Traumatic Brain Injury and Substance Use Disorder in Aotearoa New Zealand: Characteristics, Correlates, and the Role of Social Cognition in an Inpatient Addictions Treatment Sample

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ABSTRACT

Traumatic Brain Injuries (TBIs) and Substance Use Disorder (SUD) often cooccur, yet the underlying mechanisms linking these conditions remain unclear. One potential explanation is that TBI disrupts neuropsychological functioning, particularly Social Cognition, thereby increasing the risk of SUD. The overall objective of this thesis is to explore these relationships in depth. To achieve this, the first study aimed to gather a detailed history of head-injury characteristics among individuals with SUD in Aotearoa, including TBI with loss of consciousness (LOC). By ascertaining these characteristics, the second study aimed to examine their association with neuropsychological outcomes. Third, our final study aimed to explore the potential role of Social Cognition in explaining the relationship between TBI and SUD.

A total of 77 adults (aged 18-64) engaged in residential treatment for SUD, participated in the current research. During their residential treatment program, participants completed self-report questionnaires to ascertain head-injury, TBI and SUD history, mental health, and TBI-related symptom severity. Of this sample, 70 went on to complete neuropsychological tasks.

Study 1 revealed that one hundred percent of the sample endorsed one or more lifetime head-injury events. 81.8% of the sample had experienced a self-reported TBI featuring LOC, with the remaining 18.2% having a history of a 'possible TBI' where they sustained a head-injury event without LOC. Overall, 91% sustained multiple lifetime head-injuries (either with or without LOC). Compared to the general New Zealand population, this sample featured a higher rate of TBIs of moderate severity, and most events were untreated. Many individuals sustained head-injuries at a young age and sustained repeated injuries into adulthood. Study 2 found that individuals who had a high number of lifetime head-injuries showed significantly lower scores on executive functioning and self-reported experiencing more cognitive difficulties. Study 3 found that within Social Cognition, the interpretation of complex social cues, particularly those involving deception and subtle social intentions, may mediate the relationship between TBI and SUD.

This research contributes to identifying unique rates, patterns, and outcomes of head-injury including TBI among treatment-seeking substance users and highlights factors which may increase individuals' vulnerability. Social Cognition appears to be a mechanism worthy of future exploration as it may explain the relationship between TBI and SUD. Implications of these results for treatment and rehabilitation and directions for future research are discussed.

Acknowledgements

I would first like to thank my God and saviour Jesus for his provision, and the way He works through circumstances and other people to open opportunities and show His love.

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To my Mum and Dad, thank you for your unconditional love and support in so many ways in the process of completing this thesis. To my wonderful friends who kept me sane throughout this long journey (you know who you are). Especially, Lydia and Courtney for sharing your space and your food, for your laughs, adventures, and your prayers.

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PREFACE

This thesis is comprised of four manuscripts as well as thesis chapters. One manuscript has been published, and the remaining three have been prepared for submission to academic journals. The focus is on head injuries and Traumatic Brain Injuries (TBI) which occur in a population in treatment for a variety of Substance Use Disorders (SUD) in New Zealand, and cognition. The manuscripts summarise the current international literature on these topics, detail the methodological processes, and provide a discussion of the findings. The chapters introduce the thesis, provide a general discussion of the thesis findings, and offer reflections on the thesis journey. Manuscripts are presented in a submission format. However, references are presented in a single list at the end of this thesis to maintain flow. Figures and tables are included within each manuscript. Some repetition exists between the manuscripts to ensure each manuscript provided sufficient information to standalone for a publication. Specifically, abbreviations will be restated in each manuscript. Additionally, there will be some repetition and similarity in definitions of TBI and SUD across manuscripts, as well as in the demographic information presented in certain tables. However, some variables have been grouped differently across the manuscripts for statistical purposes and therefore must be described in each.

In total, the thesis is presented in ten chapters. The first presents the background and inspiration for this thesis. Chapter two provides a brief overview and introduction of the rationale for this project. It also introduces the key concepts which are the main focus in this thesis, that will be expanded on in the manuscripts. Chapter three presents a published manuscript of a research proposal for the thesis. Chapter four includes a personal reflection about the planning and data collection phases of the project. Chapters five, six and seven are presented in manuscript form. Chapter eight includes a general discussion and conclusions of the research findings as a whole, as well as implications and directions for future research. Chapter nine is my personal reflections from completing this thesis.

CHAPTER ONE

AUTHOR'S BACKGROUND

Prior to beginning this thesis, I had spent three years working in a residential SUD rehabilitation setting. Staff in this setting conducted brief cognitive screens using the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) to identify whether any general cognitive impairment may be interfering with clients' abilities to engage with treatment. In addition, within the setting of a group therapy programme for SUD, I witnessed patterns of behavioural presentations which a body of literature attributes to impairment in 'Social Cognition'. In the therapeutic environment, this included unhelpful social behaviours such as interrupting often, inappropriate humour, focusing conversation on the self with lack of interest in others or switching the topic suddenly. In other situations, these behaviours themselves may be appropriate and adaptive. However, in the context of group-based SUD treatment, these behaviours could create unhelpful group dynamics, interfering with the goal of the therapy, and were often not appropriate for the situation. Behaviours could also look like fixation and difficulty shifting focus or topics, slow comprehension, bluntness, oversharing or inappropriate comments (McDonald et al., 2003). These behaviours were common to clients in this setting and appeared to create social conflict and pose barriers to remaining in treatment for SUD. For example, off-topic comments by one group member could distract other members from the therapeutic topic at hand, or misinterpretation of others' intentions or message could interfere with creating an open sharing environment. Social Cognition, therefore, may be an important area of cognition to consider in this population. This personal experience sparked an interest and curiosity into how TBI may be impacting behaviours I was seeing, and whether it was an important factor driving impairments within the SUD treatment setting. The research undertaken by this thesis, aimed to explore some of these questions.

When the opportunity arose to complete the Doctor of Clinical Psychology, with support of my supervisors I set up a partnership with The Salvation Army Bridge Programme in Wellington. A research proposal was then formulated and presented to the Massey University Human Ethics Committee, to recruit participants from this SUD treatment setting. The goal of this partnership and research, was to contribute to knowledge and empirical evidence of how services such as The Bridge could further improve their treatment services and promote better outcomes for their clients. In 2021, Ethical approval was obtained from the Massey Human Ethics Committee (SOA 21/28).

CHAPTER TWO

Introduction

SUD is defined as the use of substances that result in maladaptive patterns of behaviour, leading to harmful consequences and significant impairment and distress (Sadock et al., 2015). Approximately 12% of substance users worldwide will become addicted, but recent New Zealand (NZ) estimates suggested 27% of New Zealanders were at moderate to high risk for experiencing SUD (NZIER, 2024; United Nations, 2016). The Diagnostic and Statistical Manual of mental disorders- 5th Edition (DSM-5; American Psychiatric Association) is commonly used to diagnose the presence and severity of a SUD. Criteria for a SUD is met when individuals display a 'problematic pattern of substance use leading to clinically significant impairment or distress', manifested by at least two of a possible 11 criteria (American Psychiatric Association, 2013). This includes 1) using the substance in increasingly larger amounts over a longer period of time than planned, 2) unsuccessful efforts to reduce or control use of the substance, 3) spending significant amounts of time in activities to obtain the substance or recover from its effects, 4) strong craving or urge to use the substance, 5) failure to complete major role obligations in employment, education or home life due to recurrent substance use, 6) continued use despite repeated interpersonal problems resulting from the substance use or exacerbated by it, 7) ceasing meaningful activities because of the substance use, 8) recurrently using the substance in situations where it is physically hazardous, 9) using despite awareness of a physical or psychological issue caused or exaggerated by the substance, 10) tolerance, demonstrated by either; need for increase amounts of the substance to become intoxicated/high or feel the desired effects, or diminished effect with repeated use of the same amount, and or 11) withdrawal as demonstrated by either; the withdrawal syndrome for the specific substance (also outlined in the DSM-5) or taking a closely related substance to relieve the symptoms of withdrawal (e.g., benzodiazepine for alcohol withdrawal) (American Psychiatric Association, 2013). A greater number of symptoms present at one time indicates greater disorder severity with mild SUD being reflected by meeting 2-3 criteria, moderate 4-5 and severe 6+.

Men, individuals of Māori ethnicity, and others who live in socio-economically deprived neighbourhoods have a higher risk of experiencing problems related to their substance use than other demographics in NZ (Ministry of Health, 2020). While tobacco and alcohol use represent the largest proportions of problematic substance use (around 20% and 15% respectively; Ministry of Health, 2020), marijuana, cocaine, hallucinogens, heroin, inhalants, and prescription medication (e.g., opioids such as codeine, or cannabis in countries where this is prescribed for medicinal purposes) are also common substances of abuse (Saddock et al., 2015). While around 50,000 people receive support for problematic substance use yearly in NZ, it is estimated that only one third of individuals who need help; seek or receive it (NZ Drug Foundation, 2020). The estimated 2023 annual social cost of alcohol-related harm in NZ amounted to $9.1 billion (NZIEP, 2024), and the drug-related harms for 2023 are estimated to exceed $19 million (National Drug Intelligence Bureau, 2024). Over 41% of NZ adults reported being impacted by alcohol use of a family member or close friend in a yearly period, and 29% by drug use of another (McFadden et al., 2022). Not only is the wellbeing and quality of life of substance using individuals negatively impacted, but of their families and communities lives as well.

Scientific research has endeavoured to identify factors associated with the development and exacerbation of SUD. Individuals with a SUD are more likely to experience problems with education, employment and finances, problem-solving, parenting, anti-social cognitions, legal issues, family conflict and medical care (Green & Rempel, 2012; Daley, 2013; Underhill et al., 2014; Wenzel et al., 2001). SUD is also associated with increases in psychological disorders (e.g., depression, anxiety or personality disorders), neurotoxic induced cognitive dysfunction, and health problems such as cardiomyopathy, liver disease and hepatitis, (Brenner, et al., 2019; Marel et al., 2019; Ministry of Health, 2020; Neeki et al., 2016; Zhong et al., 2016). Other associated factors include Adverse Childhood Experiences (ACEs; McDonald, 2020), exposure to violence and trauma (Hautala & Sittner, 2021), obesity (Wadekar, 2020), lower family income and emotional support (Hautala & Sittner, 2021), and intellectual disability (ID; Salavert et al., 2018). Continued understanding of contributing factors may assist to reduce the burden and occurrence of SUD, and its related harms and costs to society.

There is evidence that substance use increases the risk for sustaining a TBI (Albrecht et al., 2020). TBI is defined as an alteration in brain function or other evidence of brain pathology caused by an external force to the head or neck (Carroll et al., 2004). The acute impairment may look like confusion, feeling dazed, disorientation or unconsciousness which may be followed by Post-Traumatic Amnesia (PTA; a state of memory loss and prolonged confusion), or other neurological symptoms including seizures or focal signs (e.g., limb weakness, balance and coordination issues, vision or speech disturbance) or intracranial lesions (Gardner & Yaffe, 2015; National Institute of Neurologic Disorders and Stroke, 2023). TBI is a specific type of injury within a broader category of Acquired Brain Injuries (ABI). ABI includes injury to the brain occurring after birth from any mechanism, including but not limited to external force, internal pressure change, poisoning, medical events or tumors (Manning et al., 2021). Mechanisms include hypoxia where cell death is due to extended oxygen deprivation, strokes/transient ischemic attacks where blood clots result in cell death within the brain, other medical events such as hydrocephalus where an increase of fluid builds up within the skull and compresses the brain, or encephalitis; an infection within the brain (Manning et al., 2021). While TBI is considered a form of ABI, TBI specifically is limited to brain injury from an external force (Carroll et al., 2004). Substance use has repeatedly been associated with TBI specifically (Davies et al., 2023). Therefore, TBI will be the focus of this thesis rather than the broad category of ABI.

In TBI, damage can occur from the impact of the brain against the closed skull from events such as a fall, whiplash, or other incident. TBI can also occur after penetration through the skull into the brain (Gennarelli & Graham, 2005). The length, level, and type of impairment depends on where in the brain the trauma was localised and the severity of the injury. TBI severity can be categorised as either mild, moderate, or severe (National Academies of Sciences, Engineering, and Medicine, 2019). A mild TBI (mTBI) would present with a Glasgow Coma Scale score of 13-15 after 30 minutes post-injury or later (Teasdale & Jennett, 1974) with an acute presentation lasting for 30 minutes or less and

PTA duration of less than 24 hours (Barman et al., 2016). A moderate TBI is marked by LOC for between 30 minutes and 24 hours, or an acute Glasgow Coma Scale score of 9-12. Finally, severe TBI would receive an acute Glasgow Coma Scale score below 8, and is characterised by LOC of greater than 24 hours and a PTA duration greater than 7 days (Nakase-Richardson et al., 2011). In the instance of mTBI, it is possible for these presentations to feature an alteration in mental status (e.g., dazed, confused or disoriented) without LOC (Sergeyenko et al., 2025). In cases where LOC has not occurred, medical professionals diagnose a TBI through investigating the mechanism of injury to determine whether sufficient force was applied to cause brain injury, supported by witness accounts (Silverberg et al., 2023). Such injuries must be accompanied by at least one (of a variety) of newly onset symptoms (i.e., headache, nausea, vomiting, dizziness, balance problems, blurred or double vision, light/sound sensitivity, drowsiness, sleep disturbance, memory problems, mental slowness, difficulty concentrating, mood swings, and reporting “brain fog”) which may indicate neurological disturbance, and is not better explained by an alternative confounding factor (Chen et al., 2020; Randolph et al., 2009; Sergeyenko et al., 2025; Silverberg et al., 2023). Questionnaires such as the Rivermead Patient Questionnaire (King et al., 1995), exist to support assessment of TBI-associated symptoms. An additional classification of “suspected mTBI” has recently been proposed by American Congress of Rehabilitation Medicine (Silverberg et al., 2023), for use when a plausible mechanism of TBI cannot be confirmed, despite presence of two or more clinical signs (Sergeyenko et al., 2025). The rationale for this new label is to allow individuals to be treated as if they have sustained a mTBI in order to mitigate risk of false-negative diagnosis, whilst protecting against possible inappropriate conflation of mTBI diagnosis (Sergeyenko et al., 2025; Silverberg et al., 2023).

SUD is associated with increased rates of interpersonal violence, risk taking behaviours, accidental injuries such as collision with objects, motor vehicle crashes, and falls, all of which can cause TBI (Bjork & Grant, 2009; Kolakowsky-Hayner et al., 1999; Macias-Konstantopoulos et al., 2014; McKinlay et al., 2014; Olsen & Corrigan, 2022; Rockett et al., 2005). Such events that are associated with TBI are more likely to occur when individuals are intoxicated (Bjork & Grant, 2009). Compared to the general population, TBI presence has been found at high rates in international SUD treatment samples of up to 31, 40, 72 and 80% respectively (Walker et al., 2007; Felde et al., 2006; Corrigan & Deutschle, 2008; McHugo et al., 2017). In these SUD treatment samples, trends are emerging of TBIs that are more severe and more frequent over the lifetime and are occurring from an early age (Corrigan & Deutschle, 2008; McHugo et al., 2017). Studies reporting rates and characteristics of TBI in SUD samples remain limited internationally with varied TBI rates reported across MHA samples (Davies et al., 2023; West et al., 2011). In the general NZ population, TBI rates are estimated to sit at 790 cases per 100,000 person-years for mild-TBI, and around 41 cases per 100,000 person-years for moderate to severe TBI (Feigin et al., 2013). These rates may be greater than in other high-income countries (Feigin et al., 2013). NZ Māori have been found to be more at risk of TBI and SUD than Pākeha amongst prisoner and general populations (Barnfield & Leatham, 1998; Mitchell et al., 2017; Ministry of Health, 2020; Stats NZ, 2022). However, studies exploring TBI characteristics within SUD samples have not been conducted in NZ to date.

Population based studies commonly use hospital and medical records as a means to identify TBI occurrence (Feigin et al., 2013; Te Ao et al., 2015; Zhong et al., 2025). While this is effective for gathering rates of TBI in large samples, it is limited to occurrences which have been reported to the medical system. Other TBI identification methods used in research include single-item questions which often refer to hospitalisation (Murrey et al., 2007; Felde et al., 2006), or structured self-report questionnaires which enquire for instances of altered consciousness or LOC due to a blow to the head (McHugo et al., 2017; Mitchell et al., 2017). Certain demographic factors may influence whether an individual seeks treatment upon sustaining a brain injury, or not. Socio-economic status or poverty may de-incentivise poorer populations from seeking medical care in order to avoid bills (Ayton et al., 2021; Crozes et al., 2024). This may vary geographically depending on the nation's healthcare policies, reliance on insurance to gain medical aid, or regional fees (Wadhwa et al., 2024). Mistrust of the government or healthcare system may deter certain individuals from seeking medical care (Griffith et al., 2021). Engagement in criminal activity, education, and numerous other factors may also impact the likelihood of individuals to seek medical care (Ayton et al., 2021). These factors are common in samples with SUDs (Baptiste-Roberts & Hossain, 2018; Merrill et al., 2002; Muncan et al., 2020; Pierce et al., 2017). Corrigan et al. (2012) and Pitman et al. (2015) have reported low rates of seeking medical care for a TBI in substance using samples. All these factors can create difficulty for accurately assessing the burden of TBI within SUD populations (Davies et al., 2023).

Like SUD, TBI is costly to society, negatively impacts the wellbeing of individuals and families (Feigin et al., 2013). Recent literature has found negative long-term consequences after even mild TBI which impacts functioning, quality of life and the healthcare burden (Stocchetti & Zanier, 2016; Theadom et al., 2012; van der Naalt et al., 2017). TBI can precipitate cognitive, physical, psychological and social impairment (Barman et al., 2016). This includes impairments in complex attention, executive functions, processing speed, and socio-cognitive functions, as well as reduced life satisfaction, increased mood difficulties, and persistent post-concussion symptoms (i.e., headaches, dizziness, fatigue) (Barker-Collo et al., 2015; McMahon et al., 2014; Theadom et al., 2012). Psychosocial difficulties include disinhibition and impulsivity, labile mood, aggression, irritability, apathy and social deficits (Wilson et al., 2021). These difficulties are often linked to pathology in the frontal lobes and result in trouble with everyday tasks such as following instructions, prioritising, adapting to change, completing or forming plans needed to meet goals and interacting prosocially (Loe et al., 2019). Interestingly, these mechanisms have been proposed as being crucial in the development, maintenance and exacerbation of SUD (Ryan et al., 2021).

Frontal regions which are important for motivation and impulse control also connect to emotion centres and regulate pleasure and reward. These are activated throughout substance addiction (i.e., craving, binging, intoxication and deactivated during withdrawal), and are involved in the overvaluation of substances and under-valuation of healthy alternatives (Goldstein & Volkow, 2002). Damage to these cognitive functions following TBI may exacerbate substance abuse and lower impulse control, making it more difficult for individuals to remain in recovery from the disorder. In support of this, TBI has been implicated as a risk factor for the development of SUD (Olsen & Corrigan, 2022). Childhood TBI has been found to increase the chances of hazardous alcohol, tobacco and cannabis use in later years, as well as increased police involvement and parent-reported conduct problems (Kennedy et al., 2017). In a NZ longitudinal study with a birth cohort, childhood TBI was correlated with risky substance use in adolescence (McKinlay et al., 2014). Individuals who have required treatment for TBI have been found to frequently misuse substances (Olsen & Corrigan, 2022). Thus, TBI and SUD appear to be closely linked.

In attempting to understand the apparently bidirectional relationship between TBI and SUD, a myriad of factors must also be considered. TBI and SUD share a number of risk factors in their aetiologies, which may influence the relationship between the two conditions. These include mental health disorders; antisocial behaviours; and social and environmental factors such as poverty, impaired family functioning, family history of alcohol use disorder (AUD) and family exposure to adverse life events (Max et al., 1998; McKinlay et al., 2010; Vasallo et al., 2007). The main substance to which an individual is addicted may also have a role due to the risk-taking behaviours which more often accompany different substance classes (Hawley et al., 2018; Jacotte-Simancas et al., 2021). Therefore, the relationship between TBI and SUD is complex with many influential factors involved. In order to gain a clearer picture of what connects and perpetuates TBI and SUD, underlying mechanisms that could explain the link between the two must be examined (Olsen & Corrigan, 2022). An "underlying mechanism" refers to an unseen pathway, structure or process which is involved in connecting two variables (Carver, 2001). Cognitive mechanisms are of interest in this case, as cognitive impairment is found more regularly in both SUD and TBI samples compared to healthy controls (Cannella et al., 2019; Hill & Colistra, 2014).

Cognitive impairment in SUD samples is often attributed to the neurotoxic effects of substances on the brain (Koob & Volkow, 2010; Kalechstein et al., 2008; Sofuoglu et al., 2010; Yücell & Lubman, 2007). Toxicity of prolonged substance use on the brain can induce deficits in attention, learning, memory, and most commonly deficits in executive functions including decision making and organisation abilities (Hill & Colistra, 2014; McDonald et al., 2002; Yücell & Lubman, 2007; Verdejo-Garcia et al., 2019). These functions are crucial for forming new behaviour patterns and being responsive to SUD treatment (Bruijnen et al., 2019). Similarly, a wide array of cognitive impairments can follow TBI such as slowed processing speed, memory, attention, concentration, and executive dysfunction (Haarbauer-Krupa et al., 2017). These can depend on severity and location of injury (Cannella et al., 2019; Flynn, 2010; McDonald et al., 2002; Stubbs et al., 2020; Wilson et al., 2020). Such impairment can limit individuals' impulse control and judgement, increasing difficulty with controlling their substance use and consequently maintain patterns of addiction (Bechara & Damasio, 2002). Intact cognitive skills are important for learning and engaging in rehabilitative treatment for SUD (Gargaro & Gerber, 2016; Haarbauer-Krupa et al., 2017). Increasing understanding of specific cognitive mechanisms which are associated with increased SUD severity, and how TBI contributes to these, may provide valuable information for interrupting the cycle of addiction (Hill & Collistra, 2014).

One potential cognitive mechanism, that has been associated with both TBI and SUD separately (Bosco et al., 2018; Quednow, 2020), is Social Cognition. The term 'Social Cognition' encapsulates cognitive functions involved in the recognition, interpretation and output of social behaviours (Quednow, 2020). This includes emotion perception, theory of mind, inference making, and social decision making (McDonald et al., 2003; Rodríguez-Rajo et al., 2022). Impairment in these abilities has been seen in populations with AUD (Onuoha et al., 2016), cocaine use disorder (Bland & Ersche, 2020) and heroin use disorder (Fernandez-Sarrano et al., 2011), as well as in populations who have sustained a TBI (Maggio et al., 2020; McDonald et al., 2003; Theadom et al., 2012). Impairment in Social Cognition can result in misinterpretation of social interactions, altered social decision making, interpersonal difficulties, and can increase experiences of psychological distress (Alvi et al., 2020; Kornreich et al., 2017; Shany-Ur et al., 2012). Impairment in Social Cognition may be involved in the development and maintenance of SUD (Bora & Zorlu, 2017) and may be important to consider as a mechanism in understanding the relationship between SUD and TBI. However, profiles of Social Cognition in the presence of cooccurring SUD and TBI are not well understood.

In summary, while a strong link has been established between SUD and TBI, much of the existing literature has explored SUD in TBI samples rather than exploring TBI in SUD samples (Davies et al., 2023; West, 2011). The possibility exists that variations in TBI rates and characteristics may be due to different SUD features between the samples which remain to be identified. Furthermore, exploration of TBI within SUD samples is geographically limited. NZ SUD samples would benefit from exploration locally due to NZs unique bicultural climate, considering indigenous Māori are overrepresented in both TBI and SUD populations (Barnfield & Leatham, 1998; Mitchell et al., 2017; Ministry of Health, 2020; Stats NZ, 2022). Therefore, the aims of this thesis are to comprehensively explore the rates and characteristics of TBI in a SUD treatment sample in NZ. As well as to identify and describe the SUD features that accompany this sample and identify associations with injury characteristics and demographic factors that may warrant further exploration. This exploration of TBI will include head-injuries which have not involved a LOC but may be a "suspected TBI" (in line with recent classification; Sergeyenko et al., 2025). Thus, the term "head-injury" will be used and discussed throughout the thesis. Furthermore, although a relationship between TBI and SUD has been established, the underlying cognitive mechanisms that link TBI and SUD remain unclear (Olsen & Corrigan, 2022). Both TBI and SUD have been linked separately to impairments in Social Cognition, suggesting that this construct may be a potential mechanism that explains the relationship between these conditions. Therefore, the final aim of this thesis will be to examine profiles of Social Cognition in the presence of both TBI and SUD. Overall, the aim of this thesis is to examine a small number of factors in an in-depth way, within this complex area. Specifically, in depth characteristics of both SUD and head-injuries (including TBI), and cognitive profiles associated with characteristics of the two, specifically relating to Social Cognition. This exploration may aid in reconciling inconsistent findings in the current body of literature.

CHAPTER THREE

The following chapter is presented in the form of a published manuscript. This manuscript contains a research proposal that was published in the journal of New Zealand College of Clinical Psychologists (NZCCP), in November of 2022. This manuscript was submitted for publication whilst the data for this thesis was still being collected. This research proposal is presented as the first manuscript in this thesis, to outline the original plans and intentions of the thesis in a summarised manner and discusses some of the complexities that arise when TBI and SUD cooccur.

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Manuscript 1

Exploratory Study of Traumatic Brain Injury and Social Cognition in Residential Substance Use Disorder Rehabilitation: A Research Proposal

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Substance use disorder (SUD) is defined as the use of substances that result in maladaptive patterns of behaviour, leading to harmful consequences and significant impairment and distress (Sadock et al., 2015). Approximately 12% of substance users worldwide will become addicted, but recent New Zealand estimates suggested 32% of New Zealanders were at moderate to high risk for experiencing SUD (Ministry of Health, 2020; United Nations, 2016). There is evidence that substance use increases the risk for sustaining a traumatic brain injury (TBI) (Albrecht et al., 2020). TBI is defined as an alteration in brain function or other evidence of brain pathology caused by an external force to the head or neck (Carroll et al., 2004). SUD is associated with increased rates of accidental injuries, interpersonal violence and motor vehicle crashes, all of which can cause TBI (Macias-Konstantopoulos et al., 2014).

Furthermore, individuals with TBI frequently misuse substances (McHugo et al., 2017). TBI can precipitate cognitive, physical, psychological and social impairment (Barman et al., 2016). Psychosocial difficulties include disinhibition and impulsivity, labile mood, aggression, irritability, apathy and social deficits (Wilson et al., 2021). These difficulties are often linked to pathology in the frontal lobes and result in trouble with everyday tasks such as following instructions, prioritising, adapting to change, completing or forming plans needed to meet goals and interacting prosocially (Loe et al., 2019). Interestingly, these mechanisms have been proposed as being crucial in the development, maintenance and exacerbation of SUD (Ryan et al., 2021). In support of this, TBI has been shown to be a risk factor for the development of SUD. For example, childhood TBI has been found to increase the chances of hazardous alcohol, tobacco and cannabis use in later years, as well as increased police involvement and parent-reported conduct problems (Kennedy et al., 2017). Therefore, it appears that TBI and SUD are closely linked.

However, the relationship between TBI and SUD is complex. A myriad of factors have been implicated in the aetiology of both TBI and SUD that may mediate or moderate the relationship between the two. Such variables include: mental health disorders; conduct disorder and antisocial behaviours; and social and environmental factors such as poverty, impaired family functioning, family history of alcohol use disorder (AUD) and family exposure to adverse life events (Max et al., 1998; McKinlay et al., 2010; Vasallo et al., 2007). Furthermore, the main substance to which an individual is addicted also has a role in the relationship between SUD and TBI. For example, TBI caused by falls is mostly associated with alcohol use, and TBI from violence is associated with alcohol or heroin use (Jacotte-Simancas et al., 2021). Alternatively, individuals with cannabis use disorder are more likely to sustain TBI from motor vehicle accidents than any other cause (Hawley et al., 2018). However, complicating the matter further, SUD samples have high rates of poly-substance use (Erga et al., 2021) and as a result, isolating the effects of a specific substance on TBI is a challenging endeavour. Finally, the majority of studies investigating comorbid SUD and TBI often anchored to one recent TBI event or the presence or absence of TBI, and did not collect detailed information on earlier TBI history (Kolakowsky-Hayner et al., 1999). Some studies reported limited information about the association between age of TBI and other TBI characteristics and substance-using behaviours (Olsen & Corrigan, 2022). Other studies relied heavily on medical records to determine TBI occurrence (Johnson et al., 2015), which is potentially limiting as this population is less likely to receive medical attention (Corrigan et al., 2012).

Therefore, the relationship between TBI and SUD is complex, and causality is difficult to establish because of the many influential factors potentially involved (Olsen & Corrigan, 2022). To understand the link between TBI and SUD more clearly, Olsen and Corrigan (2022) argued that research in this area must consider the following three principles. First, the incidence, characteristics and age of onset of TBI must clearly be established. Second, underlying mechanisms that could explain the link between TBI and SUD need to be examined. Third, confounding factors that increase risk for both TBI and SUD separately must be considered.

One mechanism that could explain the link between TBI and SUD is Social Cognition, which refers to a range of cognitive functions that process, perceive and interpret social information. This includes abilities of emotion recognition from verbal and nonverbal cues, theory of mind (ToM; the ability to understand that another's thoughts values and beliefs differ from one's own) and social perception, which integrates cues, norms and context to make meaning (McDonald et al., 2003). Social Cognition enables us to understand ourselves, predict the intentions and behaviour of others, modify and improve our social behaviours, and know how to interact appropriately in different social situations (Quednow, 2020). Impairment in Social Cognition is a common consequence of TBI and often results in disinhibited social behaviours, which can reduce the quality of life for patients with TBI and their families (Maggio et al., 2020). Patients with TBI have shown moderate to severe deficits in Social Cognition, which is linked to right frontal lesions, and these individuals may have particular difficulty recognising negative emotions in others (May et al. 2017). TBI-positive individuals have also been found to have lower empathy and lower facial and vocal affections, indicating there is some impairment in processing emotional information (Neumann et al., 2012). Furthermore, patients with TBI have shown inferior Social Cognition performance in comprehending and producing sincere, deceitful and ironic communicative exchanges compared with controls, leading Bosco and colleagues (2018) to consider social skills training to be important in TBI rehabilitation.

Social Cognition impairment comes with increased interpersonal conflict, trouble complying with social norms and trouble using social supports (Shany-Ur et al., 2012). Impairment in Social Cognition also increases the likelihood of experiencing negative emotions and other forms of psychological distress (Alvi et al., 2020). The implications of such social impairment may increase the risk that individuals will turn to substances as a maladaptive means of managing emotional distress (Carrigan & Randall, 2003). Over time and with reinforcement, this could lead to the development of SUD (Bora & Zorlu, 2017). In support of this, findings have emerged illustrating Social Cognition impairments in addictive disorders (Kornreich et al., 2016). Samples with cocaine, opioid and alcohol use disorders have displayed impaired Social Cognition abilities, even after 6 months of abstinence (Bland & Ersche, 2020; Onuoha et al., 2016). These impairments include reduced ability to share the emotions of others, particularly for positive emotions (Carlyle, 2020). This impairment is likely related to the impairment in ability to recognise facial emotional expressions found in individuals with cocaine use disorder (Preller et al., 2014). Similar impairments in emotion recognition have been found in individuals with AUD as well as deficits in ToM (Bora & Zorlu, 2017). In polysubstance users, deficits in cognitive aspects of ToM have been found to persist after six months of abstinence (Fernandez-Sarrano et al., 2011). However, other studies found individuals with AUD had no impairment in ToM abilities, suggesting there may be some other factors involved in Social Cognition impairment in AUD (Amenta et al., 2013).

SUD is associated with increased neurotoxic-induced cognitive dysfunction from prolonged use of substances on the brain (Zhong et al., 2016). It has been hypothesised that this physical impact of substances on the brain may cause impairment in SC, as can happen after TBI (Maggio et al., 2020). Longer duration of AUD has been related to higher severity of Social Cognition impairment, which supports this hypothesis (Bora & Zorlu, 2017). However, Social Cognition impairment has been found in individuals with gambling use disorder, an addictive disorder requiring no heavy or prolonged substance-use (Kornreich, 2017). This suggests that neurotoxic-induced cognitive dysfunction may not be a complete explanation for the presence of Social Cognition impairment in addiction (Bora & Zorlu, 2017). Therefore, it may be that individuals who develop addiction have predisposed vulnerabilities regarding their Social Cognition. Although the direction of the relationship between Social Cognition and SUD remains unclear in the literature, it is possible that pre-existing difficulties with Social Cognition may increase the risk for maladaptive substance use and subsequently lead people to develop SUD (Kornreich, 2017).

In summary, although a clear relationship between TBI and SUD has been established, the underlying mechanisms that link TBI and SUD remain unclear. Therefore, the overall objective of this exploratory study is to examine the relationship between Social Cognition and TBI in SUD. To achieve this, we aim to test Social Cognition performance in a sample of people with SUD and explore the association between Social Cognition performance and history of TBI. In this study, Olsen and Corrigan's (2022) proposed principles will be applied given the complexities of the studied population. First, an in-depth assessment of TBI will be used so that a range of TBI characteristics will be ascertained. We aim to examine the relationship between these TBI characteristics and Social Cognition performance in a sample of people with SUD. When exploring the relationship between TBI and Social Cognition in SUD, we also aim to control for possible confounding variables that may also explain these relationships. We are mindful that all possible confounders cannot be controlled, but will attempt to explore a range of factors. Therefore, given the exploratory nature of this study, we aim to explore the social, demographic and health-related variables that are also associated with Social Cognition in SUD. We will control for these variables in subsequent analyses to examine the relationship between TBI and Social Cognition.

Method

The study will be completed in partnership with the Wellington Salvation Army Bridge Programme. Ethical approval has been obtained from the Massey Human Ethics Committee (SOA 21/28).

Participants

All clients admitted to a residential rehabilitation programme in Wellington between August 2021 and March 2023 will be invited to take part in this study. Participants will be adults aged 18+ years with SUD of any kind.

Measures

A summary of the outcome and predictor variables that will be assessed in this study is presented in Table 1.

Table 1

Summary of the Outcome and Predictor Variables Measured in This Study

Outcome variable	Predictor variables			
	TBI characteristics	**Demographic variables**	**Substance use behaviours**	**Clinical variables**
Social Cognition: • Emotion recognition • Conversational inference making • Theory of mind	• History of TBI • TBI severity • Number of TBI • Age of TBI • Current TBI-related symptoms	• Ethnicity • Gender • Education • Medical history • Family history • Psychiatric history	• Main problem substance • Age of regular problematic substance use	• Current mental health status • Current cognitive status

TBI, traumatic brain injury.

Outcome Variable

Social Cognition. The Awareness of Social Inference Test-Short (TASIT-S) will be used to measure Social Cognition (McDonald et al., 2003). The TASIT-S has three subtests measuring different components of Social Cognition: emotion recognition, conversational inference making and ToM. This comprises a series of 28 short (15–60 second) videotaped scenes where actors interact in everyday social situations. Participants are asked questions after each video to assess their recognition of spontaneous emotions (happy, sad, angry, anxious, surprised, disgust and neutral), comprehension level of social exchanges (sarcastic or sincere) and detection of and ability to distinguish sarcasm from lies. Intended meaning of each exchange is indicated through speaker demeanour (voice and facial expression). Additional contextual cues are given to convey meaning in subtest 3, which are not provided in subtest 2.

Predictor Variables

TBI screening questionnaire. To assess TBI in this population we adapted a screening tool previously used in a NZ prison population (Mitchell et al., 2017). This questionnaire screens for the occurrence of any historical TBI and details related to the event. The screen asks for the total number of lifetime TBIs, allows for reports of up to five separate injuries and covers age of TBI, mechanism of injury, whether or not loss of consciousness occurred as well as any treatment for this injury. If one or more head or neck injuries are reported by a participant, the presence of TBI-related symptoms will be assessed using the Rivermead Post-Concussion Questionnaire (King et al., 1995).

Demographic variables. A demographic questionnaire will be used to collect demographic information for each participant. Variables assessed will include age, ethnicity, highest level of education, medical history, family history (of SUD) and mental health history.

Substance use behaviours. Substance-use behaviours will be explored by asking questions about specific substances used/not used, as well as age of problematic substance use. A range of other substance use behaviours are also assessed (i.e. routes of administration, age of first use of their ‘problem substance’, period of heaviest use, any periods of voluntary abstinence, overdoses and treatment history). However, for this study, the aforementioned variables will be used.

Current mental health status. Participants’ current mental health status will be assessed using the Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 is a 21-item self-report with three subscales that measure depression, anxiety and stress over the previous week. Furthermore, participants will be asked to report any current mental health diagnoses and a screen will be conducted for any experiences of a range of mental health conditions within the last month (e.g. depressive symptoms, anxiety, psychosis whether drug induced or not, trauma symptoms).

Current cognitive status. A broad screening assessment of cognition will be administered using the Neuropsychological Assessment Battery – Screening (S-NAB; Stern, White & Lutz, 2003). The S-NAB provides information regarding cognitive functioning in five main areas: (a) attention, (b) language, (c) memory (assessing immediate and delayed verbal and visual memory), (d) spatial reasoning and (e) executive functioning, as well as an index of overall cognitive functioning. S-NAB scores are corrected for age-group, gender and education level.

Procedure

Upon client's admission to the SUD rehabilitation programme and following their orientation, programme staff will invite clients to participate in this study. All consenting clients will then be referred by staff to the researcher, who will subsequently meet with the participant for the first time at the rehabilitation facility. The researcher will complete the TBI screen, demographic screen and DASS-21, followed by the S-NAB and the TASIT-S across two or three sessions with each participant during their 10-week stay at the programme. Completion of these measures will be staggered with breaks between sessions according to clients' needs to accommodate for individuals' fatigue and concentration abilities. Cognitive testing will occur within 5 days of the participant providing a negative urine drug screen as per programme requirements. If a participant is reported by the facility to score below a 19 in the Montreal Cognitive Assessment (Nasreddine et al., 2005), which is used as a screening tool, that participant will not carry on and complete the S-NAB or TASIT-S to avoid putting them under unnecessarily difficult testing or embarrassment.

Statistical Analysis

Descriptive analyses will be used to characterise the study variables. Because of the exploratory nature of the study, the relationship between the demographic and clinical variables (outlined in Table 1) and Social Cognition will first be undertaken. This is to determine what variables are significantly associated with Social Cognition in our sample and therefore need to be considered in further analyses. To achieve this, Pearson's correlations will be used to examine the relationship between continuous variables (i.e. age, mental health status). Independent sample t-tests and one-way analysis of variance will be used for categorical variables, assuming the assumptions of normality are met (if not, non-parametric analyses will be conducted). Because of the number of comparisons being conducted, Bonferroni correction will be applied to mitigate type 1 errors. Next, regression analysis will be conducted to examine the predictive role of TBI on Social Cognition. A model will be computed for each of the TBI characteristics outlined in Table 1; therefore five regression models will be conducted for each of the three TASIT-S subtests. For each regression analysis, significant demographic and clinical variables identified in the analyses described above will be included as additional predictors. If all of the demographic and clinical variables outlined in Table 1 are significantly associated with Social Cognition, then 10 predictors plus one TBI-related variable will be included in the model.

A power analysis using the G*power software (Faul et al., 2009) estimated that a minimum sample of 123 participants will be needed (assuming a medium effect size (f^2) of 0.15, an alpha of 0.80 and a maximum of 11 predictors). We believe this number is achievable as we plan to collect data over an 18-month period. Over a period of seven months, data from 66 participants have been collected.

Implications of the Proposed Research

Because of differences in substance accessibility across countries, it is important to explore TBI within NZ SUD samples to identify incidence, causes and characteristics specific to the location and culture of NZ. These may differ from international findings and reveal unique cultural factors contributing to comorbid TBI and SUD in indigenous people of NZ. NZ Māori are overrepresented in both the SUD and TBI populations (Feigin et al., 2013). Exploratory research in this area may enable culturally appropriate modification of prevention and rehabilitation efforts and clarify important areas of focus for NZ rehabilitation programmes (Taylor et al., 2010).

Social skills training interventions are available to help improve social behaviours (Dahlberg et al., 2007). Understanding how Social Cognition is associated with comorbid TBI and SUD may raise awareness of the potential importance of such interventions in SUD rehabilitation and lead to incorporation of these interventions in treatment settings. This research may also identify some of the static and dynamic risk factors for impaired Social Cognition, and factors that lead to more severe SUD behaviours, especially cultural factors specific to NZ Māori, which may help inform treatment and prevention initiatives.

For neuropsychologists, this exploratory research on TBI may identify some TBI characteristics that are important to screen in neuropsychological assessments and formulation. Social Cognition training is helpful and important in rehabilitation after TBI (Bosco et al., 2018), and highlighting a possible need for this in SUD rehabilitation in NZ may enable funding and collaboration opportunities for neuropsychologists in and outside the addiction treatment field. Discovering rates of TBI in SUD settings in NZ may also reveal an area of need within addictions treatment that currently exists as a separate service, and pave the way for integrating TBI and SUD rehabilitation.

Summary

During my personal experience working in a SUD rehabilitation setting over a 4-year period, I have seen behavioural presentations common to clients in this setting that are attributed to impairment in Social Cognition in the literature. Such unhelpful social behaviours can include interrupting often, inappropriate humour, focusing conversation on the self with lack of interest in others or switching the topic suddenly. It could also look like fixation and difficulty shifting focus or topics, slow comprehension, bluntness, oversharing or inappropriate comments (McDonald et al., 2003). These appear to create social conflict and pose barriers to remaining in treatment. Social Cognition may therefore be a common area of cognitive impairment in this population and TBI may be an important factor in driving these impairments. The proposed research aims to explore some of these questions.

CHAPTER FOUR

The previous chapters outlined the focus of the thesis, and plans made to achieve these aims. This chapter includes a personal reflection about the planning and data collection processes involved in this thesis. This is to provide an overview of the challenges involved in this research, the ways in which these challenges were overcome, and the change of plans from those outlined in the research proposal, which was included in the previous chapter.

Personal Reflection: The Evolution of the Project

"The only constant in life is change" – Heraclitus

The year of 2021 could be summarised as a year of momentum; from planning of the project and beginning to review the literature, applying and receiving approval from the Massey University Human Ethics Committee, to completing the confirmation event, and beginning data collection (commencing in August 2021). Everything was running along smoothly, and a list of consenting participants was beginning to build up at a quick pace. As the sole researcher collecting the data, I was becoming very busy and a significant amount of the collected data was piling up, waiting to be coded. This sparked the idea of recruiting an undergraduate psychology student as a research assistant (RA) to continue the momentum of the project and manage the time to complete the thesis. At this stage, reaching the goal of over 120 participants was looking promising. Unfortunately, great plans can be made, and ambitions can be had, but a sure constant in life is change.

The second year of this project was not like the first. When 2022 rolled around, data collection continued, and a RA was successfully recruited to assist with collection of the data. In June 2022, the RA was oriented to the Bridge programme, introduced to staff, and began training in data collection processes and methods. Submission of the research proposal to the NZCCP journal was completed a month later. In the latter half of 2022, the Wellington Bridge management team had a complete change of staff. The end of August featured the departure of the staff member who had been regularly offering clients information sheets and inviting them to participate. With the turn-over of new staff learning roles and processes, the intake of clients to the programme slowed down, as well as the invitation of potential participants for the project. With the support of my supervisors, I approached the new management team requesting a meeting and offering to provide them with a briefing of the project. I hoped this would reaffirm the relationship that had been established the previous year. From late August to early December, multiple attempts were made to meet with Bridge management, who conveyed that they were keen to meet, but busy. In this time, data collection was still occurring at a slowed rate. While meeting dates were set a number of times, these were cancelled or rescheduled repeatedly by the service. On December 7th this meeting finally occurred, where the service agreed to continue the relationship and a plan was made to increase the rate of data collection going forward. A week later, the service ceased replying to our emails. With time running out to complete the project, and a continued communication barrier with the service, the decision was made to cease data collection in late December 2022. Data had been collected for 77 participants.

As described in the earlier chapters, the aims of this thesis were to ascertain a range of head-injury and TBI characteristics present in the SUD sample and examine the relationships between these characteristics and SC performance. This aim could still be achieved with a smaller participant sample than originally intended. In addition, this thesis aimed to control for a range of possible confounding variables (social, demographic, and cognitive) that may also explain relationships between TBI, SC and SUD. Due to the smaller overall sample than planned for, there was concern about having sufficient statistical power to control for possible confounding variables in the originally planned analyses. It appeared that the analysis now possible would be a preliminary exploration of whether Social Cognition was an important mechanism underlying the relationship between TBI and SUD. This prompted a re-evaluation of the thesis aims, and an embrace of the change.

When considering that Social Cognition may be an important underlying mechanism involved in the relationship between TBI and SUD, I also wondered what other cognitive mechanisms had been associated with the two conditions. General cognitive impairment after TBI is suspected to be an important factor in maintaining SUD (Corrigan & Deutschle, 2008; Davies et al., 2023; Hill & Collistra, 2014; Walker et al., 2007). Therefore, it seemed fitting to seek a better understanding of how general domains of cognition may influence the relationship in focus. Especially when general cognitive data was being collected to use as a control variable in the original plan. After a review of existing literature in this area, an additional aim was constructed; to explore associations between head-injury and TBI characteristics and general cognitive profiles among individuals with SUD, whilst considering the impact of substance abuse. In addition, to the aims stated in the introduction chapter, this thesis will include an exploration of neuropsychological profiles and cognitive impairment relating to head-injury and TBI in SUD samples.

CHAPTER FIVE

Following the collection of the raw data, this was coded in a variety of ways to fit the research aims presented in each of the manuscripts below. Descriptions of how the data was coded are included within each manuscript. This thesis utilises a variety of statistical analyses which were also chosen based on the aims and data specific to each manuscript. All analyses were conducted on SPSS version 29.0. Statistical methods utilised in this thesis include correlation analysis, chi-square analysis, independent sample t-tests, linear regression, generalized linear mixed models, and the bootstrapping method for mediation analysis. This chapter contains a brief rationale for the selection of certain statistical methods, and the minimum sample size needed.

Measures and Statistical Analyses Rationale

Selection and Operationalisation of Main Measures

Traumatic Brain Injury

Due to the low treatment seeking rates for head-injury which is suspected to occur in SUD populations (Corrigan et al., 2012; Pitman et al., 2015), a self-report head-injury screening tool was selected rather than being limited to medical or hospital records. The rationale for this is to enable this thesis to investigate the impact that cumulative milder injuries may have (Walker et al., 2007), and account for the possibility of low seeking of medical care in the current SUD population. In the context of the overall aims of the thesis, and the limitations of time and resource, it was not realistic for additional data which corroborated self-report information through family reports or medical records, to be collected. Therefore, the use of self-report to identify head-injuries meant that injuries are not clinically confirmed TBI, and head-injuries without LOC are only 'possible TBIs'. The group of injuries described in this thesis will be described as head-injuries (overall), 'possible TBIs' where self-reported head-injuries did not feature LOC, and self-reported TBIs where injuries did feature LOC.

TBI-Associated Symptoms

The Rivermead Patient Questionnaire (King et al., 1995) is included at the end of each head-injury screening tool and was completed with each participant to assess the overall TBI-associated symptoms they still experienced at the time of testing. This tool asks participants to endorse symptoms which onset at the time of a previous head-injury (discussed earlier in the questionnaire), that were still present in the past 30 days. The onset of these symptoms may have been associated with any of the five past head-injury events. In clinical settings this tool is used to ascertain the presence of neurological symptoms relating to a recent head-injury event, as well as assessing the persistence of those symptoms (Chen et al., 2020; Sergeyenko et al., 2025). In the thesis, information from certain items is used as a measure of self-reported cognitive difficulty in the third manuscript only, rather than using the tool how it is utilised in clinical settings. A description of this, as well as psychometrics of the tool can be found in Chapter Seven. This data was not utilised in the remaining manuscripts as it was not the main focus of those manuscripts, and therefore was omitted from those specific methods sections.

Social Cognition

The Awareness of Social Inference Test- Short (TASIT-S) was selected to assess Social Cognition as it has strong ecological validity (McDonald, 2013; Hynes et al., 2011; McDonald et al., 2004), and previous use in both TBI and SUD populations (McDonald et al., 2003; McDonald et al., 2013a; McDonald et al., 2013b). It is strongly correlated with the full TASIT and shows high item reliability (0.89-0.97) (Honan et al., 2016), however is quicker to administer (35-45 minutes) than the full version of the TASIT. The TASIT-S has acceptable psychometric properties (Pinkham et al., 2016). An array of alternative tools exist to measure Social Cognition, however many comprise of photos or scripted scenarios rather than videos (Pinkham et al., 2016). The video-vignettes in the TASIT-S, each come with a context of their own, anchoring the interaction and mannerisms within a specific situation. This provides a test is more similar to real life, and has been rated by strangers and relatives to predict real life social behaviours (McDonald et al., 2004). The TASIT-S has been validated within an Australian population and has show good utility in Western European participants (McDonald et al., 2017), although is yet to be validated in a New Zealand Māori population (Shostack, 2025). The tool has however been reported to have good cross-cultural and transdiagnostic use (Pinkham et al., 2025).

Neuropsychological Assessment Battery-Screening Module (S-NAB)

The S-NAB was chosen as for neuropsychological screening, as it is more comprehensive and sensitive than a very brief screen such as the MoCA which was already being utilised by the rehabilitation programme. A neuropsychological screening battery was sufficient for the focus of the research, and demands less time from participants than a full comprehensive neuropsychological assessment, so not to submit them to unnecessary testing which would be ethically unjustifiable, and may have begun to interfere with participants time in the SUD treatment programme. The S-NAB has shown good utility in both a substance-use population (Cannizzaro et al., 2014) and has been validated in a traumatic brain injury population (Hacker et al., 2020).

Mental Health Distress

Co-occurrence of mental health distress is found at high rates and in various forms, among SUD populations (National Institutes on Drug Abuse, 2020). To sufficiently account for all forms of mental distress in the current thesis, screens would need to be undertaken for personality disorders, mood anxiety and trauma-related disorders, as well as neurobiological disorders (i.e., Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorder). Collecting information on lifetime presence of all possible disorders in validated ways would have required many additional hours of data collection. In the process of obtaining ethical approval for the project from the Massey University Human Ethics Committee, the hours of data collection were examined so not subject participants to unreasonable amounts of testing. Adding additional hours of interviews and screens was not justifiable for the aims and focus of this thesis. Therefore, the Depression Anxiety and Stress Scale (DASS-21) was selected to measure current mental health distress as a control variable, for how current distress may impact performance on the neuropsychological testing. Additionally, a brief self-report screen was used to endorse (through yes/no responses) whether a participant had ever experienced certain forms of distress in their life. This questionnaire was not focused on history of a diagnosis, or meeting criteria of DMS-5 disorder categories, but rather on experiences of distress. However, due to lower number of participants than hoped (see Chapter Four), this data was not utilised in analysis. Using validated structured interviews (e.g., MINI, SCID) to collect information on mental health diagnoses in the context of TBI SUD and Social Cognition would be valuable in future research.

Power Analysis for Linear Regression

A power analysis using the G*power software (Faul et al., 2009) was used to ensure adequate size for the linear regression analyses in the following manuscripts. Assuming a medium effect size

(f^2) of 0.2, an alpha of 0.8, and planning for a maximum of 5 predictors, power analysis suggested a minimum sample of 67 participants.

Linear regression is a popular method used to examine the relationship between continuous variables (Hope, 2020). Multiple predictor variables can be examined, to control for the impacts of potential confounding variables. Linear regression assumes a linear relationship between the predictor and outcome variables and is a beneficial statistical method to use with small samples (Hope, 2020; James et al., 2023). Assumptions for conducting linear regression were met and therefore this statistical method was used in the following manuscripts (Statistics Solutions, 2025).

Generalized Linear Mixed Models

Generalised linear mixed models (GLMM) are used in one of the following manuscripts. Due to the clustering of data, with each participant having potentially up to five data points attributed to them, generalized linear mixed models was selected which does not assume independence of data. This statistical method is appropriate for the current dataset as the outcome variables in this study are categorical rather than continuous, therefore linear regression was not appropriate (Hope, 2020; Salinas Ruíz et al., 2023).

Schools of Thought in Mediation Analysis

Mediation analysis is used in one of the following manuscripts. This manuscript details that a strong theoretical justification exists for exploring the possible role of Social Cognition in mediating the common cooccurrence between TBI and SUD, which has been empirically evidenced (Davies et al., 2023; Kornreich, 2017; Marshall et al., 2022; McHugo et al., 2017; Quednow, 2020; West et al., 2011). Baron and Kenny (1986) recommend three preconditions to run a mediation analysis, in their stepwise approach; a) a significant association between the predictor and outcome variables, b) the predictor variable is significantly associated with the mediator variable, and c) that the mediating variable is significantly associated with the outcome variable, when the predictor variable is controlled for in the equation (investigated through a multiple regression) (Jose, 2013). Using this approach, the effect of X on Y must reduce to demonstrate a significant mediation. The preliminary analysis in the manuscript below met two of three of these preconditions. Preconditions *b* and *c* were met, while precondition *a* was not met. However, there are other existing approaches to conducting mediation analysis.

Another school of thought on mediation analyses argues that use of the bootstrapping method for mediation analysis, can be beneficial to mitigate against type 1 error, due to the resampling rate of 5,000 (Preacher & Hayes, 2008). This method focuses directly on the indirect effect (X > M > Y) to determine whether this is significant, and does not require that a significant association be found between X and Y. This method is useful as suppression effects can mask a significant indirect pathway, and a small or null total effect can still occur when the indirect pathway is meaningful (Precher & Hayes, 2008). Due to the theoretical justification that exists for why TBI may have an effect on SUD through Social Cognition (Davies et al., 2023; Kornreich, 2017; Marshall et al., 2022; McHugo et al., 2017; Quednow, 2020; West et al., 2011), and the benefits of the bootstrapping method which tests the indirect effect directly (Preacher & Hayes, 2008), it was decided to proceed with the mediation analysis. Limitations were discussed, acknowledging that these are preliminary findings which are not causal or directional. The possibly of type 1 error has been noted, and it is recommended that these results be treated with caution and investigated further.

CHAPTER SIX

This chapter is in the form of a manuscript, which is to be submitted to an academic journal. It provides a review of self-reported TBI and head-injury within SUD samples, as well as an exploration of important injury characteristics, and how they are associated with substance using behaviours.

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Hannah Marshall
Name and title of main supervisor:	Associate Professor Ian de Terte
In which chapter is the manuscript/published work?	Chapter 6

Describe the contribution that the student and members of the supervisory team have made to the manuscript/published work:[1]

Student: Literature review, research design, fieldwork/data collection, laboratory work, data analysis, drafting and revising the manuscript

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Manuscript 2

An in-depth examination of Traumatic Brain Injury (TBI) Characteristics in a Sample of Inpatient Substance Use Disorder Treatment Users in Aotearoa New Zealand

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Abstract

The objective of this study was to explore Traumatic Brain Injury (TBI) among individuals engaged in a residential treatment programme for a Substance Use Disorder (SUD) in Aotearoa/New Zealand. Specifically, rates and characteristics of TBI and head-injury were identified, and their relationship with substance use behaviours and demographic variables were examined. The study also aimed to explore the possible implications of substances being involved in the head-injuries.

Seventy-seven adult participants were asked to complete a self-report screening of head-injuries in which they could describe up to five historic injuries. For these injuries the following characteristics were identified: frequency, loss of consciousness (LOC) and duration, age at occurrence, mechanism and treatment. Chi square and generalized linear mixed models were used to examine the association between these characteristics and demographic and substance use behaviours.

One hundred percent (N=77) of participants reported a lifetime history of a head-injury event. Of these, 81.8% (N=63) screened positive for a self-reported TBI which featured a LOC. The remaining 18.2% (N=14) who had not experienced a TBI with LOC, all screened positive for a lifetime history of '*possible TBI*' where a head-injury occurred without LOC. 91% of participants had experienced multiple head-injury events. The sample provided detailed information of 291 events. The characteristics of these injuries revealed that this SUD sample experienced more moderate-severe TBIs than the general population, from a younger age with most TBIs going untreated. Males who used substances multiple times per week in adolescence and did not complete secondary school, were most at risk of more severe and/or recurrent head-injuries. When substances were involved in the event this increased the risk of more severe and accidental head-injuries.

The burden of TBI is substantial in those engaged in residential treatment for a SUD. This study has identified unique rates and patterns of TBI and head-injury, and concerningly the majority of these injuries go untreated. Further research is needed to guide SUD treatment programmes to mitigate the potential impact of TBI within this population.

Key words: traumatic brain injury, substance use disorder, screening, rehabilitation.

Traumatic Brain Injury (TBI) is a major international health problem, causing physical, cognitive, emotional, and behavioural difficulties which can disrupt lives (Te Ao et al., 2014; Brown et al., 2011; Piccolino & Solberg, 2014; Scholten et al., 2015; Theadom et al., 2016). Over 20 million TBIs occur internationally each year (Zhong et al., 2025), and in New Zealand (NZ) the annual incidence of TBI has been estimated at approximately 790 per 100,000 population (Feigin et al., 2013), and an estimated 35,000 New Zealanders sustain TBI annually (Accident Compensation Corporation (ACC), 2023). Research has found a strong bidirectional relationship exists between TBI and substance use (McHugo et al., 2017; Olsen & Corrigan, 2022). Estimates suggest that 36-81% of TBIs occurred whilst an individual was under the influence of a substance (Corrigan, 1995; Kolakowsky-Hayner et al., 1999; Parry-Jones et al., 2006). In addition, TBI can precipitate substance use disorders due to difficulties with impulse control, challenges with adjustment, psychological distress, and/or maladaptive coping (Yue et al., 2020). The majority of TBI literature when it accompanies substance use is gathered from TBI patient samples (West, 2011). There is limited research examining TBI in individuals seeking treatment for a Substance Use Disorder (SUD) (Davies et al., 2023). Such research would provide more accurate information to guide treatment and care provisions for this population.

A recent scoping review by Davies et al. (2023) highlighted the limitations of current research on TBI among mental health and addiction (MHA) service users. Of 28 studies included in the review, the majority consisted primarily of "various psychiatric diagnoses" with only four studies consisting exclusively of participants with a SUD diagnosis. Outside of the review by Davies and colleagues (2023), three additional studies have investigated rates of TBI in individuals with SUD. These seven samples were gathered from a variety of SUD treatment programmes in the USA and one in Sweden. Types of treatment services included a range of inpatient rehab, inpatient detox services, short-term treatment programmes, methadone maintenance, transitional living facilities, outpatient SUD treatment centres, and outpatient community mental health and comorbid SUD programmes (Hillbom & Holm, 1986; Sacks et al., 2009). Rates of TBI found in these US SUD samples ranged from 31.7% to 80% respectively in mixed samples, and 42.3% in US females (Walker et al., 2007;

Felde et al., 2006; Sacks et al., 2009; Corrigan & Deutschle, 2008; McHugo et al., 2017; Murray et al., 2007). The sample in Sweden found TBI rates at 41% in males and 22% in female alcoholics (Hillbom & Holm, 1986). Rates of reporting two or more TBI were found at 11.9% to 30% (Walker et al., 2007; Corrigan & Deutschle, 2008). Sacks et al. (2009) found individuals reported 6-8 injuries on average, with the average age of earliest TBI being 14.5 years. One study reported 25% had sustained at least one moderate to severe TBI, which was defined as sustaining loss of consciousness (LOC) for over 30 minutes (McHugo et al., 2017).

Overall, the research regarding the rates and characteristics of TBI in SUD is currently limited. Certain methodological features limit the inferences that can be drawn when attempting to accurately infer the burden of TBI within SUD. First, existing studies vary in the method used to ascertain TBI. This included an examination of previous medical records (i.e., Hillbom & Holm, 1986); the use of a single item question limited to hospitalisation (i.e., Murrey et al., 2007; Felde et al., 2006) or more extensive self-report questionnaires including blows to the head resulting in being dazed and confused (i.e., McHugo et al., 2017; Sacks et al., 2009). Differences in the estimated rates of TBI within these studies may, in part, be a consequence of these various approaches. Structured self-report questionnaires have been argued to be more accurate for assessing a history of TBI, than single-item questions or solely reviewing past medical history (Davies et al., 2023; Corrigan & Bogner, 2007; Diamond et al., 2007). Relying on medical records or informant reports to identify TBI occurrence is limiting, as instances of mild-TBI are often not reported to the health system or can be overshadowed by other physical injuries (Corrigan et al., 2012; Feigin et al., 2013; Pitman et al., 2015; Theadom et al., 2012). Furthermore, SUD populations are less likely to receive medical attention for TBIs or have their injuries included in medical records than populations who do not abuse substances (Corrigan et al., 2012; Pitman et al., 2015).

When determining the existence of historical TBI in SUD, some studies tend to identify TBI when there has been a loss of consciousness (Walker et al., 2007; Corrigan & Deutschle, 2008; Felde, et al., 2006). Although the provision of loss of consciousness can be a hallmark of TBIs particularly those that are more severe (i.e., severe and moderate TBI) and some mild injuries, it does not capture all TBIs. In fact, it has been estimated that only 10% of mild TBIs cause a loss of consciousness (Silverberg et al., 2015). Recent literature has found long-term negative consequences occurring in individuals after mild TBI, which impacts their functioning, and quality of life (Stocchetti & Zanier, 2016; van der Naalt et al., 2017). Considering that mild TBI is believed to account for 70–90% of all TBIs (Theadom et al., 2012), identifying TBI by only using LOC is likely to under-represent the rate and influence of TBI in SUD.

Existing studies are varied regarding the reporting of SUD characteristics in the sample and the treatment programme participants were engaged in. Differences in SUD related to severity, duration, age at onset, and type(s) of substances an individual is addicted to may impact the relationship between SUD and TBI (Corrigan & Deutschle, 2008; McHugo et al., 2017). Therefore, providing detailed information on this matter is important. For example, TBI caused by falls are associated most with alcohol use, and TBI from violence is associated with alcohol or heroin-use (Jacotte-Simancas et al., 2021). Alternatively, individuals with cannabis-use disorder are more likely to sustain TBI from motor vehicle accidents than any other cause (Hawley et al., 2018). Populations with SUD have high rates of poly-substance use which can further complicate this matter (Erga et al., 2021). The treatment for SUD is broad and varied and consists of many different approaches and settings; from low-support community programmes to residential multidisciplinary intensive treatment programs (Sacks et al., 2009). Broadly speaking, the type of treatment provided is reflective of the severity of the SUD (Cunningham et al., 2018). Furthermore, a more longstanding SUD may bring increased number of opportunities for sustaining TBI through risky behaviours accompanying intoxication (McKinlay et al., 2014). In summary, TBI characteristics may vary according to the different SUD features between samples. Therefore, SUD features should be reported in detail to enable comparison between samples and allow for robust interpretation of results.

Finally, research studies have been relatively restricted geographically with the majority conducted primarily in America with only one study from Sweden identified. A unique bicultural population exists in Aotearoa with indigenous Māori comprising approximately 17% of the population (Stats NZ, 2022). The indigenous cultural history, and the effects of colonisation which has impacted generations, may reveal characteristics of TBI within SUD which are unique to the country. To date, one longitudinal NZ birth cohort has found that childhood TBI was correlated with risky substance use in adolescence (McKinlay et al., 2014). TBI has also been explored in NZ prison populations featuring high rates of illicit substance use (Barnfield & Leatham, 1998). In this sample TBI rates were found to be 86.4%, with 56.7% having sustained multiple TBIs. More recently, 63.7% of a NZ male prison population were found to have a history of TBI, with 20% experiencing their first before age 15 and 32.5% of this population having sustained multiple TBIs (Mitchell et al., 2017). In both prison samples, Māori were more at risk of TBI and reported more substance use than Pākeha inmates. Other studies have highlighted increased TBI risk among ethnic minorities internationally (Burnett et al., 2003; Hyder et al., 2007; Langlois et al., 2005; Hart et al., 2005), including an NZ incidence study which found Māori to be at three to four times greater risk of TBI especially due to assault (Feigin et al., 2013). While increased exposure to interpersonal violence is involved increasing TBI risk for NZ Māori (Martin et al., 1998), the wider reasons explaining this are largely unclear (Feigin et al., 2013). This highlights the importance of local research in Aotearoa. Māori also report more substance use than non-Māori in NZ’s general population (Ministry of Health, 2020). Over-representation of Aotearoa's indigenous people within both TBI and SUD populations, demonstrates the importance of exploring this association in specific geographical regions such as NZ. Further research into this area may aid in identifying culturally specific causes and characteristics of TBI and inform prevention efforts to utilise in NZ’s bicultural climate.

Although current evidence demonstrates that TBI can be prevalent in individuals with SUD, when dissecting this evidence, some conclusions can be inferred. The current evidence base is limited and even more so when considering the appropriateness of the methods used to identify TBI or how TBI was conceptualised. Existing research studies are varied regarding their conceptualisation of SUD and the treatment service in which participants have been recruited. Furthermore, these studies tend to be restricted to specific geographical regions further limiting the ability to generalise current evidence outside of these areas. Consequently, this study will aim to examine TBI within SUD whilst aiming to address some of the limitations noted in the current evidence. Much of the previous literature has evaluated TBI coarsely in large samples. This comes at the expense of collecting in depth information about the TBIs. Thus, the overall objective of this study is to comprehensively assess TBI in a sample of individuals engaged in a residential treatment programme for SUD in Aotearoa New Zealand.

Specifically, this study has three aims. First, we aim to explore the rates and characteristics of TBI, as well as head-injury events that do not feature LOC (i.e., number of historical head-injuries, severity, whether loss of consciousness occurred, mechanism of injury, age of first injury, substance involvement in the event). Second, we aim to explore associations between head-injury characteristics and substance use features (i.e., SUD type, age of substance addiction onset, history of SUD treatment, overdoses). In addition, we will explore associations between head-injuries and demographic variables (i.e., gender, ethnicity, educational attainment) to identify whether specific subgroups of substance users in NZ are more at risk of certain head-injury characteristics. Finally, we aim to explore possible implications of substances being involved in the event. This will be done by examining the relationship between events with and without substance involvement, with other injury characteristics (e.g., loss of consciousness).

Method

The study was completed in partnership with the Wellington Salvation Army Bridge Programme. The project received ethical approval from the Massey Human Ethics Committee (SOA 21/28).

Participants

All clients admitted to a residential rehabilitation programme in Wellington between August 2021 and December 2022 were invited to take part in the study. Participants invited were adults who were 18 years of age or older with a SUD of any kind. Admission to this programme required individuals to be diagnosed with a SUD as consistent with the DSM-5 criteria (American Psychiatric Association, 2013), and be experiencing significant functional impairment and or distress as a result of their substance use. Individuals admitted to the programme were unable to reduce their use or symptoms associated with their SUD by utilising community supports, therefore requiring more intensive treatment. Participation in the research did not impact the treatment the individuals received at the programme.

Measures

Head-injury characteristics: Due to limitations with gathering TBI rates via medical records in previous SUD samples, self-report methods were utilised, which has previously been found to match well with medical records (Mitchell et al., 2017; Schofield et al., 2011). To assess TBI and head-injury rates and characteristics in this population we adapted a self-report screen previously used in a NZ prison population (Mitchell et al., 2017). This questionnaire screens for the occurrence of any historical head-injury and details related to the event, by asking “In your lifetime, have you ever hit your head and been left feeling dazed, confused, or lost consciousness?”. The screen asks for the total number of lifetime head-injuries and allows for reports of up to five separate events. The questionnaire also asks about the individuals age when the injury occurred, mechanism of injury, whether or not LOC occurred and for how long (no LOC, LOC <30 minutes, LOC >30 minutes and <24 hours, and LOC >24 hours), as well as any treatment for each of the five injuries. As these retrospective head-injury events could not be clinically confirmed as a TBI, only the events featuring LOC were operationalised as a self-reported TBI. The remaining head-injury events sustained without any LOC, were considered to be ‘*possible TBIs*’. Severity of TBI was categorised by length of time consciousness was lost (National Academies of Sciences, Engineering and Medicine et al., 2019). Upon endorsement of an event, the participants were asked to describe what happened, and follow up questions were used by the interviewer to understand the involvement of substances in the event.

Demographic and Substance-use Questionnaire: A demographic questionnaire was used to collect demographics for each participant. Variables assessed include age, ethnicity, and highest level of education. A section of this questionnaire was dedicated to exploring information on lifetime substance use; including variety and number of substances addicted to, main problem substance(s), age when problematic substance use began multiple times per week, history of overdose, and a brief AOD treatment history.

Procedure

Upon client's admission to the SUD rehabilitation program and following their orientation, programme staff provided information to clients about this research and invited them to participate. All consenting clients were then referred by staff to the first author, who subsequently met with the participant for the first time at the rehabilitation facility. The first author completed the head-injury screen and demographic and substance-use screen, in one session with each participant during their 10-week stay at the programme. Completion of these questionnaires was staggered with breaks according to clients' needs accommodating for individuals' fatigue and concentration abilities. Sessions occurred in a private interview space at the rehabilitation facility. All participants had been through substance withdrawal before being invited to participate, and a negative drug screen was collected from the programme before participation commenced.

Statistical Analysis

Head-injury characteristics were examined in this cohort in two ways. First, the overall sample was used to ascertain the number of head-injuries experienced by participants'; this was categorised into no history of head-injury, low lifetime head-injury frequency (1-4 injuries) and high lifetime head-injury frequency (5+). This data was coded categorically due to the large spread of data with some participants reporting a very high number of total lifetime head-injuries which could not be verified using the current methods, to control for the impact of outliers. Second, a more comprehensive analysis of head-injury characteristics was completed by examining each of the up to five events described by each participant; herein referred to as the head-injury events sample. These characteristics included loss of consciousness and duration, age at occurrence, mechanism of injury and treatment-seeking behaviours. Mechanism of injury was dichotomised into intentional (i.e., assault) and non-intentional (i.e., hit by a falling pipe in the workplace, fall, motor vehicle accident, sports collision). In accordance with our first aim, descriptive statistics were first used to describe these head-injury characteristics. We then examined the relationship between demographic and substance-use behaviours and head-injury characteristics in accordance with our second aim. To achieve this, Chi-Square analysis was used to determine if any of these variables were significantly associated with the number of lifetime head-injuries using the overall sample. Using the head-injury events sample, generalized linear mixed models was used to analyse the relationship between demographic/substance use behaviour and the following head-injury characteristics: age of head-injury, length of LOC time, intentionality of cause, substance involvement in event and head-injury treatment seeking. In these models, demographics, substance use behaviour and head-injury characteristics were fitted as fixed factors and participants as random factor. For the LOC variable, two groups (LOC between 30 minutes and 24 hours, and LOC >24 hours) were collapsed into one group due to the comparatively small numbers in these two groups. This resulted in three LOC duration groups of no LOC (‘*possible TBI’* only), LOC <30 minutes (mild-TBI), and LOC = 30+ minutes (moderate-severe TBI). Finally, in regards to our third aim Chi-square analysis was conducted using the head-injury events sample to explore the relationship between substance involvement in the head-injuries, and the other characteristics (LOC, intentionality, age of injury, head-injury treatment). All analyses were conducted on SPSS version 29.0.

Results

During the study period, 86 individuals were admitted to the residential treatment programme. 86 individuals were approached and invited to participate. Of these, 83 participants met the eligibility criteria and consented to participate. However, six participants were withdrawn from the study due to exiting the residential programme early. The study consisted of 77 participants aged between 20-64 years old. Participants were more commonly male (68.8%), identified as Māori (46.8%) and NZ European (51.9%) ethnicity, who did not complete secondary school (66.2%). In regard to substance use behaviours, over half of the sample endorsed polysubstance addiction. Amphetamines were the most common substance of addiction, followed by cannabis at half the rate, alcohol, then other substance categories. Just over half of the sample were using their addicted substance multiple times per week during their adolescence (defined as SUD onset). For 45.5% of the sample, this was their first residential AOD treatment programme (see Table 1).

Table 1

Demographic and substance use characteristics (n=77)

Demographics	**N (%)**
Gender	
Male	53 (68.8%)
Female	24 (31.2%)
Ethnicity	
Māori	36 (46.8%)
NZ European	40 (51.9%)
Unknown	1 (1.3%)
Highest Education	
Completed high school or above	26 (33.8%)
Did not complete high school	51 (66.2%)
Substance Use Behaviours	N (%)
Substance Type	
Polysubstance addiction	43 (55.8%)
Mono-substance addiction (alcohol or cannabis)	8 (10.4%)
Mono-substance addiction (Amphetamines)	26 (33.8%)
Distribution of Problem Substances	
Amphetamine addiction	63 (81.8%)
Cannabis addiction	31 (40.3%)
Alcohol Addiction	29 (37.7%)
Sedative, hypnotic or tranquilliser addiction	5 (6.5%)
Opiates	4 (5.2%)
Cocaine, hallucinogens, or synthetics	3 (3.9%)
SUD onset	
10-17	39 (50.6%)
18+	38 (49.4%)

Lifetime Overdoses	
None	59 (76.6%)
Yes	18 (23.1%)
Previous AOD treatment attempts	
0	35 (45.5%)
1+	42 (54.5%)

One hundred percent (N=77) of the sample endorsed a history of at least one lifetime head-injury. 81.8% of the sample (n=63) reported experiencing at least one TBI in their lifetime which featured LOC. The remaining 18.2% of the participant sample (n=14) reported experiencing at least one '*possible TBI'* in their lifetime where they sustained a head-injury without LOC. 31.2% of participants (n=24) had sustained a self-reported TBI categorised as either moderate or severe in their lifetime (26% & 5.2% respectively). Approximately 46% of the participant sample reported a low frequency of lifetime head-injuries (1= 9%, 2 = 12%, 3 = 16%, 4 = 9%) and 54% of the sample reported a high frequency of lifetime head-injuries (5-10 = 29%, 11-19 = 9%, 20+ = 17%). As shown in Table 2, education history and age of frequent problematic substance use (occurring at least three times per week every week) were significantly associated with lifetime frequency of head-injuries. Specifically, participants who did not complete secondary school were significantly more likely to have a high lifetime frequency of head-injuries (40.8%) compared to those who did complete secondary school (14.5%). Furthermore, participants who engaged in problematic substance use as an adolescent were also significantly more likely to have a higher lifetime frequency of head-injuries (36.8%) compared to those who first engaged in problematic substance use in adulthood (18.4%). No other demographic or substance use characteristics were significantly associated with lifetime frequency of head-injuries.

Table 2

Differences between those with a low (1-4) and high (5+) number of lifetime head-injuries according to demographic and substance using variables (n=76)[1]

	1-4 Injuries	5+ Injuries	Chi Square	P Value
		Demographics		
Gender				
Female	37.5% (9)	62.5% (15)	0.74	.195
Male	48.1% (25)	51.9% (27)		
Ethnicity				
Māori	18.7% (14)	26.7% (20)	.20	.327
NZ European	26.3% (20)	29.3% (22)		
Education				
Completed secondary school	19.7% (15)	14.5% (11)	2.68	**.05**
Did not complete secondary school	25.0% (19)	40.8% (31)		
		Substance Use Behaviours		
Substance type				
Mono	21.1% (16)	22.4% (17)	.33	.283
Poly	23.7% (18)	32.9% (25)		
Overdose				
No	35.5% (27)	40.8% (31)	.33	.284
Yes	9.2% (7)	14.5% (11)		
Age of onset of problematic substance use				
10-17	10.5% (8)	36.8% (28)	14.02	**<.001**
18+	34.2% (26)	18.4% (14)		
Previous Treatment				
0	10.5.4% (8)	18.4% (14)	1.11	.287
1+	34.2% (26)	36.8% (28)		

[1]One participant was excluded from this analysis because their ethnicity was unknown.

Detailed information was collected for up to five injuries per participant. Among the 77 participants, detailed reports of 291 injuries were collected to form the head-injury events sample. This included LOC and duration, age at each injury, the mechanism of each injury, whether it was intentional or unintentional, whether substances were involved in the cause, if treatment was sought and what types of treatment they had. As shown in Table 3, the majority of events were experienced during adulthood, although a substantial proportion occurred during adolescence (22.7%) and in childhood (16.5%). Further, 48.5% of events experienced did not involve a loss of consciousness, whereas 49.5% of events did experience LOC (of which, 39.5% featured LOC less than 30 minutes; 8.6% featured LOC greater than 30 minutes and less than 24 hours; 1.4% featured LOC greater than 24 hours). Due to comparatively small numbers in the group with LOC greater than 24 hours, the final two categories were collapsed to make one group of events featuring LOC greater than 30 minutes; 10%). Just over half of the head-injuries were experienced due to a non-intentional cause (i.e. being hit by a falling object at work or in a sports collision), whereas 45.7% were due to an intentional cause (i.e., assault); there was an equal possibility that substances were likely to be involved in the head-injury. Interestingly, treatment was most likely to not be received following a head-injury (63.6%) with only 0.7% of injuries having treatment by a specialist brain injury rehabilitation service.

Table 3

Characteristics of 291 head-injuries for which detailed reports were collected (N=291)

	N (%)
Age at Head-Injury	
12 or less	48 (16.5%)
13-17	66 (22.7%)
18+	177 (60.8%)
Loss of Consciousness	
No	141 (48.5%)
Yes	144 (49.5%)
• <30 minutes	115 (39.5%)
• 30+ minutes	29 (10%)
>30 minutes, <24 hours (moderate self-reported TBI)	25 (8.6%)
>24 hours (severe self-reported TBI)	4 (1.4%)
Unknown	6 (2.1%)
Mechanism	
Intentional	133 (45.7%)
Not-intentional	158 (54.3%)
• Hit with object or collision	65 (22.3%)
• Motor vehicle accident	44 (15.1%)
• Fall	45 (15.5%)
• Other	4 (1.4%)

Treatment sought for head-injury when it occurred	
No	185 (63.6%)
Yes	105 (36.1%)
• Hospital or ambulance	86 (29.6%)
• Primary health provider (GP, Nurse)	17 (5.8%)
• Brain Injury Rehabilitation	2 (0.7%)
Unknown	1 (0.3%)
Substance involvement in head-injury	
No substances involved	145 (49.8%)
Substances likely to have been involved	146 (50.2%)

Generalized linear mixed models was applied to the head-injury events sample to identify whether specific demographics and substance use behaviours were associated with head-injury characteristics (see Table 4) whilst accounting for participant head-injury endorsement within the event sample. In regards to age of injury, in this model, males were significantly more likely than females to experience a head-injury during childhood (OR = 2.50) and adolescence (OR = 2.55) than in adulthood. Participants who identified as Māori ethnicity were significantly less likely than participants who identified as NZ Europeans to experience a head-injury in childhood than in adulthood (OR = 0.47). Participants who began frequently using their problematic substance in their adolescence were significantly more likely to also have a head-injury during their adolescence (OR = 2.39) than in adulthood. In regard to whether substances were involved in the head-injury, in this model, females were significantly more likely to have substance use involved in the event (OR = 3.46), as well as those participants who completed secondary school or above (OR = 1.79), compared to sustaining a head-injury without substance involvement. For loss of consciousness, head-injury treatment, and intentionality of head-injury, no demographic or substance use behaviour reached significance in these models.

Table 4

Independent predictors of generalized linear mixed models of head-injury characteristics (N=291), with predictor and outcome variables as fixed factors, and participants as a random factor.

Age of Head-injury[1]							
12 years of age or less	**B**	**SE**	**t**	**Sig**	***Exp (B)***	**95% C.I.**	
						Lower	**Upper**
Gender[2]	0.92	0.42	2.19	**.029**	2.50	1.10	5.70
Ethnicity[3]	-0.76	0.36	-2.14	**.034**	0.47	0.23	0.94
Education[4]	-0.75	0.34	-0.22	.827	0.93	0.47	1.83
SUD Type[5]	-0.45	0.34	-1.35	.180	0.64	0.33	1.23
SUD Onset[6]	0.34	0.33	1.03	.303	1.40	0.74	2.66
ODs[7]	-0.62	0.40	-1.52	.129	0.54	0.24	1.20
Previous AOD Treatment[8]	-0.19	0.39	0.48	.633	0.83	0.38	1.79
13-17 years of age							
Gender	0.94	0.40	2.33	**.021**	2.55	1.15	5.62
Ethnicity	0.24	0.33	0.73	.466	1.27	0.66	2.44
Education	-0.23	0.35	-0.07	.947	1.00	0.49	1.93
SUD Type	-0.64	0.35	-2.13	.134	0.48	0.32	0.72
SUD Onset	0.87	0.33	2.63	**.009**	2.39	1.25	4.58
ODs	-0.08	0.36	-0.21	.834	0.93	0.45	1.90
Previous AOD Treatment	0.03	0.41	0.07	.941	1.03	0.46	2.31
LOC[9]							
<30 min	**B**	**SE**	**t**	**Sig**	***Exp (B)***	**95% C.I.**	
						Lower	**Upper**
Gender	0.35	0.35	-1.49	.137	0.64	0.35	1.16
Ethnicity	0.37	0.32	1.14	.257	1.44	0.77	2.71
Education	0.10	0.45	0.23	.820	1.11	0.45	2.72
SUD Type	0.47	0.44	1.06	.291	1.60	0.67	3.85
SUD Onset	0.37	0.35	1.06	.290	1.44	0.73	2.85
ODs	-0.13	0.38	-0.34	.731	0.88	0.42	1.84
Previous AOD Treatment	-0.18	0.32	-0.55	.579	0.84	0.45	1.57
30min+							
Gender	0.28	0.50	0.55	.586	1.32	0.49	3.54
Ethnicity	0.31	0.45	0.70	.487	1.36	0.57	3.29

Education	-0.14	0.33	-0.42	.672	0.87	0.45	1.67
SUD Type	0.03	0.31	0.10	.917	1.03	0.55	1.92
SUD Onset	-0.01	0.51	-0.01	.994	0.97	0.37	2.71
ODs	0.30	0.46	0.41	.523	1.34	0.54	3.33
Previous AOD Treatment	0.17	0.57	0.30	.768	1.18	0.39	3.61
Mechanism of Injury[10]							
Gender	0.19	0.34	0.56	.573	1.21	0.62	2.39
Ethnicity	0.43	0.32	1.34	.181	1.54	0.82	2.89
Education	-0.27	0.33	-0.82	.414	0.77	0.40	1.46
SUD Type	0.23	0.31	0.73	.466	1.25	0.68	2.30
SUD Onset	0.02	0.31	0.07	.942	1.02	0.55	1.90
ODs	-0.36	0.37	-0.97	.332	0.70	0.33	1.45
Previous AOD Treatment	-0.17	0.35	-0.49	.624	0.84	0.43	1.67
Substance Involvement[11]							
Gender	-1.24	0.29	4.33	**<.001**	3.46	1.97	6.10
Ethnicity	-0.35	0.27	-1.28	.202	0.71	0.41	1.21
Education	-0.58	0.27	2.14	**.034**	1.79	1.05	3.07
SUD Type	-0.02	2.45	-0.01	.995	0.98	0.01	2.45
SUD Onset	0.04	0.24	0.17	.867	1.04	0.65	1.66
ODs	-0.22	0.29	-0.76	.449	0.80	0.45	1.43
Previous AOD Treatment	-0.23	0.26	-0.89	.381	0.79	0.47	1.33
Head-injury Treatment[12]							
Gender	0.57	0.29	1.95	.053	1.76	0.99	3.13
Ethnicity	-0.20	0.25	-0.79	.433	0.82	0.50	1.34
Education	0.44	0.25	1.72	.086	1.55	0.94	2.56
SUD Type	0.22	0.30	0.75	.454	1.25	0.70	2.23
SUD Onset	0.03	0.30	0.10	.918	1.03	0.57	1.86
ODs	-0.23	0.36	-0.64	.524	0.80	0.40	1.61
Previous AOD Treatment	-0.40	0.33	-1.17	.244	0.68	0.35	1.31

Reference group = [1] Head-injury at 18+, [2] Males, [3] Māori, [4] Did not complete high school, [5] Monosubstance, [6] 10-17, [7] None, [8] None, [9] No LOC, [10] Non-intentional, [11] Unlikely/no, [12] No treatment

Finally, the potential consequences and correlates of substances being involved in the head-injury was explored in the event sample (see Table 5). Unsurprisingly, a head-injury involving substances did not occur in any events which occurred during childhood. However, a head-injury involving substances was significantly more likely to be associated with involving loss of consciousness, and the duration of loss of consciousness was significantly longer than in those who did not have substance involved in the event. A head-injury involving substances was also significantly more likely to be associated with an unintentional cause, whereas a head-injury not involving a substance was more likely to be intentional.

Table 5

Differences between head-injuries with substance use involved, compared to head-injuries without substance use involved, according to head-injury characteristics (N=291)

	Likely	**Unlikely**	**Chi Square**	**P Value**
	Substances Involved in Head-Injury Event			
Consciousness				
No LOC	20.0% (57)	29.5% (84)	10.47	**.005**
LOC < 30 mins	23.2% (66)	17.2% (49)		
LOC 30+ mins	6.7% (19)	3.5% (10)		
Intentional				
No	32.6% (95)	15.5% (45)	33.78	**<.001**
Yes	17.5% (51)	34.4% (100)		
Age of Head-injury				
12 or less	0.0% (0)	16.5% (48)	58.99	**<.001**
13-17	12.4% (36)	10.3% (30)		
18+	37.8% (110)	23% (67)		
Head-injury Treatment				
No	33.3% (97)	30.6% (89)	0.81	.369
Yes	16.8% (49)	19.2% (56)		

Discussion

The overall objective of this study was to conduct an in-depth examination of TBI in a sample of inpatient SUD treatment users in Aotearoa/New Zealand. To achieve this, the first aim of the study was to explore the rates and characteristics of self-reported TBI and head-injuries in this population. The rate of self-reported TBI in our sample (81.8%) was consistent with the highest rate found in a previous study completed in a US treatment programme (McHugo et al., 2017), and exceeded rates found in other SUD samples internationally (31.7% - 80%; Corrigan & Deutschle, 2008; Felde et al., 2006; Walker et al., 2007). The remaining participants (18.2%) who had never experienced a TBI with LOC, all had a history of at least one head-injury event where they reported feeling dazed or confused. Therefore, the rate of mild TBI may be even higher than could be confirmed with the methods utilised in this study. Despite the high rates of self-reported TBI and head-injury, rates of treatment seeking were very low (only 36.1% of head-injury events having contact with a health service). This finding suggests that the occurrence of untreated TBI and head-injury is rife in this population. It highlights the importance that TBIs are identified in SUD treatment settings, and if needed, support is provided to manage and treat any sequelae that may be associated with these injuries (Murray et al., 2007). As TBI-related sequelae are suspected to negatively impact treatment progress, identifying and treating these are important for improving efforts to maintain sobriety and improve quality of life (Bjork & Grant, 2009; Davies et al., 2023; McHugo et al., 2017; Murray et al., 2007; Weil et al., 2018). The results of this study also support the use of self-report methods to identify TBI and head-injuries, instead of relying on broad markers (hospitalisation, contact with the medical system) which likely result in underreporting (Corrigan & Bogner, 2007; Davies et al., 2023; Setnik & Bazarian, 2007). In accordance with the usefulness of self-report measures for the identification of TBI in this population, this method was also used by the study which found similarly high rates of TBI (80%) (McHugo et al., 2017). The high rates of TBI and head-injury in our study may also be explained by the characteristics of our sample. Individuals in our study were all engaged in a residential rehabilitation programme and therefore may reflect a group with severe and longstanding substance addiction. Furthermore, males and Māori were overrepresented in our sample (46.8%, while comprising only 17% of the national population; Stats NZ, 2022), as were individuals with lower educational attainment (66.2% of the sample did not complete secondary school). These are all known risk factors for sustaining TBI and could also account for the high burden of this injury in our study (Barnfield & Leathem, 1998; Feigin et al., 2013; Mitchell et al., 2017; Woolhouse et al., 2018).

Additionally, we conducted an in-depth analysis of 291 head-injuries described by participants. This revealed unique head-injury characteristics that may be evident in SUD populations. Compared to the general population (5%), our sample showed more self-reported TBI events in the moderate-severe category (10%; Feigin et al., 2013), and higher rates of LOC (49.5% vs 10%; Best Practice Advocacy Centre New Zealand, 2022). Our sample also had a higher risk of sustaining a head-injury in adulthood than the general population, despite also having high rates of head-injury occurring in childhood and adolescence, which is a trend seen in the general population (Feigin et al., 2013; Grant & Laskowitz, 2016). Additionally, we found more recurrent lifetime head-injuries (91% of participants) (with a large range and number) at more than double the rate recorded in the general population (0.43-41.92%), and a NZ prison population (32.5%) (Corrigan et al., 2016; Feigin et al., 2013; Lasry et al., 2017; Mitchell et al., 2017; Theadom et al., 2015). Similar trends have been reported in the SUD literature (Corrigan & Deutschle, 2008; McHugo et al., 2017). These results provide confronting information regarding the rates and burden of head-injuries and TBI within SUD. In addition, the finding that only 0.7% of events received treatment from a brain injury rehabilitation, despite 10% of events being classified as a moderate or severe self-reported TBI is extremely concerning and highlights, that within a New Zealand context, there is a significant gap in providing TBI services to those who are likely to need them (Gavett et al., 2011; McAllister, 2011).

The second aim of our study was to explore the association between demographics and substance use behaviours on head-injury characteristics. We identified that using substances multiple times per week in adolescence as opposed to any other age, significantly increased the risk of sustaining a higher number of head-injuries. Furthermore, this risk was also increased for individuals who did not complete secondary school. Adolescence is a critical stage for brain development including impulse control and higher-order cognitive functions promoting prosocial behaviour (McDonald et al., 2013). Regular substance use in adolescence is likely to increase a developmental tendency towards risky behaviours that increases TBI risk. In addition, a lack of engagement in school is likely to increase involvement in activities associated with using substances, as well as those with increased risk of TBI (MacDonald et al., 2003; McAllister, 2011; McKinlay et al., 2014; Olsen & Corrigan, 2022). A bidirectional cycle is also likely to emerge where the cognitive and general TBI effects will impact learning and school completion, increasing the likelihood of disengagement of learning towards greater involvement with peers and activities involving substances and TBI risk. These findings highlight the need for intervention in adolescents who are using substances weekly and at risk of not completing high school, as they are especially vulnerable to sustaining a high number of TBIs. It may be important to educate teachers, parents and youth workers on signs and symptoms of TBI and risky substance use to aid in prevention of such a cycle.

Additionally, as seen in the general population, we found that being male was predictive of earlier head-injuries (Feigin et al., 2013), as was being of NZ European descent. Individuals of Māori descent were significantly less likely (than NZ Europeans) to experience head-injuries in childhood, compared to sustaining head-injuries in adulthood. This was an unexpected finding as there is consistent empirical evidence that Māori are at greater risk of TBI (Barnfield & Leathem, 1998; King et al., 2023; Mitchell et al., 2017; Smith et al., 2017). It may be that our findings are an artifact of a relatively small sample size, a large proportion of events featuring no LOC (48.5%) or categorised as mild TBI (39.5%), with a minority of the detailed reports featuring head-injuries which occurred in childhood (16.4% of all TBIs). These results should therefore be treated cautiously with a need for replication in a larger sample. Consistent with previous findings, we found no effect of demographic or substance-using behaviours on the remaining head-injury characteristics (loss of consciousness, injury mechanism (intentional or not), or head-injury treatment) (McHugo et al., 2017).

Our third aim was to explore the consequences and correlates of substances being involved in the head-injury. Events involving substances constituted 49.8% of the head-injuries examined in the study. This exploration found that head-injuries involving substances were significantly more likely to occur in females, higher educated individuals, and to result in a longer duration of LOC (for more than 30 minutes). We also found that these injuries were more likely to occur from unintentional mechanisms (i.e., MVAs, falls, sports collisions). Importantly though, our findings show that these accidental substance-related events are linked with more severely classified TBIs (either moderate, or severe, rather than mild or a '*possible TBI*'). The remaining head-injuries that did not involve substances, were most likely to occur from intentional mechanisms (largely from assault, which was the most common cause of head-injury; 45.7%). This finding reveals a close association between violence and risk of TBI among SUD service-users. Although this part of the study did not explore the specific nature of the assault pertaining to the event, it is well known that TBI and its effects are endemic in the context of interpersonal violence (Stoddard & Zimmerman, 2011; Hunnicutt et al., 2019). This highlights the importance of wider environmental and cultural factors contributing to TBI by assault in substance users when they are sober (de Souza et al., 2024; McDonald et al., 2013; Mitchell et al., 2017; Olsen & Corrigan, 2022). Our findings illustrate the need to examine TBI, SUD and interpersonal violence within a New Zealand context (Mitchell et al., 2017).

In summary, this New Zealand SUD cohort featured extremely high rates of TBI and head-injury, that are more often recurrent, more often of moderate severity, and most likely to have not received specialist brain injury treatment. In addition, our findings reveal unique patterns of head-injuries amongst people entering SUD services. Individuals who are male, who have not completed secondary school or who began using substances regularly in adolescence, are more likely to have a head-injury at a younger age and/or more frequent head-injuries. The close association between substance use and sustaining self-reported TBI with LOC greater than 30 minutes was also revealed in our study. These findings can help inform clinical practice by ensuring that these individuals who are at heightened risk are appropriately screened for TBI given the impact this could have on their addiction and overall wellbeing. Such screening may identify treatment needs for individuals experiencing residual TBI sequelae, that may otherwise negatively impact their treatment engagement and recovery from substances. Our study illustrates the importance of using self-report methods to ensure that a comprehensive assessment of historical TBIs can be undertaken.

This study was exploratory. While our participant sample was small, we were able to collect a sufficient sized, detailed head-injury events sample (of up to five events per person). Many participants reported more than five lifetime head-injuries (54% approximately). In efforts to avoid remembering traumatic experiences (Seifert, 2012), it is possible that a number of impactful head-injuries relating to more traumatic circumstances may have been omitted from the reports. Alternatively, participants may have been more likely to recall more malicious and intentional events with higher emotionality (van Giezen et al., 2005), meaning a number of milder head-injuries may have been omitted. While self-report methods are useful in TBI identification (Davies et al., 2023), it is still subject to recall issues, and memory is a function compromised by TBI (McAllister, 2011). In this study, we also did not control for the role that comorbid conditions, for example ADHD or PTSD, could have on the relationship between SUD and TBI. Given this population often presents with complex comorbid conditions (Parmar & Kaloiya, 2018; Swendsen & Merikangas, 2000; van Duijvenbode et al., 2015; Wilens et al., 2011), many of which can increase the risk of SUD and/or TBI, future research would benefit from factoring this in when examining the relationship between SUD and TBI. The current participant sample was limited to substance users from rural and urban areas in the central to lower north island region. Additionally, this is a population who have accessed SUD treatment. A subgroup of substance users who do not access SUD treatment may not be represented here. Confidence in the current findings could be increased through additional research in larger samples, from wider NZ regions, and supplementing self-report information with additional information sources such as family members or medical records to confirm self-reports of historic TBIs. Further, the results of this study were not compared with a healthy control sample and this would be a worthy avenue for future research. Although our study revealed the rates and characteristics of self-reported TBI and head-injury in SUD in NZ, its implications and effects within this context still need to be investigated. Future research would benefit from examining the impact of the head-injury characteristics identified in this study on various indices of health and wellbeing (i.e. cognition, substance use behaviours and mental health).

In conclusion, we identified unique rates and patterns of TBI in an Aotearoa/NZ SUD population which differ from the general public and substantiate other SUD specific findings (Corrigan & Deutschle, 2008; McHugo et al., 2017). With the majority of head-injuries going untreated, many individuals may be entering SUD treatment services with remaining TBI associated complications after moderate, severe, or repeated TBI. Further empirical research in this area is needed to guide SUD treatment programmes to best aid their service users toward recovery and reduce the harms of TBI within this population.

CHAPTER SEVEN

The preceding chapters presented the justification for exploring characteristics and rates of TBI and head-injury within a SUD population in Aotearoa New Zealand. This chapter is in the form of a manuscript, which will be submitted to an academic journal for publication. It explores the impacts of head-injury characteristics on a variety of measures of cognition. This is done whilst controlling for substance use factors. This chapter outlines the current literature on cognitive dysfunction in the presence of cooccurring TBI and SUD.

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Manuscript 3

Associations between Traumatic Brain Injury (TBI) Characteristics and Cognitive Outcomes in a Substance Use Disorder Treatment Population in Aotearoa New Zealand

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Abstract

The objective of this study was to explore associations between characteristics of head-injuries (including Traumatic Brain Injuries; TBI) and cognitive outcomes among individuals engaged in residential treatment for Substance Use Disorders (SUDs). The study also aimed to control for demographic, substance use and mental health factors.

Seventy adult participants completed a self-report head-injury screen, which collected a detailed head-injury history and duration of loss of consciousness (LOC), to identify self-reported TBI. Head-injury characteristics of age, frequency, severity, and contact with health services were identified. Task-based cognitive measures of attention, memory, language, visuospatial functioning, executive functioning and general cognition were then assessed using the Neuropsychological Assessment Battery- Screening Module (S-NAB). Additionally, self-reported cognitive difficulties, were examined using the Rivermead Patient Questionnaire (RPQ). T-tests, correlation analysis, and linear regression were used to identify relevant demographic, substance use and mental health confounders, before examining associations between head-injury characteristics and cognitive outcomes.

Individuals who had sustained a high number of lifetime head-injuries showed significantly lower scores on executive function, and reported experiencing significantly more cognitive difficulties. No other head-injury characteristics were associated with cognitive outcomes. Approximately 65% of the sample scored within average range for overall general cognition, likely reflective of the high proportion of mild TBI and head-injury without LOC in the sample.

Substance Use Disorder treatment users with a history of multiple head-injuries, may be especially vulnerable to persistent cognitive difficulties, especially executive dysfunction, which may disadvantage their recovery. Further research examining how head-injury characteristics impact other measures of cognition are needed.

Key words: traumatic brain injury, head-injury, substance use disorder, cognitive difficulty, rehabilitation.

Substance Use Disorder (SUD) involves excessive use of alcohol and other illicit drugs that leads to functional, social, and occupational impairment (Sadock et al., 2015). SUD is characterised by abuse, intoxication, physical and psychological dependence. Cognitive impairments are found more often in substance users compared to healthy controls (Hill & Colistra, 2014; Cannizzaro et al., 2014). This is attributed to the negative effects of substances on the brain causing neurotoxic effects and impairing cognition (Koob & Volkow, 2010; Kalechstein et al., 2008; Sofuoglu et al., 2010; Yücell & Lubman, 2007). The impairments vary depending on the substance of abuse (i.e., stimulants, depressants, and sedatives act differently on a variety of neurotransmitters and neural networks (Hayes et al., 2020; Substance Abuse and Mental Health Services Administration et al., 2016). Changes to cognition may also vary according to individuals' use amounts, frequency and durations, and subsequently require differing interventions to target specific cognitive and functional weaknesses (Lisdahl et al., 2018; Ramey & Regier, 2019). After prolonged and repeated substance use, people may have difficulties with attention, learning, memory, decision making, and organisation abilities (Hill & Colistra, 2014; McDonald et al., 2002; Yücell & Lubman, 2007; Verdejo-Garcia et al., 2019). These are domains of *cognition*, which can be defined as the mental states and processes involved in thinking, perceiving, acquiring knowledge and understanding, including both conscious and unconscious processes (Encyclopaedia Britannica, 2025). While cognition is not limited to the aforementioned domains, the domains named above are crucial functions for being responsive to treatment and forming new behaviour patterns in recovery (Bruijnen et al., 2019). Cognition is important to understand and consider in the context of SUD rehabilitation (Hill & Colistra, 2014).

Traumatic Brain Injury (TBI) also commonly cooccurs with SUD (Olsen & Corrigan, 2022; McHugo et al., 2017). TBI occurs when external force to the head or neck causes an alteration in brain function (Carroll et al., 2014). This can occur to various severities and be followed by several short and long-term complications (Te Ao et al., 2014). In treatment seeking SUD populations, TBI presence has been found at rates of up to 72 and 80% respectively, and 81.8% in a study of our own (Corrigan & Deutschle, 2008; McHugo et al., 2017; Marshall et al., 2025). Trends of more unfavourable TBI characteristics are emerging in these SUD samples compared to the general population, such as more severe and more frequent TBIs, which often occur from an early age (Corrigan & Deutschle, 2008; McHugo et al., 2017; Sacks et al., 2009). Multiple reasons have been offered for why TBI characteristics are worse in SUD populations. Risk-taking behaviours often accompany substance abuse and increase risk of TBI (McKinlay et al., 2014; Olsen & Corrigan, 2022). Motor vehicle crashes, falls, or accidental collisions with objects can cause TBI and are more likely to occur when individuals are intoxicated (Bjork & Grant, 2009; Kolakowsky-Hayner et al., 1999; Macias-Konstantopoulos et al., 2014; Rockett et al., 2005). TBI can also directly impact cognition (Cannella et al., 2019; Flynn, 2010; McDonald et al., 2002; Stubbs et al., 2020; Wilson et al., 2020). Similar to substance-induced cognitive impairment, symptoms of slowed processing speed, memory, attention, concentration, and executive dysfunction are common after TBI (Haarbauer-Krupa et al., 2017). Such impairment can limit individuals' impulse control and judgement, increasing difficulty with controlling their substance use and consequently maintain patterns of addiction (Bechara & Damasio, 2002).

Intact cognitive skills are important for learning and engaging in rehabilitative treatment for SUD (Gargaro & Gerber, 2016; Haarbauer-Krupa et al., 2017). Popular addiction treatments such as Cognitive Behavioural Therapy or Motivational Interviewing require attention, language, memory and executive functions to be effective (Copenhaver et al., 2003; Hill & Colistra, 2014). These cognitive abilities can be damaged by TBI and/or SUD (Flynn, 2010; McDonald et al., 2002; Wilson et al., 2020). These functions are also utilised in building relationships which is especially important in the context of group therapy, finding a sponsor, and utilising social supports which are key aspects of many SUD treatments (Hill & Colistra, 2014; McDonald, 2013). Unfortunately, TBI-positive individuals (people who have previously sustained a TBI) have trended toward benefiting less from treatment than their TBI-negative peers (individuals who have never sustained a TBI), and potentially experiencing more treatment failures (Burg et al., 2000; Holtzer et al., 2000; Sacks et al., 2009). Experts who have begun to advocate for adapting SUD treatment for cognitively impaired individuals, have highlighted the TBI field will be useful to draw upon (Hill & Colistra, 2014; Gargaro & Gerber, 2016). The body of literature concerning how best to do this is still growing (Hill & Colistra, 2014).

Due to high comorbidity, in progressing this field it would be valuable to continue to examine how TBI contributes to cognitive impairment in the SUD context.

A small body of literature exploring neuropsychological domains and substance use in mental health or SUD treatment seekers, has associated TBI with poorer cognitive outcomes (Burg et al., 2000; Gargaro & Gerber, 2016; Walker et al., 2007). Burg et al. (2000)'s TBI group had higher impairment in verbal learning, verbal recall, and information processing speed. A greater proportion of this TBI group reported a substance using history than the non-TBI group, although the associations between TBI and both cognition and worse mental health treatment outcomes still stood when controlling for this (Burg et al., 2000). Gargaro and Gerber (2016) found homeless individuals with TBI reported more difficulty with memory, comprehension, concentration, or impulse control relating to violence than the TBI negative group. This sample had high rates of SUD (at least 33%; Gargaro & Gerber, 2016). Finally in a SUD treatment sample, clients with multiple TBIs with LOC, compared to those with one or none, reported increased difficulties with concentrating, remembering, and controlling violence (Walker et al., 2007). An additional study in an SUD sample reported more disruptive or unstable behavioural markers in the TBI group compared to controls, which may stem from damage to cognitive domains (Corrigan & Deutschle, 2008). Therefore, a subgroup of SUD treatment seekers who have also sustained TBI, may be more cognitively impaired and be more disadvantaged in treatment (Gargaro & Gerber, 2016).

There is some evidence that examining characteristics of TBI may be important rather than broadly categorising into presence or absence (Corrigan & Deutschle, 2008; Walker et al., 2007). Firstly, outcomes are not expected to be uniform across the TBI severity spectrum (Golden & Golden, 2003; Goldstein & Levin, 2001; Kim et al., 2023; Rohling et al., 2003). A dose-response relationship has been observed between LOC and cognitive impairment (Dikmen et al., 2009; Rohling et al., 2003). Greater and longer-lasting impairments are expected after more severe injuries (Dikmen et al., 2009; Golden & Golden, 2003; Goldstein & Levin, 2001; Schretlen & Shapiro, 2003). While most individuals fully recover following mild TBI and experience minimal long-term issues, others can have a variety of persistent difficulties (Barlow, 2016; Haarbauer-Krupa et al., 2021; Kim et al., 2023;

Weil & Karelina, 2020). Presence of persistent difficulties following milder injuries with and without LOC, may be influenced by prior repeated head-injuries, and pre-injury mental health conditions such as SUD, as well as many other factors (Brooks et al., 2014; Kim et al., 2023; Weil & Karelina, 2020; Whittaker et al., 2007; Wojcik, 2014). In substance users, a greater number of TBIs has been linked to more severe psychiatric illness (Corrigan & Deutschle, 2008; Walker et al., 2007). Sustaining multiple TBIs has been linked to more severe current substance use (McHugo et al., 2017; Walker et al., 2007). Complications after multiple TBI may be attributed to cumulative effects disrupting impulse control and inhibitory skills (Corrigan & Deutschle, 2008). One study found cognitive challenges to be associated with sustaining two or more TBIs with LOC but not with sustaining only one TBI, which may suggest that different severity and number of TBIs between the samples are impactful characteristics that contribute to contradictory findings (Walker et al., 2007). A combined TBI weighted score comprised of multiple injuries with LOC for over 30 minutes, worst injury severity, and age of first TBI has been associated with more unfavourable psychiatric outcomes and more severe current substance use in an SUD sample (McHugo et al., 2017). While important, this combined TBI score makes it difficult to determine which TBI characteristic contributes most to negative outcomes. An earlier study of our own found that head-injury in adolescence was associated with going onto sustain more lifetime head-injuries (Marshall, Faulkner & de Terte, 2025). This supports trends found in other SUD samples and potentially indicates that age at TBI, and potentially earlier interruption to cognition may be an important factor influencing outcomes (Corrigan & Deutschle, 2008; Sacks et al., 2009). These findings suggest that worse TBI characteristics may have meaningful impacts among substance users and encourage further exploration. However, to our knowledge, neuropsychological outcomes according to TBI severity or age at injury in SUD samples have not yet been separately explored (McHugo et al., 2017; Davies et al., 2023).

Furthermore, in endeavouring to understand how TBI is associated with cognitive outcomes in SUD samples, the toxicity of prolonged substance use on the brain must also be considered (Carpenter, 2001; Felde et al., 2006; Malloy et al., 1990; Tateno et al., 2003). Existing literature has varied approaches in how it includes, or controls for presence of substance use when exploring cognition and mental distress associated with TBI (Davies et al., 2023). Some associations between TBI and cognitive outcomes have remained significant after accounting for substance use or abuse (Burg et al., 2000; Hanson et al., 2016; McHugo et al., 2017). Whereas other methods have included substance use as an outcome variable, rather than a control variable (Albicini et al., 2020; Garago & Gerber et al., 2016; Holtzer et al., 2000; Walker et al., 2007). Others have attempted to ascertain whether specific cognitive impairments could be attributed to SUD or TBI to differentiate the two; this approach has found no unique deficits (Iverson et al., 2005; Lange et al., 2008). However, both studies were limited to presence of mild TBI only. Additionally, a TBI history was not collected in the group representing SUD alone, and the TBI group included individuals with a previous SUD (Lange et al., 2008). These methods have limited the implications which can be drawn from these studies. Further exploration into cognitive outcomes relating to TBI while considering the impact of substance abuse and gathering in depth histories, will extend current findings in this area (Burg et al., 2000; Corrigan & Deutschle, 2008). While attributing causality for cognitive damage will remain difficult due to the overlap and possible contribution of a myriad of factors, this may aid in reconciling inconsistent findings in the current body of literature.

In summary, cognitive impairments after TBI is suspected to be an important factor in maintaining SUD, although exact contributing mechanisms are yet to be fully recognised (Olsen & Corrigan, 2022). Experiencing greater TBI frequency and severity from an earlier age is common in SUD populations and is linked to worse outcomes (Corrigan & Deutschle, 2008; McHugo et al., 2017). While this is suspected to be explained in part, by increased cognitive impairment, the current body of literature is not consistent on this (Davies et al., 2023; Olsen & Corrigan, 2022). Thus, cognitive profiles after early, recurrent, and more severe TBIs should be explored in individuals accessing SUD treatment. This is the overall objective of this study which is to explore the impacts that TBI characteristics may have on cognitive outcomes in an SUD sample. Due to the low TBI treatment seeking rates which is suspected to occur in SUD populations (Corrigan et al., 2012; Pitman et al., 2015), it is valuable to utilise self-report methods in such a population rather than being limited to medical or hospital records. Especially when endeavouring to understand the impact of milder injuries. Reliance on self-report methods without medical records mean that head-injuries without LOC cannot be confirmed to be TBIs, although estimates suggest that only 10% of mild TBIs cause a loss of consciousness (Silverberg et al., 2015). Cumulative mild injuries may be an important part of the picture to capture (Corrigan & Deutschle, 2008; Stocchetti & Zanier, 2016; van der Naalt et al., 2017; Walker et al., 2007). Therefore, the current study will include both TBI with LOC, and head-injuries without LOC which may be '*possible TBIs*', in a general exploration of head-injuries (which includes TBIs). Specifically, the study aims to examine the association between the number of head-injuries, injury severity/LOC duration, age of first injury, and treatment seeking following head-injury, with cognitive outcomes. We aim to explore how these head-injury characteristics impact different cognitive domains (attention, language, memory, executive function, and overall cognition) measured through both objective task-based performance and self-report. This will be done whilst controlling for demographic factors (gender, ethnicity and education), substance use characteristics and mental health factors.

METHOD

The study was completed at Wellington Salvation Army Bridge Programme and had their support. The project received ethical approval from the Massey Human Ethics Committee (SOA 21/28).

Participants

All clients admitted to a residential rehabilitation programme in Wellington between August 2021 and December 2022 were invited to take part in the study. Participants invited were adults aged 18 years and over and had received a DSM-5 diagnosis of a current SUD(s) of any kind (American Psychiatric Association, 2013). Individuals admitted to the programme were unable to reduce their use or symptoms associated with their SUD by utilising community supports, therefore requiring more intensive treatment. Participants with a diagnosis of schizophrenia were excluded from this study due to the confounding impact this diagnosis has on cognition. Additional exclusion criteria was significant cognitive impairment in which more comprehensive cognitive assessment would not be appropriate/ethical. This was determined by an individual scoring below 19 (out of a possible 30) in a Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) which was completed by the SUD treatment centre early in the participants stay. However, no participants scored below this threshold. Participation in the research did not impact the treatment the individuals received at the programme. All participants had been through substance withdrawal before being invited to participate, and a negative drug screen was collected from the programme before participation commenced and prior to the programme's completion of the MoCA.

Variables

Cognitive Outcome Variables

The outcome variables that were assessed in this study include a General Cognition total score, task-based measures of separate cognitive domains; Attention, Memory, Language, Spatial, and Executive Functioning, as well as one variable of self-reported cognitive difficulties.

Head-injury Predictor Variables

The predictor variables comprised of four head-injury characteristics 1) number of lifetime head-injuries (0-4, 5+), 2) age at earliest head-injury (12 or earlier, 13+), 3) head-injury/TBI severity (severe/moderate, mild TBI, or 'possible TBI' determined by self-reported LOC), and 4) had contact with a health service regarding their head-injury. For the variable of number of lifetime head-injuries, multiple participants had self-reported high numbers of lifetime head-injuries (e.g., 20 or 50) meaning there would likely be multiple outliers if using this as continuous data. Therefore, this was used as a categorical variable due to the large spread of data in the sample.

Demographic, Mental Health and SUD Control Variables

Control variables included 1) demographic variables (ethnicity, gender, education), 2) overall level of mental distress, and 3) historic and current SUD variables (age of onset of problematic substance use multiple times per week, and Alcohol and Drug Outcome Measure (ADOM; Hanton,

2019) total score reflecting their SUD severity over the recent month, as well as type of substance addicted to (mono or poly substance addiction)). The highest level of education in the sample was entering or completing a bachelor's level qualification (n=3). Due to the small number of participants who had completed education above high-school level, education was categorized into two groups (did not complete high-school, completed high-school or above). Use of education as a categorical variable limits conclusions that could be drawn, but even if using this variable as continuous, we would likely not have had the power to detect any meaningful findings due to limited spread of education level in the sample.

Measures

Head-Injury Characteristics

An adapted self-report screening tool was used. This tool has previously been used in NZ samples and found to match well with medical records of TBI events (Mitchell et al., 2017; Schofield et al., 2011). This collected information on the total number of head-injuries an individual had sustained in their lifetime. Additional details were collected for up to five injuries per person on: the age of their earliest and subsequent head-injuries, whether loss of consciousness occurred and if so the duration unconscious, and whether any contact with medical services was sought for each injury. Presence and severity of a TBI was categorised by duration of loss of consciousness (head-injury without LOC categorised as a '*possible TBI'*, head-injury with LOC for less than 30 minutes categorised as mild TBI, LOC greater than 30 minutes but less than 24 hours categorised as moderate TBI, and LOC greater than 24 hours categorised as severe TBI) (National Academies of Sciences, Engineering and Medicine et al., 2019).

Cognitive Outcomes

Neuropsychological Assessment Battery- Screening module (S-NAB; Stern, White & Lutz, 2003): The S-NAB is a task-based measure of functioning in five cognitive domains: (a) attention, (b) memory, (c) language, (d) spatial, and (e) executive functions, as well as an index of overall cognitive functioning. This battery of 15 neuropsychological tests, takes a total of approximately 35-45 minutes to administer. Tasks assessing memory include: shape and story learning (immediate and delayed). Tasks assessing attention include: digits forward and backward tasks, and letter cancellation. Tasks assessing language include: object naming and auditory comprehension. Visuospatial assessment tasks include: a three-dimensional design-construction, and a visual discrimination task. Tasks assessing executive functioning include: a word generation/anagram task and a paper-and-pencil maze task. These scores are corrected for gender, age-group and education level. Standardised scores are used to make a composite score of overall cognitive function. A *T*-score of 40 or less (one SD below the mean) is considered to indicate possible cognitive concerns, as this threshold has been used previously in a treatment seeking cocaine-use sample (Cannizzaro et al., 2014) (see Strauss, Sherman & Spreen (2006) for a review of the S-NAB). This tool has been validated for use in a TBI population (Hacker et al., 2020).

Rivermead Post-Concussion Questionnaire (RPQ; King et al., 1995): The RPQ is a self-report measure of TBI-related symptoms present in the past 30 days which began or increased since the head-injury occurred. Three of these items include symptoms reflecting cognitive difficulty including "forgetfulness/poor memory", "poor concentration", and "taking longer to think". Scores on these three items were combined for each participant, to derive our variable of self-reported cognitive difficulty. Higher ratings indicated greater difficulty. Spearman rank correlation coefficients have showed high reliability for total symptom score ratings (Rs= + 0.87 and 0.91) at days and months after injury (King et al., 1995).

Demographics

Demographic information was collected from each participant. A questionnaire was used to obtain information for each participant on their gender, age, ethnicity, and highest level of education.

Substance Use Characteristics

Questionnaire of Historical Substance Use Behaviours: A questionnaire was used in an interview, asking questions about specific substances used/not used, what substances an individual has ever been addicted to in their life, and ages at which an individual (a) first tried their problem substance(s), (b) began using a substance regularly and how regular that was, and (c) when the substance use increased to multiple times per week. These questions were used to determine whether individuals were classed as having mono or polysubstance use disorders, and to determine the age when problematic substance use began. '*Problematic substance use'* was defined as using the main problem substance multiple times per week or more, every week. All participants had developed a SUD consistent with the DSM-5 (American Psychiatric Association, 2013), as entry criteria to the rehabilitation programme required all individuals to have received an SUD diagnosis. Thus, the age when *problematic substance use* began, was operationalised as the age at onset of SUD for the purposes of this study.

Alcohol and Drug Outcome Measure- version 3 (ADOM; Hanton, 2019): The ADOM is a self-report questionnaire on current substance using behaviours over the past 28 days. Section 1) Alcohol and Drug use, asks eleven questions about frequency and amounts of use of any substance including cigarettes, main substance(s) of concern, and use of injecting equipment over the past 4 weeks. Section 2) Lifestyle and wellbeing, asks seven questions about frequency of problems related to substance use in the past 4 weeks (general physical health, mental health, relationship troubles, responsibilities and activities, living situation and criminal activity). Section 3) Recovery, asks two questions about a) how close the participant feels they are in their recovery in relation to where they want to be on a scale of 1-10 with 10 being the best possible, and b) how satisfied the participant is with their progress toward their recovery goals on a 5-point scale from 1-not at all, to 5-extremely. This tool has shown acceptable reliability and validity statistics (Pulford et al., 2010). Further information on the psychometric properties of the ADOM have been reported by Deering et al. (2009) and Pulford et al. (2010).

Mental health

Depression Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995): The DASS-21 is a 21 item self-report questionnaire which collects information on an individual's level of mental distress over the past seven days. Mental distress is categorised into three subscales (depression, anxiety, and stress), each consisting of seven items such as "I felt down-hearted and blue" and "I found it difficult to relax". Participants are asked to rate their experience of each statement over the past 7 days, on a 4-point Likert scale: '0-Never, 1-Sometimes, 2-Often or 3-Almost Always'. A total score can be derived for each scale of depression, anxiety, and stress. For the purposes of this study, the scores of the three subscales were combined to make a total score of '*current mental distress'* (higher scores reflecting more overall distress). The DASS-21 total score has shown good internal consistency (Cronbach's *alpha* = 0.92) in a SUD sample (Moska et al., 2023).

Procedure

Upon client's admission to the SUD rehabilitation program and following their orientation, programme staff provided information to clients about this research and invited them to participate. All consenting clients were then referred by staff to the researcher, who subsequently met with the participant for the first time at the rehabilitation facility. The researcher completed the head-injury screen, demographic and substance-use screens, and the DASS-21 in one session with each participant during their 10-week stay at the programme. Completion of these questionnaires was staggered with breaks according to clients' needs accommodating for individuals' fatigue and concentration abilities. Subsequently, upon confirmation of a negative drug screen in the form of a urine sample, participants were invited to the second data collection session. During this session the researcher completed a S-NAB with the participant. Sessions occurred in a private interview space at the rehabilitation facility.

Statistical Analysis

Descriptive statistics were used to examine cognitive outcomes including responses on the RPQ(Cog), performance on each cognitive domain, the total S-NAB composite score, and the proportion of participants meeting impairment criteria. Impaired performance was defined by S-NAB *T*-scores of 40 or less (1 SD below the mean) (Cannizzaro et al., 2014; Stern, White & Lutz, 2003).

Next, we examined the association between demographic factors (gender, ethnicity, education history), substance use characteristics (age when problematic substance use began, substance of addiction (mono-substance vs. polysubstance), and current SUD severity), and current mental health. For categorical data (i.e., gender, education) independent sample-*t* tests were used as the data was normally distributed. For continuous variables (i.e., mental distress), Pearson's correlations were calculated. Variables that were associated with each cognitive outcome defined as $p < .10$ were then included as covariates in the linear regression analysis. For this analysis, a linear regression model was computed to examine the predictive role of head-injury characteristics (frequency of head-injuries, severity, age of first head-injury, and treatment seeking) on each cognitive outcome. All analyses were conducted on SPSS version 29.0.

RESULTS

The overall study consisted of 77 participants aged between 20-64 years old, with comorbid SUD and a history of sustaining at least one lifetime head-injury. In the participant sample, 81.8% had sustained at least one self-reported TBI with LOC. The remaining 18.2% all reported sustaining at-least one lifetime '*possible TBI*'/head-injury without LOC. Participants were more commonly male (68.8%), of Māori (46.8%) and NZ European (51.9%) ethnicity, who did not complete secondary school (66.2%). Just over half of the sample began using substances multiple times per week during adolescence (defined as SUD onset). Descriptive statistics are demonstrated in Table 1. Of the 77 participants, only 70 went onto complete the full cognitive assessment due to seven participants self-discharging from the SUD treatment early or being asked to leave the programme for various reasons.

Table 1

Demographic and substance using features of the overall sample (N=77)

Demographics	N (%)
Gender	
Male	53 (68.8%)
Female	24 (31.2%)
Ethnicity	

Māori	36 (46.8%)
NZ European	40 (51.9%)
Unknown	1 (1.3%)
Highest Education	
Completed high school or above	26 (33.8%)
Did not complete high school	51 (66.2%)
SUD Characteristics	N (%)
Age of Problematic Substance Use	
10 -17	39 (50.6%)
18+	38 (49.4%)
Substance Type	
Polysubstance addiction	43 (55.8%)
Mono-substance addiction	34 (44.2%)
Distribution of Problem Substances	
Amphetamine addiction	63 (81.8%)
Cannabis addiction	31 (40.3%)
Alcohol Addiction	29 (37.7%)
Sedative, hypnotic or tranquilliser addiction	5 (6.5%)
Opiates	4 (5.2%)
Cocaine, hallucinogens, or synthetics	3 (3.9%)
Previous AOD treatment attempts	
0	22 (28.6%)
1+	55 (71.4%)
Current SUD Severity[1]	M =13.5, SD = 7.4
Mental Health	M (SD)
Overall score of *current mental distress*	16.4 (12.2)
Depression	4.4 (4.4)
Anxiety	5 (4.2)
Stress	7.1 (5.2)
Head-Injury Characteristics	N (%)
# lifetime head-injuries	
1-4	35 (45.5%)

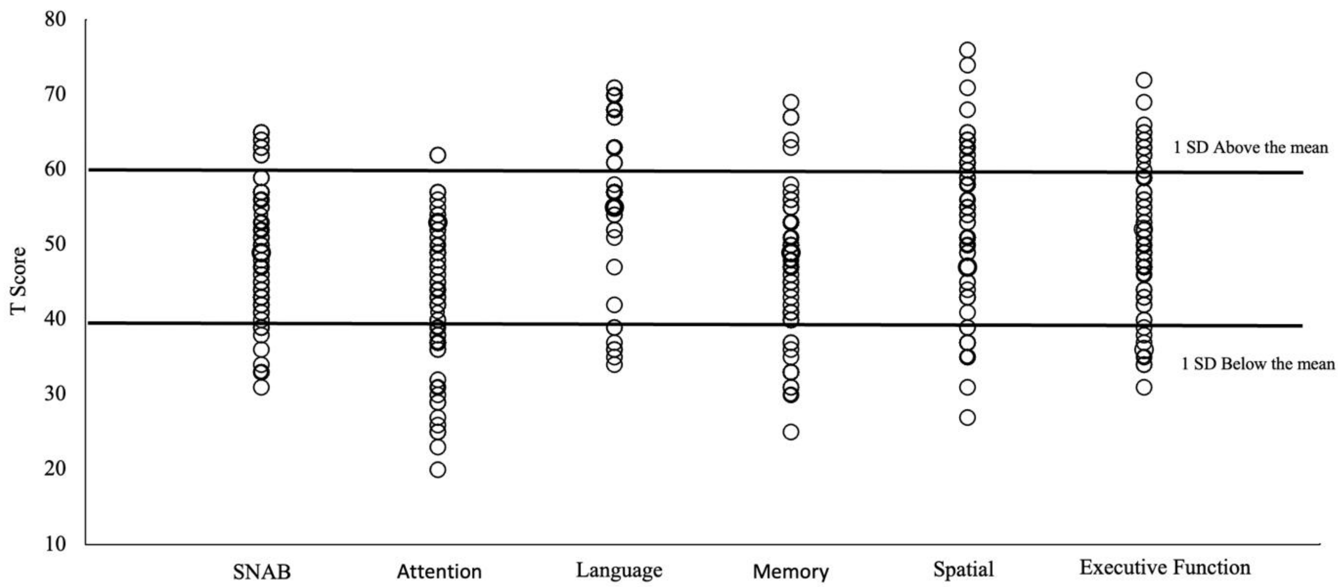
5+	42 (54.5%)
Worst Lifetime Self-reported TBI Severity	
Moderate/Severe (LOC 30+ minutes)	24 (31.2%)
- Severe (LOC >24 hours)	4 (5.2)
- Moderate (LOC 30 minutes-24 hours)	20 (26%)
Mild (LOC <30 minutes)	39 (50.6%)
'*Possible TBI*' (head-injury without LOC)	14 (18.2%)
Contact with health service after head-injury at least once	
Yes	55 (71.4%)
- Primary Care (Ambulance, Hospital, GP, Nurse)	53 (68.8%)
- Secondary Care (TBI rehabilitation programme)	2 (2.6%)
No	22 (28.6%)
Age at earliest head-injury (years)	
12 or below	42 (54.5%)
13+	35 (44.5%)

[1]Data for 14 participants current SUD severity scores on the ADOM was unable to be obtained. Higher scores on the ADOM indicated worse SUD severity (0-30).

The sample's mean composite S-NAB score was 49.19 (SD = 8.87), reflecting general cognitive ability scoring in the average range. Of the five domains, the language domain yielded the highest mean score (M = 57.18, SD = 9.34) in the average range, while the attention domain yielded the lowest mean score (M = 42.96, SD = 9.74), also within the average range. The mean memory score was 46.23 (SD = 9.58), the mean spatial score was 52.77 (SD = 10.58) and the mean executive functioning score was 50.73 (9.34). Figure 1 shows the sample's distribution of S-NAB scores. The mean score on the RPQ (Cog) was 5.05 (SD = 3.14, with a maximum possible score of 12 and a minimum possible score of 0). 64.9% of the sample (n=50) scored within average range for overall general cognition. 15.6% of the sample (n=11) performed at below average level indicating possible cognitive weakness (scores at or below 40) on S-NAB composite score. This rate of below average scores is expected in a normal distribution. 11.7% (n=9) of the sample performed in the above average range overall on S-NAB composite scores. Attention and memory had the highest proportion of possible cognitive weakness (35.9% (n=28) and 21.8% (n=17) respectively) at a rate greater than expected in a normal distribution, followed by executive function and spatial (both 14.1% (n=11), and then language (11.5% (n=9)). On the other hand, the highest proportion of strengths sat in the language, visuospatial, and executive function domains (28.6% (n=22), 27.3% (n=21), and 16.9% (n=13) respectively), followed by memory (6.5% (n=5)) then attention (2.6% (n=2)).

Figure 1

Distribution of Neuropsychological Assessment Battery-Screening Module (S-NAB) scores



The relationship between cognitive outcomes and demographic, substance use characteristics and mental distress were examined (see supplementary material). A summary of the variables selected to include in the linear regression models is presented in Table 2. More specifically, in regards to the overall S-NAB composite, surprisingly, participants with higher education attainment had lower scores (M = 46.57), than those with a lower education attainment (M = 50.47) (t (67) = -1.75, p = .042). For attention, male participants had lower scores (M = 41.44) than female participants (M = 46.27) (t (67) = 0.88, p = .027). Participants who had a higher educational attainment also had lower scores (M = 38.00) than those with lower education attainment (M = 45.38) (t (67) = -3.17, p = .001). High levels of SUD severity and mental distress were also associated with lower scores on the attention domain (*r* = -.227, *p* = .045; *r* = -.248, *p* = .019). For the language and spatial domains, only those who had a monosubstance addiction had lower scores on these domains (M = 54.70, M = 59.13) than those with a polysubstance addiction (M = 49.43, M = 55.28) (*t* (67) = -1.98, *p* = .026; *t* (67) = -2.36, *p* = .011). In regards to the memory domain, participants who had a monosubstance addiction (M = 49.43) had lower scores then participants with a polysubstance addiction (M = 55.28) (*t* (67) = -2.36, *p* = .011). Higher levels of mental distress were also associated with lower scores in the memory domain (*r* = -.226, *p* = .030). For the executive function domain, NZ Europeans had lower scores (M = 48.68) than Māori (M=53.03) (*t* (67) = 1.96, *p* = .027), as too did those with a higher education attainment (M = 47.30) than those with a lower education attainment (M = 52.40) (*t* (67) = -2.20, *p* = .015). Finally in regards to self-reported cognitive outcomes, NZ Europeans and those with higher education attainment (M = 5.63; M = 6.04) reported more cognitive difficulties than Māori and those with lower education attainment (M = 4.43; M = 4.55). Higher SUD severity and mental distress were associated with higher self-reported cognitive difficulties (*r* = .184, .429; *p* = .075, <.001).

Table 2

Summary of variables selected to include in the linear regression models

S-NAB	Attention	Language	Memory	Spatial	Executive Function	RPQ (Cog)
Education	Gender	Addicted substance	*Gender	Addicted substance	Ethnicity	Ethnicity
*Age of problematic use	Education		*Ethnicity		Education	Education
*Addicted substance	SUD Severity		Addicted substance			SUD Severity
	Mental distress		Mental distress			Mental distress

*Variables were non-significant in t-tests, however were included as control variables as they approaching statistical significance; Participants who engaged in problematic substance use at a younger age (M= 47.70) had lower scores on the S-NAB composite than those that began using at an older age (M = 50.85) (*t*(67) = -1.49, p = .070), as too did participants who were addicted to one substance (M=47.30) compared to those who had a polysubstance addiction (M=50.60) (*t*(67) = -1.56, p = .062) ; for memory, females had lower scores (M=43.77) than males (M=47.35) (*t*(67) =1.46, p = .074). Participants who were Māori also had lower scores (M=44.69) than NZ Europeans (M=47.59) (*t*(67)=-1.25, p = .107).

Linear Regression

A power analysis using the G*power software (Faul et al., 2009) was used to ensure adequate same size for the regression analyses. Assuming a medium effect size (f^2) of 0.2, an alpha of 0.8, and a maximum of five predictors, power analysis suggested a minimum sample of 67 participants. Our sample exceeded this estimate. Linear regression model was computed for each cognitive outcome to determine the predictive role of each head-injury characteristic. Variables that were associated with each cognitive domain were included in each model as covariates (see Table 2). All assumptions for linear regression were met. As shown in Table 3, the only head-injury characteristic associated with cognitive outcomes was number of head-injuries. More specifically, this variable was significantly associated with executive function ($\beta = -0.13$, $p = .045$) and self-reported cognitive difficulties ($\beta = 2.64$, $p <.001$). The overall model for executive function was statistically significant, (F (3,64) = 4.29, $p = .008$). The model accounted for 16.7% of the variance in the executive function domain ($R^2 = .167$). The overall model for self-reported cognitive difficulties was statistically significant (F (5,56) = 6.53, $p < .001$). The model accounted for 36.8% of the variance in self-reported difficulties ($R^2 = .368$). No other head-injury characteristics were significantly associated with cognitive outcomes. A full summary of the regression models is provided in the supplementary materials for this manuscript.

Table 3

Linear regression for the predictive role of head-injury characteristics when controlling for relevant contributing variables

	Number of Injuries				**Severity**				**Age of first Injury**				**Contact with Health Service**			
	β	**Std Error**	**t**	**p**	**β**	**Std Error**	**t**	**p**	**β**	**Std Error**	**t**	**p**	**β**	**Std Error**	**t**	**p**
S-NAB	-0.41	2.09	-0.20	.846	1.99	2.60	0.77	.447	-0.16	2.05	-0.08	.939	-1.37	2.33	-0.59	.559
Attention	-2.65	2.54	-1.05	.301	0.35	2.92	0.12	.904	1.04	2.44	0.43	.672	-3.67	2.79	-1.32	.194
Language	2.92	2.22	1.32	.193	4.60	2.61	1.76	.083	-2.03	2.27	-0.89	.375	-3.44	3.18	-1.08	.283
Memory	0.76	2.36	-1.05	.301	-0.50	3.08	-0.16	.873	-3.10	2.52	-1.23	.223	-1.15	2.71	-0.42	.673
Spatial	-2.14	2.49	-0.86	.392	4.55	3.02	1.51	.136	2.79	2.48	1.13	.263	1.41	2.77	0.51	.612
Executive Function	-0.13	0.06	-2.05	.045**	-2.62	2.80	-0.94	.354	0.18	2.23	0.08	.937	1.01	2.51	0.40	.690
RPQ(Cog)	2.64	0.76	3.48	<.001**	1.59	1.01	1.57	.122	0.13	0.83	0.15	.880	-0.34	0.90	-0.38	.703

**Model statistically significant, *Model approaching significance.

Discussion

The objective of this study was to explore the impacts that certain head-injury and TBI characteristics have on cognitive domains, in a sample of SUD treatment users. Previous studies that have attempted to examine such associations have not controlled for confounds that could potentially account for or explain some of these associations (e.g., Centre for Disease Control, 2024; McHugo et al., 2017; Walker et al., 2007; Gargaro & Gerber, 2016). Specifically, substance using behaviours and mental health distress (Burg et al., 2000; Corrigan & Deutschle, 2008; Felde et al., 2006; Fernández-Serrano et al., 2011; Gargaro & Gerber, 2016). Therefore, in order to draw more direct links, this study controlled for these factors. This approach revealed one major finding discussed below.

Being included in the group who sustained five or more lifetime head-injuries significantly predicted lower executive function scores and self-reported cognitive difficulties. This finding was still evident even when controlling for relevant demographic and substance use characteristics. This is consistent with the findings of Walker et al. (2007), who found, in an SUD treatment sample, individuals who had sustained a higher number of lifetime TBIs had significantly more cognitive difficulties. Executive dysfunction is known to be associated with TBI and substance use (Berry et al., 2019; McDonald et al., 2002; Wilson et al., 2021). Our findings suggest that the number of head-injuries an individual experiences in their lifetime could be particularly important in driving these relationships. While executive function was significantly lower on the task-based measure, alongside subjective cognitive difficulties in the group with a higher number of head-injuries, this group scored similarly on task-based measures of memory and attention to the group with a low number of head-injuries. However, the group with five or more head-injuries was significantly associated with self-reported difficulties in these cognitive domains. Executive functioning is important for other cognitive domains such as memory and concentration, among other functions. Consequently, the self-reported cognitive difficulties captured in the RPQ(Cog) may be experiential difficulties with executive functions (Barker-Collo et al., 2015; Walker et al., 2007). Alternatively, it may suggest that objective cognitive measures and more specifically the S-NAB are not sensitive enough at identifying these cognitive difficulties. A distinction between self-report and neuropsychological task-based measures is well established in the literature (Howlett et al., 2022). Common neuropsychological measures have been described as “reductionist”, capturing optimal performance in specific cognitive skills; whereas self-report have greater ecological validity capturing appraisals of typical ability and behaviour (Wennerhold & Friese, 2020). Despite these differences, our findings emphasise the important role that repeated head-injuries may have in the cognitive difficulties reported by individuals engaging in SUD treatment.

For the remaining three head-injury characteristics examined in this study, neither age of earliest injury (before or after age 13), injury severity, nor having contact with a health service after a injury, were found to impact the cognitive outcomes explored. Apart from the attention and memory domains, the current sample displayed largely average general cognitive functioning (64.9% scoring within average range overall). This is likely reflective of the large proportion of the sample (68.8%) sustaining mild TBI (50.6%) or head-injury without LOC (18.2%) as their most severe injury. Previous studies have implicated more severe TBI and earlier age of injury in contributing to cognitive sequalae (Anderson et al., 2009; Dikmen et al., 1995; Rabinowitz & Levin, 2014). Additionally, these two TBI characteristics have been associated with SUD and mental health severity, and worse current functioning (Corrigan & Deutschle, 2008; Felde et al., 2006; McHugo et al., 2017). Our findings may be explained by a small proportion of participants in the current sample having sustained moderate or severe TBIs (26% and 5.2% respectively). A lack of findings could also be due to reliance on self-report methods to determine duration of loss of consciousness, without verification through medical records. Time unconscious was used to determine TBI severity, which may have been confounded by intoxication at the time of TBI, and lack of supplementation with medical records. In regard to age of TBI, a previous study found associations between cognition and TBI age when exploring associations with cognition at multiple ages throughout childhood in non-substance using children (Anderson et al., 2009). Our study explored cognitive differences between only two groups; those sustaining TBI before, versus after childhood (age 13 and above). There is potential that meaningful associations between TBI age and cognition were condensed into the same “childhood” group, leading to a lack of findings (Anderson et al., 2009). The cross-sectional design limits the findings on cognitive profiles by being unable to capture whether any cognitive recovery had occurred following early life injuries (Thomas, 2023). Future research would benefit from examining the impact of these TBI characteristics using multiple methods of data collection (i.e., collateral reports and medical records), over the lifespan with use of longitudinal methods. Furthermore, having contact with a health service upon sustaining a head-injury was not associated with better cognitive scores. The majority of contact with health services in this sample occurred as a result of contact with ambulance, GPs, nurses, or short hospital stays, with very few participants receiving treatment from a specialty TBI facility (2.6%). While primary health care services appear to be the main point of contact after head-injury for this population, it does not seem to promote better cognitive function than no contact with health care. This finding combined with the largely average cognitive functioning overall, may be due to the majority of mild or 'possible' TBIs that likely did not result in significant cognitive impairment to recover from, aside from possible cumulative impacts on executive function. Nonetheless, this may highlight an area for growth in NZ primary health services, to re-evaluate and develop ways to better utilise this opportunity for brief education on TBI recovery. Additionally, several individuals (11.7%) reported that only their bodily injuries were attended to which overshadowed milder head-injuries. Others (10.4%) reported that despite initial contact with health services after LOC, they quickly disengaged with the service upon regaining consciousness for various reasons (e.g., worried about legal ramifications for themselves or others). These individuals are potentially more likely to engage in behaviours in the acute stages of the TBI that hamper recovery, (e.g., substance intoxication and increase risk of more chronic cognitive impairments) (VanderVeen, 2021; Weil et al., 2016). These factors may have contributed to finding no association between contact with health services and cognition.

Another possibility pertains to the limited cognitive domains that were examined in this study. For example, impairment to Social Cognition has been found after both TBI and SUD separately (Bland & Ersche, 2020; Bora & Zorlu, 2017; Maggio et al., 2020). Social Cognition is comprised of higher order functions and is used to understand and navigate social interactions across contexts (McDonald et al., 2013). Damage to Social Cognition may be a mechanism through which

TBI increases psychological distress and perpetuates SUD (Bora & Zorlu, 2017; Maggio et al., 2020; Pettersen et al., 2019). This may occur through increased difficulty navigating interpersonal relationships and social contexts, subsequently increasing stress, conflict, and reliance on substances or other unhealthy coping strategies (Arabacı et al., 2018; Merinuk, et al., 2021; Pettersen et al., 2019). Therefore, severity and age at TBI may yet be important characteristics which significantly predict other cognitive outcomes not explored in this study.

In support of this, we found some surprising associations between cognitive domains and control variables. Specifically, the lower education group had higher overall S-NAB, attention and EF scores than the higher education group, as well as more self-reported cognitive difficulties. In a previous study with the same sample, the higher-education group was found to be more likely to sustain a head-injury when substances were involved in the event. Such substance-involved events predicted a TBI of greater severity (moderate-severe rather than mild or no LOC). A possible explanation for this is that greater representation of substance-related moderate-severe TBIs occurred in the high-education group to lead to significantly lower scores on the overall, attention, executive function domains and self-reported difficulties. However, results showed no significant effect of LOC duration on cognition. Additionally, those with mono-substance compared to polysubstance addition, had lower scores on some of the cognitive domains examined. These findings may be a consequence of the relatively small sample of this study and should therefore be treated with caution. Additionally, higher SUD severity and mental distress was associated with more self-reported cognitive difficulties, but not associated with executive function scores, a finding inconsistent with those reported in the literature (Barker-Collo et al., 2015; Walker et al., 2007). These associations indicate that something else may be going on. While executive dysfunction likely plays an important role, other cognitive processes not explored in the current study (e.g., Social Cognition) may be important mechanisms maintaining relapse, and increasing severity of SUD and mental distress in SUD populations (Barker-Collo et al., 2015; Corrigan & Deutschle, 2008; McHugo et al., 2017; Walker et al., 2007). It is therefore important to replicate these results and explore other areas of cognition.

In summary, the findings of this study indicate that SUD treatment programmes should aim to identify individuals who have sustained multiple head-injuries in their lifetime. These individuals may likely be experiencing more difficulties with executive function, which could impact treatment engagement, compliance and progress. Also, the findings suggest that these individuals may benefit from additional support when engaging in SUD treatment to manage their cognitive difficulties. Drawing on the field of TBI rehabilitation could be particularly helpful for these individuals to introduce cognitive strategies (i.e., the Goal Management Training for executive dysfunction) that could increase their chances of treatment success (Levine et al., 2012). This study, however, does need to be considered in the context of its limitations. This exploration was conducted on a relatively small sample which limited statistical analyses that were able to be conducted. These findings should be interpreted with caution and replicated in larger samples. Our method of identifying TBIs was not confirmed using medical records or family reports, therefore the injuries in this study were not clinically confirmed TBIs and a number of injuries without LOC classified as ‘possible TBIs’ may have been solely head-injuries with no acute neurological disturbance, or may have been mild TBIs. Additionally, categorising the number of head-injuries into two groups limits the conclusions that can be drawn about impacts of increasing number of head-injuries, compared to assessing any dose-response effect which may be possible if used as a continuous variable. The S-NAB is a cognitive screening assessment. Although it is more comprehensive than other cognitive screening tools (i.e., MoCA), it is more limited than a comprehensive neuropsychological assessment. The limited sensitivity of the S-NAB could be reflected in our findings. Additionally, the S-NAB has been validated on individuals of European Descent (Stern et al., 2003), while almost half of the current sample identified as being of Māori descent. Research has demonstrated that Māori may be disadvantaged on Western neuropsychological tasks when culture is not considered in the assessment (Dudley et al., 2014). Our method of ascertaining self-reported cognitive difficulties was based on only 3-items; a small amount of information to form a construct. However, these findings are in accordance with two previous studies finding similar associations with more extensive measures of self-reported cognitive difficulties (Barker-Collo et al., 2015; Walker et al., 2007).

In conclusion, this research illustrates that the number of head-injuries someone sustains in their lifetime, may have important implications for cognitive outcomes in individuals seeking treatment for SUD. Contact with primary health services following a head-injury, may be a brief window of opportunity to improve education around recovery, that may not currently be utilised to its full potential. Our findings also suggest that there is a relationship between repeated head-injury and higher self-reported cognitive difficulties, and more specifically executive function processes may be impacted. SUD treatment programmes would benefit from identifying this specific characteristic, as this group may be at risk for more cognitive difficulties, and possibly poorer treatment outcomes.

Supplementary Materials

Supplementary Table 1

Associations between demographics, substance use characteristics and S-NAB scores using independent sample t-tests

	S-NAB			Attention			Language			Memory			Spatial			Executive Function		
	Mean	T score	P Value	Mean	T score	P Value	Mean	T score	P Value	Mean	T score	P Value	Mean	T score	P Value	Mean	T score	P Value
Gender																		
Male	48.98	-0.29	.388	41.44	0.88	**.027***	58.13	1.22	.113	47.35	1.46	**.074**	52.90	0.14	.443	50.52	-0.27	.393
Female	49.64			46.27			55.18			43.77			52.50			51.18		
Ethnicity																		
Māori	49.56	0.20	.422	44.00	0.81	.211	56.83	-0.52	.302	44.69	-1.25	**.107**	53.34	0.25	.401	53.03	1.96	**.027***
NZ European	49.14			42.08			58.00			47.59			52.70			48.68		
Education																		
Secondary school or less	50.47	-1.75	**.042***	45.38	-3.17	**.001****	56.65	0.67	.254	46.81	-0.72	.237	52.64	0.15	.441	52.40	-2.20	**.015***
Post secondary school	46.57			38.00			58.27			45.04			53.04			47.30		
Age of Problematic Use																		
10-17	47.70	-1.49	**.070**	41.84	-1.02	.156	58.26	0.98	.165	45.32	-0.83	.203	52.81	0.03	.487	49.05	1.61	**.056**
18+	50.85			44.21			56.03			47.24			52.73			52.61		
Addicted Substance																		
Mono	47.30	-1.56	**.062**	42.03	-0.68	.248	54.70	-1.98	**.026***	47.43	0.91	.183	49.43	-2.36	**.011***	49.57	-0.90	.186
Poly	50.60			43.65			59.13			45.33			55.28			51.60		

**significant <.001, *significant <.050, those approaching significance also included in bold.

Supplementary Table 2

Associations between demographics, substance use characteristics, and RPQ(Cog) cognitive outcomes

	RPQ (COG)		
	Mean (SD)	T score	P Value
Gender			
Male	4.85	-0.77	.221
Female	5.50		
Ethnicity			
Māori	4.43	-1.33	**.093**
NZ European	5.46		
Education			
Secondary school or less	4.55	1.84	**.035***
Post secondary school	6.04		
Age of Problematic Use			
10-17	5.46	1.07	.145
18+	4.63		
Addicted Substance			
Mono	4.64	-0.93	.179
Poly	5.37		

**significant <.001, *significant <.050, those approaching significance also included in bold.

Supplementary Table 3

Associations between substance use severity, mental distress and cognitive outcomes

	S-NAB	Attention	Language	Memory	Spatial	Executive Function	RPQ (Cog)
SUD Severity							
Pearson Correlation	-.020	-.227	-.081	.114	.081	-.131	.184
P value	.442	**.045***	.276	.199	.275	.165	**.075**
Mental Distress							
Pearson Correlation	-.085	-.248	.030	-.226	.103	-.057	.429
P value	.241	**.019***	.403	**.030***	.198	.321	**<.001****

**significant <.001, *significant <.050, those approaching significance also included in bold.

Supplementary Table 4

Linear regression models for S-NAB Composite Score

	β	**Std Error**	**t**	**p**
		No of Head-Injuries		
Education	4.45	2.20	2.03	.046
Age of problematic use	4.58	2.13	2.15	.035
Substance Addicted	4.32	2.10	2.06	.043
No. of Injuries	-0.41	2.09	-0.20	.846
		TBI Severity		
Education	4.98	2.25	2.21	.030
Age of problematic use	4.77	2.14	2.22	.030
Substance Addicted	4.50	2.17	2.07	.043
TBI Severity	1.99	2.60	0.77	.447
		Age of First Head-Injury		

Education	4.52	2.18	2.08	.042
Age of problematic us	4.66	2.10	2.22	.030
Substance Addicted	4.20	2.12	2.03	.047
Age of First Head-injury	-0.16	2.05	-0.08	.939
		Contact with Health Service		
Education	5.80	2.16	2.67	.009
Age of problematic us	4.55	2.04	2.23	.029
Substance Addicted	4.79	2.07	2.317	.024
Contact with Health service for Head-injury	5.74	2.37	2.43	.018

Supplementary Table 5

Linear regression models for Attention Domain Score

	β	Std Error	t	p
		No of Head-Injuries		
Gender	2.84	2.64	1.08	.287
Education	5.71	2.41	2.37	.022
SUD Severity	-0.17	0.13	-1.26	.214
Mental Distress	-0.19	0.09	-2.04	.047
No. of Injuries	-2.65	2.54	-1.05	.301
		TBI Severity		
Gender	3.72	2.45	1.52	.136
Education	6.08	2.52	2.41	.020
SUD Severity	-0.20	0.13	-1.55	.128
Mental Distress	-0.22	0.09	-2.32	.024
TBI Severity	0.35	2.92	0.12	.904
		Age of First Head-Injury		
Gender	3.55	2.60	1.36	.178
Education	5.85	2.43	2.41	.020
SUD Severity	-0.21	0.13	-1.57	.123

Mental Distress	-0.19	0.09	-2.05	.045
Age of First Head-Injury	1.04	2.44	0.43	.672
		Contact with Health Service		
Gender	3.36	2.47	1.36	.179
Education	6.71	2.56	2.62	.012
SUD Severity	-0.21	0.13	-1.60	.116
Mental Distress	-0.21	0.09	-2.24	.029
Contact with Health service for Head-injury	2.28	2.79	0.82	.418

Supplementary Table 6

Linear regression models for Language Domain Score

	β	Std Error	t	p
		No of Head-Injuries		
Addicted Substance	4.30	2.22	1.93	.058
No. of Head-Injuries	2.92	2.22	1.32	.193
		TBI Severity		
Addicted Substance	4.84	2.20	2.04	.045
TBI Severity	4.60	2.61	1.76	.083
		Age of First Head-Injury		
Addicted Substance	4.10	2.27	1.81	.075
Age of First Head-Injury	-2.03	2.27	-0.89	.375
		Contact with Health Service		
Addicted Substance	4.11	2.20	1.87	.066
Contact with Health service for Head-Injury	3.26	2.50	1.30	.197

Supplementary Table 7

Linear regression models for Memory Domain Score

	β	Std Error	t	p
		No of Head-Injuries		
Gender	-3.53	2.60	-1.36	.287
Ethnicity	4.06	2.37	1.72	.022
Substance Addicted	-0.97	2.50	-0.3	.214
Mental Distress	-0.18	0.10	-2.04	.047
No. of Head-Injuries	0.76	2.36	-1.05	.301
		TBI Severity		
Gender	-3.83	2.57	-1.49	.140
Ethnicity	3.78	2.53	1.50	.140
Substance Addicted	-1.26	2.68	-0.47	.641
Mental Distress	-0.17	0.11	-1.57	.122
TBI Severity	-0.50	3.08	-0.16	.873
		Age of First Head-Injury		
Gender	-2.41	2.72	-0.89	.379
Ethnicity	3.30	2.41	1.37	.176
Substance Addicted	-1.25	2.49	-0.50	.617
Mental Distress	-0.19	0.10	-1.19	.068
Age of First Head-Injury	-3.10	2.52	-1.23	.223
		Contact with Health Service		
Gender	-3.84	2.52	-1.53	.132
Education	3.80	2.37	1.61	.113
SUD Severity	-0.72	2.52	-0.29	.776
Mental Distress	-0.17	0.10	-1.73	.088
Contact with Health service for Head-Injury	3.69	2.64	1.40	.167

Supplementary Table 8

Linear regression models for Spatial Domain Score

	β	Std Error	t	p
		No of Head-Injuries		
Addicted Substance	5.98	2.49	2.41	.019
No. of Head-Injuries	-2.14	2.49	-0.86	.392
		TBI Severity		
Addicted Substance	6.66	2.52	2.64	.010
TBI Severity	4.55	3.02	1.51	.136
		Age of First Head-Injury		
Addicted Substance	6.21	2.49	2.49	.015
Age of First Head-Injury	2.79	2.48	1.13	.263
		Contact with Health Service		
Addicted Substance	6.28	2.54	2.47	.016
Contact with Health service for Head-Injury	2.19	2.91	0.75	.454

Supplementary Table 9

Linear regression models for Executive Function Domain Score

	β	Std Error	t	p
		No of Head-Injuries		
Ethnicity	-4.00	2.16	-1.84	.070
Education	4.15	2.32	1.79	.078
No. of Head-Injuries	-0.13	0.06	-2.05	.045*
		TBI Severity		
Ethnicity	-4.20	2.60	-1.83	.072

Education	4.21	2.45	1.72	.091
TBI Severity	-2.62	2.80	-0.94	.354
		Age of First Head-Injury		
Ethnicity	-3.71	2.25	-1.65	.104
Education	4.81	2.37	2.03	.046
Age of First Head-Injury	0.18	2.23	0.08	.937
		Contact with Health Service		
Ethnicity	-3.76	2.19	1.72	.091
Education	5.85	2.41	2.43	.018
Contact with Health service for Head-Injury	4.61	2.58	1.79	.079

Supplementary Table 10

Linear regression models for Self Reported Cognitive Difficulties (RPQ(Cog))

	β	**Std Error**	**t**	**p**
		No of Head-Injuries		
Ethnicity	0.05	0.76	0.07	.944
Education	-0.83	0.78	-1.07	.289
SUD Severity	0.04	0.04	1.01	.317
Mental Distress	0.09	0.03	3.02	.004
No. of Head-Injuries	2.64	0.76	3.48	<.001
		TBI Severity		
Ethnicity	0.39	0.84	0.46	.648
Education	-0.56	0.86	-0.65	.517
SUD Severity	0.07	0.05	1.43	.159
Mental Distress	0.10	0.03	2.92	.005
TBI Severity	1.59	1.01	1.57	.122

Age of First Head-Injury				
Ethnicity	0.11	0.85	0.13	.898
Education	-0.82	0.86	-0.96	.340
SUD Severity	0.07	0.05	1.41	.164
Mental Distress	0.11	0.03	3.20	.002
Age of First Head-Injury	0.13	0.83	0.15	.880
Contact with Health Service				
Ethnicity	0.07	0.85	0.08	.937
Education	-0.66	0.91	-0.73	.469
SUD Severity	0.07	0.05	1.45	.154
Mental Distress	-0.11	0.03	3.30	.002
Contact with Health service for Head-Injury	0.69	1.01	0.68	.499

CHAPTER EIGHT

This chapter is in the form of a manuscript, which will be submitted to an academic journal for publication. It provides a review of how Social Cognition may be an important mechanism to consider in understanding the association between TBI and SUD. As discussed in chapter four, some of the statistical analyses in the subsequent manuscript have changed from the original plans stated in the research outline (see Chapter Four).

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Manuscript 4

Reading between the lines: The mediating role of Social Cognition on the relationship between Traumatic Brain Injury and Substance Use Disorder

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Abstract

A well-established relationship exists between Traumatic Brain Injury (TBI) and Substance Use Disorder (SUD). However, the mechanisms that may explain this relationship are not well understood. Both TBI and SUD have been linked to impairments in Social Cognition, suggesting that this construct may be a potential mechanism that explains the relationship between these conditions. This study aimed to examine the mediating role of Social Cognition on this relationship.

Participants were 70 adults (aged 18-64) admitted to a residential addictions treatment programme in Wellington, New Zealand. The Awareness of Social Inference Test-Short version (TASIT-S) was administered to assess Social Cognition. TBI risk and SUD severity scores were ascertained from questionnaires and interviews used to collect in-depth head-injury and substance-use histories. The indirect effect of the TASIT-S, and its subscales, on the relationship between these constructs were examined through meditation analysis.

Interpreting complex social inference as measured by the TASIT-S was found to mediate the relationship between TBI risk and SUD severity. More specifically, detecting deceitful exchange, and inferring what others are thinking, explained the mediating effect of complex social inference. No mediating effects were found for the Emotion Recognition or the minimal Social Inference subscales in the TAIST-S.

Difficulties in SC may be a mechanism that explains the relationship between TBI and SUD. This finding may be only evident for the interpretation of complex social cues, particularly those involving deception, and subtle social intentions. The cross-sectional design of this study precludes any inferences regarding causality in these relationships and future research would benefit from a longitudinal design to examine the influence of these constructs over time.

Keywords: social cognition, substance use disorder, traumatic brain injury

Substance use disorder (SUD) and traumatic brain injury (TBI) have a complex bidirectional relationship (Olsen & Corrigan, 2022). SUD is the abuse of substances resulting in maladaptive behaviour patterns, and significant impairment and distress (Sadock et al., 2015). Increased rates of accidental injuries occur alongside SUD (i.e., interpersonal violence and motor vehicle crashes) (Macias-Konstantopoulos et al., 2014), which increases the risk of sustaining a TBI for individuals with SUD (Albrecht et al., 2020). TBI occurs when brain function is altered due to external force to the head or neck (Carroll et al., 2004). This can precipitate cognitive, physical, psychological and social impairment (Barman et al., 2016). Furthermore, frontal brain regions are especially vulnerable to TBI (Loe et al., 2019). The scientific evidence suggests that functions located in the frontal lobe are crucial in the development, maintenance, and exacerbation of SUD (Ryan et al., 2021). Thus, TBI and SUD appear to be closely linked.

A myriad of factors have been implicated in the aetiology of both TBI and SUD that may influence the relationship between the two. Such variables include mental health disorders; antisocial behaviours; and social and environmental factors such as poverty, impaired family functioning, family history of alcohol use disorder (AUD) and family exposure to adverse life events (Max et al., 1998; McKinlay et al., 2010; Vasallo et al., 2007). Furthermore, the main substance to which an individual is addicted may also have a role (Hawley et al., 2018; Jacotte-Simancas et al., 2021). Thus, the relationship between TBI and SUD is complex, and causality is difficult to establish because of the many influential factors potentially involved (Olsen & Corrigan, 2022). To understand the link between TBI and SUD more clearly, Olsen and Corrigan (2022) argued that research in this area must examine underlying mechanisms that could explain the link between TBI and SUD. One mechanism that has been associated separately with each (Bosco et al., 2018; Quednow, 2020), and could explain the link between TBI and SUD, is Social Cognition.

Social Cognition refers to a range of cognitive functions that perceive, process and interpret social information (Quednow, 2020). Together these enable us to understand ourselves, predict the intentions and behaviour of others, modify and improve our social behaviours, and know how to interact appropriately in different social situations (Quednow, 2020). In the literature, the umbrella term Social Cognition has been used to describe a variety of abilities (Happé & Frith, 2014; Quednow, 2020). Three abilities are widely agreed upon (McDonald et al., 2003; Rodríguez-Rajo et al., 2022). These are emotion recognition, theory of mind (ToM), and social inference making (McDonald et al., 2003). Emotion recognition reflects the ability to perceive and understand others' emotions from gestural, facial and vocal cues in different situations (McDonald et al., 2003). Theory of mind describes the ability to take another's perspective, which first requires awareness that other people's mental and affective states, as well as beliefs and values may differ from one's own (Stuss et al., 2001). Subsequently this allows us to construct a mental representation of someone else's mental state (thoughts, feelings, beliefs), in a particular context (McDonald et al., 2003). Additionally, there is social inference making (alternative terms used to describe overlapping abilities include attributional style, meaning making, or social perception) (McDonald et al., 2003; Rodríguez-Rajo et al., 2022) which encapsulates the ability to integrate verbal and non-verbal cues, with contextual information, and social norms to make meaning (Rodríguez-Rajo et al., 2022). While we acknowledge that Social Cognition may be more complex than this and also involves making decisions about one's own behaviour, for the purposes of this study, the term Social Cognition will be used to refer to these facets focusing on interpreting the social world (McDonald et al., 2003). We rely on these abilities for optimal social functioning (Quednow, 2020). However, impairments in these abilities can increase interpersonal difficulties (Kornreich et al., 2017; Kornreich et al., 2002).

More specifically, socio-cognitive impairment comes with increased interpersonal conflict, trouble complying with social norms and trouble using social supports (Shany-Ur et al., 2012). Impairment in Social Cognition also increases the likelihood of experiencing negative emotions and other forms of psychological distress (Alvi et al., 2020). The implications of such social impairment may increase the risk that individuals will turn to substances as a maladaptive means of managing emotional distress (Carrigan & Randall, 2003). Over time and with reinforcement, this could lead to the development of SUD (Bora & Zorlu, 2017). In support of this, findings have emerged illustrating socio-cognitive impairments in a variety of addictive disorders (Kornreich et al., 2016; Quednow, 2020). Samples with cocaine, opioid, alcohol, and polysubstance use disorders have displayed impaired Social Cognition abilities, even after 6 months of abstinence (Bland & Ersche, 2020; Fernandez-Sarrano et al., 2011; Onuoha et al., 2016). However, while this impairment is present in SUD, the type, level, and effect sizes are inconsistent (Quednow, 2020). Other studies have discovered an absence of socio-cognitive deficit in alcohol and drug users (Amenta et al., 2013; Kemmis et al., 2007; Kim, Kwon & Chang, 2011), or only in the presence of other modulating factors such as ADHD (Preller et al., 2014; Wunderli et al., 2016). A possible explanation is that there may be important other factors that influence Social Cognition more than just SUD alone. A possible factor could be TBI.

Impairment in Social Cognition is a common consequence of TBI (Maggio et al., 2020). Individuals with TBI have shown moderate to severe deficits in Social Cognition, which is linked to right frontal lobe lesions, and these individuals may have particular difficulty recognising negative emotions in others (May et al. 2017). TBI-positive individuals have also been found to have lower empathy and lower facial and vocal affections, indicating possible impairment in processing emotional information (Neumann et al., 2012). Furthermore, individuals with TBI have shown reduced socio-cognitive performance in comprehending and producing sincere, deceitful and ironic communicative exchanges compared with controls, leading Bosco and colleagues (2018) to consider social skills training to be important in TBI rehabilitation. While the majority of studies have investigated socio-cognitive impairment following moderate and severe TBI, more recent literature has discovered deficits in Social Cognition even four years after mild TBI (Theadom et al., 2019). Brain regions which are vulnerable to brain injury and associated with socio-cognitive deficits (i.e., the pre-frontal cortex), are also important areas maintaining addiction (Happe & Frith, 2014; Volklow et al., 2011). Therefore, the interaction of TBI and Social Cognition in SUD should be explored.

In summary, although a relationship between TBI and SUD has been established, the underlying mechanisms that link TBI and SUD remain unclear. While impairment in Social Cognition has been linked separately to each TBI and SUD, limited research exists exploring Social Cognition in the presence of both. Furthermore, TBI can impair Social Cognition, and these associated brain regions may exacerbate substance addiction. Therefore, the overall aim of this exploratory study is to examine these relationships. The field would benefit from research exploring these factors simultaneously in multiple directions. However, the focus of this study will be to examine whether Social Cognition is a plausible mechanism by which TBI may impact SUD. This research may enhance the body of knowledge which implicates TBI in the development and maintenance of SUD. To achieve this, our first objective is to examine performance of Social Cognition in a sample of people with SUD and explore the association between socio-cognitive performance and history of TBI and head-injuries, as measured by a range of characteristics (i.e., frequency of lifetime head-injuries, severity of TBI, earliest head-injury age, injury treatment). Additionally, we endeavour to explore the association between Social Cognition performance and SUD, as measured by a range of substance using behaviours (i.e., age of onset of problematic use, durations of abstinence periods, SUD type, and previous SUD treatment attempts). In accordance with Social Cognition's proposed role as a mechanism, our second objective is to conduct mediation analyses to examine how different socio-cognitive facets (abilities of emotion recognition and social inference) may mediate the relationship between TBI and SUD. Finally, we are mindful of the complexities of this population and the evidence that factors other than Social Cognition, could influence the relationship between TBI and SUD. Thus, our final objective is to explore the associations between Social Cognition, TBI and SUD, and possible confounding variables. We are mindful that all possible confounders cannot be examined but we will attempt to begin by exploring demographic factors (ethnicity, education, gender and age), current mental health distress, and family history of SUD.

METHOD

The study was completed at the Wellington Salvation Army Bridge Programme and had their support. This project received ethical approval from the Massey Human Ethics Committee (SOA 21/28).

Participants

All clients admitted to a residential rehabilitation programme in Wellington between August 2021 and December 2022 were invited to take part in the study. Participants invited were adults aged

18 years and over and had received a DSM-5 diagnosis of a current SUD(s) of any kind (American Psychiatric Association, 2013). Individuals admitted to the programme were unable to reduce their use or symptoms associated with their SUD by utilising community supports, therefore requiring more intensive treatment. Participants with a diagnosis of schizophrenia were excluded from this study due to the confounding impact this diagnosis has on cognition. Additional exclusion criteria was significant cognitive impairment in which more comprehensive cognitive assessment would not be appropriate/ethical. This was determined by an individual scoring below 19 (out of a possible 30) in a Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) which was completed by the SUD treatment centre early in the participants stay. However, no participants scored below 19. Participation in the research did not impact the treatment the individuals received at the programme. All participants had been through substance withdrawal before being invited to participate, and a negative drug screen was collected from the programme before participation commenced and prior to the programme's completion of the MoCA.

Measures

Demographics: A questionnaire collected demographic information about age, ethnicity, gender, education history, and family history of SUD

SUD Severity Factor: A questionnaire was used in an interview, to assess lifetime substance use. This included: specific substances used/not used, what substances an individual has ever been addicted to in their life, ages at which an individual began using substances multiple times per week, and durations of any abstinence periods since the onset of their SUD (in the community, prison or other institutional settings). The SUD variables were categorised in the following manner: Addiction type (mono-substance or polysubstance addiction), age at onset of problematic substance use multiple times per week (childhood 10-13, adolescence 14-17, or adulthood 18+), previous SUD treatment attempts (0, 1-2, or 3+; where more treatment attempts reflects relapse despite trying to recover), and durations of abstinence periods achieved in the community (1 year or longer, between 10 days and 8 months, and never or only in prison or other restrictive institution). These four variables were coded to correspond with higher and lower SUD severity and combined to make a total “SUD severity score”. The variables coded as more severe were polysubstance use reflecting cross-addiction, earlier onset of SUD, more treatment attempts reflecting more repeated relapse despite intervention, and short total duration of lifetime abstinence periods. Possible scores range between 4 and 11 where higher scores reflect more severe SUD.

TBI Factor: An adapted self-report head-injury screening tool was used. This tool has previously been used in NZ samples and found to match well with medical records (Mitchell et al., 2017; Schofield et al., 2011). This collected information on the total number of head-injuries an individual had sustained in their lifetime, that caused them to feel “dazed, confused, or lost consciousness”. Additional details were collected for up to five injuries per person on: the age of their earliest head-injury and age at any subsequent head-injuries, whether loss of consciousness occurred and if so the duration unconscious, and whether any contact with medical services was sought for each injury, and if so what type of medical service. Head-injuries which did not feature LOC but were self-reported to cause feeling “dazed or confused” were categorised as ‘*possible TBI*’ as a mild TBI could not be confirmed in such cases. These injuries received the lowest score on the *TBI factor*. Head-injuries featuring LOC were classified as either a mild, moderate, or severe self-reported TBI. Severity of TBI was categorised by duration of loss of consciousness (National Academies of Sciences, Engineering and Medicine et al., 2019). This TBI factor is based solely off self-report and was not corroborated with medical records or family reports. The variables were categorised in the following manner: Lifetime head-injury frequency (1 (lowest score), 2-4, 5-7, 8+ (highest score), age at earliest head-injury (childhood 12 or younger (highest score), adolescence 13-17, or adulthood 18+ (lowest score)), worst lifetime head-injury severity (‘*possible TBI*’ without LOC (lowest score), mild TBI with LOC <30 minutes, moderate-severe TBI with LOC >24 hours (highest score)), having contact with a health service for a head-injury at least once in their lifetime (no (lowest score), yes (highest score, as receiving treatment is likely to correspond with a more severe injury). These items were coded on a scale of low to high risk, and combined together to make a total “TBI Factor” Score. A similar severity index factor for TBI has been used previously within a SUD population (McHugo et al., 2017). Possible TBI factor scores ranged from 4 (scoring a minimum of 1 on each variable reflecting lowest risk), to a maximum of 12 (reflecting higher risk).

Social Cognition*: The Assessment of Social Inference Test- Short version (TASIT-S; McDonald et al., 2003)* is a task-based measure of Social Cognition as reflected by three subscales; Emotion recognition, Social Inference- Minimal (SI-M), and Social Inference- Enriched (SI-E). The emotion recognition task evaluates individuals' abilities to detect a range of positive and negative emotions through 10 short videos. The following two social inference tasks evaluate affective and cognitive Theory of Mind, and ability to make inference of others actions and intentions in different ways. The SI-M task evaluates individuals' abilities to distinguish between sincere and sarcastic social exchange and draw social inference, by relying on facial, gestural, vocal and bodily cues. The SI-E task evaluates complex social inference making through individuals' abilities to distinguish between counterfactual social exchanges (deceit and sarcasm) by relying on cues provided in the SI-M task as well as additional contextual cues. Each of the Social Inference tasks shows nine short videos of interactions between two or more people. After each video the participant is asked multichoice questions about what the video characters were saying, doing, thinking, and feeling, and asked to provide either a "yes", "no", or "I don't know" answer. Determining the correct answers requires a combination of reading facial, body and vocal expressions, understanding points of view of each character, and integrating information into the social context. The TASIT-S takes 35-45 minutes to administer and is strongly correlated with the full TASIT, showing high item reliability (0.89-0.97) (Honan et al., 2016). This assessment tool of Social Cognition was chosen for its strong ecological validity (McDonald, 2013; Hynes et al., 2011; McDonald et al., 2004), and previous use in both TBI and SUD populations (McDonald et al., 2003; McDonald et al., 2013a; McDonald et al., 2013b). The TASIT-S has acceptable psychometric properties (Pinkham et al., 2016). This tool has been validated within an Australian population and has shown good utility in Western European participants (McDonald et al., 2017). The TASIT-S is yet to be validated in a New Zealand Māori population (Shostack, 2025). The tool has however been reported to have good cross-cultural and transdiagnostic use (Pinkham et al., 2025). Cut off scores for the TASIT-S can be found in the footnote of Table 2.

Mental Health Distress: The Depression, Anxiety and Stress Scale (*DASS-21; Lovibond & Lovibond, 1995*) is a 21 item self-report questionnaire which collects information on an individuals' level of mental distress over the past seven days. Mental distress is categorised into three subscales (depression, anxiety, and stress), each consisting of seven items such as "I felt down-hearted and blue" and "I found it difficult to relax". Participants are asked to rate their experience of each statement over the past week on a 4-point Likert scale from '0-Never, 1-Sometimes, 2-Often or 3-Almost always'. A total score can be derived for each scale of depression, anxiety, and stress. For the purposes of this study, the scores of the three subscales were combined to make a total score of '*current mental distress'* (higher scores reflecting more overall distress). The DASS-21 total score has shown good internal consistency (Cronbach's alpha= 0.92) in a SUD sample (Moska et al., 2023).

Procedure

Upon clients' admission to the SUD rehabilitation program and following their orientation, programme staff provided information to clients about this research and invited them to participate. All consenting clients were then referred by staff to the researcher, who subsequently met with the participant for the first time at the rehabilitation facility. The researcher completed the head-injury screen, demographic and substance-use screen, and the DASS-21 in one session with each participant during their 10-week stay at the programme. Completion of these questionnaires was staggered with breaks according to clients' needs accommodating for individuals' fatigue and concentration abilities. Subsequently, upon confirmation of a negative drug screen in the form of a urine sample, participants were invited to the second data collection session. During this session the researcher completed the TASIT-S with the participant. Sessions occurred in a private interview space at the rehabilitation facility.

Statistical Analysis

We used Pearson's correlations to examine the associations between Social Cognition scores (for each item and subscale), TBI factor scores, and SUD severity scores. Next, multiple linear regression was used to examine whether SUD severity scores were significantly predicted by each mediating variable (Social Cognition scores), whilst controlling for TBI factor scores. Mediation analysis was then used as evidence suggests that Social Cognition influences both SUD, TBI, and holds the potential to have a mediating influence on this relationship (Maggio et al., 2020; McDonald et al., 2013; Olsen & Corrigan, 2022; Quednow, 2020). While a potential mediating role of Social Cognition may exist in both directions, the focus of this study is to examine how TBI factors play a predictive role in impacting SUD behaviours through Social Cognition and exacerbating SUD. Therefore, this study will examine the potential mediating effect of Social Cognition solely in this direction. Mediation analyses were conducted using PROCESS for SPSS (Hayes, 2012) to evaluate the indirect effects of SC on the relationship between the predictor (TBI factor) and dependent variable (SUD severity scores). Mediation analyses were conducted for each score on the TASIT-S that was found to be significantly associated with SUD severity. Reliability of the mediation effects were assessed using the percentile (nonparametric) 95% confidence interval (CI) generated by a bootstrapping procedure, which is a computational nonparametric resampling technique, enabling estimates of population characteristics to be taken from the current sample (Mooney & Duval, 1993). A resample rate of 5,000 was used to avoid inflation of type 1 error rate (Preacher & Hayes, 2008; Fritz et al., 2012).

Finally, we examined the associations between scores of the TASIT-S, TBI factor and SUD severity, on the following: demographic variables (age, ethnicity, education history), current mental health distress, and family history of SUD. For continuous data (e.g., age, mental distress) Pearson's correlations were calculated. For categorical data (e.g., gender, ethnicity, education history, and family SUD history) independent sample *t*-tests were used as the data was normally distributed. All analyses were conducted on SPSS version 29.0.

RESULTS

The overall study consisted of 77 participants aged between 20-64 years old, with comorbid SUD and a history of sustaining at least one lifetime head-injury (18.2% experienced '*possible TBI*'/head-injury without LOC only. Of the 81.8% who had sustained at least one lifetime TBI with

LOC; 50.6% experienced mild TBI as their most severe injury; 26% experienced moderate TBI; and 5.2% experienced severe TBI). Table 1 provides a detailed summary of the characteristics of the sample. In brief, participants were more commonly male (68.8%), of Māori (46.8%) and NZ European (51.9%) ethnicity, who did not complete secondary school (66.2%). Just over half of the sample began using substances multiple times per week during adolescence (defined as SUD onset). In this sample, occurrence of the first lifetime head-injury more often preceded the onset of SUD (head-injury first; 74%, SUD first; 20.8%, Onset within the same year; 5.2%). Of the 77 participants, only 70 went onto complete the assessment of Social Cognition due to seven participants self-discharging from the SUD treatment early or being asked to leave the programme for various reasons.

Table 1

Demographic Factors, Substance Using Features, and Head-Injury Characteristics of the Overall Sample (N=77)

Demographics	N (%)
Gender	
Male	53 (68.8%)
Female	24 (31.2%)
Ethnicity	
Māori	36 (46.8%)
NZ European	40 (51.9%)
Unknown	1 (1.3%)
Highest Education	
Completed high school or above	26 (33.8%)
Did not complete high school	51 (66.2%)
Mental Health	M (SD)
Overall Mental Distress	16.4 (12.2)
Depression	4.4 (4.4)
Anxiety	5 (4.2)
Stress	7.1 (5.2)
SUD Characteristics	N (%)

Age at onset of SUD	
10 - 13	15 (19.5%)
14 -17	24 (31.2%)
18+	38 (49.3%)
Substance Type	
Polysubstance addiction	43 (55.8%)
Mono-substance addiction	34 (44.2%)
Previous AOD treatment attempts (community, prison or residential treatment)	
0	22 (28.6%)
1- 2	37 (48%)
3+	18 (23.4%)
Previous Abstinence Periods	
Never / only in prison or institutional facility	33 (42.8%)
10 days – 8 months in the community	26 (33.8%)
1 year or more in the community	18 (23.4%)
Family History of SUD (blood relatives)	
Yes	67 (87%)
No	10 (13%)
Head-Injury Characteristics	N (%)
# lifetime Head-Injuries	
1	7 (9.1%)
2-4	27 (35%)
5-7	15 (19.5%)
8+	28 (36.4%)
Worst TBI Severity	
Severe/Moderate TBI	24 (31.2%)
- Severe	4 (5.2%)
- Moderate	20 (26%)
Mild TBI with LOC	39 (50.6%)
'Possible TBI' Head-Injury without LOC	14 (18.2%)
Contact with health service for head-injury at least once	
Yes	55 (71.4%)

Never	22 (28.6%)
Age at earliest head-injury (years)	
12 or below	42 (54.5%)
13-17	17 (22.1%)
18+	18 (23.4%)
Order of Onset	
Head-Injury first	57 (74%)
SUD first	16 (20.8%)
Onset occurred within the same year	4 (5.2%)

Figure 1 and Figure 2 illustrates the distribution of TBI factor scores and SUD severity scores in the sample. The average TBI factor score was 8.57, with a minimum of 4, and maximum of 12. The mean SUD severity score was 7.40, with a minimum of 4 and a maximum of 11. Table 2 provides a summary of participants performance on the TASIT-S which includes total and subscale scores. Item scores within the Social Inference tasks (assessing recognition of what others are doing, saying, thinking, and feeling) as well as scores in recognising positive or negative emotions, are included in supplementary Table 2.

Figure 1

TBI Factor Scores for the Overall Sample (N=77)

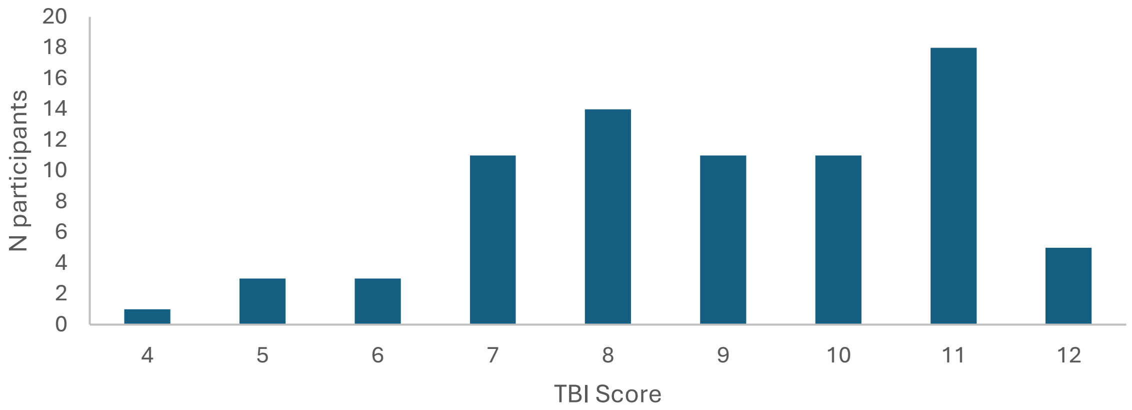


Figure 2

SUD Severity Scores for the Overall Sample (N=77)

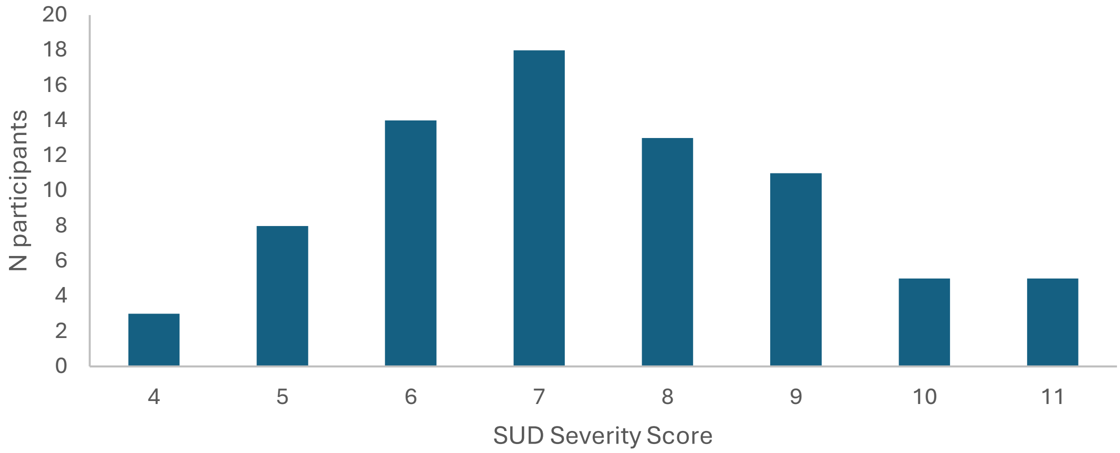


Table 2

Summary of Performance on the TASIT-S, a Measure of Social Cognition (n=70[1])[2]

TASIT-S	**Average**	**Min**	**Max**	**Highest possible score**
Emotion recognition				
Total	6.94	4	10	10
Social Inference: Minimal				
Sincerity	12.34	0	16	16
Sarcasm	16.53	7	20	20
Total	28.9	19	34	36
Social Inference: Enriched				
Lies	13.09	4	16	16
Sarcasm	15.57	9	20	20
Total	28.64	14	36	36

[1]Data for the TASIT-S could not be collected for seven participants of the overall sample, due to them exiting the programme for various reasons. [2]Cut off scores for age groups (16-19, 20-36, 40-59, and 60-74 respectively): Part 1: Below average (5, 6, 6, 5), Impairment (4, 6, 6, 5). Part 2: Below average (23, 26, 25, 23), Impairment (21, 25, 24, 22). Part 3: Below average (25, 24, 25, 24), Impairment (22, 24, 23, 24). While these cut off scores are provided as a reference, the focus of this exploration is not clinical impairment, but rather exploring whether significant relationships exist between Social Cognition performance, TBI and SUD.

As seen in Table 3, correlation analysis revealed five significant relationships between scores on the complex social inference (SI-E) task and SUD severity scores variable. Specifically, SUD severity was significantly negatively associated with item scores for recognising what others are saying (*r* (69) = -.25, *p*=.040), thinking (*r* (69) = -.31, *p*=.009) and feeling (*r* (69) = -.24, *p*=.048), the subscale for detecting deceit (*r* (69) = -.34, *p*=.004), and the total score for complex social inference

(r (69) = -.30, p=.011). Two of these scores on the complex social inference task were also significantly negatively associated with the TBI factor. Specifically, recognising what others are thinking (r (69) = -.37, p=.002), and total (r (69) = -.24, p=.046) scores. Additionally, a significant negative correlation was found between the TBI factor and the item score for recognising what others are saying, on the minimal social inference (SI-M) task (r (69) = -.29, p=.014). No significant relationships were found between scores on this task and SUD severity scores. No other significant relationships were observed with scores on tasks assessing minimal or complex social inference. No significant correlations were observed with the emotion recognition task scores (see supplementary materials). The TASIT-S scores that were significantly associated with the outcome variable SUD severity, were further examined using mediation analysis. An additional correlation analysis was conducted to examine the association between the combined TBI factor and the SUD severity score to investigate the presence of a direct effect, which was non-significant (r (76) = 0.132, p=.252). While this was non-significant, the empirical evidence discussed above provides a strong theoretical justification for conducting mediation analysis to examine whether Social Cognition may underlie the common cooccurrence of TBI and SUD (Davies et al., 2023; Kornreich, 2017; Marshall et al., 2022; McHugo et al., 2017; Quednow, 2020; West et al., 2011). The bootstrapping procedure used in the following mediations, examines the indirect effect (of X > M > Y) and does not require this total effect (X > Y) to be significant (Preacher & Hayes, 2008). Therefore, the decision was made to proceed with mediation analysis in an exploratory manner, using bootstrapping procedure in the absence of a significant direct effect of TBI factor scores on SUD severity scores.

Table 3

Significant Correlations between Social Cognition item and subscale scores, TBI Factor and SUD Severity Scores on the Minimal and Complex Social Inference tasks

	SI-M "say" [1]	SI-E "say"	SI-E "think"	SI-E "feel"	SI-E Lie	SI-E Total
TBI factor						
Pearson	-.29*	-.17	-.37*	-.18	-.20	-.24*
Sig (2-tailed)	.014	.167	.002	.140	.093	.046
SUD severity						

Pearson	-.15	-.25*	-.31*	-.24*	-.34*	-.30*
Sig (2-tailed)	.207	.040	.009	.048	.004	.011

* association significant p < .05 level. [1] While scores on this item of the TASIT-S were significantly correlated with TBI factor scores, it did not have a significant relationship with SUD severity scores, therefore this was not included in mediations.

Note. Additional non-significant correlations can be found in a supplementary results table.

Linear Regression

Multiple linear regression models were computed for each Social Cognition score (that had showed a significant correlation with SUD severity) to determine their predictive role on SUD severity scores. The combined TBI factor score was included in each model as a covariate (see Table 4). All assumptions for linear regression were met (see Chapter Five). As shown in Table 4, three Social Cognition scores were associated with SUD severity. Specifically, SUD severity score was significantly associated with inferring what others are *thinking* (β = -0.30, p = .018) and *lying* (β = -0.33, p = .006) and *total scores* (β = -0.29, p= .019) on the task assessing complex social inference making. No other Social Cognition scores were significantly associated with SUD severity scores.

Table 4

Linear regression models examining whether Social Cognition scores are significantly associated with SUD severity, whilst controlling for TBI factor scores

	β	**Std Error**	**t**	**p**
		SUD Severity Score		
SI-E Say	-0.23	0.16	-1.94	.057
TBI factor scores	0.09	0.13	0.74	.460
SI-E Think	-0.30	0.20	-2.42	.018*
TBI factor scores	0.02	0.14	0.13	.900
SI-E Feel	-0.22	0.15	-1.85	.069
TBI factor scores	0.09	0.13	0.73	.467
SI-E Lie	-0.33	0.08	-2.81	.006*
TBI factor scores	0.06	0.13	0.52	.604
SI-E Total	-0.29	0.05	-2.40	.019*
TBI factor scores	0.06	0.13	0.49	.626

* association significant p < .05 level.

Mediation effects of Social Cognition scores on the relationship between the TBI factor and SUD severity scores

The bootstrapped method (PROCESS) with *n* = 5000 bootstrap resamples and 95% bias corrected and accelerated confidence intervals was used in a mediation analysis to examine the indirect effects of Social Cognition (understanding what others are thinking, detecting lies, and overall scores in the complex social inference-making task), on the relationship between the TBI factor and SUD severity scores.

All three indirect effect models, with the TBI factor as a predictor and SUD severity scores as the outcome variable, showed a significant indirect effect of Social Cognition scores (inferring what others are thinking, when they are lying, and total task scores on complex social inference-making). Detailed results of each model are summarised in Table 5.

Table 5

Total, Direct, and Indirect effects of TBI Factor on SUD Severity Scores, using Social Cognition Scores as Indirect Effect

Y	X	m	a path coefficient	b path coefficient	Total effect (c)	Direct effect (c')	Indirect effect		
								CI (95%)	
							Effect (SE)	LCI	UCI
SUD Severity	*TBI*	*SIE Total*	-0.615*	-0.124*	0.141	0.065	0.076*	0.002	0.182
SUD Severity	*TBI*	*SIE Lie*	-0.313	-0.235*	0.141	0.067	0.074*	0.001	0.198
SUD Severity	*TBI*	*SIE Think*	-0.259*	-0.478*	0.141	0.018	0.124*	0.025	0.275

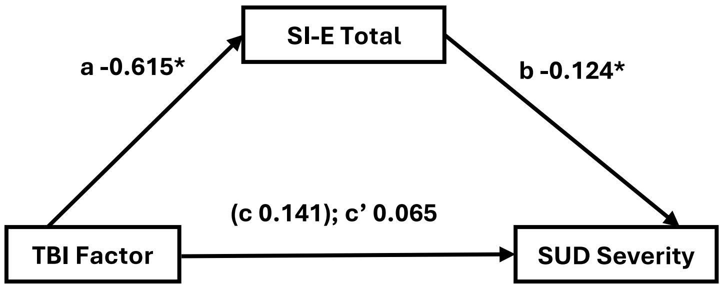
* $p < .050$

TBI factor, overall enriched Social Inference, and SUD severity scores

The full model showed a significant indirect effect of total scores for the complex social inference-making task, on the relationship between TBI factor and SUD severity scores (path $a \times b$; β = 0.076, LLCI = .002, ULCI = .182). On each respective path, the total score showed significant coefficients in both paths (see Figure 3). The total effect of TBI factor on SUD severity was not significant (*c* =0.141, *p* =.293), nor was the direct effect of TBI on SUD severity (*c'* = 0.065, *p* =.626), indicating a mediation. The model explained 9.4% of the variance on SUD severity.

Figure 3

Path Coefficients and Direct Effect of TBI Factor on SUD Severity, Mediated by Overall Social Inference Scores on the SI-E Task

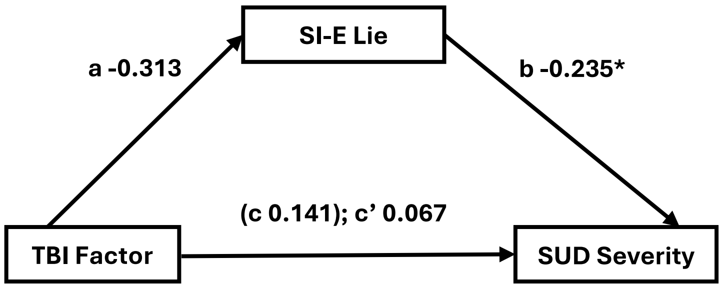


TBI factor, inferring deceitful exchange, and SUD severity scores

The full model showed a significant indirect effect of scores in detecting deceitful exchange, on the relationship between TBI factor and SUD severity scores (path *a* x *b;* β = 0.074, LLCI =.001, ULCI = .198) (within the complex social inference task). On each respective path, scores in detecting lies showed a significant *b* path coefficient, however the *a* path coefficient was non-significant (see Figure 4). The total effect of TBI factor on SUD severity was not significant (*c* =0.141, *p* =.293), nor was the direct effect of TBI on SUD severity (*c'* = 0.067, *p* =.604), indicating a mediation. The model explained 12% of the variance on SUD severity.

Figure 4

Path Coefficients and Direct Effect of TBI Factor on SUD Severity, Mediated by Lie-Subscale Scores on the SI-E Task

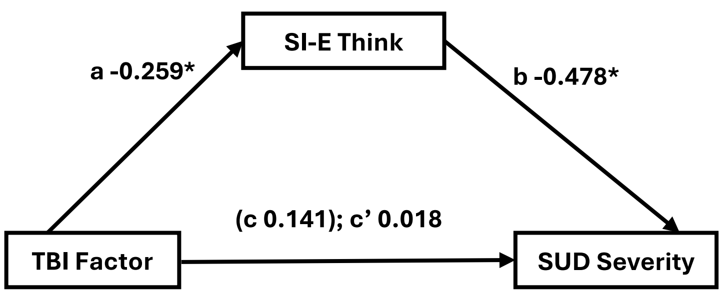


TBI factor, inferring others' thoughts, and SUD severity scores

The full model showed a significant indirect effect item scores for inferring others' thoughts, on the relationship between TBI factor and SUD severity scores (path *a* x *b;* β = 0.124, LLCI = .025, ULCI = .275) (within the complex social inference task). On each respective path, the scores on inferring what others are thinking (cognitive ToM), showed significant coefficients in both paths (see Figure 5). The total effect of TBI factor on SUD severity was not significant (c =0.141, p =.293), nor was the direct effect of TBI on SUD severity (c' =0.018, p =.900), indicating a mediation. The model explained 9.5% of the variance on SUD severity.

Figure 5

Path Coefficients and Direct Effect of TBI Factor on SUD Severity, Mediated by Think-Item Scores on the SI-E Task



Finally, to identify potential confounding variables (continuous; age, current mental distress, categorical; gender, ethnicity, education, and family history of SUD) that should be considered in future research, correlation analyses and independent sample *t*-tests were conducted to explore associations with predictor and outcome variables (TBI factor, TASIT-S scores, and SUD severity scores). These revealed a significant negative relationship between age and SUD severity score (r (76) = -.25, p =.030), indicating that being of younger age was associated with having higher SUD severity scores. Independent sample *t*-tests revealed a significant positive association between gender and the TBI factor (t (75) = 3.55, p <.001), indicating that being of female gender was associated with higher TBI factor scores. Additionally, a significant association was found between ethnicity and overall scores on the enriched social inference task (t (67) = -0.266, p= .010), indicating that being of Māori descent was significantly associated with higher overall scores on this task. No other significant associations were found (see Table 6).

Table 6

Correlations and independent sample t-tests between age, gender, ethnicity, education, mental distress and family SUD history, with the predictor (TBI factor), mediating (Social Cognition score), and outcome variables (SUD severity score)

Age	**Pearson's correlation**	**Sig (2-tailed)**				
TBI Factor	0.10	.387				
SUD Severity Score	-0.25	.030*				
SI-E think	-0.045	.710				
SI-E lie	0.003	.979				
SI-E total	-0.036	.768				
Mental Distress						
TBI Factor	0.173	.133				
SUD Severity Score	0.192	.095				
SI-E think	-0.066	.587				
SI-E lie	-0.127	.296				
SI-E total	-0.057	.642				
	T	**P (two sided)**	**Mean diff**	**Std. Error**	**Lower CI**	**Upper CI**

Gender						
TBI factor	3.55**	<.001	1.38	0.39	0.61	2.15
SUD severity score	1.20	.235	0.52	0.44	-0.35	1.40
SI-E think	-1.40	.167	-0.41	0.29	-0.99	0.17
SI-E lie	-1.13	.262	-0.74	0.65	-2.04	0.56
SI-E total	-1.41	.162	-1.52	1.07	-3.65	0.62
Ethnicity						
TBI factor	-0.59	.558	-0.23	0.39	1.01	0.55
SUD severity score	0.99	.326	0.41	0.42	-0.42	1.23
SI-E think	-0.79	.432	-0.22	0.28	-0.78	0.34
SI-E lie	-1.61	.111	-0.93	0.57	-2.08	0.22
SI-E total	-2.66*	.010	-2.54	0.95	-4.45	-0.63
Education						
TBI factor	-0.12	.904	-0.05	0.41	-0.87	0.77
SUD severity score	-1.15	.256	-0.49	0.43	-1.35	0.36
SI-E think	0.34	.734	0.10	0.29	-0.48	0.68
SI-E lie	-0.40	.693	-0.26	0.65	-1.55	1.04
SI-E total	0.80	.426	0.86	1.07	-1.28	2.99
Family SUD History						
TBI Factor	-0.14	.887	-0.08	0.58	-1.23	1.07
SUD Severity Score	-0.30	.768	-0.08	0.28	-0.64	0.47
SI-E think	-0.09	.933	-0.03	0.39	-0.82	0.75
SI-E lie	-0.65	.517	-0.57	0.87	-2.30	1.17
SI-E total	-0.85	.399	-1.22	1.43	-4.08	1.65

** p < .001 , * p < .050

Discussion

The overall objective of this study was to examine the role of Social Cognition as a possible mechanism that explains the link between TBI and SUD. Before discussing our findings, it is worth noting that the majority of this sample (74%) sustained at least one TBI before the onset of their SUD. This supports the directionally of our analysis in which we stipulated TBI as the predictor and SUD as the outcome. Based on the mediation analyses we found that Social Cognition may indeed be an important factor explaining the relationship between TBI and SUD. More specifically, our analyses revealed that the following facets of Social Cognition significantly mediated this association: a) integrating information of social context, norms, verbal and non-verbal cues, b) perspective taking and understanding what another is thinking, and c) detecting deceitful exchanges. Additionally, where these three indirect effects were significant, direct effects between TBI and SUD were not significant, indicating a mediation. This exploration was theoretical, given the non-significant direct effect between the TBI and SUD factors, these findings provide tentative evidence for the possibility of Social Cognition as a mediator. These findings indicate that substance-addicted individuals with more risky TBI histories may have increased difficulty interpreting social information, which potentially mediates the severity of their SUD behaviours. In other words, our findings suggest that abilities in social inference-making may explain a significant portion of the relationship between TBI and SUD.

This study appears to be the first to explore the role of Social Cognition as a mediating factor in the presence of comorbid TBI and SUD (Davies et al., 2023; Olsen & Corrigan, 2022). The current findings emphasise the importance of considering Social Cognition when examining comorbid TBI and SUD, as well as considering TBI risk factors when examining the relationship between Social Cognition and SUD. A small number of studies examining Social Cognition in SUD, have attempted to control for the presence of a TBI and found no impact. However, TBI in these samples was either found at very low rates (6%), was limited to identification of severe TBI or TBI with LOC only, or limited information on identification and rates of TBI were reported (Foisy et al., 2005; Kornreich et al., 2003; McDonald et al., 2013). The possibility exists that many TBIs in SUD populations are unrecognised due to low seeking of medical attention (Corrigan et al., 2012). Therefore, variations in TBI histories across samples may explain varied findings about the profile of Social Cognition in SUD, when TBI has not been accounted for (Quednow, 2020).

Interestingly, the only elements of Social Cognition that mediated the relationship between TBI risk and SUD severity were scores from the enriched social inference task. Neither abilities in social inference as measured by the minimal task nor scores on the emotion recognition task were found to mediate this relationship. Both social inference tasks rely on abilities of ToM and drawing meaning from verbal and non-verbal cues (McDonald et al., 2003). The minimal task involves interpreting sincere and counterfactual exchanges (sarcasm). Whereas the enriched task is comprised totally of counterfactual exchanges, where the literal meaning of the words spoken are contradicted by the context (through either sarcasm or lies) (McDonald et al., 2003). In the enriched task, each scene includes extra visual or verbal clues about the context which reveal the contradiction and the true nature of the interaction (i.e., someone is joking, sarcastic, or lying). The creators of the TASIT-S, McDonald et al., (2003) described that the extra cues included in the SI-E task should assist comprehension of the social situation, because they add information about the beliefs and knowledge of the speakers. However, the additional information from another source requires a higher level of cognitive resource to integrate. Therefore, individuals with socio-cognitive deficit may be distracted rather than aided by this information, leading to interference with inference making (McDonald et al., 2003). The relationship between TBI and SUD was mediated by the enriched (SI-E) task, but not the minimal (SI-M) task nor the emotion recognition task. More specifically, the only significant mediators were lower scores in a) perspective taking and understanding what another is thinking, and b) detecting deceitful exchanges, while being required to integrate counterfactual information from the social context, norms, verbal and non-verbal cues. This indicates that reduced performance in integrating conflicting cues which is required by the enriched task, especially when another is trying to conceal information, is an important ability which may be associated with SUD severity after TBI (McDonald et al., 2004; McDonald & Flanagan, 2004). The increased difficulty with social inference and integrating information, may make substance users with complicated TBI histories more susceptible to conflicted interpersonal relationships, or social avoidance due to diminished reward being derived from pro-social experiences (McDonald et al., 2003; Maggio et al., 2020; Preller et al., 2014; Quednow, 2017; Quednow, 2020; Verdejo-Garcia, 2014). This could be due to increased misinterpretation of social interactions and others unspoken thoughts, intentions, motivations and agendas, caused by the deficit in Social Cognition (McDonald et al., 2013). These results indicate that inference making is an important skill which is vulnerable to TBI, and difficulties in this may be driving substance abuse. This holds important implications for TBI and SUD treatment.

Finally, when aiming to achieve the objectives of this study, we were mindful of the complexities of this population and the evidence that other factors could impact the relationships between TBI, Social Cognition and SUD. Therefore, we conducted exploratory correlational analysis to identify some possible confounding variables. In regards to demographic characteristics, we found that being of female gender was associated with higher scores on the TBI factor. The evidence pertaining to the impact of gender on TBI is mixed, but there is evidence that females may be at a heightened risk (Mollayeva et al., 2018). Being of younger age was associated with increased SUD severity scores, indicating an earlier onset of substance misuse, more different substances addicted to, more treatment attempts followed by relapse, and less time abstinent over the lifetime. Older age may allow more time for individuals to achieve longer abstinence periods as the trajectory of antisocial behaviour as well as substance use is projected to drop (Moffitt, 1993; Royle & Connolly, 2024). Worse overall severity of SUD characteristics in younger individuals may reflect the increased accessibility to a variety of illicit substances in more recent years, in turn making it easier for younger individuals to access these substances at younger ages compared to the previous generation (Ministry of Health, 2024). Additionally, being of Māori descent was associated with better overall performance on social inference enriched task than being of NZ European descent. These findings do need to be treated with caution given the small size and the fact that the TASIT-S is yet to be validated for use with NZ Māori. Our findings do however suggest that when examining these relationships, it is important that future research consider the possible impact of confounding variables such as gender, age, and ethnicity.

In summary, this study provides novel insights into a possible mechanism that could explain the relationship between TBI and SUD; Social Cognition. This provides direction for addictions treatment and indicates there could be benefits in including rehabilitation techniques that aim to address Social Cognition deficits (Togher et al., 2023; Pettersen et al., 2019). These findings also indicate that screening for a TBI history is important in SUD contexts to identify individuals who may be more at risk of socio-cognitive deficit and increased SUD morbidity. Our findings suggest that substance addicted individuals with a more complicated TBI history may be more at risk of misunderstanding the social world. Therefore, assessing Social Cognition in individuals who have previously sustained a TBI may inform treatment strategies. An increased risk of misunderstanding social interactions is likely to have negative impacts on navigating group treatment environments and forming new pro-social relationships that are needed for recovery from SUD (McDonald et al., 2003; Maggio et al., 2020; Preller et al., 2014; Quednow, 2017). Social Cognition deficits may also negatively impact treatment seekers perceptions of important treatment principles. Potential avenues for exploration may include staff of addictions rehabilitation aiding clients understanding by explaining treatment information in a literal manner, overtly naming ideas without sarcasm, hinting or joking which could be misunderstood (McDonald et al., 2013). This may reduce misinterpretation of nonverbal information. Assessment and treatment of social inference making abilities may be beneficial to administer in SUD rehabilitation contexts, as well as in TBI rehabilitation. Social skills training interventions are available to help improve social behaviours (Dahlberg et al., 2007).

The findings of this study do need to be treated within the context of their limitations. First, while social inference and emotion recognition were examined in this study, a number of other abilities exist which are included in the “Social Cognition umbrella” that were not examined here (Quednow, 2020). Further exploration of other abilities included in the Social Cognition umbrella relating to social output and behaviours (i.e., moral decision making), in the presence of both TBI and SUD would be beneficial to examine. Second, these current findings do not indicate causation or directionality. Further research is still needed to determine whether reduced social inference abilities arise after SUD onset, or if they are pre-existing (Quednow, 2020). Adopting a longitudinal design so that these relationships can be examined over time will be imperative in this endeavour. Furthermore, correlation analysis revealed that TBI factor scores were not significantly associated with SUD severity scores. While the bootstrapping method for mediation does not require the total effect to be significant as a precondition (Preacher & Hayes, 2008), the possibility of type 1 error still exists. The significant mediations found should be treated with caution and investigated further. Third, TBI and head-injuries in this study were self-reported. Future research would benefit from replicating these results with methods where TBIs can be verified through medical records or family reports. Fourth, our sample size was relatively small. Whilst we were cognisant of the potential impact of confounding variables in our analysis, we were only able to examine these through correlational analysis. A larger powered study with a greater sample size is needed so that these variables can be controlled for within the mediation analysis. Utilizing structural equation modelling in future research with larger samples would be beneficial to simultaneously examine various confounds. Finally, we also acknowledge many other potential confounding factors (e.g., history of psychological trauma, ADHD) were not considered in this study and are worthy of future exploration when examining the relationships between TBI, Social Cognition and SUD. Factors such as ADHD, ASD, and personality disorders have been associated with socio-cognitive difficulties (Bölte, 2025; Çiray et al., 2022; Herpertz & Bertsch, 2014) and have been linked to increased risk of both TBI and SUD (Biederman et al., 2015; Köck & Walter, 2018; McDermott et al., 2008; McHugo et al., 2017; Moley et al., 2022; Walhout et al., 2022; Zulauf et al., 2014). While this study focused on exploring the plausibility of social cognition as a mediator, exploring mediations between TBI, SUD and SC in other directions is also important.

In conclusion, these findings provide preliminary evidence that Social Cognition may play an important role in explaining the relationship between TBI and SUD severity in individuals with a SUD. We have found indications that difficulty integrating social information and correctly inferring others' thoughts and intentions, may put individuals with a complicated TBI history at heightened risk of more severe SUD. These individuals may be more disadvantaged in understanding social situations which has the potential to interfere with their SUD rehabilitation. Social inference making and integrative abilities may be important factors to rehabilitate after a brain injury and in SUD contexts, in order to reduce barriers to recovery for individuals suffering from SUD. Future research should explore Social Cognition alongside a continuum of TBI and SUD factors, whilst controlling for other factors implicated in these relationships. This may aid in informing clinical practise and intervention development for SUD treatment.

Supplementary Materials

Supplementary Table 1

Non-Significant Correlations between Social Cognition item and subscale Scores, Predictor and Outcome Variables

	EmoRec (pos)	EmoRec (neg)	EmoRec Total	SI-M "think"	SI-M "feel"	SI-M "do"	SI-M Sincere	SI-M Sarcasm	SI-M Total	SI-E "do"	SI-E Sarcasm
TBI factor											
Pearson	.05	.04	.07	-.13	-.14	-.12	-.18	-.12	-.23	-.07	-.17
Sig (2-tailed)	.673	.731	.592	.283	.247	.344	.131	.339	.059	.544	.150
SUD severity											
Pearson	.13	.10	.16	12	-.01	.14	.01	.02	.03	-.16	-.14
Sig (2-tailed)	.275	.397	.175	.315	.925	.267	.918	.866	.804	.200	.257

Supplementary Table 2

TASIT-S Item Scores

	Average	Min	Max
Emotion recognition			
Pos	1.34	0	3
Neg	5.6	3	7
Social Inference: Minimal			
Do	7.63	5	9
Say	6.87	4	9
Think	7.16	5	9
Feel	7.24	4	9
Social Inference: Enriched			
Do	7.23	4	9
Say	7.21	4	9
Think	7.63	4	9
Feel	6.57	2	9

CHAPTER NINE

Overall Discussion

Summary of aims

The overall aim of this thesis was to conduct an in-depth exploration of the relationship between Substance Use Disorder (SUD) and Traumatic Brain Injury (TBI), in Aotearoa New Zealand. While the two conditions frequently cooccur, the mechanisms underlying this bidirectional relationship, are not fully understood (Olsen & Corrigan, 2022; West, 2011). Each is associated with deficits in neuropsychological functioning, including Social Cognition (McDonald et al., 2013; Quednow, 2020). These impairments may be contributing to the development and maintenance of SUD (Quednow, 2020). However, limited research exists exploring all these conditions simultaneously (Davies et al., 2023). Therefore, after reviewing the existing literature, this thesis aimed first to explore rates and characteristics of head-injuries (including self-reported TBI and '*possible TBIs*') among individuals in SUD treatment. Implications of substances being involved in the head-injuries were also explored. Second, this thesis aimed to explore associations between the head-injury characteristics and outcomes of general cognition in the SUD sample. Third, the thesis aimed to examine the role of Social Cognition as a possible mechanism involved in explaining the link between TBI and SUD. These aims were undertaken whilst considering relationships with potential confounding factors; demographics, mental distress, and substance use behaviours.

Main findings

This thesis identified extremely high rates of self-reported TBI with LOC (81.8%), and multiple lifetime head-injuries (91%) in a sample of SUD treatment users in NZ, compared to previously studied international SUD samples (Corrigan & Deutschle, 2008; Davies et al., 2023; Hillbom & Holm, 1986; McHugo et al., 2017). 100% of participants self-reported a lifetime head-injury event. Head-injury events which involved substances, increased the risk of accidental injuries and TBIs with longer LOC duration, especially for females and higher educated individuals. These findings were consistent with the large body of research implicating substance abuse as a factor increasing risk of TBI with problematic outcomes (Corrigan, 1995; Davies et al., 2023; Felde et al., 2006). Using substances multiple times weekly in adolescence, and noncompletion of secondary school were identified as risk factors for sustaining a high number of lifetime head-injuries, which was operationalised for this thesis as five or more head-injuries. Sustaining a high number of lifetime head-injuries predicted greater executive dysfunction, and more self-reported cognitive difficulties. Executive dysfunction, particularly delay discounting, cognitive disinhibition and impulsivity in decision-making has previously been found to negatively impact individuals' ability to maintain abstinence from substances (Stevens et al., 2014). Thus, our findings suggest that individuals cumulative head-injury histories may have important implications for recovery from SUD.

No other singular head-injury characteristics were found to predict poorer outcomes of general cognition (attention, memory, language, visuospatial functioning, executive functions), despite indications from previous research that these may be impactful factors for cognitive and substance using outcomes (Beaulieu & Ouellet, 2017; Corrigan et al., 2012; Hillbom & Holm, 1986). This may be reflective of the large proportion of the sample who had sustained either mild self-reported TBIs (50.6%) or a head-injury without LOC (18.2%) as their most severe injury. While males of NZ European descent were more at risk of sustaining head-injuries at an earlier age, we found no impact of this characteristic (age at earliest head-injury) on general cognition. Additionally, we found no indication that contact with health care promoted better scores of general cognition than having no contact. While brief primary healthcare (GPs, nurses, very short hospital stays) was the main care sought after a head-injury, it was done so at low rates (36.1% of events). The lack of findings regarding the effect of treatment on general cognition, may in part reflect the extremely low engagement with specialist brain injury services (0.7% of events), despite 10% of events being classified as either moderate or severe TBIs (8.6% and 5.2% respectively). The final characteristic, TBI severity; assessed by duration of loss of consciousness (LOC; Corrigan et al., 2010), also had no significant impact on outcomes of general cognition. While these head-injury characteristics are typically regarded as important in healthcare settings (Al-Hassani et al., 2018; Corrigan et al., 2012; Rabinowitz & Levin, 2014), our limited findings of their impact on general cognition provide support for previous trends that cumulative lifetime TBI history may be a more relevant prognostic marker for cognitive outcomes, and treatment needs (Corrigan et al, 2012; de Souza et al., 2024; Lasry et al., 2017; Walker et al., 2007). This highlights the need for both SUD and TBI treatment services to consider individuals lifetime history of recurrent head-injuries/TBIs, rather than only focusing on the characteristics of the single most recent injury (de Souza et al., 2024). While the second study found no effect of TBI severity on the general cognitive outcomes measured, previous research has identified that TBIs of greater severity are associated with other unfavourable outcomes (i.e., increased mental and physical fatigue, depression, insomnia and pain, as well as reduced activity and employment) (Beaulieu & Ouellet, 2017). Therefore, finding that 31.2% of sample had sustained either a moderate or severe lifetime TBI is still alarming. This research shows that in New Zealand there is a gap in providing TBI services to those who are likely to need them, as the majority of the injuries in SUD samples go untreated (Corrigan et al., 2012; Gavett, Stern & McKee, 2011; McAllister, 2011). Primary health services in NZ may be a brief window of opportunity where education facilitating TBI recovery may be improved on, in attempt to mitigate the potential burden of TBI in substance users.

For the final study, the head-injury characteristics were combined to make a cumulative *TBI risk factor,* enabling exploration of how Social Cognition mediates the relationship between someone's cumulative head-injury and TBI history and their substance using behaviours (also combined into a *SUD severity factor)*. This revealed that Social Cognition may be an important area of cognition to explore further in understanding the relationship between TBI and SUD. Lower scores on a task of social inference making (perspective taking and understanding what another is thinking, and detecting deceitful exchanges, whilst integrating conflicting information of social context, norms, verbal and non-verbal cues) mediated the relationship between the *TBI risk factor* and the *SUD severity factor*. Substance-addicted individuals with more complicated head-injury and TBI histories had increased difficulty interpreting social information, which mediated the severity of their SUD behaviours. Such that greater difficulty with social inference predicted greater severity of the SUD behaviours. While we found these significant effects, it remains unclear whether the difficulty with social inference-making was predicted by a combination of variables comprising this factor (multiple events from an early age, longer duration of unconsciousness, and less contact with health services), or by one variable within the *TBI risk factor*. While findings were limited regarding general cognition and separate head-injury characteristics within SUD, this may not be the case when investigating the impacts of separate head-injury characteristics on Social Cognition. These findings suggest that further exploration into the impacts of separate head-injury characteristics on Social Cognition may be worthwhile. Additionally, Social Cognition warrants further exploration as a mediating factor in the relationship between TBI and SUD. Difficulty with Social Cognition may contribute to increased social conflict and subsequently may increase the chance of interpersonal violence, and TBI (de Souza et al., 2024; McDonald et al., 2003). This may be even more likely when combined with substance abuse and executive dysfunction (as seen in this sample) which are associated with emotional dysregulation, anger, aggression and externalising behaviours (Arabacı etal., 2018; Felde et al., 2006; Krämer et al., 2011; Noël, Brevers & Bechara, 2013; Perron & Howard, 2008; Rohlf et al., 2018). Assault was responsible for a causing a large proportion of head-injuries in this sample. This highlights the importance of further research into interpersonal violence occurring in NZ SUD populations (Mitchell et al., 2017). Exploring the possible contribution of Social Cognition to this phenomenon may also be informative.

Clinical Implications

The findings of this thesis highlight the importance of screening for history of head-injuries including TBIs in SUD treatment settings to identify individuals with a history of repeated injuries. Our findings suggest individuals with such histories may be more at risk of executive dysfunction, and self-reported cognitive difficulties. These difficulties are likely to be occurring at high rates in SUD populations, especially among males who did not complete high school and used substances regularly in adolescence. This may make them more vulnerable to difficulty with treatment engagement, compliance and progress (Burg et al., 2000; Lasry et al., 2017; Stevens et al., 2014). SUD rehabilitation providers would benefit from screening for these risk factors. Adolescents who are using substances multiple times per week and are not completing high school are at increased risk of sustaining a high number of head-injuries and experiencing greater executive dysfunction, self-reported cognitive difficulties, and potentially also greater difficulty with social inference making. These factors may increase their difficulty regulating their substance use and make them more vulnerable to suffering from a SUD in adulthood (Stevens et al., 2014; McKinlay et al., 2014). Therefore, adolescence is a critical stage for intervention. Education is important for teachers, youth workers, adolescent community groups, and parents so they can recognise and respond appropriately to signs of risky substance use, brain injury, and seek the appropriate help (McKinlay et al, 2014).

The increased difficulty with Social Cognition seen among substance users with more “risky” head-injury histories, likely makes them more susceptible to conflicted interpersonal relationships, or social avoidance due to diminished reward being derived from prosocial experiences (McDonald et al., 2003; Maggio et al., 2020; Preller et al., 2014; Quednow, 2017; Quednow, 2020; Verdejo-Garcia, 2014). The increased risk of misunderstanding social interactions is likely to have negative impacts on navigating group treatment environments and forming new pro-social relationships that are needed for recovery from SUD (McDonald et al., 2003; Maggio et al., 2020; Preller et al., 2014; Quednow, 2017). This may contribute to perpetuating substance abuse as we found lower scores in social inference-making predicted greater severity of SUD behaviours, as well as potentially contributing to the high levels of interpersonal violence causing head-injuries in this sample (Heleniak & McLaughlin, 2020). Therefore, SUD treatment centres may benefit from including rehabilitation techniques that aim to provide training for Executive Functioning and Social Cognition deficits (Togher et al., 2023). Drawing on the field of TBI rehabilitation could be particularly helpful for these individuals to introduce cognitive strategies (i.e., the Goal Management Training for executive dysfunction, and Social Skills Training interventions which are available to improve social behaviours), that could increase their chances of treatment success (Dahlberg et al., 2007; Levine et al., 2012).

Limitations and Future Research

The tools used to assess cognitive domains; the S-NAB and the TASIT-S, have not yet been validated for use with NZ Māori. These tools have been constructed and validated within a Western

European culture, and evidence suggests that indigenous populations including Māori may be disadvantaged on Western assessments when culture is not considered (Dudley, Wilson & Barker-Collo, 2014; Ogden, Cooper, & Dudley, 2003; Ogden & McFarlane-Nathan, 1997). This may vary depending on cultural affiliation, linguistic diversity, education experiences, and other factors (Agranovich & Puente, 2007; Holdnack & Weiss, 2013; Walker, Batchelor & Shores, 2009). Validation studies should be conducted in NZ Māori population as next steps to ensure the findings are appropriate to apply to the NZ context and indigenous people of Aotearoa.

While self-report methods of TBI history do not have the same limitations as reliance on medical records, such as underreporting (Corrigan & Bogner, 2007; Davies et al., 2023), they bring limitations of their own. These include being subject to recall issues, such that earlier-life or childhood injuries may have been forgotten, or TBIs from more traumatic circumstances may have been omitted due to a desire to avoid recounting traumatic experiences (Seifert, 2012). Additionally, details surrounding the events, such as durations of LOC and mechanism of injuries were not able to be verified by medical records or collateral reports. This is especially important when considering the large number of head-injury events reported which did not feature LOC, and the inability to verify whether these were mild TBIs or head-injuries which did not injure the brain, with the current methods. Confidence in the current findings surrounding the rates and characteristics of TBIs, could be increased through additional research gathering reports of TBIs using both self-report methods and supplementation with collateral information from health records or families. The current participant sample was limited to substance users from rural and urban areas in the central to lower North Island region, who have successfully accessed residential SUD treatment. Different barriers and opportunities are known to exist regarding SUD treatment access and provisions, between rural and urban communities (Pearce et al., 2008; Pullen & Oser, 2014). Therefore, these findings may not be generalisable to all groups of individuals across NZ who are struggling with SUD. In conducting future research, it may be beneficial to invite participants from a variety of regions throughout the north middle and southern areas cities and rural areas of NZ to ensure fair representation of the wider country (Pearce et al., 2008). Exploration of comorbid TBI, substance abuse, and Social Cognition in homeless or prison populations may also be of value to substantiate the findings in a SUD sample who may not have had access to addictions treatment (Gargaro & Gerber, 2016).

The current sample size was relatively small, which limited the amount of potential confounding variables (i.e., family history of SUD, mental distress, demographic factors) that were able to be included within regressions in the studies. The first and second studies identified some factors associated with head-injury characteristics which may be important to control for in future research (gender, age, ethnicity). However, in the third study these were not included in the mediation analysis as control variables, due to statistical power. Furthermore, TBI and SUD share many additional risk factors which were not within the scope of this study but would be equally important to consider in future research examining mechanisms which may link TBI and SUD. Additional important confounders to consider in such research may be adverse childhood experiences, commonly comorbid disorders categorised in the DSM-V (such as bipolar-type disorders, ADHD, borderline or antisocial personality disorders, or history of psychological trauma) a risk-taking personality trait, or socioeconomic and parenting factors (i.e., parental personalities, mental health conditions, or parenting styles) (Alhammad et al., 2022; Olsen & Corrigan, 2022; Walker et al., 2007). For example, executive dysfunction, impulsivity and increased risk-taking behaviours which are characteristic of ADHD, personality disorders, and bipolar-type disorders, all increase the risk of sustaining a TBI and developing a SUD (Alhammad et al., 2022; American Psychiatric Association, 2013; Santucci, 2012). Research in a larger powered study, with a greater sample size would enable these potential confounding factors to be considered whilst exploring relationships between TBI, SUD and Social Cognition. Furthermore, research is still needed to determine directionality in the role of Social Cognition, and whether reduced social inference abilities arise after SUD onset and are mostly involved in perpetuating the disorder, or if it is a predisposing factor, or both (Quednow, 2020). Longitudinal studies following participants throughout their lives from early childhood may be beneficial to examine directionality. Examining potential confounders (i.e., the family environment, or attachment) over the lifespan while using a longitudinal design may also give helpful insights into the relationships between TBI, SUD and Social Cognition over time.

Conclusions

This thesis identified rates, patterns, and outcomes of head-injury including TBI among a SUD sample which indicate a substantial burden of TBI in SUD that often goes untreated. Routine screening of risk factors for increased cognitive difficulties should be undertaken in SUD treatment settings. Addictions rehabilitation services should draw upon the TBI treatment field to offer appropriate cognitive training programmes available to those suffering from difficulties with executive dysfunction and social inference making. This may contribute positively to mitigating lasting effects of repeated TBI in individuals looking to recover from SUD.

CHAPTER TEN

Personal Reflection

This thesis was completed as part of my Doctoral degree. I will briefly reflect on learnings I have made throughout the Doctoral journey, which will inform my practice as a clinical psychologist. I am sure I will continue to reflect on this research and grow from the experience of completing it, long after it is finished.

In the final few months of completing this thesis, I began work in an intensive brain injury rehabilitation centre for moderate and severe brain injuries. Through this research, the learnings I gained on the signs and symptoms of Social Cognition impairment, improved my clinical ability to recognise individuals who may display such deficits in a brain injury rehab setting, and knowledge of assessment and treatment options that may be of benefit. This improved my clinical practise to provide recommendations for community treatment provisions for patients leaving our service (i.e., such as social skills training (Dahlberg et al., 2007). This Doctorate has also equipped me to better understand complexities that may arise in formulation and treatment planning for individuals who present to brain injury services with pre-existing patterns of substance misuse, which I believe has strengthened my clinical practice and ability to provide psychoeducation to patients, families and coworkers. In this way, this Doctorate has helped me be an evidence-based practitioner as I am familiar with a body of research that is relevant to the area of my work.

Reading literature which highlights the variability in cognitive impairment and recovery after brain injury of different severities, as well as the literature on the involvement of many other factors, has reinforced the sense of wonder and amazement I feel when considering the brain! The human brain is a remarkable part of God's creation, mysterious, and humbling. When I research it and consider all we know, it reminds me how complex an organ it is, and how great God's glory is that He knows and creates each human and their brain. Equally, when considering all that we do not know about the brain, and the questions and confusion that remains in the literature, it is humbling to contrast our lack of knowledge with God's wealth of it. In this way, the experience of completing a

Doctorate in this topic, has strengthened my faith and trust in the God of the Bible. It has increased my desire to disciple under Jesus in doing life his way, because he knows so much, and I (as well as humanity) know so little. I am reminded of two scriptures which showcase God's care, love, and craftmanship of each human, and how nature points to truth about God. To me, the brain also teaches about Him in the same way:

Psalm 139:13-18 "You made all the delicate, inner parts of my body and knit me together in my mother's womb.[14] Thank you for making me so wonderfully complex! Your workmanship is marvelous—how well I know it. [15] You watched me as I was being formed in utter seclusion, as I was woven together in the dark of the womb. [16] You saw me before I was born. Every day of my life was recorded in your book. Every moment was laid out before a single day had passed. [17] How precious are your thoughts about me, O God. They cannot be numbered! [18] I can't even count them; they outnumber the grains of sand! And when I wake up, you are still with me!"

Psalm 19:1-4 "The heavens proclaim the glory of God. The skies display his craftsmanship. [2] Day after day they continue to speak; night after night they make him known. [3] They speak without a sound or word; their voice is never heard. [4] Yet their message has gone throughout the earth, and their words to all the world."

The combination of a) contemplating literature on the complexities of the brain after injury, how cognition, recovery, and our social behaviours may be influenced by many factors, b) hearing the participants life-experiences, and c) seeing patients recover from brain injury and make significant gains in the brain injury rehabilitation service where I have had the recent pleasure of working, has reinforced to me how resilient the brain is after injury, and the hopefulness of existing interventions which can be offered in both the SUD and TBI rehabilitation contexts. I feel incredibly grateful to have heard the life-experiences of the participants in this project, about the evolution of their substance use, and brain injuries, and to have the opportunity to research and work in such a context. Whilst the journey of completing this thesis has been a great challenge, it has strengthened my aspirations to be involved in this area of research and healthcare, to contribute to treatment in both SUD and TBI settings.

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List of Appendices

Exploring TBI in Substance Addiction: Incidence, Characteristics and Implications.

INFORMATION SHEET

What is this study about?

The aim of this research is to identify traumatic brain injury (TBI) in people with substance addiction and explore how this may impact certain thinking skills. By understanding this, we hope to better support people who have a TBI and a substance addiction. This research will be conducted by researchers from Massey University: Doctoral Student Hannah Marshall and Dr. Josh Faulkner.

A TBI includes any knock or injury to the head or neck which left you feeling dazed, confused, or unconscious. This could be from a fall, electrocution, whiplash, or other incident.

You are invited to take part

Everyone admitted to The Bridge programme Wellington is invited to take part in phase 1. Whether or not you take part is voluntary and completely your choice. If you don't want to take part, you don't have to give a reason. You can pull out of the study at any time. Whatever you decide, this will not impact the care and support you receive at the Bridge programme.

Feel free to discuss this with others before you decide (whānau, friends, healthcare providers). A Bridge staff member will contact you within 14 days of receiving this information to discuss if you would like to be involved.

What would you be asked to do?

We would arrange a time to meet you at The Bridge.

In the first phase:

- you will be asked to fill in questionnaires about your addiction, life history and if you have had a head injury.
- This will take 25 to 45 minutes.
- We would like to access some answers you provide to The Bridge on questionnaires about your life satisfaction, substance use, mental health and cognitive ability.

About 4 weeks later, we may invite you to take part in the second phase:

- Here you will complete tasks to measure thinking skills, and a short questionnaire about relapse triggers.
- These thinking skills are concentration, memory, thinking speed, ability to problem solve and skills involved in understanding social interactions.
- This will take 60 to 90 minutes (with breaks when you need).
- To be invited to take part in this, you must have passed a drug test in the past 5 days.

The information you provide, as well as the results of cognitive tests, will be anonymous. The data we collect and how it is stored will not be linked to any information that could identify you.

Project Procedure

There are no known risks caused by this study, however you may feel uncomfortable or embarrassed by some questions, or some questions may be hard to answer. You do not have to answer any questions you do not wish to.

All our researchers have received training in running these assessments.

If any concerns about your well-being occur during the study, then these will be discussed with you. If there are concerns that you or others are in immediate danger of harm, we will support your/their safety by notifying Bridge staff and phoning the emergency services (111) or the Crisis Assessment Team if required. As long as it is safe to do so, this phone call will be made while we are with you.

There are no direct costs to you in taking part in this study.

Participant's Rights

- The study files and all information you provide will be confidential and anonymous. However, if any information you provide indicates that you, your child or someone else is at risk, the researcher may have to disclose this information.
- You have the right to decline to answer any particular question.
- Participation is entirely your choice, and you will be able to withdraw from the study at any time without experiencing any disadvantage. If you withdraw, the information you provided will be destroyed.
- No material that could personally identify you will be used in any reports or discussions about this study.
- In order to protect your identity, we will not be able to send you the individual results of this study. We can provide you with a summary of the overall study findings if you wish. If interested, please provide your email address on the confidentiality sheet. You can also find these posted on the Bridge website once the study is completed.

Project Contacts

If you have any questions, concerns, or complaints about the study at any stage, you can contact:

Josh Faulkner

Clinical Psychologist/Neuropsychologist & Lecturer
Massey University, School of Psychology Wellington
Telephone number: 04 801 5799 x63601
Email: j.faulkner1@massey.ac.nz

You can also contact the health and disability ethics committee (HDEC) on:

Phone: 0800 4 ETHICS
Email: hdecs@moh.govt.nz

Support Services available:

The Brain Injury Association
Phone: (04) 473 5004
Address: Federation House, Level 2/9599, Molesworth St, Thorndon

Maori Community Health Team:
Phone: (04) 237 9608
Address: 213/217 Bedford St Cannons Creek Porirua 5024

Te Haika: Crisis Assessment Team
Phone: 0800 745 477

Mental Health Support Chatline:
Free call or text: 1737
24 hours a day to talk or text with a trained counsellor or peer support worker

Your General Practitioner Doctor
You may like to contact your own GP. While you are at The Bridge, The Bridge can pay for your appointment on request. Please organize this with The Bridge before your appointment.

Please keep this for your information.
Thank you for consideration of this study

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 21/28. If you have any concerns about the conduct of this research, please contact Dr Negar Partow, Chair, Massey University Human Ethics Committee: Southern A, telephone 04 801 5799 x 63363, email humanethicsoutha@massey.ac.nz.

Appendix A

Traumatic brain injury, Addiction and Cognition

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read, or have had read to me in my first language, and I understand the Information Sheet attached. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time.

I agree to participate in this study under the conditions set out in the Information Sheet. I agree to the researcher sharing the results of my TBI screen with The Bridge to inform my treatment. I agree for the researcher to access information gathered by the Bridge programme related to my:

- responses on questionnaires about my life satisfaction
- substance use
- mental health
- drug tests
- scores on a general cognitive screening test.

Declaration by Participant:

I ____ hereby consent to take part in this study.

Signature: ________________________ Date: ________________

Optional: If you wish to receive a summary of the overall findings, please provide your email below:

____

Appendix B Head-Injury screening tool

In your lifetime, have you ever hit your head and been left feeling dazed and confused or lost consciousness? This might have been from a car accident, sports injury, hitting your head against something or being hit by someone.

Yes ☐ No ☐ (tick one)

If yes, how many times?

____

____

Details of injury (up to 5 injuries)

Most recent injury:

What happened? Please briefly describe what you were doing and how you sustained the injury, and any involvement of substances

____

How old were you at the time of the accident?

____

Did you lose consciousness (knocked out)?

____

If yes, **how long for**?

Less than 30 minutes: ____________________

30 minutes-24 hours: ______________________

More than 24 hours: _______________________

Are you currently receiving treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, who is providing the treatment?

____

____

Did you *previously* receive treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, what kind of treatment? And for how long? ______________________________

____

If no, why not?

____

Did this head injury result in hospitalisation?

Yes ☐ No ☐ (tick one)

If yes, how long were you in hospital for?

____

Injury number 2

What happened? Please briefly describe what you were doing and how you sustained the injury, and any involvement of substances

____

How old were you at the time of the accident?

____

Did you lose consciousness (knocked out)?

____

If yes, **how long for**?

Less than 30 minutes: ____________________

30 minutes-24 hours: ______________________

More than 24 hours: _______________________

Are you currently receiving treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, who is providing the treatment?

____

____

Did you *previously* receive treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, what kind of treatment? And for how long? ______________________

If no, why not?

Did this head injury result in hospitalisation?

Yes ☐ No ☐ (tick one)

If yes, how long were you in hospital for?

Injury number 3

What happened? Please briefly describe what you were doing and how you sustained the injury, and any involvement of substances

How old were you at the time of the accident?

Did you lose consciousness (knocked out)?

If yes, **how long for**?

Less than 30 minutes: ______________________

30 minutes-24 hours: ______________________

More than 24 hours: ______________________

Are you currently receiving treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, who is providing the treatment?

Did you *previously* receive treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, what kind of treatment? And for how long? ______________________

If no, why not?

Did this head injury result in hospitalisation?

Yes ☐ No ☐ (tick one)

If yes, how long were you in hospital for?

Injury number 4

What happened? Please briefly describe what you were doing and how you sustained the injury, and any involvement of substances

How old were you at the time of the accident?

Did you lose consciousness (knocked out)?

If yes, **how long for**?

Less than 30 minutes: ______________________

30 minutes-24 hours: ______________________

More than 24 hours: ______________________

Are you currently receiving treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, who is providing the treatment?

____

____

Did you *previously* receive treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, what kind of treatment? And for how long? ______________________________

____

If no, why not?

____

Did this head injury result in hospitalisation?

Yes ☐ No ☐ (tick one)

If yes, how long were you in hospital for?

____

Injury number 5 (least recent)

What happened? Please briefly describe what you were doing and how you sustained the injury, and any involvement of substances

____

How old were you at the time of the accident?

____

Did you lose consciousness (knocked out)?

____

If yes, **how long for**?

Less than 30 minutes: ______________________

30 minutes-24 hours: ______________________

More than 24 hours: ______________________

Are you currently receiving treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, who is providing the treatment?

____

____

Did you *previously* receive treatment for this injury?

Yes ☐ No ☐ (tick one)

If yes, what kind of treatment? And for how long? ______________________________

____

If no, why not?

____

Did this head injury result in hospitalisation?

Yes ☐ No ☐ (tick one)

If yes, how long were you in hospital for?

____

Appendix B

After a head injury or accident some people experience symptoms which can cause worry or nuisance. We would like to know if you now suffer from any of the symptoms given below. As many of these symptoms occur normally, we would like you to compare yourself now with before any of your accidents.

For each one, please circle the number closest to your answer.
0 = Not experienced at all
1 = No more of a problem
2 = A mild problem
3 = A moderate problem
4 = A severe problem

Compared with before the accident, do you now (i.e. **over the last 30 days**) suffer from:

Headaches..	0	1	2	3	4
Feelings of Dizziness	0	1	2	3	4
Nausea and/or Vomiting	0	1	2	3	4
Noise Sensitivity, easily upset by loud noise .	0	1	2	3	4
Sleep Disturbance	0	1	2	3	4
Fatigue, tiring more easily	0	1	2	3	4
Being Irritable, easily angered	0	1	2	3	4
Feeling Depressed or Tearful	0	1	2	3	4
Feeling Frustrated or Impatient	0	1	2	3	4
Forgetfulness, poor memory	0	1	2	3	4
Poor Concentration	0	1	2	3	4
Taking Longer to Think	0	1	2	3	4
Blurred Vision	0	1	2	3	4
Light Sensitivity, easily upset by bright light .	0	1	2	3	4
Double Vision	0	1	2	3	4
Restlessness	0	1	2	3	4

Are you experiencing any other difficulties?

1. ________________________________	0	1	2	3	4
2. ________________________________	0	1	2	3	4

*King, N., Crawford, S., Wenden, F., Moss, N., and Wade, D. (1995) J. Neurology 242: 587-59

Appendix B Head Injury screening tool

Notes to staff completing this assessment

1. When asking about TBI please ask about the earliest injury, the most recent injuries, and any noteworthy injuries in-between.
2. If the patient indicates they have never had a head-injury, then further explore this using different words such as TBI, concussion, blow to the head etc. Following this, if they deny a TBI then tick the 'no' box and thank them.
3. It is important (if known) to determine the mechanism of injury and whether the individual was dazed or lost consciousness. This helps determine TBI severity.
4. Please ensure when asking the question about symptoms that you read the paragraph that starts with "After a head injury or accident some people experience symptoms which can cause worry or nuisance"...
5. Following the assessment categorise the Head-injury/TBI using the following criteria:
    a. Mild TBI: Loss of consciousness (or dazed) for less than 30 minutes.
    b. Moderate TBI: Loss of consciousness for less than 30 minutes but less than 24 hours.
    c. Severe TBI: Loss of consciousness for more than 24 hours.
6. If there is a history of brain injury, once categorised please enter a code into medtech. This is READ code '**H/O: head injury (14J1.00)'.** Then enter the TBI category into the notes field (mild, moderate or severe).
7. If the injury was severe, enter a Health Alert in IOMS stating history of severe TBI and add to the free text area "More info@ www.brain-injury.org.nz".

Participant Number ☐☐☐ Researcher Initials ☐☐☐

Traumatic Brain Injury and Substance Use Disorders: An Explorative Investigation

Participant Details

GENERAL INFORMATION

1. Date of Admission: ☐☐/☐☐/☐☐ (d d / m m / y y)

2. Date of Interview ☐☐/☐☐/☐☐ (d d / m m / y y)

3. SAMIS Identifier Code: ____________________

4. Gender: ☐ Male=1 Female=2 (enter appropriate number)

5. Date of birth ☐☐/☐☐/☐☐ (d d / m m / y y)

6. What ethnic group or groups, do you most identify with (choose as many as apply) [Yes=1; No=2]

   Māori ☐ Indian ☐

   NZ European ☐ Asian ☐

   Pacific Island ☐ European ☐

   Other (*please specify*)______________________

7. What is the highest level of education you have attained?

   None [1] ☐

   Primary School [2] ☐

   High School [3] ☐ Incomplete ☐

   Polytechnic [4] ☐

   University [5] ☐

   Other [6] (*please specify)*____________________

8. Usual (or last) occupation

   Specify ________________________________

MEDICAL STATUS

1. Do you have any medical problems, and/or chronic pain which continue to interfere with your life?
   A chronic medical condition is a serious physical condition that requires regular care (i.e. medications, medical interventions) preventing full advantage of their abilities

   No [0] ☐ Yes [1] ☐

   *Specify*____

2. How many days have you experienced medical problems in the past 30 days?
   Include flu, colds etc. Include problems related to drug/alcohol use, which would continue even if the patient were abstinent (e.g. cirrhosis of the liver, abscess from needles etc).

   ____

9. How troubled or bothered have you been by these medical problems in the past 30 days?

   Not at all [0] ☐ Slightly [1] ☐

   Moderately [2] ☐ Considerably [3] ☐

3. Are you taking any prescribed medication on a regular basis for a physical problem?
   Medications prescribed by a medical doctor; ***not psychiatric medicines.***

   No [0] ☐ Yes [1] ☐

   Specify____

ALCOHOL/DRUG USE

Tick if you have taken any of the following substances **in your lifetime**.

		Used in Lifetime
1	**Alcohol** (any use at all)	
2	**Heroin**	
3	**Methadone**	
4	**Other Opiates/Analgesics** (Morphine, Codeine, Tramadol, Oxycodone, fentanyl, pethidine)	
5	**Barbiturates** (Phenobarbitol, Butisol)	
6	**Other Sedatives /Hypnotics /Tranquilizers** (GHB, Benzodiazepine, Lorazepam, Zopicole, Ketamine)	
7	**Cocaine**	
8	**Amphetamines** (Meth, Ritalin, MDMA)	
9	**Cannabis**	
10	**Synthetics** (K2, bath salts, DMT)	
11	**Hallucinogens** (LSD, Mushrooms)	
12	**Inhalants** (Nos, Glue, gas)	
13	**Other:** ___________________________	

1. At what age was your first use of any substance? ______________________________
2. At what age was your first use of the problem substance? ______________________
3. At what age did regular use start? __________ How regular was this? ______________
4. When was your heaviest use? (Age) ________________
5. When was the last time you were voluntarily abstinent from this major substance? (years/months ago)

   ____

   Was this while you were in prison or in the community? _________________________
6. How long did this voluntary abstinence period last?

   ____

7. When was your last use of any substance? ___________________________

(& what substance) _______________________________

8. How many times have you overdosed on drugs?
Requires intervention by someone to recover, not simply sleeping it off, include suicide attempts by OD.

____

9. How many times in your life have you been treated for AoD use? ___________________

What kind of treatment was this, and for how long? (includes hospital, community & residential treatments etc.)
____

____

Family History

Have any of your **blood relatives** had what you would call a significant drinking, drug use, or psychiatric problem? Specifically, was there a problem that did or should have led to treatment?

No [0] ☐ Yes [1] ☐

Who: (e.g. mother, uncle)	
What:	
Who: (e.g. mother, uncle)	
What:	
Who: (e.g. mother, uncle)	
What:	

Any **non-blood** relative or significant other? (step-parent / someone you lived with growing up)?

Who: (e.g. mother, uncle)	
What:	
Who: (e.g. mother, uncle)	
What:	

MENTAL HEALTH STATUS

Have you had a significant period of time in which you have:

0 – No 1 – Yes

	Past 30 days	In your life
Experienced serious: Sadness, hopelessness, loss of interest, difficulty with daily functioning, depression		
Experienced serious anxiety or tension Uptight, unreasonably worried, inability to feel relaxed		
Experienced post-trauma symptoms: Nightmares, intrusive memories, feeling on edge, fearful		
Experienced hallucinations Saw things/heard voices/heard voices that others didn't see/hear, in the absence of any drugs *If only under the influence of hallucinogens or other substances, how long did this persist for?*		
Experienced trouble understanding, concentrating or remembering		
Experienced trouble controlling violent behaviour including episodes of rage or violence *Even if under the influence of alcohol/drugs*		
Experienced an eating disorder – anxiety/bulimia		
Been prescribed medication for any psychological or emotional problems *Prescribed for the patient by a physician. Record "Yes" if a medication was prescribed even if the patient is not taking it.*		

Life circumstance / comments:

____

____

____

____

____

____

____

____

Do you have a history of any other mental health conditions or symptoms

please specify ____

How many times have you been treated for any psychological or emotional problems?

Include anger management. Do not include substance abuse, employment or family counselling. Treatment episode = a series of more or less continuous visits or treatment days, not the number of visits or treatment days.

In a hospital or inpatient screening: ______________________________

Outpatient/private patient: ______________________________

Prison programme: ______________________________

Research Case Study

How my Doctoral Research Experience Contributed to my Clinical Practice at Wellington Massey Psychology Clinic

Hannah Marshall

Massey University Doctorate of Clinical Psychology Candidate

Student ID:

Clinical Psychology Intern with Wellington Massey Psychology Clinic

This case study represents the work of Hannah Marshall in her research from 2021-2022 and reflections as an Intern Psychologist in 2023

Abstract

The current case study outlines the lessons from my doctoral research as applied to my clinical practice as an Intern Psychologist at Wellington Massey Psychology Clinic. This case study provides a summary of my doctoral research. My doctoral research focused on the incidence and characteristics of traumatic brain injury within a population in treatment for a substance use disorder. It also focused on impairments in Social Cognition within these individuals. This overview includes a description of the background of the project, rationale, aims, and methodology. I then provide reflections on how my research experience contributed to my development as a practitioner working with children, adolescents, and adults. These reflections include how the complexities of the research area, and challenges with untangling the various amounts of confounds which arise, prepared me for keeping an abductive view in client formulation.

Doctoral Research

Project Beginnings

During my personal experience working in a Substance Use Disorder (SUD) rehabilitation setting over a 4 year period, I witnessed behavioural presentations common to clients in the setting that are often seen after Traumatic Brain Injury (TBI). These included interrupting often, inappropriate humour, focusing conversation on the self with lack of interest in others, or switching the topic suddenly. It could also look like fixation and difficulty shifting focus or topics, slow comprehension, bluntness, oversharing or inappropriate comments. Such unhelpful social behaviours are often attributed to impairment in Social Cognition (McDonald et al., 2003). After an initial literature review on SUD and TBI, it was evident that Social Cognition has been found to be impaired in each separately. These behaviours appeared to create social conflict and pose barriers to remaining in treatment, through behaviours such as are described above. Social Cognition may therefore be a common area of cognitive impairment in this population and TBI may be an important factor in driving these impairments. This research aimed to explore some of these questions (Marshall, Faulkner & de Terte, 2022).

Study Rationale and Aim

Substance use disorder (SUD) is defined as the use of substances which result in maladaptive patterns of behaviour, leading to harmful consequences and significant impairment and distress (Sadock et al., 2015). While approximately 12% of substance users worldwide will become addicted, recent estimates in New Zealand (NZ) found 32% of New Zealanders were at moderate to high risk of experiencing SUD (Ministry of Health, 2020; United Nations, 2016). There is evidence that substance use increases the risk of sustaining a Traumatic Brain Injury (TBI) (McHugo et al., 2017). TBI is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force to the head or neck (Carroll et al., 2004). SUD is associated with increased rates of accidental injuries, interpersonal violence, and motor vehicle crashes, all of which can cause a TBI (Macias-Konstantopoulos et al., 2014).

Furthermore, individuals with TBI frequently misuse substances (Albreich et al., 2020). TBI can precipitate cognitive, physical, psychological, and social impairment (Barman et al., 2016). Psychosocial difficulties include disinhibition and impulsivity, labile mood, aggression, irritability, apathy, and social deficits (Wilson et al., 2021). These difficulties are often linked to pathology in the frontal lobes and result in trouble with everyday tasks such as following instructions, prioritising, adapting to change, completing, or forming plans needed to meet goals, or interacting prosocially (Loe et al., 2019). Interestingly, these mechanisms have been proposed as being crucial in the development, maintenance, and exacerbation of SUD (Ryan et al., 2021). In support of this, TBI has been shown to be a risk factor for the development of SUD (Kennedy et al., 2017). Thus, TBI and SUD are closely linked and have a complex, bidirectional relationship.

A myriad of factors has been implicated in the aetiology of both TBI and SUD which may mediate or moderate the relationship between the two (Olsen & Corrigan, 2022). The main substance an individual is addicted to also has a role in the relationship between SUD and TBI (Hawley et al., 2018; Jacotte-Simancas et al., 2021). Complicating the matter further, SUD samples have high rates of poly-substance use (Erga et al., 2021) and as a result, isolating the effects of a specific substance on TBI is a challenging endeavour. Finally, the majority of studies investigating comorbid SUD and TBI often anchor to one recent TBI event, or the presence or absence of TBI, and do not collect detailed information on earlier TBI history (Kolakowsky-Hayner et al., 1999). Other studies report limited information about the association between age of TBI and other TBI characteristics, and substance-using behaviours (Olsen & Corrigan, 2022). Others rely heavily on medical records to determine TBI occurrence (McKinlay et al., 2014) which is potentially limiting as this population is less likely to receive medical attention (Corrigan et al., 2012). Thus, the full extent of the incidence and characteristics of TBI among substance users remains unclear, and causality is difficult to establish due to the many influential factors potentially involved (Olsen & Corrigan, 2022). In order to understand the link between TBI and SUD more clearly, underlying mechanisms that could explain the link between TBI and SUD must be examined (Olsen & Corrigan, 2022).

One mechanism that is likely involved in the relationship between TBI and SUD is Social Cognition. The term 'Social Cognition' refers to a range of cognitive functions that process, perceive, and interpret social information. This includes abilities of emotion recognition from verbal and nonverbal cues, Theory of Mind (ToM; the ability to understand that another's thoughts values and beliefs differ from one's own) and social perception; which integrates cues, norms, and context in order to make meaning (McDonald et al., 2003). Social Cognition enables us to understand ourselves, predict the intentions and behaviour of others, to modify and improve our social behaviours, and to know how to interact appropriately in different social situations (Quednow, 2020). Impairment in Social Cognition is a common consequence of TBI and often results in disinhibited social behaviours which can reduce quality of life for TBI patients and their families (Maggio et al., 2020). Additionally, difficulties relating to Social Cognition have been seen among samples with Cocaine, Opioid, and Alcohol Use Disorders, even after 6-months of abstinence (Bland & Ersche, 2020; Onuoha et al., 2016). Other samples have found individuals with AUD to have no impairment in ToM abilities, suggesting there may be some other factors involved in Social Cognition impairment within AUD (Amenta et al., 2013).

SUD is associated with increases in neurotoxic induced cognitive dysfunction from prolonged use of substances on the brain (Zhong et al., 2016). It has been hypothesised that this physical impact of substances on the brain may cause impairment in Social Cognition, as can happen after TBI (Maggio et al., 2020). However, Social Cognition impairment has been found in individuals with Gambling Use Disorder, an addictive disorder requiring no heavy or prolonged substance-use (Kornreich, 2017). This suggests that the impact of substances on the brain may be an incomplete explanation for Social Cognition impairment in addictive disorders, and predisposed vulnerabilities may be involved (Bora & Zorlu, 2017). While the direction of the relationship between Social Cognition and SUD remains unclear in the literature, it is possible that pre-existing difficulties with

Social Cognition may increase the risk of maladaptive substance use and subsequently lead people to develop SUD (Kornreich, 2017). Therefore, the aim of the research was to 1) clearly establish the incidence, characteristics, and age of onset of TBI in a SUD population, and 2) examine the relationships between Social Cognition, TBI & SUD, whilst considering possible confounding variables that may also explain these relationships.

Methodology

Ethical approval was received by the Massey Human Ethics Committee (SOA 21/28) in August of 2021. A quantitative approach was taken to address the study aim through data generated from questionnaires conducted in interview form, and neuropsychological assessment instruments. Qualitative information included in questionnaires was coded into quantitative data.

Participants

All clients admitted to a residential rehabilitation programme in Wellington between August 2021 and December 2022 were invited to take part in the study. Participants were adults aged 18+ with a substance use disorder(s) of any kind.

Procedure

Upon clients admission to the SUD rehabilitation program and following their orientation, the programme staff invited clients to participate. All consenting clients were then referred by staff to the researcher, who subsequently met with the participant for the first time at the rehabilitation facility. The researcher completed a screen for TBI, collected information on demographics and general physical and mental health using a demographic questionnaire and the Depression Anxiety and Stress Scale (DASS-21). This was followed by the Neuropsychological Assessment Battery- Short version (S-NAB) to assess general cognition, and a measure of Social Cognition using The Awareness of Social Inference Test-Short (TASIT-S). This was completed across 2-3 sessions with each participant during their 10-week stay at the programme. Completion of these measures was staggered with breaks in between sessions according to clients' needs accommodating for individuals' fatigue and concentration abilities. Cognitive testing occurred within 5 days of the participant providing a negative urine drug screen for programme requirements. If a participant was reported by the facility to score below a 19 in the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) which was used as a screening tool, that participant did not carry on to complete the S-NAB or TASIT-S, to avoid putting them under unnecessarily difficult testing or embarrassment.

Measures

The Awareness of Social Inference Test-Short (TASIT-S; McDonald et al., 2003)

The TASIT-S was used to measure Social Cognition. The TASIT-S has 3 subtests measuring different components of Social Cognition; emotion recognition, conversational inference making, and theory of mind. This comprises a series of 28 short (15–60 seconds) videotaped scenes where actors interact in everyday social situations. Participants are asked questions after each video to assess recognition of spontaneous emotions (happy, sad, angry, anxious, surprised, disgust and neutral), comprehension level of social exchanges (sarcastic or sincere), and detection of and ability to distinguish sarcasm from lies. Intended meaning of each exchange is indicated through speaker demeanor (voice and facial expression). Additional contextual cues are given to convey meaning in subtest 3, which are not provided in subtest 2.

TBI Screening Questionnaire

To assess TBI in this population we adapted a screen previously used in a NZ prison population (Mitchell et al., 2017). This questionnaire screens for the occurrence of any historical TBI and details related to the event. This includes the involvement of substances in the event. The screen asks for the total number of lifetime TBIs and allows for reports of up to 5 separate injuries. Age of TBI, mechanism of injury, whether or not loss of consciousness occurred, as well as any treatment for this injury, is asked. If one or more head or neck injuries are reported by the participant, they are also asked about the presence of current self-reported cognitive difficulties which began after any of these TBIs. The Rivermead Post-Concussion Questionnaire was utilised to assess these (King, 1995).

Demographic Questionnaire

A self-report questionnaire was used to collect demographics for each participant. Variables assessed include age, ethnicity, highest level of education, medical history, family history (of SUD) and mental health history.

Substance Use Questionnaire

Substance-using behaviours were explored by asking questions about specific substances used or not used, as well as age of problematic substance use. A range of other substance use behaviours were also assessed (i.e., routes of administration, age of first use of their ‘problem substance’, period of heaviest use, any periods of voluntary abstinence, overdoses and treatment history).

The Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995)

Participants current mental health status was assessed using the DASS-21. The DASS-21 is a 21-item self-report with three subscales that measure depression, anxiety, and stress over the previous week. Further to this, clients were asked to report any current mental health diagnoses and a screen was conducted for any experiences of a range of mental health conditions within the last month, and in their lifetime (e.g., depressive symptoms, anxiety, psychosis whether drug induced or not, trauma symptoms).

The Neuropsychological Assessment Battery – Screening (S-NAB; Stern, White & Lutz, 2003)

A broad screening assessment of cognition was administered to assess general cognition. The S-NAB provides information regarding cognitive functioning in five main areas: (a) attention, (b) language, (c) memory (assessing immediate and delayed verbal and visual memory), (d) spatial reasoning, and (e) executive functioning, as well as an index of overall cognitive functioning. S-NAB scores are corrected for age-group, gender, and education level.

Data analysis

Data from a total of 77 participants was collected. With this data, we explored the relationships between the demographic and clinical variables (TBI characteristics, substance use behaviours, general cognitive outcomes, self-reported cognitive symptoms, and scores of Social Cognition). These relationships were explored whilst considering associations with additional variables (family history of SUD, current mental health distress). To achieve this, descriptive statistics were used to describe the rates and characteristics of the sample. Pearson's correlations were used to examine the relationship between continuous variables (i.e., age, mental health status). Independent sample t-test and One-Way ANOVA were used for categorical variables, as the assumptions of normality were met. First, associations between TBI characteristics, substance using behaviours, and demographics were explored. Secondly, we explored associations between TBI characteristics, general cognitive outcomes, substance use behaviours, current mental health distress, and family history of SUD. Regression analysis were then conducted to examine the predictive role of TBI characteristics on general cognitive outcomes, whilst controlling for relevant confounding variables (as determined by significantly associated variables). Next, we explored associations between TBI and SUD characteristics with scores of Social Cognition. Finally, mediation analysis were used to explore the impact of TBI on SUD through Social Cognition scores.

Results and Discussion

At the time of writing this research case study and reflections on the impacts of my doctoral research on my clinical practice during my internship, the data had been completely collected. However, statistical analysis and write up of the results was yet to be completed. Therefore, the following reflections are based on the doctoral journey up until the end of my internship in December 2023.

Clinical Psychology Internship

My internship began in January 2023 at Massey University Psychology Clinic in Wellington. This service operated in a similar way to a private practice. The following reflections were made during my time at this setting. This includes reflections when engaging with adults who presented with comorbidities of mental health difficulties, including some with substance use difficulties which accompanied other forms of distress.

Complexities of client presentations & implications for assessment, formulation, and treatment planning

The complexities and challenges with untangling the various amounts of confounds which arise when conducting research, prepared me well for conceptualising the complexities and variations of client presentations. In the process of completing this Doctorate, and reviewing literature on substance use disorders, traumatic brain injuries and cognitive difficulties within these presentations, I quickly became aware of how complex this field of research is. In designing the project, I had a desire to try to answer specific research questions. My research collected a lot of data in order to untangle multiple confounds. However, it became apparent that there were still limits to drawing conclusions with so many variables and questions around directionality. Furthermore, there were limits to the methods able to be used dependant on participant numbers for statistical power, which limited the amount of 'untangling' my research could do, compared to what I had initially hoped. Therefore, the project became more exploratory in nature. There is a temptation in research and clinical work to be reductionistic, and take a narrow view, focusing only on the factors which are obvious, or search for information that fits our hypothesis and neglect to incorporate in additional information that doesn't fit so well. Similarly, we untangle confounds in our clinical work.

Quickly into my internship, I realised working with clients is much more complex than it seems when we learn about it in a classroom setting or reading through the DSM-V (American Psychiatric Association, 2013). Everyone has a unique backgrounds, values, strengths, thinking styles, and experiences. Clients often do not neatly fit into one 'box' or diagnosis. Two clients with the same diagnoses can look very different. This helped me realise the importance of going into assessment with an open mind, and not forming expectations or assumptions about what is going on for a client after one or two sessions.

This has emphasised to me to go into assessment and formulation with an open mind and to remain flexible to new information to change my impression. This has also emphasised to me that while evidence-based treatment plans and structures are important to draw on and incredibly helpful, that these must be individualised to suit the clients needs, and to be built upon in collaboration with the client, and what is most fitting and important to them.

I learnt from my research, to go into the area of TBI within substance use exploratively, and open minded (Marshall et al., 2022). This helped me in keeping an abductive view in client assessment. As well as to remain flexible with formulation, and treatment planning with my clients.