where the ball reaches high velocities players (Bangsbo et al.,1991; Bunc et al., 2017; Ekblom, 1986; Jordan et al., 1996; Rodrigues et al., 2016; Spiotta et al., 2012; Tysvaer & Storli, 1981). This has led to estimates of professional footballers heading on average 2,000 times across their career (Rodrigues et al., 2019). Central defenders and strikers are reportedly more likely to sustain the majority of head injuries, due to partaking in the most penalty box competition for the ball (Hunt & Fulford,1990; Kirkendall et al., 2001).

Football heading results in repeated impact, acceleration–deceleration of the brain inside the skull, and possible rotation of the brain (Rodrigues et al., 2016). This involves both linear and angular components, potentially resulting in structural and functional changes to the brain (Rutherford et al., 2003). Head impacts thus result in neuropsychological impairment, with a dose-response relationship seen between history of concussion, heading exposure, and neurological test-performance (Autti et al., 1997; Matser et al., 1998, 1999, 2001; Sortland & Tysvaer, 1989). Performance on measures of attention, concentration, memory, planning, visuo-perceptual processing, and cognitive flexibility have been found to be inversely related to the number of concussions and lifetime heading in football (Matser et al., 1998, 1999, 2001; Witol & Webbe, 2003). This further increases the chance of subsequent injury and residual effects (Al-Kashmiri & Delaney, 2006; Benstein, 1999; Nordstom et al., 2014).

However, it is not just heading, but a combination of all football-related behaviours that may result in TBI and also leave footballers exposed to numerous subconcussive blows. These include unintentional head impacts between the head and ball, body parts of other players such as “head to heads”, and “elbow to head”, which Armstrong et al. (2020) report as the most common, as well as contact between the head and the ground or goalposts; often lacking recognition (Bunc et al., 2017; Rutherford et al., 2003). While implications of neurological damage and neuropsychological impairment have been hypothesised, epidemiological studies and media attention mainly centres on the impact of sporting concussions. As such, a scarce number of studies have implied a link between heading and neuropsychological impairment in the footballing population (Levitch et al., 2018; Lipton et al., 2013; Matser et al.,1998, 1999, 2001; Sortland & Tysvaer, 1989; Tysvaer & Lochen, 1991). Moreover, identification of contributing factors such as age (Downs & Abwemder, 2002) and gender often act as confounding variables, thus limiting the reliability and validity of results (Colvin et al., 2009; Covassin et al., 2013; Kontos et al., 2011; Mooney et al., 2020; Putukian et al., 2000; Tsai et al., 2015).

Conversely, a number of studies have failed to identify an association between football-related behaviours and cognitive functioning (Collie et al., 2006;

Delaney et al., 2002; Green & Jordan, 1998; Guskiewicz et al., 2002; Jordan, 1996; Kemp et al., 2016; Kirkendall & Garrett, 2001; Kontos et al., 2011; McCrory, 2003; Rutherford et al., 2009; Straume-Naesheim et al., 2005). Nevertheless, such studies have been methodologically questioned and are subjected to biases (i.e. sampling bias, selection bias, and social desirability bias). In particular, Straume-Naesheim et al.'s study (2005), is considered one of the largest FIFA studies yet, may be subject to a conflict of interests due to such funding and questionable analyses. Additionally, the data analysis performed in this study utilised a whole group concussion score, which inaccurately represents the distribution of concussions in the sample. As such, these results remain questionable and should be interpreted cautiously.

Most recently, a study of a population of Brazilian Championship footballers (Rodrigues et al., 2019) further failed to confirm an association between football heading and cognitive performance. This may however be due to the recruited sample group lacking variance in footballing characteristics, as all participants were of a Championship level. It is also important to note the cultural and contextual implications of conducting a study limited to Brazilian footballers competing at a championship level, whilst acknowledging the limitations of attempting to generalise findings cross-culturally. One may thus infer that across the literature, the lack of consistency in findings may be attributed to inconsistencies in study design and participant recruitment. Varying sample sizes, participant demographics, football-related behaviours, and estimated frequency of heading are reported, alongside differing cognitive assessments and the incomparable presence and composition of control groups.

In addition to the conflicting evidence, the impact of football-related behaviours and the potential role of subconcussive impacts across a career often spanning 10-20 years, remains largely neglected. A lack of exploration of football-related behaviours as an additional mechanism of cumulative TBI remains in the current literature (Bunc et al., 2017; Grenn & Jordan, 1996; Matser et al., 1999; Rodrigues et al., 2016). The current study thus aims to add to the scarcely available literature, whilst addressing methodological critiques as deemed appropriate. This will aim to address inconsistencies in the literature and subsequently, direct future research.

1.4 Neuropsychological Impact of Sporting Head Injuries

1.4.1 Cognitive Functioning

TBI results in significant disability due to cognitive deficits particularly in attention, learning, memory, and higher-order executive functions (Walker & Tesco, 2013). Executive functions refer to those cognitive abilities that enable a person to determine goals, formulate ways of achieving them and adapt in the face of competing demands and changing circumstances (Goldstein & McNeil, 2012). Executive functions are supported by the frontal lobes (Miller & Cohen, 2001), with damage to these areas and subsequent processes thus resulting in a range of symptoms often collectively referred to as 'frontal dysexecutive syndrome', (Baddeley & Wilson, 1988). Whilst the terms "frontal syndrome" and "dysexecutive syndrome" are often used interchangeably, cognitive deficits mainly result in impaired language and executive disorders (dysexecutive syndrome), while behavioural changes are primary concerned with social and affective processes (frontal syndrome) (Cummings & Miller, 2007).

In addition, cognitive deficits following TBI may also be attributed to damage to the medial temporal regions, dorsolateral prefrontal cortex, and the sub-cortical white matter tracts (McAllister, 2011). The hippocampus, which is crucial for declarative memory formation demonstrates atrophy via MRI in a significant proportion of patients who receive moderate to severe TBI (Bigler et al., 1997). Moderate and severe TBIs are understood to cause long-term, persistent cognitive deficits (Dikmen et al., 2009), and mTBI is most often associated with short-term cognitive impairment that resolves within three months of injury (Levin & Robertson, 2012).

1.4.2 Neuropsychological Impact of Sporting Concussion

Deficits in executive functioning (verbal fluency or response inhibition), memory, and cognitive processing speed are reported following TBI (McCauley et al., 2014). In addition, American studies highlight the potential cumulative neurocognitive impact of sporting concussions and subconcussive impacts, in the NFL (Bailes et al., 2013; Jennings et al., 2015; Tsushima et al., 2016). In particular, an autopsy of a retired NFL player revealed neuropathological changes consistent with long-term repetitive concussive brain injury (Omalu et al., 2005). This indicates potential long-term neurodegenerative outcomes for players subjected to repeated mTBI. This has been supported across the lifespan in other NFL studies. An increased prevalence of later life cognitive impairment in retired NFL players, reflects a diminished cerebral reserve (Randolph et al., 2013). This also appears impacted by age of play, with participation prior to the age of 12 associated with greater later-life cognitive impairment, as measured by neuropsychological tests (Stamm et al., 2015).

Furthermore, prior concussion resulting in loss of consciousness was found to be a risk factor for increased hippocampal atrophy and the development of mTBI (Strain et al., 2015). Of the minimal conducted studies implying cognitive impairment in footballers, Rutherford et al.'s (2005) preliminary results in a sample of university footballers based in the UK revealed deficits in attention accuracy and sorting category shifts, when compared with rugby players and non-contact sportsmen. Stephen et al. (2005) supported findings of decreased attention accuracy in footballers, reporting decreased accuracy by 1% for every 10 headers. This implies a potentially cumulative effect for football-related behaviours; however, such studies may be criticised for failing to control individual differences across sample groups, thus limiting the ecological validity of findings. Further investigation is therefore required, whilst controlling for group differences.

1.4.3 Neuropsychological Assessment and Management

The issue of player safety in contact sports has gained increased attention worldwide over the past several years, particularly for contact sports such as football, across ages and abilities (Stuart et al., 2018). As sporting injuries are a significant clinical and public health concern, there has been a growing call to improve the translation of evidence-based and expert-informed sports injury prevention interventions, into sustained practice (Donaldson et al., 2016). The care of athletes experiencing sporting concussions should ideally be undertaken by healthcare professionals, with specific training and experience in the assessment and management of concussion (Harmon et al., 2013). Whilst historically reliant on self report measures, there appears a systemic underreporting of post-concussion symptoms from athletes and their teams

(Meier et al., 2015; Stuart et al., 2018). This may reflect motivated behaviour including cultural and external pressures to lessen injury time (Gronwall, 1976; Kerr et al., 2014; Kroshus et al., 2015; Sye et al., 2006). As such, there appears a need for objective measures.

Over the past 20 years, clinical neuropsychologists have been at the forefront of scientific and clinical initiatives developing evidence-based approaches that are key in the evaluation and management of sporting concussions (Echemendia et al., 2011). Neuropsychological tests have become commonplace in the assessment of sporting concussions (Echemendia et al., 2012), enabling evaluation of the nature, duration, location, and severity of the injury, as well as the subsequent impact. Numerous sporting organisations thus advocate for neuropsychological testing, as part of the current clinical management of sporting concussions. This enables the assessment and quantifying of the impact of a sporting TBI (both mild and severe), in comparison to the subjective reporting of symptoms (Guskiewicz & Broglio, 2011). As no single test demonstrates the sensitivity or specificity necessary for clinically relevant and empirically supported return-to-play decisions (Echemendia et al., 2001), recommendations for a battery of tests are made to capture variability among injured athletes (Goswami et al., 2016; Guskiewicz & Broglio, 2011).

In sporting organisations, we now see a mixture of paper and computerised neuropsychological testing. The Immediate Post-Concussion Assessment and Cognitive Test (ImPact) is often used to assess sporting concussions (Gaudet & Weyandt, 2017). This highlights the direct impact neuropsychology has had on current policy strategies for injury assessment and return-to-play following sporting concussions (Walker & Tesco, 2013). However, the accurate diagnosis of mTBI requires considerable experience, a high index of suspicion, a careful history and a series of examinations, alongside a working knowledge of the athlete's personality, demographic factors, comorbid conditions and likelihood of minimising of symptoms (Kutcher & Eckner, 2010). As such it is been recommended that neuropsychologists be included as licensed health care professionals authorised to evaluate, clinically manage, and provide return to play clearance for athletes who sustain sporting concussions (Echemendia et al., 2011). Unfortunately, such recommendations remain largely ignored, and may result in professionals who do not possess the adequate neuropsychological knowledge attempting to assess cognitive domains (executive functioning, learning, attention, memory, verbal ability, and emotional functioning). This has the potential to result in uncontextualised interpretations of results and possible misdiagnoses.

1.4.3.1 On field assessment of sporting concussion

Careful and well-planned side-line assessments of sporting concussions serve as a screen to establish whether a more serious and potentially catastrophic condition could be developing (Guskiewicz & Broglio, 2011). Emphasis is placed on the adequate medical evaluation of athletes, to ensure recovery and prevent serious consequences of repeated injury (Bruno et al., 1987). We therefore see brief screening tools such as the sports Concussion Assessment Tool version 5 (SCAT5), being developed to assess sporting concussions on the field of play (Echemendia et al., 2017). Whilst a useful snapshot, this tool is not a formal diagnosis and is not sensitive to mTBI (McCrory et al., 2005). Consequently, a tool designed for improved player safety, may inadvertently increase risk by failing to detect mTBI and allowing players to return to play.

1.4.3.2 Return to play assessment

As the neuropsychological impact of sporting concussions on functioning is well established, evidence supports the use of neuropsychological assessment to inform treatments and in return-to-play decision making (Taylor, 2012). Trainers and team physicians continue to attempt to gain a better understanding of the mechanisms and severity of mTBI, to develop meaningful return-to-play criteria (Barth et al., 2001). Whilst one would aim for a recovery to baseline (Echemendia et al., 2012), in the absence of such data, comparison with group norms and tests of premorbid functioning (e.g. Test of Premorbid Functioning UK [TOPF-UK], Wechsler, 2011), provide a reliable and valid assessment of an athletes return to baseline following sporting concussions. Furthermore, athletes should not return to play if experiencing PCS however, this may be missed if symptoms align with mTBI, leaving athletes susceptible to SIS (APA, 2013; Bey & Ostick, 2009; Cantu, 1992; Saunders & Harbaugh, 1984). As such, return-to-play assessments should incorporate a range of testing modalities, alongside clinical symptoms of concussion. Testing across the neurocognitive domains featured in a neuropsychologist's core assessment battery of tests is recommended, during the recovery phase (McCrory et al., 2005), with neuropsychologist involvement in return-to-play assessments where necessary.

1.4.3.3 Recommendations for sporting legislation

Particularly in community and non-professional 'grassroots' contact sports in England, there is an increased risk of sporting concussions and subsequent TBI being overlooked, due to the majority of teams not having adequately trained pitch-side medical staff (Stuart et al., 2018). A single healthcare professional is often responsible for the treatment and management of post-match and training injuries of all athletes within a single club, often without appropriate expertise of sporting concussions. Legislative efforts are required to provide a uniform standard for sports organisations, regarding the safe management and return to play of athletes which is accessible across all levels (Harmon, et al., 2013; Kuiper, 2005; Stuart et al., 2018). More concerted, coordinated, and theory-informed efforts are required to facilitate the widespread dissemination, translation, and implementation of such guidelines (Donaldson et al., 2016). Following this, greater efforts to educate involved parties (i.e. athletes, parents, coaches, officials), adherence to and proper enforcement of concussion protocols are required, to promote player health and safety and influence the officiating, coaching, and playing of football worldwide (Tarzi et al., 2019).

1.4.4 Neuroimaging and Sporting Concussion

Advances in functional neuroimaging have enabled research into the cerebral changes associated with TBI. Slobounov and Sebastianelli (2006) highlight frontal brain areas, namely the PFC as vulnerable to damage after TBI, resulting in long-term cognitive impairments (Echemendia et al., 2001; Levin et al., 2002; Lowell et al., 2003). Regarding sporting concussions, again most studies have been conducted in America and focus on the NFL or boxing (Casson et al., 1984; Ford et al., 2013; Hart et al., 2013; Koerte et al., 2015, Strain et al., 2015). Evidence exists in former boxers demonstrating mild to moderate cerebral atrophy, which has been suggested to be caused, at least in part, by multiple subconcussive blows (Casson et al., 1984). Whilst interest has begun to surface regarding the cerebral changes linked to football, research is lacking. Limited research has identified cerebral atrophy in retired association footballers, alongside mild to moderate neuropsychological impairment, unrelated to age (Baroff, 1998; Tysvaer, 1992).

Such findings are in line with neuroimaging findings regarding mTBI, showing structural lesions (Johnston et al., 2001), particularly diffuse axonal injury (DAI) most commonly involving the white matter of the frontal lobe (Gentry et al., 1998) and cellular damage. With regards to football-related behaviours, some evidence of an association between heading and abnormal brain structure exists, but such data are preliminary (Rodrigues et al., 2016). Armstrong et al. (2020) again highlights the frontal region as the most vulnerable area, resulting in deficits in language, memory and perception, which Johnston et al. (2001) hypothesise as due to disruption in the frontal-limbic reticular activation system. This occurs alongside neuroanatomical changes in the anterior cingulate cortex and orbital frontal cortex, post sporting concussions and subconcussive mTBI (Meier et al., 2016). As such, this points to the potential importance of such impacts regarding football-related behaviours. Such studies are however yet to be replicated and must be interpreted with caution, when directing future research.

1.4.5 Sporting Concussion and Impairment

TBI has long been linked to chronic neurodegeneration and the development of neurodegenerative diseases including AD, Parkinsonism and most recently CTE (Walker & Tesco, 2013). It has been suggested that TBI accelerates the onset of cognitive decline and thus leads to dementia (Gedye et al., 1989; Nemetz et al., 1999; Schofield et al., 1997; Sullivan et al., 1987). Recent years have seen increased media attention on the long-term effects of sporting TBI, with accumulating evidence from case studies of retired high-profile athletes developing neurodegenerative conditions, following concussive and subconcussive sporting TBI.

A study of NFL players demonstrated neurodegenerative mortality rates three times higher than the general population, and four times the national rate for neurodegenerative sub-categories (i.e. AD) (Lehman et al., 2012). The risk of cognitive impairment appears to increase with the number of sporting concussions, with one study demonstrating a five-fold increase in mild cognitive disorders and a three-fold prevalence of memory deficits in players suffering three or more concussions (Guskiewicz et al., 2005). Omalu et al. (2005) documented the first clinical and pathological findings of two retired NFL players having diverse forms of accumulated tau protein and cerebral atrophy. This highlights unique histomorphologic features of CTE from other neurodegenerative disorders such as AD (Montenigro et al., 2015; Omalu et al., 2011). Further support has been provided by later studies, indicating a diverse accumulation of tau protein and atrophy of the cerebral hemispheres, thalamus, medial temporal lobe, hippocampus, subcortical nuclei, basal ganglia, and brainstem (Ford et al., 2013; McKee et al., 2013; Omalu et al., 2011).

1.4.5.1 Neurodegenerative conditions and football

As CTE is now reported to occur due to the cumulative mTBI athletes are exposed to throughout their sporting career, the field has seen a recent surge in media and subsequent public interest. The potential link between sport, CTE and neurodegenerative conditions has received significant attention in football. Multiple high-profile footballer deaths linked to neurodegenerative conditions over the past three years (Barth et al., 2001), has added to the considerable evidence of increased incidence of dementia in retired footballers (Edgar, 2001; Holdenm, 2001a, 2001b; Sutton, 1999). Spear (1995) first raised this possibility, due to increased incidence of AD. This is aligned with Ling et al.'s (2017) research into retired footballers with a history of chronic repetitive head injuries and diagnosed dementia, in which six post-mortems showed the pathology for CTE in four cases and all six had AD, following a history of chronic repetitive head impacts. Again, neuropathology was characterised by an abnormal build-up of tau protein and has been interpreted as linking repetitive head impacts in football with CTE (Ling et al., 2017).

1.4.5.2 Public health interest: football and dementia

This highlights the current public health interest in football-related behaviours and neurodegenerative conditions. Media attention and public interest has heightened over the last three years, in light of the high-profile deaths of England 1966 World Cup-winners. Nobby Stiles passed away in late 2020, following dementia, whilst his former England team-mate Sir Bobby Charlton has recently received this diagnosis and their team mates Jack Charlton, Martin

Peters, and Ray Wilson were also diagnosed with dementia prior to their deaths (BBC Sport, 2020). This comes following the inquest into former England Footballer Jeff Astle's death, which concluded that repeated heading contributed to dementia and subsequent CTE-related death, which the coroner described as an "*industrial disease*" (BBC News, 2016).

In light of this, the Football Association (FA) and Professional Footballers' Association (PFA) came together to commission the 'Football's influence on lifelong health and dementia risk' or 'FIELD' study, in collaboration with the Glasgow brain injury research group (2020). This retrospective cohort study, aimed to analyse data from former professional footballers to assess the incidence of neurodegenerative diseases in this population (Russell et al., 2019). Comparison of National Health Service (NHS) Scotland records of 7,676 professional male footballers born between 1900 and 1977 (of which 1,180 had died), with socio-demographically matched NHS medical records of 23,028 men, revealed footballers showed higher mortality from neurodegenerative diseases (Mackay et al., 2019). 11% of the professional footballers identified in the FIELD study experienced dementia related death, compared to 3% of the control population (FA, 2019), translating to a three and a half times increased risk of neurodegenerative associated death, then the general population.

The FA (2019) response to the findings of their commissioned study, highlighted that whilst footballers were three and a half times more likely to die from dementia, they did not 'die earlier' due to dementia, lived over three years longer than the general population, and were less likely to die of other diseases (i.e. heart disease or lung cancer). This response appears to play down the increased risk of footballers developing dementia as highlighted in the study, by focusing solely on the positive health implications of football participation. Whilst, both the PFA (2019) and FA (2019) acknowledge that the study could not determine the cause of such increased rates of dementia, this was used to imply that the study could not link the cause to football-related behaviours. As opposed to recommending further research into the underlying causality, the FA (2019) constituted an independently chaired medical and football advisory group to review the findings and recommending the re-issuing of the current FA concussion guidelines (2019). This could be critiqued for placing the attention back onto the management of football-related head injuries and neurodegenerative impact, as opposed to acknowledging the need for deeper understanding of the causal factors underlying this increased risk in the footballing population, such as the potential impact of repetitive mTBI caused by football-related behaviours.

The PFA (2019) go a step further, by highlighting the need for a collaborate, international approach amongst organisations and governing bodies. This would enable a move towards a game-wide strategy to manage dementia and neurodegenerative conditions, whilst providing adequate support for the footballing population. Whilst the PFA have called for restrictions on heading in training, high-profile managers, such as Frank Lampard and England Manager Gareth Southgate have also expressed their concerns and called for change (Sky Sports News, 2020a, 2020b). However, at present, research does not provide a robust link between increased risk of dementia and heading directly. This could be attribute to a lack of studies failing to investigate the neuropsychological impact of football-related behaviours. As such, the PFA's new neurodegenerative disease working group was created, to provide a holistic support system for footballers and their wider networks (BBC News, 2020). This alongside the International Football Association Board's (IFAB, 2020) recent approval for trials of concussion substitutes in football, appear a more appropriate next step for the management of player safety, whilst further research is conducted.

In January 2021, the premier league followed this advice, becoming the first competition to approve the implementation of permanent concussion substitutes, giving teams two concussions replacements in addition to the usual three (Sky Sports News, 2021). Whilst a much-needed step in the right direction, a lack of understanding regarding the underlying causality of the link between football and dementia related deaths, requires further investigation. By aiming to explore the cumulative impact of football-related behaviours, the current study thus takes a necessary step in adding to a field currently lacking research. Through investigating the impact of a broad range of football-related behaviours on both cognitive functioning, and as a novel approach, social cognition, the current study aims to begin directing future recommendations.

1.5 Social Cognition

In the field of clinical psychology, social cognition denotes the mental processes underpinning the capacity to attend to, recognise and interpret, interpersonal cues that enable us to understand the behaviour, intentions, thoughts, and feelings of others, and to share experiences and communicate effectively (Adolphs, 2009). This term has been applied across disciplines, with evolutionary psychology framing it as the explanation for competition and cooperation for survival emerging in human evolution (Emery & Clayton, 2009).

Cognitive neuroscience owes a debt to social psychologists, who initially began constructing the study of social cognition in the 1940s. Described as the understanding of social knowledge, influences, and processing biases, social cognition was first highlighted in an experiment where participants demonstrated their innate capacity to attribute mental states to others (Adolphs, 1999). Throughout the 20th century discoveries included how an individual's behaviour could be shaped, changed and even criminalised, by systematic manipulation of social interactions, as in the famous experiments by Asch (1951, 1952, 1956), Milgram (1963, 1965) and Zimbardo (1971, 1974).

However, it was not until the technological breakthrough of brain imaging methodologies, that the field of social psychology could transform itself into the field of social cognitive neuroscience (Frith & Frith, 2008). Ochsner and Lieberman (2001) celebrated the emergence of this new field, infusing social psychology with brain science methodology, in attempts to decipher how the brain controls such cognitive processes as memory and attention, which then influence social behaviours (Frith & Frith, 2008). Furthermore, concepts of domain specificity have now been extended to social cognition, with suggestions that some aspects of neural processing are specialised for particular types of stimuli including language, face perception, and theory of mind (ToM) (Spunt & Adolphs, 2017).

1.5.1 Social Cognition in Clinical Psychology

Social cognitive functioning is now known to involve a myriad of intersecting cognitive processes, which includes predominantly unconscious perception, attention, and interpretation of social information (Christidi et al., 2018). Assessment of social cognition mainly focuses on four key domains; ToM, emotional empathy, social perception, and behaviour (Christidi et al., 2018). These processes rely on higher-cognitive abilities to enable the creation of representations of the self and others, enabling engagement in the social world. Interpreting social signals such as facial expressions and gaze, facilitate physiological social processes of imitation, emotional resonance and empathy, enabling learning and survival through avoidance of danger (Frith & Frith, 2012; Rizzolatti & Craighero, 2004; Wicker et al., 2003). As detailed later, impairments in these domains present core diagnostic criteria for some neurodegenerative diseases and are thus increasingly evaluated in clinical settings, due to having implications for therapeutic decision-making (Christidi et al., 2018).

1.5.2 Levels of Social Cognition

Today, research in social neuroscience addresses diverse abilities and capacities. The construct ‘social cognition’ still lacks consensus, regarding the dimensions to be studied and methodology of clinical assessment. Etchepar and Prouteau’s (2018) systematic review highlights the relevance of integrating models of level of information processing (low-level *vs*. high-level) and the nature of processed information (affective *vs*. cognitive), to form a multi-dimensional model of social cognition.

Focusing on levels of information processing, Frith and Frith (2008) differentiate between implicit and automatic, lower-level processes and higher-level explicit processes of self-monitoring and reflection. Low-level processes enable accurate prediction of others' changeable dispositions. This can be demonstrated through assessments of emotion recognition, including recognition of facial expressions, gestures, and tone of voice (Mancuso et al., 2011). Alternatively, uniquely human high-level processes of mentalising referred to as ‘meta-cognitive process’ (Frith & Frith, 2012), are observable through ToM tasks, such as detecting sarcasm (Channon et al., 2004; Frith &

Frith, 2008). Together these processes can be observed directly through real-time social interactions of mutual give and take (Frith & Frith, 2008).

Moving onto the nature of processed information, distinction is made between affective and cognitive functioning (Kalbe et al., 2010). Affective functioning refers to the processing of emotional information through empathetic appreciation, whereas cognitive functioning refers to understanding and inferring intention, belief, and knowledge (Kalbe et al., 2010). Following the integrated model highlighted by Etchepar and Prouteau (2018), attempts are often made to assess a range of overlapping domains within social cognition such as emotional expression, reading faces, eye gaze, perception into action, ToM, empathy, deception, and morality. In clinical neuropsychology assessments tend to focus on ToM, emotion perception, and empathy, as evidence links TBI deficits to these domains (Baron-Cohen et al., 1994; Decety & Meyer, 2008; Philips et al., 2003).

1.5.3 Neural Basis for Social Cognition

The neural processes supporting effective social interactions in everyday life and the consequences of dysfunction in these processes, have been the focus of intense research over the last two decades (Elamin et al., 2012). Studies in humans and other primates utilise neuroimaging techniques to investigate which processes may underlie attribution of mental states. Four main regions are thought to be activated during social cognition; the medial prefrontal cortex (mPFC), temporoparietal junction (superior temporal sulcus), basal temporal regions (fusiform gyrus and temporal poles adjacent to the amygdala), and extrastriate cortex (occipital gyrus) (Carr et al., 2003; Castelli et al., 2000; Decety & Jackson, 2006). Whilst the temporal lobe appears to play a role in perceiving socially relevant stimuli, the other identified areas (amygdala, right somatosensory cortices, orbitofrontal cortices, and cingulate cortices) are thought to link the perception of stimuli relative to motivation, emotion, and cognition (Adolphs, 1999, 2002, 2009; Phillips et al., 2003). Together, this forms a network for processing information about intentions and inferences about other's mental states.

As such, four separate neural networks have been recognised regarding social cognitive processes. Firstly, the social perception network appears linked to amygdala connectivity (Bickart et al., 2012), and is deemed responsible for social decision making and response. Second, the mentalising network appears associated with the dorsomedial prefrontal cortex (dmPFC), temporoparietal junction, and medial frontal cortex (MFC) (Adolphs, 1999; Bickart et al., 2012; Daneshavar et al., 2011; Mitchel et al., 2005; Spunt & Lierberman, 2012), enabling self-reflection and metacognitive processes. Third, the empathy network uses different systems for cognitive and affective empathy. The anterior mid-cingulate and dmPFC appear active for cognitive empathy (Lamm et al., 2007), while the insula and midbrain are aligned with affective empathy, although the insula appears key across both (Carr et al., 2003; Fan et al., 2011). Fourth, the mirror network involving the cortical midline structures (mPFC, anterior cingulate cortex and praecuneus), enables observation and imitation (Rizzolatti & Craighero, 2004).

1.5.4 Social Cognition and Traumatic Brain Injury

Skuse et al. (2003) highlight the amygdala as part of an extended network of neural circuits, critically involved in the processing of socially salient stimuli. Studies in humans and primates suggest the dysregulation of basic emotions, especially the processing of fear and anger, is an almost invariable consequence of disruption of the coordinated interplay between neural activity in the amygdala and brain regions including the medial prefrontal and occipitofrontal cortex, fusiform gyrus, and superior temporal sulcus (Bickart et al., 2012). Skuse et al. (2003) thus highlight TBI as disruptive to this network and subsequently impacting on social behaviour. Furthermore, McDonald et al. (2019) suggest while damage to focal temporal and frontal areas has been implicated in disorders of social cognition after TBI, white matter plays a role even when controlling for non-social cognition. The corpus callosum, fornix, bilateral thalamus, right external capsule, and right temporal lobe remained significant contributors to social cognitive performance (McDonald et al., 2019). This highlights the importance of loss of white matter connectivity in producing complex social information processing deficits, after TBI.

Clinically, this results in observable shifts in empathy, personality, and behaviour, particularly following damage to the PFC (McDonald, 2013). TBI patients showing a general weakness in inference-making that, when combined with linguistic and working memory limitations, impairs performance on ToM tasks (Bibby & McDonald, 2005). Clinicians have long been aware of the impact of severe TBI on social cognition (Lezak, 1978), with such social cognitive changes estimated in 60-80% of people with severe TBI (McKay, 2015*;* Oddy et al., 1985; Weddell & Leggett, 2006). Recent evidence compiled in meta-analyses by Fazaeli et al. (2018) and Babbage et al. (2011) bring together literature highlighting impairments in ToM and facial emotion recognition retrospectively, whilst Beauchamp et al.'s (2013) preliminary investigation supports impaired empathy and moral judgement in adolescents. However, to date the impact of mTBI on social cognition continues to be neglected by the literature.

1.5.5 Social Cognitive Impairment

With regard to neurodegenerative conditions, several are associated with impairments of social cognitive function, with consequent negative effects on patient management (Christidi et al., 2018). Specifically, in some neurodegenerative conditions these deficits may represent core diagnostic criteria. Behavioural variant frontotemporal dementia (bvFTD) displays changes in behaviour and social conduct that are influenced by context, cultural, and experience (Elamin et al., 2012). Studies implicate impaired gaze detection, ToM, and facial recognition of emotions (anger and fear) as particularly relevant in bvFTD (Diehl-Schmid et al., 2007; Gregory et al., 2002; Snowden et al., 2003). Patients with Huntington's Disease (HD) displayed a tendency to draw faulty inferences from social situations (Snowden et al., 2003), while impaired understanding of intention in others is considered an early socio-cognitive index of onset of Dementia Alzheimer's Type (DAT) (Verdon et al., 2007). Additionally, deficits in social cognitive function may emerge during the disease course, with critical aspects such as memory deficits seen in Parkinsonism and AD (Christidi et al., 2018; Gray & Tickle-Degnen, 2010; Gregory et al., 2002). Moreover, AD patients consistently demonstrate impaired performance on tests of facial emotion processing (Teng et al., 2007), highlighting the separability of social and general cognition in this population (Cosentino et al., 2014).

As such, it is becoming increasingly apparent that the identification of social cognitive deficits in neurodegenerative conditions, may provide a better understanding of the behavioural changes observed in these conditions (Elamin et al., 2012). Neuroimaging studies identify deterioration in ventromedial and orbitofrontal cortices, as associated with deficits in social and affectively influenced decision-making, thus impacting social judgments in patients with frontotemporal lobar degeneration (FTLD) (Abu-Akel & Shamay-Tsoory, 2011; Grossman et al., 2010). Moreover, bvFTD patients show behavioural changes such as empathy loss and altered personality traits, which appear associated with atrophy in superior temporal and orbitofrontal and anterior cortical regions (Happé et al. 1999; Harciarek & Cosentino, 2013; Mahoney et al., 2011; Rankin et al., 2006). Such neurodegenerative conditions thus appear linked to deficits in the recognition of signals from multiple modalities, rather than facial expression processing alone (Keane et al., 2002). Assessment of social cognition domains may therefore enhance diagnosis and management.

1.5.5.1 Chronic traumatic encephalopathy

Research suggests CTE may be characterised by emotional dysfunction (Yuan & Wang, 2018), with behavioural changes including emotional lability a first clinical indication of CTE (Stern et al., 2013). As presented earlier, CTE is thought to develop specifically following repeated head impacts (Martland, 1928; McAllister & McCrea, 2017; McKee et al., 2015; Mez et al., 2017; Omalu et al., 2005; Slobounov et al., 2017) yet there remains a gap in the literature regarding exploration of associations between sporting mTBI, and social cognition. Furthermore, it is important to note that it can be difficult to distinguish CTE from FTLD, due to TBI impacting the symptomology and increasing the risk of FTLD (Deutsch et al., 2015). Such correlations between CTE and FTLD highlight an important similarity in social cognitive deficits that may be observable in the sporting population susceptible to CTE, due to the cumulation of subconcussive injuries.

This is an area that as of yet, have not been investigate in the football population, highlighting the novel contribution of the current study to the literature. Furthermore, social cognitive impairments linked to neurodegenerative conditions often result in communication difficulties and subsequent difficulty maintaining social relationships (Radice-Neumann et al., 2007). A reduction in social relationships and networks will often have a detrimental impact on mental health, wellbeing, and subsequent quality of life (QoL) (Christidi et al., 2018). Sporting concussions implications for mental health have been demonstrated in the NFL, where athlete's lifetime concussions appear significantly correlated with depressive symptoms (Didehbani et al., 2013), which in turn appears to predict post-concussive depression and anxiety (Yang et al., 2015). This psychological impact alongside potential social cognitive impairment and subsequent detrimental QoL, signifies the importance of improved understanding and identification of at-risk sporting populations.

1.5.6 Theory of Mind

Originally identified by Premack and Woodruff (1978), ToM refers to an individual having 'metacognition', defined as awareness of one's own mental state, as well as the ability to recognise and infer others' mental states. This system of inferences is viewed as a "theory" because such states are not directly observable, and the system can be used to make predictions about the behaviour of others not yet observed. This provided a major push in the development of social neuroscience and remains one of the dominant theories in social psychology. Frith and Frith (2008) however, suggest that the phrase ToM indicates a conscious process, whereas mentalising is a more accurate term as it encompasses both implicit and explicit information processing. In clinical neuropsychology, we favour the term ToM due to explicit mentalising being most measurable (Frith & Frith, 2012), thus forming the definition in the current research.

Regarding the development of ToM, infants as young as 6-months appear to anticipate other's behaviour, showing preference for novel-goals and the ability to attribute false beliefs (Southgate et al., 2007; Woodward, 1998). Over the first year of life, evidence suggests children develop higher-level social processing. Children of this age demonstrate awareness of others' intentions, goals, desires, and mental states, as seen in analysis of eye gaze patterns (Liszkowski et al., 2006). At two years, children demonstrate the ability to 'mind read' (Lee et al., 1998) and engage in pretend play (Ma & Lillard, 2017). The ability to monitor one's own intentions and the intentions of others, enables an understanding of deception, and recognising and verbalising of mental states. This develops between 3-5 years old (Baron-Cohen et al., 1994; Phillips et al., 1998). After age 5, children begin to understand irony and sarcasm (Miller, 2009; Peterson et al., 2012).

1.5.6.1 Assessing theory of mind

Most assessments of social cognition centre on ToM, conceptualised in the 'false-belief task' (Wimmer & Perner, 1983). In this task, those aged 4 years and above are seen to demonstrate an understanding of the disparity in individuals' thoughts, about the same situation (Wellman et al., 2001; Wimmer & Perner, 1983). Alternative non-verbal tasks such as cartoons, strange stories and the *faux pas* test have therefore been added to the field. This enables assessment of the understanding of intentions, detection of persuasion, sarcasms, and *faux pas*, whilst avoiding the confounds of linguistic processing (Baron-Cohen et al., 1999; Dodell-Feder et al., 2013). A more sophisticated task called the Social Stories Questionnaire (SSQ) focuses on the detection of subtle and blatant *faux pas* (Lawson et al., 2004). Due to demonstrating good internal consistency for participants with TBI (Francis et al., 2017), the SSQ is utilised in the current research. One must however hold in mind that interpretations of any outcome on tests of unobservable constructs, must be made with caution. Many factors may influence results on tests of ToM including the potential impact of existing deficits, arbitrary cut offs and implicit test biases.

1.5.7 Emotion Processing and Recognition

Evidence suggests emotional processing and ToM are highly correlated, whilst facial expressions are key in recognition of emotion. The recognition of emotion thus draws on a distributed set of structures including the occipitotemporal neocortex, amygdala, orbitofrontal cortex and right frontoparietal cortices, with the amygdala key in the recognition of fear, whilst the insula and basal ganglia enable detection of disgust (Adolphs, 2002). Assessment of emotion recognition was made famous by Ekman, who identified six universally innate emotions; anger, fear, disgust, surprise, sadness, and happiness, which formed the Ekman Faces Test (Ekman & Friesen, 1971). This test has been critiqued for failing to reflect diverse emotions cross-culturally yet, remains important in clinical psychology today in modern formats. Limitations of reliability and validity have resulted in Wechsler's Advanced Clinical Solutions (ACS) Social Perception subtests being put forward (Pearson, 2009). This test requires participants to match Ekman's core emotions to 24 photographs. Questions remain regarding the ecological validity, however internal consistency correlates with other measures of facial affect recognition (Kandalaft et al., 2012). Evidence indicates facial emotion processing to be impaired in mTBI. Recognition of such deficits may aid early diagnosis, management, and treatment of associated conditions (Elamin et al., 2012).

1.5.8 Empathy

Empathy is a capacity that enables us to infer the feelings of others and understand their mental states and actions. Empathy thus enables subsequent adaptation of our own responses to situations (Kilroy & Aziz-Zadeh, 2017). Whether empathy involves recognition and or experience of emotion, remains debated (Bennett, 1995; Chlopan et al., 1985; Cohen & Strayer, 1996; Jolliffe & Farrington, 2006). Deficits in empathy have been observed in clinical populations of autism spectrum disorder (ASD) (Lee et al., 1998) and TBI (Wood & Williams, 2008). A review of the literature suggests empathy is not a unitary system, but rather best considered a loose collection of partially dissociable neurocognitive systems (Blair, 2005), with several brain regions responsible for the activation of these dynamic neural networks (Kilroy & Aziz-Zadeh, 2017).

As such, a distinction is often made between cognitive empathy (the ability to hold in mind and interpret information) and affective empathy that requires rapid recognition of body language, facial expressions, voices, and gestures (Carr et al., 2003; Reniers et al., 2011). While it has been suggested that definitions should include both factors (Reniers et al., 2011), conflicting definitions of empathy are reflected in the plethora of available assessments, including the empathy scale (Hogan, 1969) and empathy quotient (Baron-Cohen & Wheelwright, 2004). However, the more recent Questionnaire of Cognitive and Affective Empathy (QCAE) aims to assess the multidimensional construct, through separating empathy into both cognitive and affective responses (Reniers et al., 2011).

1.5.9 Social Cognition and Football-Related Behaviours

Due to the recency in social cognitive neuropsychology becoming a recognisably measurable field, through neuropsychological tests (Adolphs, 2009), limited studies have been conducted exploring the impact of sporting TBI on this domain. Both clinical presentations of sporting CTE and neurodegenerative conditions (e.g. Frontotemporal Dementia [FTD]) are often associated with impaired perception, interpretation, and response to others (Fiske & Taylor, 2013; Harciarek & Cosentino, 2013). Moreover, observable changes in behaviour and personality are often associated with altered social interactions (Snowden et al., 2003). Such presentations suggest damage to the frontal temporal region, an area in which an associative link with social cognition has been made.

Social cognition therefore appears to be an important cognitive domain, when considering the long-term neuropsychological impact of sporting TBI and a potential associative link with neurodegenerative disorders. Whilst one unpublished study conducted in a UK-sample implies preliminary support for weaknesses on social cognition measures of ToM and emotion recognition in rugby (York-Smith, 2019), to date, no research exploring the relationship between football-related behaviours and social cognition has been conducted. The current study, to the researcher’s knowledge, is thus the first conducted addressing this gap in the literature. Should associations be identified between football-related behaviours and social cognition, this would guide future research and suggest clinical implications for the early diagnosis and therapeutic management of sporting TBI, within the footballing population.

2. RESEARCH RATIONALE

The evidence presented above highlights the potential clinical impact of sporting head injuries, whilst shedding light on the gap in the literature regarding football. The neuropsychological impact of football-related behaviours remains under-researched, regardless of its popularity, and head-to-ball contact being an integral part of the sport. Moreover, of the limited research available, many methodological flaws are highlighted. Available studies are quasi-experimental, relying on comparisons with inadequate and unmatched control groups, as opposed to matched normative data. Studies also often fail to control for confounding variables such as age and gender, limiting the ecological validity of findings. Of the limited studies available, those of significance imply a cumulative effect of subconcussive football-related head impacts. The current study aims to investigate this, while addressing methodological short-comings.

In addition, research indicates social cognition is often associated with neurodegenerative conditions, including observed deficits in CTE, a clinical presentation heightened in the sporting population. As such, a link has been predicted between cumulative subconcussive injuries, and impairment in social cognitive skills. Should this be confirmed, early detection would aid early diagnosis of impairment in neurodegenerative conditions (Elamin et al., 2012). However, this remains an area further neglected by football-related research.

The rationale for the current research is thus two-fold. Firstly, the study aims to add to the current literature, broadening the understanding of the impact of sporting head-injuries. Secondly, the current research has the novel aspect of addressing the gap in the literature regarding the world's most popular sport (football), and the impact of head injuries on social cognition. We have a clinical duty to address the lack of research regarding the neurocognitive implications of football-related behaviours. This provides justification for the current research, which has clinical, policy-based, and wider societal implications.

Clinically, research into the potential associations between cognitive functioning, social cognition and football-related behaviours or head injuries, may enable tapered clinical screening processes and early assessment. Early concise screening measures would enhance neuropsychological diagnosis, management, and treatment of footballers. Additionally, a more in-depth understanding of the neuropsychological impact of football-related behaviours, has implications for sporting governing bodies and wider society, regarding clinical management and public dissemination. Increased knowledge regarding the impact of football-related behaviours in the sporting literature has the potential to enhance sporting policies and guidance. This may in turn, improve the sport and the safety of players, whilst enabling members of the public to engage in informed decision making, regarding participation in the sport.

2.1 Aims

The current study aims to address a lack of understanding in the literature, regarding the neuropsychological impact of football-related behaviours. At present, limited research has been conducted in a UK-based footballing population. To the researcher's knowledge, no research has been conducted exploring the association between football-related behaviours and social cognition. The current study is thus novel in approach, aiming to explore the impact of football-related behaviours and head injuries, on both general and social cognitive functioning. Subsequently, the study aims to improve understanding of sporting TBI, in the field of clinical psychology. This will inform sporting policies, with clinical implications for early neuropsychological screening, diagnoses, and management of football-related head-injuries.

2.2 Research Questions

- Is there a relationship between football-related behaviours, associated head injuries, and performance on tasks measuring cognitive functioning?
- Is there a relationship between football-related behaviours, associated head injuries, and performance on tasks measuring social cognitive functioning?
- If so, are deficits in task performance reflective of the frequency of exposure to football-related head injuries?

3. EPISTEMOLOGY AND METHODOLOGY

3.1 Epistemological Considerations and Positioning

Epistemology and ontology are essential facets of scientific study, with the philosophical context in which information is gathered thus requiring recognition. Epistemology refers to the philosophy of knowledge, that humans may come to understand through studying its nature (Burr, 2003). Methods of obtaining an understanding of knowledge are built on beliefs and assumptions (Elliot et al., 1999), of which the scope, validity and limitations of such knowledge must be acknowledged (Willig, 2001). Alternatively, ontology refers to the philosophy of reality and the conceptualisation of our world, focusing on the study of being and existence (Bunge, 1974; Burr, 2003). Together one's, ontology and epistemological position influence one's approach to research.

Whilst designed with qualitative research in mind, Carter and Little's (2007) framework is also useful to conceptualise the impact of epistemology on quantitative research. This framework highlights how from research questions, epistemological positioning has the power to modify methodology, thus justifying, guiding, and subsequently evaluating method that produces data and enables analysis (Carter & Little, 2007). In this way, method is constrained by and makes visible both methodological and epistemic choices. The ontological and epistemological underpinnings of research therefore justify and form the basis of knowledge, which sits within the context of necessary ethical considerations. It is therefore essential that researchers acknowledge their epistemological stance and the influence this may have on methodological approaches, within both qualitative and quantitative research (Barker & Pistrang, 2005). A summary of the current research as conducted from a critical-realist approach, is thus provided below.

Scientific realism is an ontology that states the external world (entities, states, and processes), described by theories exists independently of us, as humans (Burr, 2003). The world is thus seen as real, regardless of who is observing it and is therefore measurable. *Critical realism* however goes a step further, highlighting that knowledge is not and cannot be objectively measured, but stresses that 'real' processes and structures underpin and thus generate observable phenomena (Nightingale & Cromby, 1999). In line with this, a critical-realist epistemological positioning infers that the world is in a sense 'real' and can therefore be objectively measured, however one must acknowledge the fallibilism of scientific inquiry (Trochim & Donnelly, 2001). This epistemological positioning allows the researcher to quantify constructs, to objectively understand the world, whilst acknowledging the influence of human error and bias. In doing so, it is important to acknowledge the socially constructed nature of concepts.

This is of particular importance in the current research focused on neuropsychological constructs, which are ever evolving and socially constructed. Conducting the current study from a critical realist epistemology, justifies the operationalising of neuropsychological constructs, whilst acknowledging the cultural, social, and historical context in which it sits. The researcher has aimed for transparency in the methods used to measure constructs and acknowledge the possibility of inferences draw, being vulnerable to human error. Furthermore, multiple measures are utilised where possible to improve validity and reliability, thus enabling exploration of neuropsychological constructs and subsequent processes that may otherwise be unidentifiable.

3.2 Methodology

3.2.1 Design

A quantitative cross-sectional correlational design was deemed suitable, due to the exploratory nature of the current study. This enabled exploration of general and social cognition functioning, in a sample of UK-based footballers. Examination of a single group of footballers, at a single point in time, was appropriate for exploration of relationships, as opposed to identifying causality. Additionally, as Rutherford et al. (2003) critiqued the inadequate control groups utilised in the previous literature, the researcher opted for an alternative method. A control group was deemed unnecessary for the current study, particularly as no manipulations of the data were made. As indicated in the literature (Wechsler, 2011), results were compared instead to normative data provided by each selected neuropsychological test, alongside the inclusion of an estimate of optimal functioning which enabled within-subjects comparisons.

3.2.2 Sample Size

The proposed sample size reflected the limited literature currently available for football-related TBIs, which ranges from 33 to 84 recruited footballers (Matser et al.,1998,1999, 2001; Rodrigues et al., 2019). Attempts were made during the recruitment process to gather the widest possible sample, as larger samples generate increasingly reliable and valid results (Field, 2009). It is however important to acknowledge that due to the global situation at the time of the current research (Coronavirus Disease of 2019 [COVID-19]), alterations in the proposed methodology and recruitment procedure were necessary, as detailed below. This may have influenced the final sample size, with all attempts made to recruit the largest sample possible during a six-month period (July 2020-December 2020).

3.2.3 Ethics

3.2.3.1 Ethical approval

As seen in Appendix B, ethical approval was sought from the University of East London, School of Psychology Research Ethics Committee (SREC) and approved prior to recruitment. As participants were recruited from the public, NHS ethical approval was not required. A minor ethical amendment was made in June 2020 in line with COVID-19 restrictions, as seen in Appendix C, alongside a request of title change to align the research registration (see Appendix D). This enabled the research to be conducted remotely, with the researcher's academic integrity certified prior to recruitment (see Appendix E).

3.2.3.2 Informed consent

All participants were provided with the written invitation letter, given in Appendix F, which detailed research aims, confidentiality, procedures, and participants right to withdraw, prior to gaining informed consent (see Appendix G). Following participation in the study, participants were provided with a debrief letter (see Appendix H). Participants were offered an opportunity to ask questions and were asked whether they wanted to receive a summary of the study outcomes, following completion.

3.2.3.3 Confidentiality

To ensure confidentiality, all participants were assigned a unique participant code, which was stored separately from their identifiable information and data. All identifiable material was stored on encrypted password-protected documents, or in locked cabinets. Only unique participant codes were entered into electronic databases (SPSS) and utilised for data analysis. All identifiable materials remained separate and were in no way linkable to the analysed data. This ensured participant confidentiality and was detailed to each participant prior to participation and during the debrief, following participation. In line with this, all identifiable materials will be destroyed once the study has been completed. For publication purposes, the anonymised electronic data set will be held for a maximum of two years, following completion of the study.

3.2.3.4 Protection from harm

To protect participants from harm during the study, frequent breaks were offered throughout the neuropsychological assessment. This aimed to minimise the impact of fatigue. The neuropsychological test battery contained only the assessments deemed necessary, to further limit the timescale of the study. In addition, a full verbal debrief was provided post assessment, with further support and appropriate contact details provided in the written debrief letter (see Appendix H). Participants were informed that they had a three-week period following participation in the study, should they wish to withdraw their information prior to data analysis.

3.2.4 Recruitment

Participants were recruited through a mixture of convenience and volunteer sampling. The researcher initially attempted communication with Football Associations, governing bodies, football clubs and sporting head injury charities to assess the feasibility of the study. Prior to recruitment, one charity agreed to advertise the study (see Appendix I). Further communication via these avenues enabled social media advertisements, through football teams sharing the study poster (see Appendix J). This enabled unknown potential participants to contact the researcher directly and volunteer to participate. In addition, the researcher contacted known associates who matched the intended participant group, asking if they were willing to participate. Recruitment was limited to these online avenues, due to the COVID-19 pandemic.

Individuals who expressed their interest were emailed a participant invitation letter (Appendix F) and given one week to respond. Those who responded confirming willingness to participate within one week of receiving the invitation letter, were included in the study.

3.2.4.1 Inclusion and exclusion criteria

In line with study inclusion criteria, participants were required to be male, active, or retired competitive-level UK-based footballers, within an age range of 18-65. Due to study constraints in funding, the availability of interpreters, and COVID-19 restrictions, English was required as a first language and participants required sufficient hearing and vision to participate remotely. Participants were required to have experienced at least one self-reported football-related head impact. Attempts were made to recruit a range of injury histories, to avoid biases in exposure to concussive injuries.

To reduce the impact of confounding variables, exclusion criteria included females, as previous literature highlighted gender differences in cognitive performance amongst footballers (Colvin et al., 2009; Covassin et al., 2013; Kontos et al., 2011; Mooney et al., 2020; Putukian et al., 2000; Tsai et al., 2015). Furthermore, individuals who had sustained non-football related TBIs or neurological disorders, a concussion in the last three months, current substance misuse, long-term mental health diagnoses, a history of stroke or learning disabilities, were excluded in order to minimise confounding variables.

3.2.5 Procedure

Participants who met inclusion criteria and gave informed consent via email, were initially proposed to be invited to participate in assessments administered at the University of East London. Due to the current COVID-19 pandemic, a minor amendment was made (see Appendix C) to enable remote participation in the study. As such, the original plan to email participants to arrange a time and date to attend physically and complete all measures, was altered. Assessments were instead split, with demographic information and two self-report scales provided via an email link, prior to the main neuropsychological assessment session. The neuropsychological assessment subsequently took place remotely, via a Microsoft Teams video conference call.

Participants were firstly emailed to arrange a convenient time and date to participate in the study. Once a date and time were confirmed, a survey link was created by the researcher via Qualtrics (https://www.qualtrics.com). This contained instructions for participants to complete the survey on the day of the assessment, prior to the video conference call. Participants then attended the full assessment with the researcher, via Microsoft Teams video conference call. Following the assessment and verbal debriefing, an email containing the written debrief letter was provided (see Appendix H). The assessment took on average 60-90 minutes, from start to finish, including completion of the online survey and video conference assessment.

<u>3.2.6 Measures</u>

The study consisted of self-report measures regarding participant demographic information, football-related behaviours, and concussion history. In addition, a neuropsychological assessment battery containing standardised measures of premorbid functioning, cognitive functioning, and social cognition was included. The rationale for this study test battery was two-fold. Firstly, the study aimed to explore cognitive functioning in relation to football-related behaviours. Secondly, the study aimed to explore whether deficits on any cognitive domain, may impact performance in other areas cognitive functioning, including social cognition.

3.2.6.1 Online qualtrics survey

The Qualtrics survey link firstly reiterated the participation invitation letter (see Appendix F) and allowed participants to record their informed consent (see Appendix G), prior to the study. The online survey then asked participants to complete demographic information including their age, ethnicity, level of education, physical health, mental health and learning disability history. Following this, questions were included that were designed to capture football-related behaviours, as detailed below. This was followed by two measures of social cognition, the Social Stories Questionnaire (SSQ) and the Questionnaire of Cognitive and Affective Empathy (QCAE). Both measures are standardised to be completed via this medium. The Qualtrics survey was estimated to take 10-15 minutes, and enabled participants to view the debrief letter (see Appendix H), following participation.

3.2.6.2 Football-related behaviours

Included in the Qualtrics survey were questions that required participants to self-report football-related behaviours and concussion history.

i) Footballer status

Self-reported football history was recorded, with questions exploring years playing football, on field position, and whether participants were currently active footballers. Football position was recorded, as evidence suggests defenders and strikers are more likely to experience headers and subsequently, football-related head injuries (Hunt & Fulford,1990; Kirkendall et al., 2001).

ii) Football activities

Number of hours player per week and number of years actively playing football were self-reported, to enable the total number of hours played across a participant's career to be estimated, alongside reported rates. Participants self-reported approximate number of football-related head contacts per competitive football match. As the mechanisms of football-related head injuries can result from both intentional and unintentional hits to the head (including head to ball, head to head, head to elbow, head to ground or head to post); (Bunc et al., 2017), participants were required to specify the type of head contacts they had experienced, and how often these occurred per match. This enabled incidence of football-related head contacts to be categorised in line with Webbe and Ochs (2003), with 0-5 contacts categorised as low incidence, 6-10 moderate and more than 10 a high incidence rate.

iii) Estimate of cumulative football-related head impacts

Multiplying participant's self-reported number of football-related head impacts by the average games played per season, and then the number of years they reported actively playing football, enabled a cumulative estimate of football-related head impacts to be derived. In addition, specific football-related head-injuries and concussions experienced by participants and any clinical symptoms were recorded, alongside the age of first sporting concussion.

3.2.6.3 Neuropsychological assessment battery

Participants completed a comprehensive neuropsychological test battery. As displayed in table 1, the neuropsychological test battery consisted of measures of optimal functioning, general cognitive and social cognitive functioning. Administered via Microsoft Teams video conference call, the neuropsychological assessment took approximately one hour per participant, with short breaks included to prevent fatigue. All measures were chosen due to their good psychometric properties (reliability and validity) and large normative sample in their standardisation. This enabled comparison with general population norms and current research, which increased reliability and validity. All measures were administered according to test manuals to ensure reliable testing of cognitive domains, except that tests were completed via screen sharing in a Microsoft Teams video conferencing call, due to the COVID-19 pandemic.

Table 1

Neuropsychological Test Battery

Test Component	Cognitive Domain	Subset
Optimal Functioning		Test of Premorbid Functioning UK
Executive Functioning	Word generation: verbal and semantic fluency	D-KEFS Verbal Fluency
		D-KEFS Category Fluency
	Verbal switching	D-KEFS Verbal Switching
	Rule deduction and planning	Brixton Spatial Anticipation Test
	Working Memory	WAIS-IV Digit Span Backward
		WAIS-IV Digit Span Sequencing
Learning and Memory	Immediate recall	WMS-IV Story Recall: Immediate
	Delayed recall	WMS-IV Story Recall: Delayed
	Recognition	WMS-IV Story Recall: Recognition
	Visual functioning	WAIS-IV Matrix Reasoning
	Verbal functioning	WAIS-IV Similarities
Attention	Verbal Attention	WAIS-IV Digit Span Forward
	Visual Attention	Symbol Digit Modality Test
Social Cognition	Theory of Mind	Social Stories Questionnaire
	Emotion Recognition	ACS Affect Naming Test
	Empathy	Questionnaire of Cognitive and Affective Empathy

i) Remote adaptations

The Division of Neuropsychology (DON, 2020) supports remote technologies and administration of standardised tests, which was thus deemed a pragmatic solution during the COVID-19 pandemic. Microsoft Teams was therefore permitted, so long as the researcher mimicked the experience of a face-to-face assessment, via screen sharing. In line with this, the researcher ensured participants were comfortable with the technology and had sufficient visual and hearing abilities to participate via this medium, although this may have biased the sample. Participants were required to have access to a quiet, undisturbed space for one hour, and were asked to remove all distractions (i.e. phones) and keep their camera on. The researcher practiced working via this medium to ensure a smooth delivery, with a plain visual background, with no materials to distract participants. While norms may be less valid due to not being intended for administration via this medium, the limited research available suggests remote administration yields comparable scores (Harder et al., 2020). Among the selected tests shown, the following have good reliability when delivered via video: TOPF-UK, WAIS-IV digit span test, D-KEFS verbal and category fluency and WAIS-IV matrix reasoning (DON, 2020).

The researcher thus worked in line with the American Psychological Association (APA, 2020) guidance on psychological tele-assessment during the COVID-19 crisis. The researcher followed the six principles of:

- Not jeopardising test security
- Doing the best possible with what was available (mindfully and ethically)
- Being rigorously mindful of data quality
- Thinking critically about tests and subtest substitutions
- Widening confidence intervals when making conclusions
- Maintaining the same ethical standards

ii) Optimal functioning

The capacity to read words spelt irregularly appears resistant to cognitive decline and correlates with general level of ability (Nelson & Willison, 1991). As such, performance on tasks such as the TOPF-UK (Wechsler, 2011), provide an estimate of optimal functioning, when compared with normative data. The TOPF-UK is formed of 70 atypically spelt words. On this task, participants are required to read aloud. Accurate reading requires previous vocabulary, as opposed to standard pronunciation rules and specific dialects. Participants were awarded one point for each correct pronunciation. Total scores were then compared against normative data. The utilisation of this test is supported by research correlating premorbid ability with memory, particularly within the verbal domain. TOPF-UK also displays good reliability and validity with participants meeting inclusion criteria for the current research (i.e. no learning disability and English as a primary language) (Lezak et al., 2012).

iii) Executive functioning

In line with Goldstein and McNeil's (2012) recommendations, the current research aimed to assess core executive functioning. This included tests of fluent output, task-set switching, and concept formation. The current study therefore utilised Delis-Kaplan Executive Function System (D-KEFS) tests of verbal fluency and set switching (Delis et al., 2001), as well as the Brixton Spatial Anticipation Test (Burgess & Shallice, 1997). D-KEFS are a set of nine tests normed to 1750 participants aged 8 to 89 (Delis et al., 2001), shown to be reliable and valid across populations (Shunk et al., 2006).

The D-KEFS word generation task (Delis et al., 2001) activates frontal lobe executive functioning, with deficits in verbal fluency observed in association with mTBI (McCauley et al., 2014). Participants received one point per correct response, with subsets of letter fluency, category fluency, and switching included. The D-KEFS letter fluency task required participants to verbalise as many words as possible beginning with a specified letter within 60 seconds, across three trials (F, A and S). This required participants to inhibit irrelevant words, to accurately retrieve appropriate words. The D-KEFS category fluency task evaluates word generation, self-monitoring, and retrieval of semantic knowledge. Participants were required to verbalise as many words as possible from within a set category, within 60 seconds (animals and boys' names). Finally, the D-KEFS switching subset assesses word generation ability, switching of attention and category fluency. In this task, participants were required to generate as many words as possible within two categories (fruit and furniture), by switching between each category after each word.

The Brixton Spatial Anticipation Test (Burgess & Shallice, 19997) was included to assess rule deduction and planning. In this test, on multiple pages, 10 circles are displayed, one of which is coloured blue. The spatial location of the blue circle moves position on each of the 56 pages of this test, according to an undisclosed rule. The participant was tasked with inferring the rule by observing the displayed pattern and thereby, predicting the next location of the blue circle. Participants were awarded one point per error. The Brixton test has been shown to be valid and reliable, with sensitivity to differences between healthy populations, versus groups who have experienced TBI (Van Dan Berg et al., 2009).

iv) Learning and memory

To assess verbal memory, the Wechsler Memory Scale – Fourth Edition (WMS-IV) logical memory (Wechsler, 2010b) was included in the neuropsychological battery. Participants were required to recall two separate, unassociated short stories, immediately and at a delayed time, later in the assessment. This addresses episodic memory. In the WMS-IV story recall immediate task, participants were required to recall as much as they could about each short story immediately after hearing it. The assessment then moved onto other tasks. For the WMS-IV story recall delayed task, participants were then asked to recall as much as they could about each story, approximately 30 minutes later. Following this, participants took part in the WMS-IV story recognition task, in which statements about each story were read out, with participants required to reply ‘yes’ or ‘no’ as to whether this statement was true of the original story.

Visual functioning was assessed using the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) matrix reasoning task (Wechsler, 2010a). In this test, participants were presented with a pattern containing a missing segment. Participants were required to use visual shape, colour, and location relationships, to determine the correct missing symbol from a choice of five possible answers. Verbal functioning was assessed via the WAIS-IV similarities task (Wechsler, 2010a). This measured verbal comprehension, expression, and abstract reasoning, by requiring participants to state how two words (e.g. green and yellow) were alike. Participants were awarded two points for an abstract response, and one-point for a good connection, comparable to normative data.

v) Attention

Following Johnson et al.'s (2011) recommendation, assessments of attention and working memory were also included, with deficits in these areas often witnessed in the sporting population (Moore et al., 2016). WAIS-IV digit span forward, backward, and sequencing tasks (Wechsler, 2010a), were thus included. The WAIS-IV digit span forward required participants to listen and repeat back a string of numbers in the same order as they were spoken. The length of this string became progressively longer, throughout this task. This enabled evaluation of participants auditory attention span (short-term stores).

The WAIS-IV digit span backward followed the same format as the WAIS-IV forward however, participants were required to repeat the string in reverse order. Finally, the WAIS-IV sequencing task again followed this format but, required participants to repeat the string of numbers back in numerical order. These latter two tasks were included to evaluate verbal working memory. Participants were awarded a point per each correct response across all three tasks and given a digit spans score.

Due to the COVID-19 pandemic and remote administration, the oral Symbol Digit Modality Test (SDMT), was used to assess visual attention (Smith, 1982). Participants were presented with a visual key numbered '1' to '9', with each number corresponding to a symbol. Below, in the response array the symbols were presented with the corresponding numbers missing. Participants were given a practice sequence and then required to verbalise as many corresponding numbers as possible, within 90 seconds. This task assessed visual attention, via processing speed.

vi) Social cognition

Tests of ToM, emotion recognition and empathy were added to the neuropsychological battery to assess social cognition. In line with the current literature, tests used supported a distinction between affective and cognitive ToM (Etchepar & Prouteau, 2018) and empathy (Carr et al., 2003; Reniers et al., 2011). The SSQ (Lawson et al., 2004) was chosen to assess mentalisation, through participants comprehension of social norms and story character beliefs.

This task was incorporated into the Qualtrics online survey that participants completed prior to assessment, as the SSQ was standardised to be read and completed by participants in this way. The task required participants to read ten short stories. Some of these stories contained utterances by one actor in the story, that may upset another person in the story. Following each passage of text, participants were required to indicate whether anything said may have upset someone in the story. If a participant answers ‘yes’, they were then prompted to indicate which sentence it occurred in. Within this task, ten blatant *faux pas* and an additional ten subtle *faux pas* were present. To be able to identify these, participants required an understanding of non-literal cognitive-linguistic social processes, to comprehend the perspective of the people in their social context. A point was scored for each correctly identified *faux pas*.

The ACS Affect Naming Task (ANT) was included to measure recognition of affect (emotion), in facial expressions (Pearson, 2009). As the SSQ relies on verbal ability, it could be impacted by verbal functions. The ANT thus serves to validate differentiative affective and cognitive mentalisation. Participants were thus presented with images of the same six actors. Each one of the images presented an actor portraying one of the six ‘universal’ emotions: anger, fear, disgust, surprise, sadness, and happiness (Ekman & Friesen, 1971), along with neutral expressions. The ANT is a standardised test of emotion recognition, in which participants were awarded a point each time they correctly identified an emotion, with scores compared to age-appropriate normative data (Pearson, 2009). Performance on this task correlates with other tasks measuring social cognition and is valid cross-culturally, in assessing these specific emotions (Kandalaft et al., 2012).

The QCAE (Reniers et al., 2011), made up the final task on the Qualtrics online questionnaire. This self-report measure that was designed to be administered in this way. Utilising the QCAE enabled differentiation between cognitive versus affective empathy. Participants were required to respond to 31 statements using a 4-point Likert scale, ranging from *strongly agree* to *strongly disagree.* Items were derived from several pre-existing measures of empathy and perspective taking. Responses were scored by adding scores from subset items, to gain a total score for cognitive empathy and affective empathy.

3.2.7 Planned Analysis

IBM SPSS Statistics (Version 26) predictive analysis software, was utilised to collate, screen, and analyse the data. Assessments were scored in line with the test manuals and where possible, converted into age scaled scores. This enabled changes in performance on cognitive test to be analysed, while accounting for age.

The planned analysis procedure was to firstly generate descriptive statistics, with examination of histograms and scatterplots to check for missing cases, outliers, and any data coding errors. Assessment of skewness and kurtosis scores (skewness>1, kurtosis>3), enabled the data to be checked for parametric violations. Although some variables might approximate to a normal distribution, most did not, and most were ordinal or frequency data, or combinations of these, unsuited to parametric procedures. In any case, the sample size was relatively small, especially when divided into groups. Non-parametric procedures were thus utilised throughout, to sustain the same levels of inferential statistics for all analyses, rather than switching between parametric and non-parametric procedures. In addition, the resampling procedures provided in SPSS were used where available, to give more powerful and robust inferential analyses. These have been indicated in the text.

Descriptive statistics and one-sample tests (i.e. Kolmogorov-Smirnov) were planned, to test whether the distribution of scores in the research group were comparable to age-scaled norms, within a defined set of parameters (M = 10, SD = 3) (Wilcox, 2003). Areas of identified discrepancy direct inferential statistical analysis, with non-parametric tests exploring the relationship between football-related behaviours of interest and performance on measures of cognitive functioning. A significance threshold of p < .05 was set (Wilcox, 2003). Due to the arbitrary nature of this statistical cut-off (Andrade, 2019), effect sizes are further interpreted to indicate the magnitude of results (Cohen, 1992).

3.2.8 Participant Demographics

Twenty-five male participants were recruited. Whilst 30 had expressed interest across the six month recruitment period, one had prior knowledge of the tests so was unable to participate, one failed to respond to invitations to participate and two completed the online demographic information, but then did not attend the assessment. A 17% attrition rate was recorded, which is acceptable for studies of this kind.

A summary of participant characteristics is depicted in table 2. Of the twenty-five participants who completed the study, age ranged between 27 and 59, with a mean of 32 years. Fifteen participants had engaged in higher education at university, with eight completing a postgraduate degree and seven an undergraduate degree. The remaining participants had been education at a vocational level (*n* = 4), tertiary level (*n* = 4) and school (*n* = 2). The sample was well educated, with an average of 17 years education and a mean TOPF-UK estimate of optimal functioning of 12.80 (*SD* = 1.35).

In terms of ethnicity, over half of the sample identified as ‘white’ (*n* = 13). The other remaining half of the sample who did not identify as ‘white’, identified as ‘black’ African, Caribbean, or British (*n* = 5), Asian or Asian British (*n* = 3), or self-identified with multiple ‘mixed’ ethnicities (*n* = 2), or specified an ‘other’ ethnicity (*n* = 2) (i.e. Cypriot).

Regarding physical and mental health, a quarter of the sample reported physical health concerns unrelated to neurological functioning (*n* = 6), whilst one participant reported undiagnosed mild anxiety. No participants reported diagnosed learning disabilities, and all were fluent in the English language. No participants reported head injuries three months prior to participation, although one participant reported an undiagnosed concussion within the last 6 months. As this fell outside the exclusion criteria, the participant was included in the study.

A subset of football-related characteristics are displayed in table 2. This are further elaborated on in the results section, due to being deemed important outcome variables analysed in association with participant performance on the neuropsychological test battery.

Table 2

Summary of Participant Demographic Data

	Mean	SD	Min	Max	Skew.	Kurt.
Age	31.8	7.85	27	59	2.563	6.361
Education in Years	17.1	3.24	12	24	.313	-.715
Years Playing Football	14.0	8.68	4	41	1.252	2.406
Number of Football-related concussions	2.6	2.58	0	10	1.320	1.797
Number of Football-related head contacts per game	5.4	3.79	1	15	.694	-.101

4. RESULTS

4.1 Football-Related Characteristics

A total of 25 participants were included for the main analysis. Half (*n* = 13) identified as active footballers, whilst the remaining half (*n* = 12) had retired. Over half of the participants self-reported their on field football position as defender (*n* = 14), a quarter reported playing as a striker (*n* = 4), another quarter played in midfielder (*n* = 4), and the remaining quarter were goalkeepers (*n* = 3). Whilst one participant appeared at the highest level of the English Football league (EFL), the majority of participants were non-league footballers (*n* = 17). The remaining participants played at a lower level (e.g. academy teams) (*n* = 7). Self-reported age at which participants first played for a football team ranged from 5 to 18 years, with a mean of 9 years (*SD* = 3.00).

Years active football play ranged from 4 to 41 years, with a mean of 14 years (*SD* = 8.68). Hours participants engaged in football-related behaviours per week, including training and competitive matches, ranged from 1 to 26 hours, with a mean of 5 hours, per week (*SD* = 4.74). Across participants footballing careers, all 25 reported head contacts. Nearly all participants self-reported frequently heading the ball (*n* = 24). The majority (*n* = 18), experienced head to head, head to body, and head to floor collisions. Five participants also reported head to goal post collisions. The number of such head contacts experienced per football match ranged from 1 to 15, with a mean of 5 football-related head contacts per competitive match (*SD* = 3.79). In line with Webbe and Ochs' (2003) study, incidence of football-related head contacts was categorised into low incidence in 16 participants (0-5) and medium incidence in 8 participants (6-10), with only one participant experiencing high incidence (10>).

As the majority of participants fell within the low incidence category (*n* = 16), the mean number of football-related head contacts reported per football match was used alongside mean self-reported years actively playing football, to estimate cumulative football-related head impacts for this sample. The sample's mean of five head contacts per football match was multiplied by a conservative estimate of 38 matches per season, in line with the Premier League (Premier League, 2021). Participants in the current sample were estimated to experience an average of 190 football related head-contacts per year, in competitive matches alone. This multiplied by the mean number of years played in this sample (*M* = 14, *SD* = 8.68), resulted in a cumulative estimate of 2,660 football-related head impacts across the footballing career of this sample. This is in line with estimates in the literature (Rodrigues et al., 2019). In addition, 19 participants reported football-related specific head injuries requiring treatment or classified as sporting concussions, between the ages of 10 and 27 (*M* = 12, *SD* = 8.65).

4.2 Exploratory Data Analysis

Raw scores were coded in line with test manuals for each measure and transformed to normative age-scaled scores (*M* = 10, *SD* = 3). The Brixton Spatial Anticipation test raw scores were transformed to normative data scores, due to lack of appropriate age scaled norms for young adults, who formed the majority of the sample. Examination of histograms and scatterplots of transformed scores enabled checking for outliers, missing cases, and amendment of data coding errors.

4.3 Descriptive Data Analysis

As depicted in table 3, descriptive statistics were produced across all measures of general cognitive functioning and social cognition. The data were checked for parametric violations, by assessing skewness and kurtosis scores (skewness>1, kurtosis>3).

4.3.1 Analysis of Cognitive Functioning

On initial inspection, mean scores for cognitive functioning were above the normative data score of 10, on several tests (see table 3). Scores close to the population mean were demonstrated across WAIS-IV digit span tasks (forward, backward, sequencing). Lower scores were observed on WMS-IV story recall immediate and delayed, WAIS-IV similarities, and Symbol Digit Modality Test (SDMT). One-sample Kolmogorov-Smirnov tests were conducted, to assess whether subset scores were in line with the normative data (*M* = 10, *SD* = 3).

Table 3

Descriptive Statistics for Subsets of Cognitive Tests

Test: Subsets	Mean	SD	Min	Max	Skew.	Kurt.
D-KEFS Verbal fluency	11.20	2.20	6	15	-.532	-.178
D-KEFS Category fluency	12.12	2.40	5	16	-1.073	1.758
D-KEFS Switching output	12.16	3.31	5	17	-.467	-.766
D-KEFS Switch accuracy	11.72	2.57	6	16	-.36	-.51
Brixton Test*	12.88	2.46	8	16	-.346	-.948
WMS-IV Story recall: Immediate	7.60	1.69	4	11	-.387	.271
WMS-IV Story recall: Delayed	6.96	1.72	2	9	-1.055	1.528
WMS-IV Story recall: Recognition	11.08	3.32	5	16	-.188	-.842
WAIS-IV Digit Span Forward	10.80	3.33	6	19	1.214	.757
WAIS-IV Digit Span Backward	9.92	3.27	3	15	-.040	-.155
WAIS-IV Digit Span Sequencing	10.08	1.73	7	13	-.133	-.535
WAIS-IV Matrix Reasoning	11.32	2.06	6	15	-.501	.637
WAIS-IV Similarities	9.28	1.97	6	14	.358	.629
Symbol Digit Modality Test	6.56	3.08	1	13	.044	-.790
Social Stories Questionnaire	7.24	3.75	1	15	.365	-.206
ACS Affect Naming	10.04	3.57	2	15	-1.085	.788
QCAE Cognitive	9.76	2.98	4	16	.398	-.334
QCAE Affective	7.52	2.87	1	12	-.572	-.496

* Norms not Age-Scaled.

Results in table 4 show non-significant Kolmogorov-Smirnov statistics across all WAIS-IV digit span tasks, confirming the sample performed comparatively to age-scaled normative data. Statistically significant Kolmogorov-Smirnov tests confirmed mean scores for WAIS-IV matrix reasoning, Brixton Spatial Anticipation, and across all D-KEFS tests of verbal and category fluency and verbal switching were above normative data. As depicted in table 4, a medium effect size was observed for the WAIS-IV matrix reasoning task. D-KEFS verbal fluency fell just short of a medium effect size, whilst measures of category fluency and verbal switching fell between medium and large effect sizes. Brixton Spatial Anticipation test revealed a large effect size, with participants scoring significantly higher than normative data. One must however note, scaled scores for the Brixton task did not account for age due to a lack of appropriate age-scaled norms for young adults who form the majority of the current sample. Results must therefore be interpreted with caution.

In contrast, Kolmogorov-Smirnov tests revealed participants scored significantly lower than normative data, on both WMS-IV story recall immediate and delayed. This is in disparity with WMS-IV story recognition, on which participants scored higher than normative data. Scores on WAIS-IV similarities and oral SDMT also appeared significantly below normative data.

A mean score across all domains of cognitive functioning was computed (M = 10.26, SD = 1.32). This was normally distributed with skewness below 1 (-.281) and kurtosis below 3 (-.429). Across domains of cognitive functioning, the samples' score was in line with normative data (M = 10, SD = 3).

Table 4

Kolmogorov-Smirnov scores of General Cognitive Functioning and Social Cognition compared with Normative Data, including effect sizes

Scaled Subsets	**K-S**	**p-value**	***d***
Verbal fluency ↑	1.55	.016	.46
Category fluency ↑	2.33	<.001	.78
Switching Output ↑	1.80	.003	.68
Switch Accuracy ↑	1.75	.004	.62
Brixton Test* ↑	2.35	<.001	1.05
Story recall: Immediate ↓	2.75	<.001	-.99
Story recall: Delayed ↓	3.15	<.001	-1.24
Story recall: Recognition ↑	1.34	.056	.34
Digit Span Forward	1.06	.209	.25
Digit Span Backward	.90	.393	-.03
Digit Span Sequencing	1.25	.089	.03
Matrix Reasoning ↑	1.75	.004	.51
Similarities ↓	1.70	.006	-.28
Symbol Digit Modality ↓	2.55	<.001	-1.13
Social Stories Questionnaire ↓	2.14	<.001	-0.81
ACS Affect Naming	.90	.393	0.01
QCAE Cognitive	.95	.324	-0.08
QCAE Affective ↓	1.90	.001	-0.84

* Norms not Age-Scaled.

↑ Indicates performance above normative data.

↓ Indicates performance below normative data.

No symbol indicates performance in line with normative data.

4.3.2 Analysis of Social Cognitive Functioning

Descriptive statistics and Kolmogorov-Smirnov tests were conducted to assess performance on social cognition subsets, compared with age-matched normative data (*M* = 10, *SD* = 3).

On initial inspection, mean scores for test of social cognitive functioning revealed a potential weakness in scores on the Social Stories Questionnaire (SSQ) and Questionnaire of Cognitive and Affective Empathy (QCAE) affect empathy subset, both of which fell below that of the normative data. Kolmogorov-Smirnov tests revealed that participants performed close to the population mean on both ACS Affect Naming Task (ANT) and QCAE cognitive empathy (see table 4). However, scores on subsets for SSQ and QCAE affective empathy were significantly below the normative data.

4.3.3 Analysis of Optimal Ability

The TOPF-UK was used to estimate participants optimal functioning, comparable to the general population. The mean score for the sample was 12.80 (*SD* = 1.35). Optimal ability for the sample was therefore higher than that of normative data (*M* = 10, *SD* = 3). A one-sample Kolmogorov-Smirnov test, confirmed participants optimal ability significantly differed from the population average. This should be taken into account when evaluating the data.

4.4 Inferential Data Analysis

4.4.1 Contrasting the Sample

4.4.1.1 general and social cognition

As participants scores were significantly higher than age-matched normative data on optimal functioning, a Wilcoxon signed-rank test was used to assess whether participant's social cognition differed from general cognitive functioning. Comparison of each measure of social cognition with the computed mean cognitive functioning score across domains for the research group (*M* = 10.26, *SD* = 1.32), was conducted.

This revealed a significant difference between participants general cognitive functioning versus social cognition for SSQ, z (N = 25) = - 3.46, p = .001, r = - .49.

A significant difference was also identified for general cognitive functioning versus QCAE Affective Empathy, z (N = 25) = - 3.36, p = .001, r = - .48. Both demonstrated a moderate to large magnitude of effect. The ANT and QCAE cognitive empathy showed no significant difference, compared with general cognitive functioning.

4.4.1.2 Optimal ability and cognition

As participants scored significantly higher on optimal ability than the normal population, discrepancy scores were created for each measure compared to participants optimal functioning. As depicted in table 5, mean differences were found between participants optimal functioning and measures of both general cognitive functioning and social cognition. Large mean scores were revealed for both immediate and delayed WMS-IV story recall and oral SDMT, and social cognitive measures of SSQ and QCAE affective empathy.

Table 5

TOPF-UK Discrepancy Scores for Subsets of Cognitive Tests

Scaled Subsets	Mean	SD	Min	Max	Skew.	Kurt.
Verbal fluency	1.60	2.20	-2	7	.404	.305
Category fluency	.68	2.43	-3	7	.692	.525
Switching Output	.64	3.20	-5	7	.447	-.581
Switch Accuracy	1.08	2.64	-4	6	.200	-.824
Brixton Test*	-.08	2.10	-4	4	.320	-.468
Story recall: Immediate	5.20	1.53	3	8	-.061	-1.062
Story recall: Delayed	5.84	1.93	2	10	.132	-.150
Story recall: Recognition	1.72	3.46	-6	9	-.006	.125
Digit Span Forward	2.00	3.08	-4	7	-.835	-.049
Digit Span Backward	2.88	2.92	-3	10	.303	.616
Digit Span Sequencing	2.72	1.28	0	5	-.211	-.752
Matrix Reasoning	1.48	2.37	-3	6	.027	-.647
Similarities	3.52	1.69	1	6	.161	-1.117
Symbol Digit Modality	6.24	3.09	-1	12	-.310	-.131
Social Stories Questionnaire	5.56	3.49	-2	11	-.635	.074
ACS Affect Naming	2.76	3.72	-4	10	.348	-.181
QCAE Cognitive	3.04	3.37	-4	11	-.137	.389
QCAE Affective	5.28	3.34	-1	11	.605	-.392

* Norms not Age-Scaled.

4.4.2 Exploring Football-related Behaviours, Cognitive Functioning and Social Cognition

Current literature, study research questions and data analysis, informed the chosen measures of interest. Self-reported football-related behaviours of interest included on field football position, years active play, hours played per week, number of head contacts per football match, and both experience of, and number of football-related concussions across participant's careers. Measures of general cognitive functioning that differed from normative data and showed discrepancy with the samples higher than normative TOPF-UK scores (WMS-IV story recall immediate, delayed, SDMT and WAIS-IV similarities), alongside all measures of social cognition (SSQ, ANT and QCAE) forming the novel aspect of the current study, were included.

4.4.2.1 Football-related differences

Football-related behaviours of interest were transformed into categorical (group) data to enable Mann Whitney *U* tests of difference, full details of which can be seen in Appendix K.

i) Footballer status: position

In line with the literature (Hunt & Fulford,1990; Kirkendall et al., 2001), on field football position was divided into those exposed to a high header count (defenders and strikers) (n = 18) and those exposed to low header counts (goalkeepers and midfielders) (n = 7). Mann Whitney *U* tests revealed these groups did not differ significantly on general cognitive functioning measures of interest, nor on social cognitive tests of SSQ, ANT or QCAE affective empathy.

A statistically significant difference was revealed between footballer position and performance on the QCAE cognitive empathy test,
U (N = 25) = 28.00, z = - 2.14, p = .033, r = - .43. In contrast to what would be expected, this revealed strikers and defenders (whom the literature identified as exposed to a higher header count), performed better on the QCAE cognitive empathy test than goalkeepers and midfielders. Similarly, a moderate effect was revealed in this direction for position and ANT,
U (N = 25) = 38.00, z = - 1.53, p = .0127, r = - .31.

ii) Football activities: incidence of head contacts

Incidence of football-related head contacts per week, were categorised in line with current literature (Webbe & Och, 2003). Moderate to high incidence of head contacts per match (6>) (*n* = 9) were compared with those reporting a low incidence (0-5) (*n* = 16). No differences were revealed for these two groups on general cognitive functioning, or social cognition.

iii) Football-related head impacts: concussions

Participants who reported experience of football-related concussions (*n* = 19), were compared with those who reported no football-related concussions (*n* = 6). Regarding cognitive functioning, participants who had experienced football-related concussions scored significantly lower than those who had not experienced football-related concussions on WMS-IV immediate story recall, U (N = 25) = 26.00, z = - 2.01, p = .044, r = - .40. This demonstrated a moderate magnitude of difference. Regarding social cognition, participants who had experienced football-related concussions again scored significantly lower on the SSQ than those who had no experience of football-related concussions, U (N = 25) = 24.00, z = - 2.12, p = .034, r = - .42. A moderate magnitude of difference was also demonstrated in this direction for ANT, which fell short of statistical significance, U (N = 25) = 29.50, z = - 1.76, p = .078, r = - .35.

iv) Cumulative football-related head impacts: concussions

Concussions across football career were then grouped into high (3>) (*n* = 11) versus low (0-2) (*n* = 14) incidence. Participants with high incidence of concussion scored significantly lower on WMS-IV immediate story recall, compared with those who experienced low incidence of career football-related concussions, U (N = 25) = 38.50, z = - 2.15, p = .032, r = - .43. A Moderate magnitude of difference was also demonstrated for performance on SDMT, U (N = 25) = 42.50, z = - 1.92, p = .055, r = - .38, and QCAE cognitive empathy, U (N = 25) 49.00, z = - 1.55, p = .122, r = - .31. The ‘high’ incidence of football-related concussion group performed moderately worse on these tasks, with the SDMT and QCAE cognitive empathy falling short of statistical significance.

4.4.2.2 Football-related associations

Spearman's rho correlations were performed to explore associations between ordinal level football-related behaviours (hours played per week, years active footballer, number of head contacts per football match and number of football-related concussions across participant's careers), and measure of general cognitive functioning and social cognition. Full details of the correlation matrix can be seen in Appendix L.

i) Footballer status: years active footballer

Years active as a footballer did not correlate with any of the measures of general cognitive function. There was a statistically significant correlation between years active as a footballer and ANT, r_s (N = 25) = - .42, p = .038. As depicted in figure 1, this negative correlation was of moderate to large effect size, with an increase in years playing football associated with a decrease in scores on the ANT.

ii) Football activities: hours per week

A statistically significant negative correlation was revealed between hours of football per week and WMS-IV delayed story recall, r_s (N = 25) = - .55, p = .005. Depicted in figure 2, this large effect size of increased years of football correlated with a decrease in scores on WMS-IV story recall: delayed. Notably, a moderate negative association falling short of statistical significance was also demonstrated between football hours per week and WMS-IV immediate story recall, r_s (N = 25) = - .35, p = .086.

Regarding social cognition, hours of football per week was not statistically correlated with any measures but, a moderate negative association was evidence for QCAE affective empathy, r_s (N = 25) = - .35, p = .089.

iii) Football activities: incidence of head contacts

As seen in Appendix L, no statistically significant correlations were revealed for football-related head contacts per week with general or social cognitive functioning. A moderate association was demonstrated with ANT, r_s (N = 25) = - .31, p = .138.

iv) Cumulative football-related head impacts: concussions

A statistically significant negative correlation was revealed between the number of football-related concussions experienced across footballer's careers and WMS-IV immediate story recall, r_s (N = 25) = - .43, p = .032. As depicted in figure 3, this moderate to large effect size, demonstrates an association between an increase in number of career concussions and a decreased in scores on the WMS-IV story recall: immediate.

No statistically significant correlations were revealed with measures of social cognition but, a large association was seen between football-related concussions and ANT, r_s (N = 25) = - .85, p = .685.

Figure 1

Years Active Footballer by ACS Affect Naming Task Score

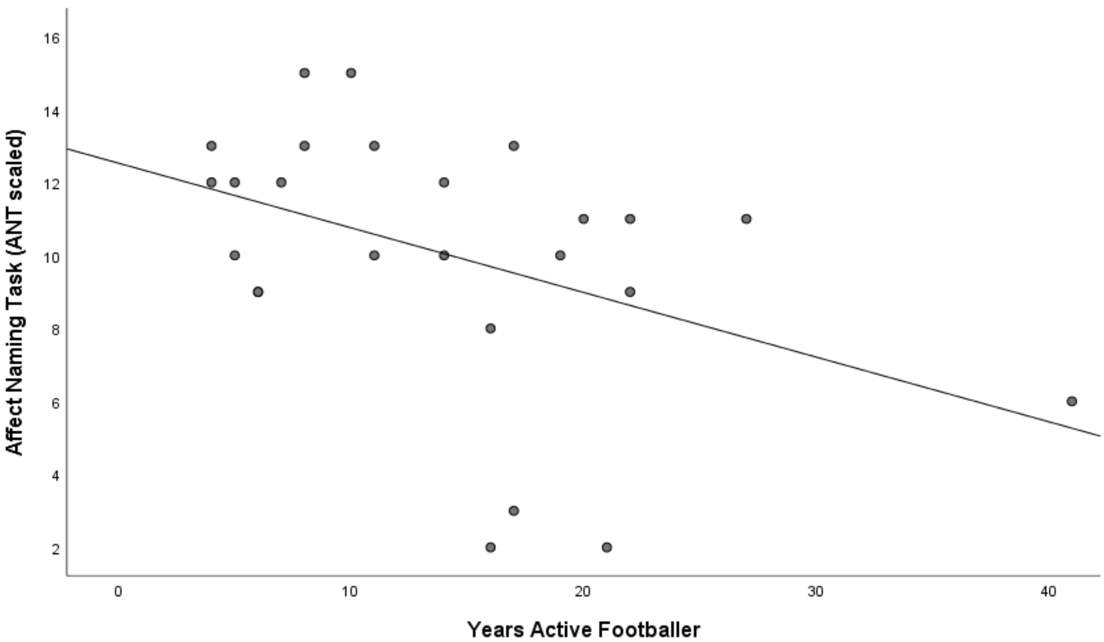


Figure 2

Hours of Football-Related Behaviours Per Week by WMS-IV Story Recall: Delayed

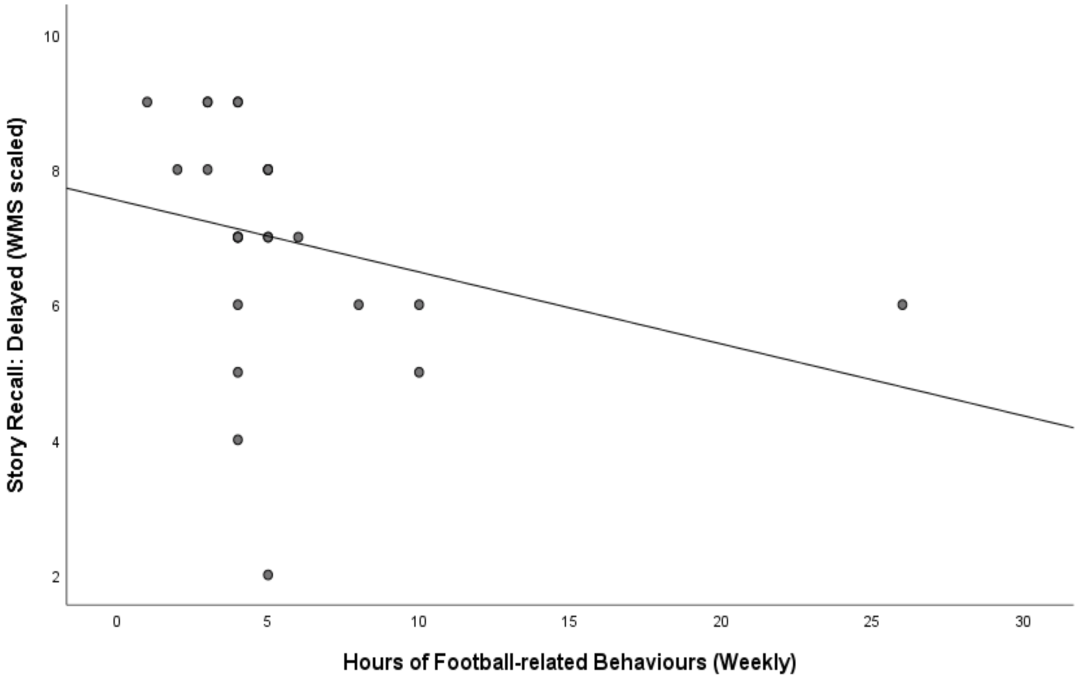
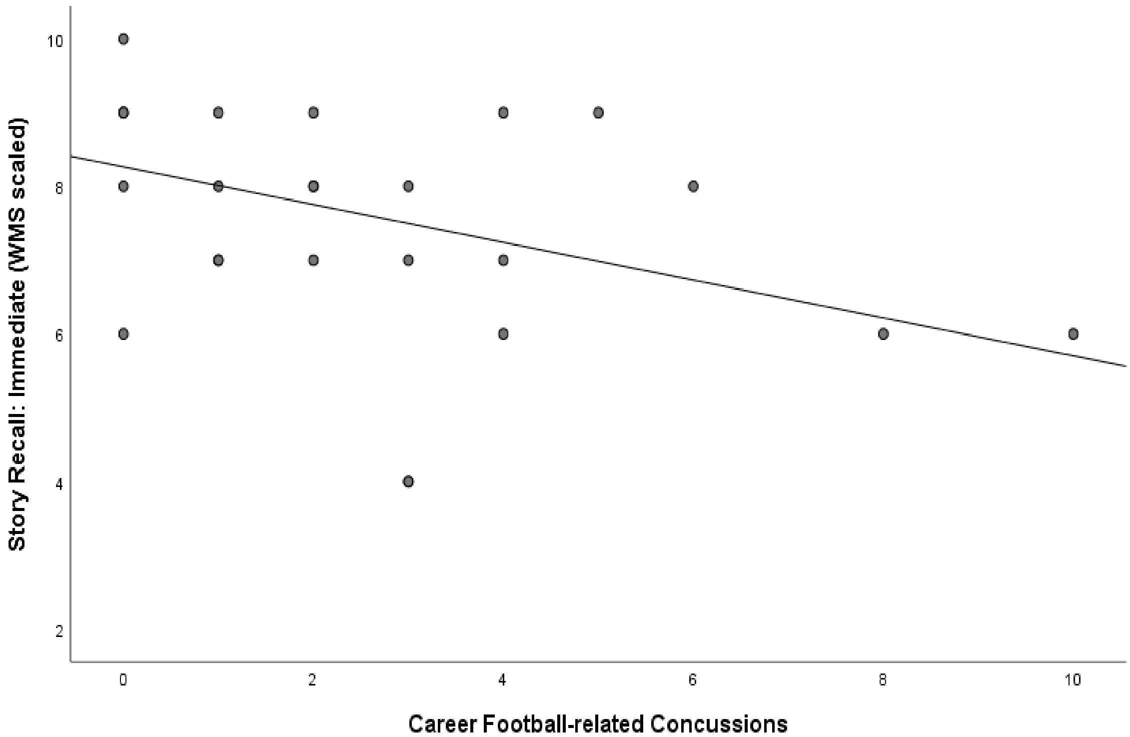


Figure 3

Career Football-Related Concussions by WMS-IV Story Recall: Immediate



5. DISCUSSION

The current study was conducted to address a gap in the literature, through exploration of the relationship between football-related behaviours, cognitive functioning, and social cognition. Hitherto, considerable attention has been paid to the impact of TBI in boxing and the NFL, with a particular focus on head injuries causing loss of consciousness and CTE (Omalu et al., 2005; Spiotta et al., 2011). However, as the world's most popular sport with over 265 million players across 204 countries (Bunc et al., 2017; FIFA, 2006; Rodrigues et al., 2016), to date football remains largely neglected in the literature. Of the limited studies that have been conducted exploring the neuropsychological impact of football, findings remain conflicted, with critiques across studies consistently highlighting methodological weaknesses and biases.

In contrast, considerable media attention has recently emerged regarding the long-term impact of football-related behaviours. Public health interest has been amplified throughout the duration of the current research, due to multiple high-profile footballer deaths and suggested associations between heading, neurodegenerative diseases, and subsequent CTE-related death (Barth et al., 2001; BBC News, 2016; BBC Sport, 2020). Moreover, whilst head injuries and several neurodegenerative disorders are associated with impairments of social cognition (Fiske & Taylor, 2013; Harciarek & Cosentino, 2013), to the researcher's knowledge no study to date has examined the relationship between football-related behaviours and social cognition. The current study is thus the first of its kind, with research questions exploring whether a relationship exists between football-related behaviours and head injuries, and performance on measures of cognitive functioning and social cognition. The study further investigated whether frequency of exposure to football-related head injuries impacted performance across measures of general cognitive and social cognitive functioning.

5.1 Sample Representation

The sample consisted of twenty-five male footballers, with diverse football histories and experiences of football-related concussions. The sample age ranged from 27 to 59 and was generally representative of the UK working population. The majority of the sample were however younger adults in their twenties and thirties whom, identified as white. Participants had played across all levels of the football pyramid, from school teams, to youth academies, non-league, and in the English football league (EFL). The sample consisted of a majority of semi-professional footballers with a mean of 14 years active play across the sample, averaging 5 hours per week. A calculated mean estimate of a 190 football related head-contacts per year was made for the sample, in competitive matchers alone. In addition, a cumulative estimate of 2,660 football-related head impacts across footballing career in this sample, was in line with the current literature (Rodrigues et al., 2019). This alongside 19 of the 25 participants self-reporting specific football-related concussions, suggests a sample representative of a group of footballers with a significant exposure to football-related behaviours and concussions, at amateur and professional levels.

With regards to functioning, the sample performed significantly above the expected level of optimal functioning observed in the general population. This is consistent with a sample of highly educated individuals, 60% of which completed education at university level, compared to 44% of the general UK population achieving a certificate of higher education (Department for Education, 2020). Whilst speculative, this largely self-selected sample of highly educated individuals may be reflective of a sample more interested in the topic area, or more likely to engage with research. Participants may have therefore had an advantage on several measures of cognitive performance, correlated with level of education (Ostrosky-Solís et al., 2004). All measures were scored by age-scaled norms, except the Brixton Spatial Anticipation Test, due to a lack of validated age-scaled norms for young adults (who formed the majority of the current sample). In addition, the sample's estimated optimal functioning was compared to scores across all measures to highlight any discrepancies in general and social cognitive functioning, within this higher-functioning sample.

5.2 Summary of Results

The current study demonstrated that a sample of active and retired male adult footballers (who performed significantly above optimal functioning based on a verbal measure with age-matched norms), showed cognitive weaknesses relative to the norm on verbal memory recall, both immediate and delayed. In addition, this sample also displayed weaknesses on two measures of social cognitive functioning, ToM, and affective empathy, compared to age-matched population normative data. Other areas of cognitive functioning appear unimpaired, with a mean cognitive functioning scaled score across measures in line with age-matched population normative data. The significance of this finding is further indicated by discrepancy between the sample's own optimal functioning and weaknesses on cognitive measures of verbal memory, both immediate and delayed, and visual attention as measured by processing speed, and social cognitive measures of ToM and affective empathy. Of key interest, were differences and associations observed within the sample which highlighted verbal memory, visual attention, ToM, emotion recognition, and empathy weaknesses associated with football-related behaviours, detailed below.

5.2.1 Cognitive Functioning

Investigation of the samples general cognitive functioning revealed weaknesses relative to the norm on visual attention, verbal functioning, and most significantly verbal memory recall, both immediate and delayed. Such deficits are surprising in this context, as such a highly educated sample performing significantly above normative age-matched data on optimal functioning, would be expected to perform in line with or above the norm on measures of cognitive functioning.

In contrast, the sample demonstrated significant strengths in performance on measures of visual functioning, word generation, verbal switching, and rule deduction and planning, relative to the norm. One complexity here is that the Brixton Spatial Anticipation Test was the only test not matched to age-scaled norms, due to a lack of appropriate age-scaled norms for young adults, who formed the majority of the current sample. The significance of the sample performing above normative data on rule deduction and planning, must therefore be interpreted with caution and suggests recommendations detailed later. All other areas of cognitive functioning, including verbal attention and working memory, remained intact, contradictory to limited literature findings (Rutherford et al., 2005; Stephen et al., 2005). The sample also performed in line with normative population data, when a mean cognitive functioning score across all measures was calculated.

5.2.1.1 Cognitive functioning and football-related behaviours

The current study revealed associations between football-related behaviours and measures of cognitive functioning, particularly verbal memory. Whilst a link between heading and neuropsychological impairment alluded to in the literature was not observed in the current sample (Levitch et al., 2018; Lipton et al., 2013; Matser et al.,1998,1999, 2001; Sortland & Tysvaer, 1989; Tysvaer & Lochen, 1991), increasing hours of play per week were reliably correlated with reduced performance on delayed verbal memory, and to a lesser extent immediate verbal memory. The current study revealed a negative association between cumulative career football-related concussions and immediate verbal memory, with a further quantifiable difference at three or more career football-related concussions. The latter was also demonstrated to a lesser extent for visual attention.

Contradictory to previous studies that have failed to identify any association between football-related behaviours and cognitive functioning, the current study highlights weaknesses in verbal functioning, memory, and visual attention in association with increased hours of play and cumulative career football-related concussions. These findings add to the current literature, supporting deficits in verbal functioning, memory and visual attention demonstrated in mTBI (Binder et al., 1997; Cicerone, 1997; Esselman & Uomoto 1995; Karr et al., 2014; McCauley et al., 2014), in sporting concussions, and as associated symptoms of CTE following both boxing and NFL head injuries (Bailes et al., 2013; Jennings et al., 2015; Mez et al., 2017; Omalu et al., 2005; Spiotta et al., 2011; Tsushima et al., 2016). Whilst one cannot infer causality from correlational data, the current study extends such findings to a football sample, thus suggesting these football-related behaviours may be risk factors for cognitive deficits, associated with CTE symptoms and neurodegenerative conditions.

Notably, verbal memory recognition remained intact. This indicates a potential link with frontal amnesia (Baddeley & Wilson, 1988), which presents as deficits in processing speed and memory, attributed to spontaneous self-organised retrieval but, not retention. While previous studies have suggested sporting TBI result in symptoms of neurological dysfunction and present a cumulative burden (Bailes et al., 2013), the current study suggests deficits at the intersection of memory and executive function to be association with football-related behaviours. Further studies assessing visuospatial memory and building on these findings, are recommended.

5.2.2 Social Cognition

The current study is the first of its kind to explore whether footballers showed weaknesses in social cognition. Within the current sample, weaknesses were demonstrated on measures of ToM and affective empathy, relative to age-matched normative data. Conversely, the sample scored close to population norms on measures of emotion recognition and cognitive empathy. Exploration of interactions between social cognition and general cognitive functioning, further supported that the observed deficits in ToM and affective empathy were not due to weaknesses in general cognitive functioning, as this was in line with age-matched normative data.

Such deficits in social cognition are therefore unlikely to be attributed to general cognitive dysfunction. This is further supported by a lack of significant impairment in cognitive empathy, compared to the sample's general cognitive functioning. Findings were in line with the 'domain specific' theory of social cognition, with social cognitive functioning being relatively independent from other domains of cognitive functioning (Spunt & Adolphs, 2017; Stone & Gerrans, 2006). Weaknesses displayed in affective empathy only in comparison to age-matched normative data, support the distinction made in the nature of processing information (Kalbe et al., 2010), detailed below.

The current study is consistent with literature regarding TBI deficits in social cognition (Babbage et al., 2011; Beauchamp et al., 2013; Fazaeli et al., 2018), with the novel addition of revealing associations with football-related behaviours. Building on research in other sporting populations utilising a similar methodological approach, the current study extends marginal findings of social cognitive weaknesses in a rugby sample (York-Smith, 2019), with more marked weaknesses in this football sample detailed below. Such findings have implications both clinically and in sporting legislation. Associations between these social cognitive domains, neurodegenerative diseases, and clinical presentations of sports related CTE (Fiske & Taylor, 2013; Harciarek & Cosentino, 2013), require further examination in the footballing population.

5.2.2.1 Theory of mind and football-related behaviours

Regarding levels of information processing, ToM refers to the uniquely human high-level mentalising observable through tasks involving non-literal language (Channon et al., 2004; Frith & Frith, 2008). Acknowledged for its high level of internal consistency regarding TBIs (Francis et al., 2017), the Social Stories Questionnaire (SSQ) was chosen as a sensitive assessment of mentalisation, with detection of subtle and blatant *faux pas* indicating comprehension of social norms (Lawson et al., 2004). The sample demonstrated weakness in ToM, in comparison to age-scaled normative population data. While the SSQ is largely reliant on reading, the sample's above average performance on TOPF-UK implies this weakness in ToM, is not due to a weakness in reading ability.

Moreover, the sample performed significantly better than age-scaled normative data on measures of verbal executive functioning (word generation: phonemic and semantic) and did not display weaknesses in attention or working memory. The sample did however display weaknesses in verbal memory, which could indicate deficits in encoding and retrieving information. Nonetheless, comparison with the sample's general cognitive functioning score across measures, supports a deficit in ToM. The significance of this weaknesses in ToM is further highlighted when comparisons are drawn within the sample. Footballers who self-reported experience of football-related concussions performed significantly worse on measures of ToM, which may indicate the impact of cumulative sporting concussions within the football sample on ToM.

5.2.2.2 Emotion recognition and football-related behaviours

Moving attention to the low-level processes, emotion recognition was measured by ACS Affect Naming Task (ANT) (Pearson, 2009) to assess participants ability to identify emotions from facial expressions (Mancuso et al., 2011), and is not reliant on verbal ability. The sample performed in line with normative data on this measure of emotion recognition. However, this may nevertheless be influenced by visuospatial abilities, in which the sample scored significantly higher than normative population data (WAIS-IV matrix reasoning). Unfortunately, a full assessment of visuospatial abilities was not possible as administration of measures was altered due to the COVID-19 pandemic. This is detailed further in the critical review and future recommendations.

Weaknesses in emotion recognition within the sample were associated with football-related behaviours. A negative association was revealed for years active as a footballer and emotion recognition. Associations were also revealed for incidence of football-related head contacts per match and cumulative career football-related concussions within the group. While interpretated cautiously, weaknesses identified in the current study provide preliminary evidence for a vulnerability in the complex neural networks that emotion recognition relies on (Adolphs, 2002), to the effects of sporting concussions and subconcussive impacts (Broglio et al., 2009; Goswami et al., 2016). These findings thus extend results highlighted in Babbage et al.'s (2011) meta-analysis of impairments in facial emotion recognition following TBI, to the footballing population.

These weaknesses in emotion recognition are demonstrated in addition to weaknesses observed in ToM. This highlights a need for further research regarding the association between sporting injuries and social cognition, specifically in the footballing population. Studies have suggested impairments in these domains of social cognition appear relevant across a range of neurodegenerative conditions including bvFTD and HD (Gregory et al., 2002: Diehl-Schmid et al., 2007; Snowden et al., 2003), and as an early socio-cognitive index of AD (Verdon et al., 2007). While the current correlational findings cannot infer a causal link and are thus interpreted cautiously, recognition of deficits in ToM and emotion recognition may aid preliminary understanding, guiding future research and clinical recommendations.

5.2.2.3 Empathy and football-related behaviours

The Questionnaire of Cognitive and Affective Empathy (QCAE) was chosen in line with the distinction made between affective and cognitive functioning (Carr et al., 2003; Kalbe et al., 2010; Reniers et al., 2011). Assessing this multidimensional construct through separating empathy into cognitive and affective responses proved important, as the sample showed weakness in affective empathy. However, when further exploring empathy, an association with football-related behaviours was demonstrated in both cognitive and affective empathy.

Weaknesses relative to the norm and the sample's general cognitive functioning in affected empathy, appeared in association with increased hours of engagement in football related-behaviours per week. On the other hand, on field football position demonstrated a reliable association with performance on cognitive empathy. Those the literature identified as more susceptible to heading surprisingly performing better on measures of cognitive empathy, than those deemed less susceptible. These groups were categorised in such a way, as central defenders and strikers are reportedly more likely to sustain head injuries due to partaking in the most penalty box competition for the ball (Hunt & Fulford,1990; Kirkendall et al., 2001). This group is therefore thought to be more susceptible to heading.

However, a key oversight is that there are other football-related behaviours that may result in TBI, including collisions with the goalpost, floor, and other players, which may also result in concussion. These football-related behaviours are more frequently observed in goalkeepers, who the literature categorised as less susceptible to headers (Hunt & Fulford,1990; Kirkendall et al., 2001) and may often result in concussion. This oversight may explain this unexpected finding, particularly as the footballers in this sample who self-reported a 'high' incidence of football-related concussions, also showed weaknesses in cognitive empathy. It is therefore cautiously hypothesised that such findings may be attributed to these overlooked football-related behaviours. Future clarity regarding the potential links between on field footballer position, headers, head impacts and concussions is thus recommended.

5.3 Summary and Interpretation of Results

In the current study, key findings emerged that are consistent with and develop on the current literature, with some warranting further research. In answer to the study research questions, cognitive weaknesses relative to the norm were demonstrated for visual attention, verbal functioning, and most significantly verbal memory recall, both immediate and delayed, as well as social cognitive weaknesses in ToM and affective empathy. This was despite the sample being significantly above the general population estimate of optimal functioning, and highly educated. These weaknesses were further associated with football-related behaviours. Of key interest is the interaction between quantified and cumulative career football-related concussions with cognitive functioning, specifically verbal memory, ToM, and emotion recognition, where performance appeared to reflect frequency of exposure to football-related head injuries. The current study thus provides preliminary support for a dose-response relationship between history of concussion (and to a lesser extent heading exposure), and neuropsychological performance suggested in previous studies (Autti et al., 1997; Matser et al., 1998, 1999, 2001; Sortland & Tysvaer, 1989). Novel associations with social cognition (particularly the moderate association seen for heading and emotion recognition), require further investigation.

The current study thus highlights the need for assessment of the full range of cognitive functions, including verbal memory and social cognition, when football-related head impacts are apparent. This has important clinical implications (detailed later), as such deficits may be associated with sports related CTE and neurodegenerative disorders (Christidi et al., 2018; Gray & Tickle-Degnen; 2010 Gregory et al., 2002; Snowden et al., 2003; Verdon et al., 2007). The inclusion of social cognitive measures in the current study provides preliminary evidence for weaknesses in the interpersonal functions, and accordingly, these preliminary findings warrant future consolidation. Implications and recommendations are outlined below for clinical psychology and sporting governing bodies, with emphasis on preventative care in improved awareness, assessment, and monitoring of sporting history in the footballing population.

5.4 Critical Review

The current study is the first of its kind to explore the neuropsychological impact of a range of football-related behaviours, on both general and social cognitive functioning. Whilst these findings remain preliminary, the current research suggests associations between football-related behaviours and verbal memory, visual attention, ToM, emotion recognition, and empathy. Despite increased acknowledgement of the impact of sporting concussive and subconcussive impacts on social cognitive functioning, previous studies have failed to explore such associations in a footballing population. A critical review of the current study is provided here below, enabling recommendations for future research, practice, and sporting legislation.

5.4.1 Methodology

5.4.1.1 Strengths

In line with literature critique, the current study avoided inadequate control groups (Rutherford et al, 2003), by comparison with age-matched population normative data, alongside an estimate of optimal functioning which enabled within-subjects' comparisons. As previous literature highlighted gender differences in cognitive performance amongst footballers (Colvin et al., 2009; Covassin et al., 2013; Kontos et al., 2011; Mooney et al., 2020; Putukian et al., 2000; Tsai et al., 2015), inclusion criteria focused on a male-only sample in order to reduce the impact of confounding variables, upon which future studies may build. The cross-sectional correlational design of the current study was suitable for such a preliminary investigation and in the context of time-constraints and the COVID-19 pandemic.

The comprehensive neuropsychological test battery utilised included measures based on neuropsychological literature and studies, in other sporting populations. This enabled measurement of relevant constructs in a standardised way. While associations revealed between football-related behaviours, ToM, emotion recognition, and empathy are made cautiously, they build upon previous sporting literature, providing novel findings in the footballing population. A strength of the current study was the adaptation to the COVID-19 pandemic. Whilst the pandemic impeded expected administration of measures and data collection, measures used were appropriate for the adapted video conferencing call administration required. Furthermore, recruiting participants via this medium may have widened the sample, given lockdown and social distancing regulations.

5.4.1.2 Limitations

All neuropsychological measures utilised were standardised and transformed according to age-scaled norms, however the Brixton Spatial Anticipation Test lacks appropriate age-scaled norms for young adults, who formed the majority of the current sample. As such, it was necessary to utilise general norms for this test, provided in the test manual. This may account for the sample's superior performance on this task, as younger people tend to perform better on this task yet, norms were derived from an older sample. In addition, football-related behaviours were measured via self-report, which are vulnerable to issues of memory recall and social desirability. This is particularly relevant in the current context, with increased awareness and media interest regarding the long-term impact of heading in football (Barth et al., 2001; BBC News, 2016; BBC Sport, 2020). For example, suggested changes to football policies (i.e., banning headers), may have negatively impacted participants responses. Participants may have potentially recorded fewer instances of head contacts, due to concerns regarding the implications of the outcomes of the study, on sporting policies. Conversely, participants concerned about the long-term impact of football participation may have responded in the opposite way, over estimating football-related behaviours in light of media attention. While participants were informed of the focus of the study in broadening understanding, it remains difficult to establish the accuracy of all self-report measures.

Moreover, while all attempts were made to achieve a sample size reflective of the current literature (Matser et al.,1998,1999, 2001; Rodrigues et al., 2019), current media coverage and the COVID-19 pandemic may have influenced recruitment. Altered methodology and recruitment procedures whilst enabling the study to remain feasible, inevitably interrupted the logical flow of the assessment and influenced the final sample size, which remained relatively small. The sample size was appropriate for this exploratory study yet, statistical power and sensitivity may have been reduced, thus heightening the risk of a type II error (Field, 2009). Furthermore, as multiple testing can increase the chance of a type I error, the researcher opted to attend to effect sizes rather than focusing solely on the p-value of statistical procedures. In the case of non-parametric statistics, exact significance levels rather than p-values were reported, wherever possible. This enabled consideration of the magnitude of effect. Whilst moderate to large effects were reported and interpreted with caution, there may not have been enough resolution in the data to identify which football-related behaviours were most predictive of cognitive functions. Should the study have utilised a larger sample, correlations may have identified trends across cognitive measures, which would have enabled further analysis of predictability (i.e., regressions).

5.4.2 Generalisability and External Validity

5.4.2.1 Strengths

Consideration of the sample characteristics has implications for the generalisability of the current study. Participants in the study had played across all levels of the UK football 'pyramid', consisting of a majority of semi-professionals. Mean years of football play and hours per week, enabled an estimate in this sample of 190 football related head-contacts per year, in competitive matches alone. This led to a cumulative estimate in this sample of 2,660 football-related head impacts, across footballing career. This was in line with the current literature (Rodrigues et al., 2019). Alongside the majority of the sample reportedly experiencing football-related concussions, this indicated a sample representative of a group of footballers with exposure to football-related behaviours associated with head contacts and concussions, at amateur and professional levels.

5.4.2.2 Limitations

Whilst the current study included an age range spanning across the working population, most individuals in the current sample were younger adults in their twenties and thirties. Furthermore, the sample were highly educated and performed significantly above population normative data on an estimate of optimal functioning. One may therefore expect a level of 'resistance' to the neuropsychological impacts, as level of education is highly correlated with performance on neurocognitive measures (Ostrosky-Solís et al., 2004).

Additionally, as previous literature highlighted gender differences in cognitive performance amongst footballers (Colvin et al., 2009; Covassin et al., 2013; Kontos et al., 2011; Mooney et al., 2020; Putukian et al., 2000; Tsai et al., 2015), females were excluded from the current preliminary research. A sample with a more evenly distributed age range, the inclusion of female participants, and a representative level of education in line with the general population, would strengthen the generalisability of findings. Regardless, the current sample still demonstrated weaknesses in general and social cognitive functioning relative to normative data, thus providing preliminary evidence for such weaknesses in a football sample.

5.4.3 Critical Reflection

One may argue that the researcher's interpretations of the world may have biased the current study in terms of interests, research questions and choice of methodology. The researcher thus acknowledges this through critical reflection and transparency. The researcher did not conduct the current study with any conflict of interest, regarding the subject area. Furthermore, the researcher has been transparent throughout the study with regards to the epistemological position taken. Taking a critical-realist epistemological positioning enabled the researcher to objectively measured constructs, whilst acknowledging the fallibilism of scientific inquiry and the socially constructed nature of concepts. The researcher is conscious of discourses of cognitive functioning being fixed and internalised. Whilst recommendations made for clinical practice are in line with current constructs of diagnosis, the researcher wishes to highlight cognitive functioning as fluid and context dependent. The researcher thus considers the impact of the current COVID-19 pandemic on the study findings below, which includes recommendations for future research.

5.4.4 Contextual Impact of the COVID-19 Pandemic

Due to the current COVID-19 pandemic, adapted remote assessments were necessary. These were completed in line with APA (2020) and DON (2020) guidance, with the researcher following the necessary principles to produce reliable and valid results. This pragmatic solution enabled administration of the neuropsychological test battery via video conference call, which has been shown to yield comparable scores with a number of the measures utilised in the current study (DON, 2020; Harder et al., 2020). The adaptability of the current study to the COVID-19 pandemic was a key strength, as it allowed the research to continue, using objective measures of cognitive functioning. However, this does not address the potential impact on recruitment mentioned previously. While this format may have widened the sample, recruitment was limited to email, online and 'word of mouth' avenues. Assessments were completed via an online platform and during the main videoconferencing call. While appropriate to be completed via this medium, this may have impacted the reliability of results, due to difficultly monitoring participants and limiting distractions remotely.

Difficulties with remote administration were also highlighted by participants when completing the oral Symbol Digit Modality Test (SDMT), remotely. Some participants mentioned 'losing their place', which may have impacted their processing speed. Furthermore, existing normative data for the SDMT has been scrutinised, with Strober et al. (2020) highlighted significant confounding impacts of age, gender, and education. This may have impacted results, with the current sample formed of a majority of highly educated, young adult, male participants. Whilst results are thus interpreted cautiously alongside future recommendations for the widening of inclusion criteria and age-range of participants, recent research in multiple-sclerosis does support the reliability of the remote administration of the oral SDMT (Eilam-Stock et al., 2021).

The potential impact of COVID-19 on participants mental health and neuropsychological performance on tasks, also requires consideration. Recruitment was completed at a time of uncertainty during the COVID-19 pandemic, when participants may have been shielding, isolated, furloughed, made redundant, or experiencing COVID-19 related difficulties or bereavements. Such circumstances would have undoubtedly impact participants wellbeing and functioning. Participants were debriefed and had access to further information regarding both football-related and general wellbeing support, following participation in the study (see Appendix H). Nonetheless, it is recommended that future studies building on the current research, consider taking mood and social context into account.

5.5 Implications

5.5.1 Clinical Practice

Deficits in executive functioning, cognitive processing speed, and memory are now widely acknowledged following cumulative effects of sporting concussions and subconcussive impacts in the NFL (Bailes et al., 2013; Jennings et al., 2015; Omalu et al., 2005, Randolph et al., 2013; Tsushima et al., 2016). The current study extends such findings to the UK footballing population. Weaknesses in verbal memory and social cognition are highlighted and require consideration in the assessment, monitoring and management of footballers, particularly post football-related concussion and with increased engagement in the sport.

Weaknesses highlighted in the current study are often seen in individuals presenting to clinic, following TBI. The quantified cumulative career football-related concussions in the current sample, supports the dose-response relationship seen between mTBI and later life risk of impaired cognitive functioning (Montenigro et al., 2017). Individuals with a football history may therefore present to services with such difficulties. It is therefore recommended that clinicians hold in mind learning and memory deficits, due to football-related behaviours. Indeed, the present study suggests that footballers may also present with social cognitive impairments manifesting as difficulties in social communication and interpersonal difficulties, with an inability to interpret social norms and cues reducing social networks (Fink et al., 2015). Although such preliminary findings cannot infer causality and must be interpreted with caution, precautionary action needs to be taken, particularly as considerable evidence indicates high incidence of dementia in retired footballers (Edgar,2001; Holdenm 2001a, 2001b; Sutton, 1999).

Clinically, memory and social cognition often play a significant role in the presentations and treatment of TBI and neurodegenerative conditions (Christidi et al., 2018; Diehl-Schmid et al., 2007; Gray & Tickle-Degnen, 2010; Gregory et al., 2002; Snowden et al., 2003; Teng et al., 2007; Verdon et al., 2007). When athletes susceptible to TBI present to services, be it clinical psychology or neuropsychology, effects of sporting concussions and football-behaviours should be held in mind. Cognitive deficits, in memory and social cognition should be considered, along with the impact on patient presentation, daily living, relationships, mental health and subsequent QoL (Christidi et al., 2018). Individuals with a history of playing football may demonstrate behaviours that are an unrecognised source of social or interpersonal problems, that often negatively impact patient management (Christidi et al., 2018).

Such deficits may impact how a person engages with healthcare professionals. Footballers may present to psychology with weaknesses in memory that manifest as struggling with between sessions tasks. In addition, interpersonal, and mentalising weaknesses may present and may be attributed to personality or interactional style, when they could be due to deficits in social cognition. It is therefore recommended that when assessing a patient's history, clinicians incorporate questions regarding sport engagement, particularly regarding football-related behaviours. Cognitive assessment may also be necessary for individuals presenting with cognitive weaknesses in memory and social weaknesses in interpersonal interactions, particularly where a history of football is present. When undertaking cognitive assessments, measures of social cognition and sporting history are required to inform the clinician's picture. This would enable early identification, diagnosis, careful monitoring, and management (Elamin et al., 2012), of individuals at risk of developing neurodegenerative conditions and CTE.

5.5.2 Wider Societal Impact

Whilst sporting governing bodies are showing progressive acknowledgement of sporting concussions and the risks associated with subconcussive impacts, it is recommended they take precautionary action in light of the current findings. Sporting bodies play an essential role in the assessment and management of sporting concussions. Whilst neuropsychological tests have become commonplace in the assessment of sporting concussions (Echemendia et al., 2012), a battery of neurocognitive tests is necessary (Goswami et al., 2016; Guskiewicz et al., 2001). Currently, assessments include memory, executive functioning, learning and attention (Feddermann-Demont et al., 2017). The current study suggests a need to incorporate more subtle cognitive measures of verbal memory, and measures of social cognition routinely, when assessing sporting concussions.

The current study also has implications for public health, with football being the world's most popular sport. Increased media attention has surrounded recent high-profile footballer deaths (Barth et al., 2001; BBC News, 2016; BBC Sport, 2020). A need for increased understanding of the long-term impact of football engagement, has thus been highlighted. The current study therefore supports the need for public health policies, alongside sporting legislation, considering the impact of sporting concussions. Footballers and the general population have a right to have access to the necessary psychoeducation, regarding the associated risk of participation and the appropriate recovery care following sporting concussions. This would improve informed consent for individuals who choose to engage in football-related behaviours. Furthermore, better understanding of potential links between football-related behaviours, CTE and the neurodegenerative process, within the field of neuropsychology is required.

5.6 Future Direction

Over the past two decades, the long-term neuropsychological impact of sporting head injuries has received significant interest. Research suggests an associative link between sporting head injuries, cognitive, behavioural, and emotional deficits. Research has previously focused on the NFL and boxing, with football largely neglected by the literature. At the time the study was proposed, limited research had explored the impact of football-related behaviours on cognitive functioning in a UK-based population; and no previous study had explored the potential relationship between football-related behaviours and social cognition. The current study consequently addresses a gap in the literature, suggesting preliminary associations between football-related behaviours, verbal memory, visual attention, and social cognition. This provides rationale for future research and recommendations for the practical management of the footballing population, as detailed below.

5.6.1 Research Recommendations

Were the researcher to conduct the current study again, it would be better to do so outside the context of a pandemic. The current global situation has impacted the study's methodology, sample size and reliability of outcomes. Should the study have been conducted without such an overarching contextual factor, the researcher expects recruitment would have led to a larger sample size, increased reliability of findings (due to the administration of measures), and reduced the impact on the psychological and physical wellbeing of participants. Many recommendations detailed below, are thus made in response to barriers created by the COVID-19 pandemic.

Future research is therefore recommended to replicate the current study, administering the neuropsychological assessment battery face-to-face, as opposed to remotely. Doing so with an older sample who may display a longer history of football-related behaviours, may uncover further effects on cognition more widely, elaborating on and strengthening current findings. Furthermore, as significant weaknesses were revealed for verbal memory, future studies should include additional measures of visuospatial leaming and memory. This would clarify whether this effect is specific to verbal memory or, may be demonstrated in general memory. Such measures were not included in the current study due to an inability to administer measures via an online medium. Recommendations for a more assertive assessment of visuospatial executive functioning include sensitive age-normed measures, such as D-KEFS tower test, or D-KEFS trail making (Delis et al., 2001). Conducting these face-to-face would ensure participants had not seen the task prior to the assessment and would enable appropriate stewarding.

Future studies may also wish to take a longitudinal approach to observe changes overtime, with recommendations for the inclusion of objective measures of football-related behaviours. This was not possible in the current study due to the COVID-19 pandemic and as there remains a lack of technological resources to reliably quantify head-impact exposure (McAllister & McCrea, 2017). Objective measures of football-related behaviours would however limit social-desirability biases and thus strengthen the current findings. Moreover, objective measures would also be useful for the assessment of empathy and perspective taking, with the current study utilising the gold standard test (QCAE), that is reliant on self-report data. Whilst the Director test (Rubio-Fernández, 2017) is available, this objective measure remains in the development phase and is only sensitive at the lowest levels of ability.

5.6.2 Clinical Recommendations

Clinical implications highlighted previously, outline recommendations for clinicians. It is recommended that questions regarding sports engagement, particularly football-related behaviours, are incorporated into routine assessments. Furthermore, cognitive assessments may be necessary for individuals presenting with memory, mentalising or interpersonal weaknesses. Cognitive assessments should include social cognitive measures and sporting history questions, to inform the clinician's picture. This would have the potential to enable early identification of individuals at risk of developing CTE and other neurodegenerative conditions. Furthermore, it is recommended that the field of neuropsychology looks to improve understanding regarding the links between neurodegenerative process and CTE progression. Doing so would enable improved understanding of observed behavioural, social, and emotional changes.

5.6.3 Sporting Recommendations

Recommendations for sporting governing bodies include precautionary action, in line with the current findings. Whilst correlational analyses cannot infer causality, findings suggest that current guidelines regarding on field assessment and return to play, require evaluation. Being the first study to explore football-related behaviours and social cognition, this area has been overlooked both in research and subsequently, in sporting legislation. To improve the prevention, assessment, and monitoring of injuries among footballers, an assertive look at the inclusion of provisional monitoring of both subtle verbal memory and social functioning is required, particularly following sporting concussions. Furthermore, it is recommended that those conducting on-field concussion assessments have necessary understanding and training on the measures used, to assess sporting concussions. As such, neuropsychologists can play a key role in the training of assessors, the educating of governing bodies and athletes (alike, and in the interpreting of collated data following sporting concussions.

5.7 Conclusion

The current study aimed to add to the current limited literature, regarding football-related behaviours and cognitive functioning, with the novel addition of social cognition. To the researcher's knowledge, this is the first study exploring social cognition in footballers. Findings suggests football-related behaviours (specifically quantified and cumulative football-related concussions), are associated with cognitive functioning, specifically verbal memory, and social cognition, in particular ToM, emotion recognition and empathy. While future research is recommended to strengthen current findings, weaknesses in verbal memory and social cognition need to be held in mind where football head-impacts are apparent. Sporting governing bodies have a duty for preventative care, with recommended precautionary adjustments in the assessment, monitoring and management processes of sporting concussions. The inclusion of subtle measures of verbal memory and social cognition are recommended. The field of clinical psychology is further required to incorporate football-related behaviours and sporting concussions history into clinical practice, with cognitive assessments and neuropsychological referrals recommended, where appropriate.

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7. APPENDICES

Appendix A: *Literature Review Search Terms*

Neuropsychology: (DE “Neuro*”)

AND

Football: (“Football” OR “Soccer” NOT “NFL”)

AND

Head-injuries: (“TBI” OR “Concussion”)

AND

Social Cognition: (“Social Cog*”)

Searches were conducted in *Cinahl, Psychinfo, Science Direct* and *Pubmed*. Combined search terms above revealed no publications in this area. As such, a narrative review was conducted using papers systematically identified from the terms above, omitting social cognition.

Appendix B: *SREC Ethics Application*

Approval

School of Psychology Research Ethics Committee

NOTICE OF ETHICS REVIEW DECISION

For research involving human participants
BSc/MSc/MA/Professional Doctorates in Clinical, Counselling and Educational Psychology

REVIEWER: Irina Anderson

SUPERVISOR: **Matthew Jones Chesters**

STUDENT: Fatma Mehmet

Course: Professional Doctorate in Clinical Psychology

Title of proposed study: Social & Cognitive Functioning in UK-based football (soccer) players

DECISION OPTIONS:

1. **APPROVED:** Ethics approval for the above named research study has been granted from the date of approval (see end of this notice) to the date it is submitted for assessment/examination.

2. **APPROVED, BUT MINOR AMENDMENTS ARE REQUIRED BEFORE THE RESEARCH COMMENCES** (see Minor Amendments box below)**:** In this circumstance, re-submission of an ethics application is not required but the student must confirm with their supervisor that all minor amendments have been made before the research commences. Students are to do this by filling in the confirmation box below when all amendments have been attended to and emailing a copy of this decision notice to her/his supervisor for their records. The supervisor will then forward the student's confirmation to the School for its records.

3. **NOT APPROVED, MAJOR AMENDMENTS AND RE-SUBMISSION REQUIRED** (see Major Amendments box below)**:** In this circumstance, a revised ethics application must be submitted and approved before any research takes place. The revised application will be reviewed by the same reviewer. If in doubt, students should ask their supervisor for support in revising their ethics application.

DECISION ON THE ABOVE-NAMED PROPOSED RESEARCH STUDY
(Please indicate the decision according to one of the 3 options above)

Approved

Minor amendments required *(for reviewer)*:

Major amendments required *(for reviewer):*

Confirmation of making the above minor amendments *(for students)*:

I have noted and made all the required minor amendments, as stated above, before starting my research and collecting data.

Student's name *(Typed name to act as signature):*
Student number:
Date:
(Please submit a copy of this decision letter to your supervisor with this box completed, if minor amendments to your ethics application are required)

ASSESSMENT OF RISK TO RESEACHER *(for reviewer)*

Has an adequate risk assessment been offered in the application form?
YES / NO

Please request resubmission with an adequate risk assessment

If the proposed research could expose the researcher to any of kind of emotional, physical or health and safety hazard? Please rate the degree of risk:

☐ HIGH

Please do not approve a high risk application and refer to the Chair of Ethics. Travel to countries/provinces/areas deemed to be high risk should not be permitted and an application not approved on this basis. If unsure please refer to the Chair of Ethics.

☐ MEDIUM (Please approve but with appropriate recommendations)

☐ LOW X

Reviewer comments in relation to researcher risk (if any).

Reviewer *(Typed name to act as signature)*:

Date: IA 25/1/20

This reviewer has assessed the ethics application for the named research study on behalf of the School of Psychology Research Ethics Committee

RESEARCHER PLEASE NOTE:

For the researcher and participants involved in the above named study to be covered by UEL's Insurance, prior ethics approval from the School of Psychology (acting on behalf of the UEL Research Ethics Committee), and confirmation from students where minor amendments were required, must be obtained before any research takes place.

For a copy of UELs Personal Accident & Travel Insurance Policy, please see the Ethics Folder in the Psychology Noticeboard

Application

UNIVERSITY OF EAST LONDON

School of Psychology

APPLICATION FOR RESEARCH ETHICS APPROVAL

FOR RESEARCH INVOLVING HUMAN PARTICIPANTS

(Updated October 2019)

FOR BSc RESEARCH

FOR MSc/MA RESEARCH

FOR PROFESSIONAL DOCTORATE RESEARCH IN CLINICAL, COUNSELLING & EDUCATIONAL PSYCHOLOGY

1. Completing the application

1.1 Before completing this application please familiarise yourself with the British Psychological Society's Code of Ethics and Conduct (2018) and the UEL Code of Practice for Research Ethics (2015-16). Please tick to confirm that you have read and understood these codes: ✓

1.2 Email your supervisor the completed application and all attachments as ONE WORD DOCUMENT. Your supervisor will then look over your application.

1.3 When your application demonstrates sound ethical protocol, your supervisor will submit it for review. It is the responsibility of students to check this has been done.

1.4 Your supervisor will let you know the outcome of your application. Recruitment and data collection must NOT commence until your ethics application has been approved, along with other research ethics approvals that may be necessary (see section 8).

1.5 Please tick to confirm that the following appendices have been completed. Note: templates for these are included at the end of the form.

- The participant invitation letter ✓
- The participant consent form ✓
- The participant debrief letter ✓

1.6 The following attachments should be included if appropriate:

- Risk assessment forms (see section 6)
- A Disclosure and Barring Service (DBS) certificate (see section 7)
- Ethical clearance or permission from an external organisation (see section 8)

- Original and/or pre-existing questionnaire(s) and test(s) you intend to use
- Interview protocol for qualitative studies
- Visual material(s) you intend showing participants.

2. Your details

2.1 Your name: Fatma Mehmet

2.2 Your supervisor's name: Matthew Jones-Chesters

2.3 Title of your programme: Professional Doctorate in Clinical Psychology (DClinPsych)

2.4 UEL assignment submission date (stating both the initial date and the resit date): May 2021 (Resit August 2021)

3. Your research

Please give as much detail as necessary for a reviewer to be able to fully understand the nature and details of your proposed research.

3.1 The title of your study:
Cognitive Functioning in UK-based football (soccer) players, with emphasis on social cognition.

Your research question(s):

- Is there a relationship between football-related behaviours (ball heading) or head injuries and performance on tasks measuring cognitive functioning?
- Is there a relationship between football-related behaviours (ball heading) or head injuries and performance on tasks measuring social cognitive functioning?
- If so, are deficits in task performance reflective of the frequency of exposure to football-related head injuries?

3.2 Design of the research:
The proposed research will utilise a cross-sectional correlational design, allowing exploration of cognitions in a sample of football players at a single time-point. This design has been deemed appropriate, due to the exploratory nature of the study.
The assessment process will include gathering of demographic information including age, ethnicity, education level, mental health and learning disability history. Participants will then be asked about their football-related concussion history.
Participants will then complete a comprehensive battery of neuropsychological tests to assess cognitive functioning. All tests will be administered according to test manuals to support reliability, with an approximated duration of one hour. Short-breaks will be provided to prevent fatigue.

3.3 Participants:
The study aims to recruit male participants ranging from age 18 to 65, who currently or historically played football at a competitive level. Due to constraints in funding and the availability of interpreters, English will be required as a primary language. Participants will have experienced a minimum of one self-reported concussion, sustained while playing football. To reduce the impact of confounding variables, those who have sustained non-football related TBI's, concussions within the last three months, have a current mental health diagnosis or learning disability, misuse of substances or a history of stroke will be excluded from the study.

3.4 Recruitment:

Participants will be recruited through convenience sampling. The researcher has contacted Football Associations and Governing bodies, as well as sport-related head injury charities and football clubs to assess the feasibility of the study. One charity has agreed to advertise the study (see Appendix 4), via the proposed poster seen in appendix 5. Additional conversations pending ethical approval. Subject to the outcome of these conversations, the researcher aims to recruit participants via these avenues, with additional recruitment via social media.

3.5 Measures, materials or equipment:

Following questions regarding demographic information and football-related behaviours, the following battery of neuropsychological tests will be administered as according to the test manuals. These will assess optimal functioning, premorbid functioning, executive functioning and social cognition:

- Premorbid Functioning (Wechsler, 2011)
- Delis-Kaplan Executive Function System: Test of verbal fluency, semantic fluency and verbal switching (Delis, Kaplan, & Kramer, 2001)
- Brixton Spatial Anticipation Test (Burgess & Shallice, 1997)
- Wechsler Adult Intelligence Scale (WAIS-IV) digit span forward, backward and Sequenced (Wechsler, 2010)
- WAIS-IV similarities and matrices (Wechsler, 2010)
- WMS-IV Story Recall: Immediate, Delayed Recognition (Wechsler, 2010)
- WAIS-IV Coding (Wechsler, 2010)
- Social Stories Questionnaire (SSQ) (Kandalaft et al., 2012)
- Affective Naming Test (ANT) (Pearson, 2009)
- Question of Cognitive Affective Empathy (QCAE) (Reniers, Corcoran, Drake, Shryane, & Völlm, 2011)

3.6 Data collection:

Participants will be recruited using convenience sampling. Assessments will take place at the University of East London, with qualitative data regarding participants demographic information (age, ethnicity, education level, mental health and learning disability history) gathered following informed consent. Participants will then be asked about their football-related concussion history.
Participants will then complete the comprehensive battery of neuropsychological tests above. All tests will be administered according to test manuals to support reliability, with an approximated duration of one hour. Short-breaks will be provided to prevent fatigue. Following the assessment, participants will be offered verbal debriefing, with collected data added to secure electronic databases, for data analysis.

3.7 Data analysis:

The study will utilise SPSS to collate and analyse the data. Data will be tested for meeting parametric assumptions, before quantitative analyses are conducted. Descriptive statistics and one-sample tests (i.e. Kolmogorov-Smirnov) will be conducted to compare the research group and age-scaled population norms. Should areas of difference be identified, correlational analysis will be utilised to explore relationships between performance on tasks and variables relating to exposure to football-related head injuries. From the associations revealed in the correlational analyses, multiple regressions will be conducted to investigate relationships between variables while controlling for covariates.

4. Confidentiality and security

It is vital that data are handled carefully, particularly the details about participants. For information in this area, please see the UEL guidance on data protection, and also the UK government guide to data protection regulations.

4.1 Will participants data be gathered anonymously? No

4.2 If not (e.g., in qualitative interviews), what steps will you take to ensure their anonymity in the subsequent steps (e.g., data analysis and dissemination)?

To ensure confidentiality collected data will be anonymised, with each participant assigned an ID number. All identifiable information will be stored in locked cabinets or on encrypted password-protected documents. ID numbers will be entered into electronic databases and SPSS for data analysis, with identifiable information omitted from collected data.

Identifiable data will be destroyed after the study is completed. The anonymised electronic data set will be kept for up to two years post study for publication purposes.

4.3 How will you ensure participants details will be kept confidential?

To ensure participant details are kept confidential, all collected data will be anonymised, with each participant assigned an ID number. All identifiable information will be stored in locked cabinets or on encrypted password-protected documents. ID numbers will then be entered into electronic databases and SPSS for data analysis, with identifiable information omitted.

4.4 How will the data be securely stored?

All identifiable information will be stored in locked cabinets or on encrypted password-protected documents. ID numbers will be entered into electronic databases and SPSS for data analysis, with identifiable information omitted from collected data.

4.5 Who will have access to the data?

The researcher and supervisor will have access to the raw data. Anonymised data utilised in the write up will be accessible to examiners, the wider research team and the general public following anticipated publication.

4.6 How long will data be retained for?

Identifiable data will be destroyed after the study is completed. The anonymised electronic data set will be kept for up to two years post study, for publication purposes.

5. Informing participants

Please confirm that your information letter includes the following details:

5.1 Your research title: ☑

5.2 Your research question: ☑

5.3 The purpose of the research: ☑

5.4 The exact nature of their participation. This includes location, duration, and the tasks etc. involved: ☑

5.5 That participation is strictly voluntary: ☑

5.6 What are the potential risks to taking part: ☑

5.7 What are the potential advantages to taking part: ☑

5.8 Their right to withdraw participation (i.e., to withdraw involvement at any point, no questions asked): ☑

5.9 Their right to withdraw data (usually within a three-week window from the time of their participation): ☑

5.10 How long their data will be retained for: ☑

5.11 How their information will be kept confidential: ☑

5.12 How their data will be securely stored: ☑

5.13 What will happen to the results/analysis: ☑

5.14 Your UEL contact details: ☑

5.15 The UEL contact details of your supervisor: ☑

Please also confirm whether:

Are you engaging in deception? If so, what will participants be told about the nature of the research, and how will you inform them about its real nature.

The proposed research does not include deception and will be transparent in informing participants that the research will be aimed at assessing cognitive functioning in football (soccer) players. Specific measures will not be detailed prior to the study, to avoid confounding variables of pre-study practice. Participants will be debriefed, with findings shared on request.

5.16 Will the data be gathered anonymously? If NO what steps will be taken to ensure confidentiality and protect the identity of participants?

No. To ensure confidentiality of participant's information, collected data will be anonymised, with each participant assigned an ID number. All identifiable information will be stored in locked cabinets or encrypted in password-protected documents. ID numbers will be entered into electronic databases and SPSS for data analysis, with identifiable information omitted from collected data.

Identifiable data will be destroyed after the study is completed. The anonymised electronic data set will be kept for up to two years post study for publication purposes.

5.17 Will participants be paid or reimbursed? If so, this must be in the form of redeemable vouchers, not cash. If yes, why is it necessary and how much will it be worth?

Participants will be entered into a prize draw for one of five £20 Amazon vouchers, to thank them for their time.

6. Risk Assessment

Please note: If you have serious concerns about the safety of a participant, or others, during the course of your research please see your supervisor as soon as possible. If there is any unexpected occurrence while you are collecting your data (e.g. a participant or the researcher injures themselves), please report this to your supervisor as soon as possible.

6.1 Are there any potential physical or psychological risks to participants related to taking part? If so, what are these, and how can they be minimised?

No physical risks to participants are anticipated. The debriefing sheet attached will be provided to participants post study, providing researcher contacts and support organisations contact information.

6.2 Are there any potential physical or psychological risks to you as a researcher? If so, what are these, and how can they be minimised?

No physical risks to the researcher are anticipated in conducting the neuropsychological test battery with participants. Lone worker policies will be endorsed if necessary.

6.3 Have appropriate support services been identified in the debrief letter? If so, what are these, and why are they relevant?

Participants will be verbally debriefed and provided with the debriefing sheet attached. This sheet provides contact information of the researcher and details of appropriate support organisations including Headway, Samaritans, Mind and The PFA. This provides support in all areas linked to the study including head injuries (Headway), Psychological difficulties (Samaritans and Mind) and Football specific support (PFA).

6.4 Does the research take place outside the UEL campus? If so, where? No

If so, a 'general risk assessment form' must be completed. This is included below as appendix 4. Note: if the research is on campus, or is online only, this appendix can be deleted. If a general risk assessment form is required for this research, please tick to confirm that this has been completed: ☐

6.5 Does the research take place outside the UK? If so, where? No

If so, in addition to the 'general risk assessment form', a 'country-specific risk assessment form' must be also completed (available in the Ethics folder in the Psychology Noticeboard), and included as an appendix. If that applies here, please tick to confirm that this has been included: ☐

However, please also note:

- For assistance in completing the risk assessment, please use the AIG Travel Guard website to ascertain risk levels. Click on 'sign in' and then 'register here' using policy # 0015865161. Please also consult the Foreign Office travel advice website for further guidance.
- For *on campus* students, once the ethics application has been approved by a reviewer, all risk assessments for research abroad must then be signed by the Head of School (who may escalate it up to the Vice Chancellor).

- For *distance learning* students conducting research abroad in the country where they currently reside, a risk assessment must be also carried out. To minimise risk, it is recommended that such students only conduct data collection on-line. If the project is deemed low risk, then it is not necessary for the risk assessments to be signed by the Head of School. However, if not deemed low risk, it must be signed by the Head of School (or potentially the Vice Chancellor).
- Undergraduate and M-level students are not explicitly prohibited from conducting research abroad. However, it is discouraged because of the inexperience of the students and the time constraints they have to complete their degree.

7. Disclosure and Barring Service (DBS) certificates

7.1 Does your research involve working with children (aged 16 or under) or vulnerable adults (*see below for definition)?

No

7.2 If so, you will need a current DBS certificate (i.e., not older than six months), and to include this as an appendix. Please tick to confirm that you have included this: ☐

Alternatively, if necessary for reasons of confidentiality, you may email a copy directly to the Chair of the School Research Ethics Committee. Please tick if you have done this instead: ☐

Also alternatively, if you have an Enhanced DBS clearance (one you pay a monthly fee to maintain) then the number of your Enhanced DBS clearance will suffice. Please tick if you have included this instead: ☐

7.3 If participants are under 16, you need 2 separate information letters, consent form, and debrief form (one for the participant, and one for their parent/guardian). Please tick to confirm that you have included these: ☐

7.4 If participants are under 16, their information letters consent form, and debrief form need to be written in age-appropriate language. ☐

Please tick to confirm that you have done this

* You are required to have DBS clearance if your participant group involves (1) children and young people who are 16 years of age or under, and (2) 'vulnerable' people aged 16 and over with psychiatric illnesses, people who receive domestic care, elderly people (particularly those in nursing homes), people in palliative care, and people living in institutions and sheltered accommodation, and people who have been involved in the criminal justice system, for example. Vulnerable people are understood to be persons who are not necessarily able to freely consent to participating in your research, or who may find it difficult to withhold consent. If in doubt about the extent of the vulnerability of your intended participant group, speak to your supervisor. Methods that maximise the understanding and ability of vulnerable people to give consent should be used whenever possible. For more information about ethical research involving children click here.

8. **Other permissions**

9. Is HRA approval (through IRAS) for research involving the NHS required? Note: HRA/IRAS approval is required for research that involves patients or Service Users of the NHS, their relatives or carers as well as those in receipt of services provided under contract to the NHS.

No

If yes, please note:

- You DO NOT need to apply to the School of Psychology for ethical clearance if ethical approval is sought via HRA/IRAS (please see further details here).
- However, the school *strongly discourages* BSc and MSc/MA students from designing research that requires HRA approval for research involving the NHS, as this can be a very demanding and lengthy process.
- If you work for an NHS Trust and plan to recruit colleagues from the Trust, permission from an appropriate manager at the Trust must be sought, and HRA approval will probably be needed (and hence is likewise strongly discouraged). If the manager happens to not require HRA approval, their written letter of approval must be included as an appendix.
- IRAS approval is not required for NHS staff even if they are recruited via the NHS (UEL ethical approval is acceptable). However, an application will still need to be submitted to the HRA in order to obtain R&D approval. This is in addition to a separate approval via the R&D department of the NHS Trust involved in the research.
- IRAS approval is not required for research involving NHS employees when data collection will take place off NHS premises, and when NHS employees are not recruited directly through NHS lines of communication. This means that NHS staff can participate in research without HRA approval when a student recruits via their own social or professional networks or through a professional body like the BPS, for example.

9.1 Will the research involve NHS employees who will not be directly recruited through the NHS, and where data from NHS employees will not be collected on NHS premises?

No

9.2 If you work for an NHS Trust and plan to recruit colleagues from the Trust, will permission from an appropriate member of staff at the Trust be sought, and will HRA be sought, and a copy of this permission (e.g., an email from the Trust) attached to this application?

Not Applicable

9.3 Does the research involve other organisations (e.g. a school, charity, workplace, local authority, care home etc.)? If so, please give their details here.

Yes, a Charity has agreed to help with advertisement of the study once ethically approved, as seen in Appendix 4.

Furthermore, written permission is needed from such organisations if they are helping you with recruitment and/or data collection, if you are collecting data on their premises, or if you are using any material owned by the institution/organisation. If that is the case, please tick here to confirm that you have included this written permission as an appendix:

Please note that even if the organisation has their own ethics committee and review process, a School of Psychology SREC application and approval is still required. Ethics approval from SREC can be gained before approval from another research ethics committee is obtained. However, recruitment and data collection are NOT to commence until your research has been approved by the School and other ethics committee/s as may be necessary.

9. Declarations

Declaration by student: I confirm that I have discussed the ethics and feasibility of this research proposal with my supervisor.

Student's name (typed name acts as a signature): F.Mehmet

Student's number: U1826620 Date: 07.11.19

Supervisor's declaration of support is given upon their electronic submission of the application.

Ethics Application Appendices *(included as separate appendices below)*

Appendix 1: Invitation letter

Appendix 2: Consent form

Appendix 3: Debrief form template

Appendix 4: Feasibility Conversations

Appendix 5: Study Advertisement

Appendix C: *SREC Ethics Minor Amendment*

UNIVERSITY OF EAST LONDON

School of Psychology

REQUEST FOR AMENDMENT TO AN ETHICS APPLICATION

FOR BSc, MSc/MA & TAUGHT PROFESSIONAL DOCTORATE STUDENTS

Please complete this form if you are requesting approval for proposed amendment(s) to an ethics application that has been approved by the School of Psychology.

Note that approval must be given for significant change to research procedure that impacts on ethical protocol. If you are not sure about whether your proposed amendment warrants approval consult your supervisor or contact Dr Tim Lomas (Chair of the School Research Ethics Committee. t.lomas@uel.ac.uk).

HOW TO COMPLETE & SUBMIT THE REQUEST

1. Complete the request form electronically and accurately.
2. Type your name in the 'student's signature' section (page 2).
3. When submitting this request form, ensure that all necessary documents are attached (see below).
4. Using your UEL email address, email the completed request form along with associated documents to: Dr Tim Lomas at t.lomas@uel.ac.uk
5. Your request form will be returned to you via your UEL email address with reviewer's response box completed. This will normally be within five days. Keep a copy of the approval to submit with your project/dissertation/thesis.
6. Recruitment and data collection are **not** to commence until your proposed amendment has been approved.

REQUIRED DOCUMENTS

1. A copy of your previously approved ethics application with proposed amendments(s) added as tracked changes.
2. Copies of updated documents that may relate to your proposed amendment(s). For example an updated recruitment notice, updated participant information letter, updated consent form etc.
3. A copy of the approval of your initial ethics application.

Name of applicant: Fatma Mehmet Programme of study: Professional Doctorate in Clinical Psychology (DClinPsych) Title of research: Cognitive Functioning in UK-based Football (Soccer) Players, with emphasis on Social Cognition. Name of supervisor: Dr Matthew Jones-Chester

Briefly outline the nature of your proposed amendment(s) and associated rationale(s) in the boxes below

Proposed amendment	**Rationale**
Additional recruitment option of: '*In addition to face to face, the study will also offer participants the opportunity to meet via video conferencing software (i.e. MS Teams).*'	Due to the current COVID-19 pandemic, face to face recruitment may not be possible for periods of time during recruitment. The additional option of video conferencing meetings will enable the project to feasibly continue during this time.

Please tick	**YES**	**NO**
Is your supervisor aware of your proposed amendment(s) and agree to them?	✓	

Student's signature (please type your name): F.Mehmet

Date: 01.06.2020

TO BE COMPLETED BY REVIEWER		
Amendment(s) approved	YES	
Comments		

Reviewer: Tim Lomas

Date: 1.6.20

Appendix D: *SREC Ethics Title Change*

University of East London Psychology

REQUEST FOR TITLE CHANGE TO AN ETHICS APPLICATION

FOR BSc, MSc/MA & TAUGHT PROFESSIONAL DOCTORATE STUDENTS

Please complete this form if you are requesting approval for proposed title change to an ethics application that has been approved by the School of Psychology.

By applying for a change of title request you confirm that in doing so the process by which you have collected your data/conducted your research has not changed or deviated from your original ethics approval. If either of these have changed then you are required to complete an Ethics Amendments Form.

HOW TO COMPLETE & SUBMIT THE REQUEST

7. Complete the request form electronically and accurately.
8. Type your name in the 'student's signature' section (page 2).
9. Using your UEL email address, email the completed request form along with associated documents to: Psychology.Ethics@uel.ac.uk
10. Your request form will be returned to you via your UEL email address with reviewer's response box completed. This will normally be within five days. Keep a copy of the approval to submit with your project/dissertation/thesis.

REQUIRED DOCUMENTS

4. A copy of the approval of your initial ethics application.

Name of applicant:	Fatma Saoirse Mehmet
Programme of study:	Professional Doctorate Clinical Psychology (DClinPsych)
Name of supervisor:	Dr Matthew Jones Chesters

Briefly outline the nature of your proposed title change in the boxes below

Proposed amendment	**Rationale**
Old Title: Social & Cognitive Functioning in UK-based football (soccer) players	The title was altered slightly to be more informative and appropriate for the study, however the old title appears on the ethics approval letter.
New Title: Cognitive Functioning in UK-based Football (Soccer) Players, with emphasis on Social Cognition	The new title appears on PhD manager.

Please tick	**YES**	**NO**
Is your supervisor aware of your proposed amendment(s) and agree to them?	Y	
Does your change of title impact the process of how you collected your data/conducted your research?		N

Student's signature (please type your name): F.S.Mehmet

Date: 08/03/2021

TO BE COMPLETED BY REVIEWER		
Title changes approved	Yes	
Comments		

Reviewer: Glen Rooney

Date: 22/03/2021

Appendix E: *Research Integrity Certificate*

CERTIFICATE of ACHIEVEMENT

This is to certify that

FATMA MEHMET

has completed successfully

Research Integrity Modules

3 April 2019

End of course quiz - Social and Behavioural Sciences Grade: 80.00 %

University of East London

Appendix F: *Participant Invitation Letter*

University of East London

PARTICIPANT INVITATION LETTER

You are being invited to participate in a research study. Before you agree it is important you understand what your participation would involve. The purpose of this letter is to provide you with the information you need to consider in deciding whether to participate. Please take time to read the following information.

Who am I?

I am a postgraduate student in the School of Psychology at the University of East London. This research is being conducted as part of my Professional Doctorate in Clinical Psychology and you are being invited to participate.

What is the research?

I am conducting research exploring Cognitive Functioning in UK-based football (soccer) players, with emphasis on social cognition.

Description

Research suggests that involvement in contact sports and sport-related concussion is associated with neuropsychological effects. More research is required to manage and detect concussions in contact-sports, including the potential long-term consequences. This study will investigate questions around the impact of football-related head injuries and whether there is a relationship between this and performance on tasks measuring cognitive and social functioning.

This research has been approved by the School of Psychology Research Ethics Committee. This means that my research follows the standard of research ethics set by the British Psychological Society.

Why have you been asked to participate?

You have been invited to participate as the research requires male active or retired competitive level footballers, aged 18 to 65.

What will your participation involve?

If you agree to participate you will be asked to attend a one-off interview at The University of East London. This one-off interview should take approximately 1 hour, with a break if required. You will be asked to provide some information about your age, education and sports history. You will then be asked to complete a range of psychological tests such as problem solving, memory and concentration. You may withdraw from the study at any time prior to the interview and up to three weeks after you have participated in the study. You will be verbally debriefed at the end of the study and debriefing sheet with further contact details will be provided.

While there will be no payment for your participation, you will be entered into a prize draw for one of five £20 Amazon vouchers, as a token of appreciation for your time. Your participation would be very valuable in helping to develop knowledge and understanding of my research topic.

Your taking part will be safe and confidential

Your privacy and safety will be respected at all times. The information you provide with remain strictly confidential and will be anonymised, using a unique identification number. Write-ups of the research will not contain any of your identifiable information.

What will happen to the information that you provide?

The results of the study are planned to be published, with only anonymised information included. Published anonymised data will be readily accessible to the public. All identifiable information will be kept securely, with hard copies stored in a locked cabinet on site and electronic data encrypted. Identifiable information will be destroyed at the end of the study, with anonymised electronic data kept for up to two years post study, for publication purposes. As information is grouped together individual feedback cannot be provided, however we are able to provide feedback of group results on request.

What if you want to withdraw?

You are free to withdraw from the research study at any time without explanation, disadvantage or consequence. Separately, you may also request to withdraw your data even after you have participated, provided that this request is made within 3 weeks of the data being collected (after which point the data analysis will begin, and withdrawal will not be possible).

Contact Details

If you would like further information or have any questions or concerns, please do not hesitate to contact me:

Principal Investigator: Fatma Mehmet. Email: U1826620@uel.ac.uk

If you have any questions or concerns about how the research has been conducted please contact the research supervisor:

Dr Matthew Jones-Chesters. School of Psychology, University of East London, Water Lane, London E15 4LZ. Email: m.h.jones-chesters@uel.ac.uk

or

Chair of the School of Psychology Research Ethics Sub-committee: Dr Tim Lomas, School of Psychology, University of East London, Water Lane, London E15 4LZ. Email: t.lomas@uel.ac.uk

Appendix G: *Participant Consent Form*

UNIVERSITY OF EAST LONDON

Consent to participate in a research study

Cognitive Functioning in UK-based Football (Soccer) Players, with emphasis on Social cognition.

Please Initial Box

I have read the information sheet and have been given a copy to keep. The nature and purpose of the research have been explained to me, and I have had the opportunity to ask questions about this information.	☐
I understand what is being proposed and the procedures in which I will be involved.	☐
I understand my involvement and the data collected, will remain strictly confidential. Only the researcher(s) involved in the study will have access to identifying data.	☐
I understand what will happen once the research study has been completed.	☐
I understand my right to withdraw from the study at any time without disadvantage or obligation to give reason. I also understand should I withdraw 3 weeks after participation, the researcher reserves the right to use my anonymous data.	☐

I hereby freely and fully consent to participate in the study.

Participant's Name (BLOCK CAPITALS)

……………………………………………………………………………………………

Participant's Signature

……………………………………………………………………………………………

Researcher's Name (BLOCK CAPITALS)

……………………………………………………………………………………………

Researcher's Signature

……………………………………………………………………………………………

Date: ……………………………..

Appendix H: *Participant Debrief Letter*

University of East London

PARTICIPANT DEBRIEF LETTER

Thank you for participating in my research study on Cognitive Functioning in UK-based football (soccer) players, with emphasis on social cognition. This letter offers information that may be relevant in light of you having now taken part.

What will happen to the information that you have provided?

The following steps will be taken to ensure the confidentiality and integrity of the data you have provided.

- Identifiable information will remain strictly confidential, with hard copies stored in a locked cabinet on site and electronic data encrypted.
- Information provided will be anonymised, using a unique identification number.
- Anonymised data will be accessible to the research team including the researcher and supervisor (contact details provided below).
- Anonymised data will be analysed and used in the write up of the research, which will be available to examiners and is planned to be published and readily available to the public.
- Once the study has been completed, identifiable information will be destroyed. Anonymised data will be kept for up to 2 years for publication purposes.
- You may withdraw at any time, without obligation to provide any reason. You have 3 weeks after data collection to request withdrawal of your data.

What if you have been adversely affected by taking part?

It is not anticipated that you will have been adversely affected by taking part in the research, and all reasonable steps have been taken to minimise potential harm. Nevertheless, it is still possible that your participation (or its after-effects) may have been challenging, distressing or uncomfortable in some way. If you have been affected in any of those ways you may find the following services helpful in relation to obtaining information and support:

Headway

Headway is the UK-wide charity that works to improve life after brain injury, providing vital support and information services.

Tel: 0808 800 2244; Email: helpline@headway.org.uk

Samaritans

Samaritans volunteers listen in confidence to anyone in any type of emotional distress, without judgement.

Tel: 116 123 (24 hours a day, 7 days a week); Email: www.samaritans.org

Mind

Mind are a charity who provide information and support on mental health issues.

Tel: 0300 123 3393 (9am to 6pm, Monday to Friday, except for bank holidays).

Email: info@mind.org.uk ; Text: 86463

PFA Members

PFA members (or concerned friends and family) can contact the PFA.

24hr Counselling Helpline: 07500 000 777; **Email:** wellbeing@thepfa.co.uk

Contact Details

If you would like further information about my research or have any questions or concerns, please do not hesitate to contact me:

Fatma Mehmet. E-mail: u1826620@uel.ac.uk

If you have any questions or concerns about how the research has been conducted please contact the research supervisor:

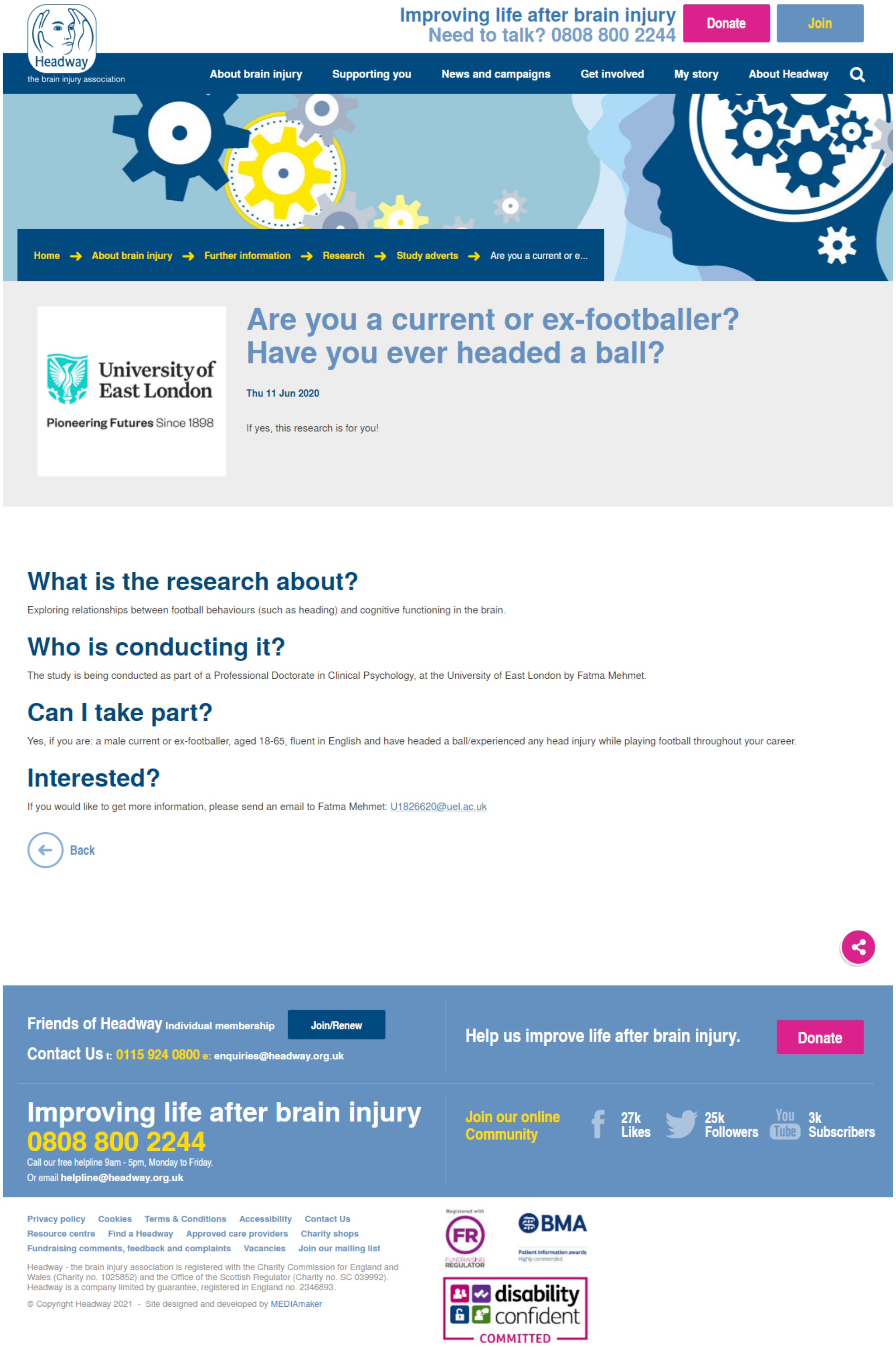
Dr Matthew Jones-Chesters. School of Psychology, University of East London, Water Lane, London E15 4LZ. Email: m.h.jones-chesters@uel.ac.uk

or

Chair of the School of Psychology Research Ethics Sub-committee: Dr Tim Lomas, School of Psychology, University of East London, Water Lane, London, E15 4LZ. Email: t.lomas@uel.ac.uk

Appendix I: *Charity Advertisement*

Available from: https://www.headway.org.uk/about-brain-injury/further-information/research/study-adverts/are-you-a-current-or-ex-footballer-have-you-ever-headed-a-ball/



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the brain injury association

Improving life after brain injury
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University of East London
Pioneering Futures Since 1898

Are you a current or ex-footballer? Have you ever headed a ball?

Thu 11 Jun 2020

If yes, this research is for you!

What is the research about?

Exploring relationships between football behaviours (such as heading) and cognitive functioning in the brain.

Who is conducting it?

The study is being conducted as part of a Professional Doctorate in Clinical Psychology, at the University of East London by Fatma Mehmet.

Can I take part?

Yes, if you are: a male current or ex-footballer, aged 18-65, fluent in English and have headed a ball/experienced any head injury while playing football throughout your career.

Interested?

If you would like to get more information, please send an email to Fatma Mehmet: U1826620@uel.ac.uk

Back

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BMA Patient information awards Highly commended
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Appendix I: *Study Advertisement Poster*

Appendix K: *Mann Whitney U Analysis*

Exploring relationships between football-related behaviours, subsets of cognitive functioning and social cognition

Football-related Behaviours	**Scaled Subsets**	**U**	**z**	**p-value**	***r***
Position	Story recall: Immediate	41.00	-1.36	.174	-.27
	Story recall: Delayed	61.00	-.124	.902	-.02
	Similarities	57.00	-.37	.710	-.07
	Symbol Digit Modality	40.50	-1.39	.166	-.28
	Social Stories Q.	46.50	-1.01	.313	-.20
	ACS Affect Naming	38.00	-1.53	.127	-.31
	QCAE Cognitive	28.00	-2.14	**.033***	-.43
	QCAE Affective	50.50	-.76	.445	-.15
Incidence of Head Contact Per Match	Story recall: Immediate	52.50	-1.13	.260	-.23
	Story recall: Delayed	61.00	-.64	.525	-.13
	Similarities	69.00	-.17	.862	-.03
	Symbol Digit Modality	67.00	-.29	.773	.06
	Social Stories Q.	51.00	-1.20	.230	-.24
	ACS Affect Naming	47.00	-1.43	.154	-.29
	QCAE Cognitive	71.50	-.03	.977	-.01
	QCAE Affective	66.50	-.31	.753	-.06
Experience of Football-related Concussion	Story recall: Immediate	26.00	-2.01	**.044***	-.40
	Story recall: Delayed	39.50	-1.14	.255	-.23
	Similarities	35.00	-1.43	.152	-.29
	Symbol Digit Modality	50.50	-.42	.674	-.08
	Social Stories Q.	24.00	-2.12	**.034***	-.42
	ACS Affect Naming	29.50	-1.76	.078	-.35
	QCAE Cognitive	55.00	-.13	.898	-.03
	QCAE Affective	36.50	-1.32	.188	-.26

Career Football-related Concussions	Story recall: Immediate	38.50	-2.15	**.032***	-.43
	Story recall: Delayed	53.50	-1.31	.189	-.26
	Similarities	57.00	-1.12	.262	-.22
	Symbol Digit Modality	42.50	-1.92	.055	-.38
	Social Stories Q.	52.00	-1.38	.167	-.28
	ACS Affect Naming	70.00	-.39	.699	-.08
	QCAE Cognitive	49.00	-1.55	.122	-.31
	QCAE Affective	62.50	-.80	.423	-.16

** Significant at the 0.01 level (2-Tailed).

* Significant at the 0.05 level (2-Tailed).

Appendix L: *Correlation Matrix*

Correlation Matrix for Football related behaviours, cognitive functioning and social cognition (N = 25).

Scaled Subsets		**Football Hours**	**Years Active Footballer**	**Head contacts**	**Career football concussion**
Story Recall: Immediate	Rho *p*	-.35 .086	.12 .575	-.01 .973	**-.43** **.032***
Story Recall: Delayed	Rho *p*	**-.55** **.005****	-.14 .499	.04 .857	-.28 .179
Similarities	Rho *p*	-.09 .672	-.12 .573	.10 .650	-.18 .386
Symbol Digit Modality	Rho *p*	.10 .648	.13 .532	.13 .546	-.22 .303
Social Stories Q,	Rho *p*	-.12 .579	.05 .808	-.06 .794	-.24 .255
Affect Naming	Rho *p*	-.21 .310	**-.42** **.038***	.31 .138	-.85 .685
QCAE Cognitive	Rho *p*	-.16 .438	.11 .599	-.05 .79	.29 .16
QCAE Affective	Rho *p*	-.35 .089	-.12 .560	.12 .574	-.02 .938

** Significant at the 0.01 level (2-Tailed).

* Significant at the 0.05 level (2-Tailed).