Acquired Brain Injury and the Unraveling of Theory of Mind: Exploring the Role of Personality Change and Spatial Cognition

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by

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Declaration

I, …………Jill Mosdell…………, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise), and that neither the whole work nor any part of it has been, is being, or is it be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: Signed by candidate …………………………… Date: …………04-01-2024……………………

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Acknowledgements

This dissertation has reinforced for me - on multiple levels - the truth of the isiZulu phrase from my home country: “Umntu ngumuntu ngabantu”, a person is a person through other people.

This is not only apparent from the work itself, the academic argument concerning the significance of our connections to others in being whole, but also the significance of my community to me in this very long journey.

Thank you to the participants who gave hours of their time and their willingness to be vulnerable and open. Thank you for allowing us to connect with you, to sit with you and experience the world as you do. Thank you to the family members of our participants who opened up about their experience of loving someone who has sustained brain injury.

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Introduction

Theory of Mind (ToM) is arguably the defining distinction between human beings and most other species (Saxe, 2006). This ability to infer the mental states of others is foundational to our ability to function in society. Research in the area has focused on the Herculean task of disentangling the neural and cognitive mechanisms underpinning ToM.

Samson's (2005) important work has illustrated the value of neuropsychological studies of patients with acquired brain damage to understand the cognitive architecture and the mechanism connecting this cognitive fallout with neural structures. Her work showed that ToM comprises specific and different cognitive and neurological systems that can be independently identified and studied. These cognitive functions, such as inhibition, working memory and perspective taking, are discrete components that can be studied and each corresponds to specific neural systems. This means that ToM can be compromised in different ways and the neuropsychological presentation of ToM deficits can vary. Lesion studies are then ideal to investigate the mechanism and qualitative features of ToM.

A gap in ToM research has been the relative lack of lesion studies that control for the cognitive functions that underpin ToM (such as intelligence, working memory and inhibition) to explore other brain functions necessary for ToM. Another gap in the literature is a lack of qualitative research methodologies in understanding *how* patients fail ToM and the role that spatial cognition and personality change may have on their performance. To understand the neuropsychology of ToM, research needs to explore the link between personality change following neurological damage that can result in ToM deficit.

This study delves into the personality and interpersonal transformations observed in patients with acquired ToM deficits. It aims to illuminate the psychological underpinnings necessary for ToM. Through experimental neuropsychological evidence, we explore how right hemisphere damage (RHD) leading to spatial cognitive deficits correlates with ToM disintegration, in comparison to left hemisphere damage and healthy controls. A notable link is drawn between spatial deficits, ToM performance, and personality changes pre- and post-morbidity.

The clinical observations of right hemisphere patients showing “acquired narcissism” (Kaplan-Solms & Solms, 2000) and “acquired sociopathy” (Saver & Damasio, 1991) guides this research into exploring the role that egocentricity and other Cluster B personality disorder traits may have on ToM.

No research has been able to provide RHD lesion studies exploring ToM where intelligence and executive functioning are relatively intact. Experimental neuropsychological evidence is provided that RHD leading to spatial cognitive deficits is related to a disintegration in ToM compared to left hemisphere and healthy control groups. This research’s original contribution to the field provides a nuanced neuropsychological depiction of *how* patients with acquired brain injury (ABI) fail ToM tasks when working memory, inhibition and intelligence are controlled for, and how that failure relates to how they interpret and navigate relationships with others.

Review of the Literature

Historically, extensive research delved into the functions of the left hemisphere in language and thought, with little attention initially given to the seemingly 'non-dominant' right hemisphere. It was only when the relationship between spatial cognition and the right hemisphere emerged that research in this area gained momentum.

This literature review will provide evidence linking changes in the right hemisphere to deficits in social cognition, personality changes, and spatial cognitive impairments. By examining the existing body of literature, the aim is to construct a neuropsychological profile of personality changes and ToM following RHD. Clinicians have often described individuals who have suffered RHD as undergoing profound changes, and these changes cannot be solely attributed to spatial cognitive deficits.

While a substantial portion of the literature has concentrated on these variations and their potential neuroanatomical underpinnings, few theoretical frameworks have been proposed to elucidate the mechanisms and characteristics of these transformations. From discussions of personality changes resulting from right hemisphere damage, this review will shift its focus to ToM, highlighting the intricate connection between social cognition and the right hemisphere.

Patients with lesions in the right hemisphere frequently manifest challenges related to self-awareness and the ability to comprehend others' motivations and mental states. Often, these patients encounter difficulties in spatial reasoning, particularly in perspective-taking. The argument to be presented suggests that a decline in ToM abilities, which entail adopting the perspective of another person's thoughts and knowledge, may be correlated with compromised spatial functions, specifically the capability to perceive spatial perspectives.

To achieve this, this literature review offers a concise overview of the primary conceptual and empirical domains underpinning this research. Specifically, we will address: 1.) Description of the Personality Profile in Acquired Brain Injury (ABI) and RHD in particular, with a Focus on Egocentric Traits; 2.) The Neuropsychology of ToM; 3.) The Role of the Right Hemisphere in Spatial Cognition and Awareness, and its Connection to ToM and; 4.) The Interplay Between Spatial Cognition and Personality.

Personality Change and ABI

Personality, as defined by the American Psychological Association (2013), refers to the unique variations in how individuals behave, feel, and think. This concept encapsulates a broad spectrum of elements contributing to one's identity, including behavioral traits, mental attitudes, and habitual patterns. It emphasizes not only the consistency in an individual's actions across different contexts but also their distinct thought processes and emotional patterns.

One of the earliest case studies exploring the connection between brain injuries and personality changes is the famous case of Phineas Gage. In 1848, Gage, a railroad foreman, survived a severe brain injury when an iron rod pierced his skull during a blasting accident. Remarkably, his survival was accompanied by profound changes in personality and behavior, as noted by his physician and acquaintances who knew him before and after the incident.

Before the accident, Gage was known for his diligence, dependability, and pleasant nature. However, post-injury, he exhibited a radical shift in personality. He became erratic, prone to mood swings, and often disregarded social norms, a stark contrast to his former self. This dramatic transformation underscored the critical role of the frontal lobes in personality, decision-making, and social behavior.

Gage's case not only holds historical significance in neuropsychology but also serves as a fundamental reference in understanding the correlation between brain trauma and changes in personality. It triggered ongoing research into the contributions of specific brain areas to personality and social interactions (Solms, 2002).

A meta-analysis by Perry et al. (2016) revealed that a considerable proportion of individuals with a history of traumatic brain injury developed personality changes even decades later, suggesting a lasting vulnerability to psychiatric conditions following such injuries. Commonly observed disorders include avoidant, paranoid, and schizoid types. Importantly, similar personality changes have been documented in younger individuals, emphasizing the far-reaching consequences of traumatic brain injuries across various age groups.

Patients with severe ABI often experience reduced self-awareness, marked by an impaired understanding of their own mental states, thoughts, and emotions. This reduction in self-awareness has been found to significantly affect their ability to take the perspective of others, which in turn can have a profound impact on their social interactions and the quality of their relationships (Bivona et al. 2014).

In a study conducted by Barrash, Tranel, and Anderson (2000), individuals with bilateral ventromedial prefrontal lesions exhibited more pronounced emotional and behavioral disturbances compared to those with non-prefrontal lesions. These disturbances encompassed emotional blunting, apathy, inappropriate affect, irritability, poor judgment, and a lack of insight. The study highlighted that participants with bilateral ventromedial prefrontal lesions consistently displayed a syndrome characterized by reduced emotional experience, unregulated emotional reactions, impaired social decision-making, and a notable lack of insight—features reminiscent of developmental psychopathy (Perry et al. 2016). These findings establish a connection between these behavioral changes and ABI.

Extensive research has shown that injuries to the right hemisphere of the brain can lead to significant shifts in personality and emotional states, with symptoms ranging from indifference and irritability to impaired judgment and low tolerance for frustration (Braun, Daigneault et al., 2008; Cummings, 1997; Hecht, 2010b; Kaplan-Solms & Solms, 2000; Perry et al., 2001; Rankin et al., 2006; Thompson et al., 2003).

Damage to the right frontal regions, especially the ventromedial prefrontal cortex, is closely linked with drastic personality transformations known as "acquired sociopathy." This condition features diminished emotional responses, severe social impairments, and compromised decision-making abilities (Damasio et al., 1991; Saver & Damasio, 1991). Further investigations have confirmed that these areas are critical in maladaptive social changes and deficits in moral judgment (Barrash et al., 1994, 2000; Brower & Price, 2001; Ciaramelli et al., 2007; Koenigs & Tranel, 2007; Koenigs et al., 2007; Lapierre et al., 1995; Saver & Damasio, 1991; Shamay-Tsoory et al., 2005), implicating the ventromedial prefrontal cortex in significant alterations including reduced warmth and other psychopathic-like behaviors (Anderson et al., 1999; Anderson et al., 2000; Blair & Cipolotti, 2000; Sollberger et al., 2009; Tranel et al., 2002).

Relevance of Posterior RH Damage to Spatial Cognition Disorders. Although traditionally less emphasized than frontal damage, injuries to the right posterior regions, particularly the right posterior parietal and occipital lobes, have significant implications for spatial cognition disorders. These areas are integral to processing spatial relationships and the orientation of objects in space, which are essential for normal functioning in daily activities. Damage here can lead to disorders such as spatial neglect, where patients fail to be aware of objects or their own body parts on the opposite side of the space relative to the lesion. These symptoms extend beyond mere personality changes and touch on substantial cognitive impairments that can manifest as inappropriate suspiciousness, paranoia, and a lack of concern. These findings suggest a profound impact on both emotional perception and the cognitive processing of spatial relationships (Price and Mesulam, 1985).

While the right ventromedial prefrontal cortex is closely associated with profound social-emotional changes, almost any cortical damage in the right hemisphere can result in noticeable personality shifts. These changes are diverse and encompass reduced emotional expression, poor decision-making, social inappropriateness, a lack of empathy, and significant problems with self-insight and goal-directed behavior. The underlying mechanisms and real-world consequences of these changes, such as the impact on decision-making abilities detailed in studies like that of Saver and Damasio (1991), underscore the complex challenges faced by patients with RHD.

Egocentricity and RHD. Kaplan-Solms and Solms (2000) elaborated on Saver and Damasio's (1991) term, 'acquired sociopathy', with what they found in patients with RHD, and understood the presentation as an 'acquired narcissism'. Many right hemisphere patients display extremely egocentric behaviour, becoming completely absorbed in their own interests while showing little empathy for others. Egocentricity refers to a person's limited or absent ability to consider others' viewpoints or feelings. These individuals tend to relate everything back to themselves and their own experiences. Acquired narcissism's characteristics include: 1. Challenges in understanding other perspectives or difficulty in understanding or acknowledging viewpoints other than their own; 2. An egocentric person may struggle to grasp or relate to the emotions or situations of others, and 3. Reduced Social Consciousness: A lack of awareness or concern for societal norms or the effects of one's actions on others (Schwartz et al. 2008).

They also do not respond well to any frustration or denial of gratification, and can become enraged as a result. Furthermore, right hemisphere areas (fronto-paralimbic areas) have been associated with Narcissistic Personality Disorder, a psychiatric diagnosis (Schulze et al. 2013). The above points reinforce the argument that the behavioural and social changes observed in these patients with RHD are linked to an acquired narcissism. However, these interpretations are speculative and would benefit from further empirical testing to solidify these connections.

Understanding Personality Disorders through Abnormal Psychology. Abnormal psychology provides valuable insights into maladaptive personality changes. For example, Cluster A personality disorders, including Paranoid, Schizoid, and Schizotypal Personality Disorders, are characterized by eccentric behaviors. In contrast, Cluster B disorders, such as Antisocial, Borderline (BPD), Histrionic, and Narcissistic Personality Disorders (NPD), display dramatic or erratic behaviors. Disorders like Avoidant Personality Disorder are marked by social inhibition and sensitivity to criticism, while Paranoid Personality Disorder involves persistent distrust and suspicion of others (American Psychiatric Association, 2013).

Focal lesion studies provide a more localized understanding of brain functions and their impacts on personality disorders, particularly useful in differentiating the effects of specific brain injuries from the diffuse damages seen in TBI. For instance, research on patients with localized damages to the ventromedial prefrontal cortex illustrates profound changes in personality traits, such as impulsivity and emotional dysregulation, which are common in Cluster B personality disorders (Damasio, 1994). These studies are crucial as they link specific brain areas with precise behavioral outcomes, unlike TBIs which affect multiple areas and lead to generalized brain dysfunction.

Moreover, studies on right hemisphere damage (RHD) that specifically involve focal lesions have shown significant impacts on personality, including the development of symptoms commonly associated with narcissism such as disinhibition, an overly positive self-assessment, and aggression (Stein et al., 1993; Braun et al., 2008; Davidson, 2001).

These studies clarify the role of specific regions within the right hemisphere in regulating emotions and social behavior, offering a clear pathway to understanding the neuropsychological underpinnings of personality disorders.

It is a common misconception that RHD patients predominantly lack negative emotions. However, focal lesion studies, such as those by Kaplan-Solms and Solms (2000) and Tondowski et al. (2007), indicate that patients can indeed experience and express negative emotions such as sadness and depression. These findings contradict the generalized views about emotional expression in RHD patients and highlight the nuanced nature of brain-behavior relationships.

This section has highlighted the significance of focal lesion studies in understanding the relationship between specific brain injuries and personality changes. Focal lesion research offers a more precise and localized approach to studying brain functions, which is essential for developing targeted interventions and therapies. The subsequent sections will delve deeper into specific research concerning emotion and the right hemisphere, further exploring how localized brain damage influences emotional and personality disorders.

Emotion processing and RHD. Since the early observations by Babinski in 1914, the right hemisphere's (RH) role in emotion processing has been extensively studied. Early research highlighted emotional inappropriateness as a result of RH damage, with subsequent studies confirming the RH's crucial role in various emotional processes (Gainotti, 1972; Rosen & Viskontas, 2008).

Acquired Brain Injury (ABI) research has been instrumental in delineating the specific functions of the RH in emotion. Focal lesions due to ABI provide clear evidence of the RH's involvement in:

1. **Emotion Expression:** Studies have shown that the RH is particularly linked to the expression of emotions, both facially and verbally. The RH dominance in facial emotion recognition and the expression of affect in speech are well-documented (Heilman et al., 1975; Ross & Mesulam, 1979).
2. **Emotion Perception:** The RH plays a critical role in the perception of emotional cues in others, particularly in recognizing facial expressions and interpreting emotional content in speech (Heath & Blonder, 2005; Joseph, 1982).
3. **Emotion Regulation:** Research indicates that the RH is involved in the regulation of emotions, particularly in response to negative stimuli. This includes studies showing right-sided prefrontal activation linked with the regulation of negative emotions and the processing of emotional conflict (Fox & Davidson, 1988; Borod et al., 1998).

Specific RH Areas and Their Emotional Components.

1. **Prefrontal Cortex:** The ventromedial prefrontal cortex (vmPFC) in the RH is particularly noted for its role in connecting cognition and emotion, moderating responses to emotional stimuli by inhibiting lower-level limbic structures such as the amygdala (Andrewes & Jenkins, 2019).

2. **Anterior Insula:** The right anterior insula is crucial for the subjective experience of emotions, integrating emotional and bodily states into a coherent subjective feeling (Giuliani et al., 2011).
3. **Amygdala:** The right amygdala's role in processing emotionally laden stimuli, particularly those that are negative or fear-related, has been emphasized in multiple studies (Adolphs et al., 1996).

Connecting RH Damage to Egocentrism. Patients with RH damage often exhibit egocentric behaviors, a phenomenon linked to impairments in these specific emotional components. Egocentrism in RH-damaged patients can be seen as a dysfunction in the integration of emotional cues from others, leading to a self-centered perspective. This is particularly evident in their impaired ability to recognize and appropriately respond to the emotional states of others, a direct consequence of deficits in emotion perception and regulation. The nuanced roles of the RH in emotion processing—encompassing expression, perception, and regulation—are critical in understanding the full impact of RH damage in ABI. While the broader implications of these findings on personality and social interactions, such as egocentrism, are complex, they underscore the importance of considering specific RH structures in the neuropsychological assessment and rehabilitation of ABI patients.

Depression and Right Hemisphere Damage (RHD). There is a growing body of literature investigating the relationship between depression and right hemisphere damage. Initially, studies focused on the left hemisphere's association with depression; however, recent evidence suggests a significant link between RHD and depressive symptoms, including emotional indifference and mood dysregulation (Andersen et al., 1995; Costanzo et al., 2015).

Patients with RHD often exhibit symptoms that diverge from typical depressive presentations, such as emotional indifference. This symptom reflects a diminished response to emotionally charged situations, which is a direct consequence of right hemisphere dysfunction (Hecht, 2010b; Henriques & Davidson, 1990). Such indifference is not merely a lack of sadness but an overall flattening of emotional responses, which can be mistakenly perceived as a lack of depression.

Studies focusing on RHD have shown that depression linked to brain injury might differ mechanistically from classical forms of depression. For example, hypoactivation in the right prefrontal cortex has been consistently observed in patients with RHD who report depressive symptoms (Rotenberg, 1993; Flor-Henry, 2004). This area of the brain is crucial for processing emotional content and its impairment can lead to a lack of emotional awareness or indifference.

Neuroimaging studies in patients with RHD further support these findings. Decreased volumes and functional abnormalities in the right amygdala, which is critical for emotional processing, have been documented in patients presenting with depressive symptoms post-RHD (Cole et al., 2011; Sheline et al., 1998). Similarly, alterations in the right hippocampus and dorsomedial thalamus are associated with the cognitive and emotional deficits observed in these patients (Kronmüller et al., 2008; Fu et al., 2004).

In RHD, there is an initial hypoactivation across various brain regions, which the brain attempts to compensate for by increasing blood flow to these areas, particularly the right prefrontal cortex. However, this compensatory mechanism often fails, potentially exacerbating depressive symptoms rather than alleviating them (Fingelkurts et al., 2004). This mechanism highlights the complex interplay between physiological and functional abnormalities in RHD and their impact on mood regulation.

The link between right hemisphere damage and depression involves complex neural dynamics that extend beyond typical depressive pathways. Emotional indifference, a common symptom in RHD patients, exemplifies how right hemisphere impairments can alter emotional processing. Understanding these specific neural and symptomatic profiles is crucial for accurately diagnosing and treating depression in patients with right hemisphere damage.

The above characterization of the profile resulting from right hemisphere damage (RHD) and the possible function of the right hemisphere in emotion suggests a multifaceted array of emotional, behavioral, and social changes:

1. ***Emotional and behavioral dysregulation***. Individuals with RHD often undergo substantial changes in how they process emotions and react affectively. These changes may include shifts in how emotions are regulated, impulses are controlled, and how social interactions are managed.
2. ***Difficulties in social cognition***. People with RHD might find it challenging to grasp social cues, understand the theory of mind (ToM), and empathize with others. These

challenges can lead to misunderstandings in social contexts and hinder the formation and maintenance of interpersonal relationships.

3. ***Egocentrism***. A noticeable shift toward self-centered behavior is common, marked by an increased focus on personal interests and diminished empathy for others. This often results in inappropriate social behavior and difficulties in sustaining meaningful relationships.
4. ***Links to personality disorders***. Research indicates that RHD might be associated with certain personality disorder traits, particularly those classified under Cluster B, like antisocial, borderline, histrionic, and narcissistic personality disorders.
5. ***Mood regulation and depression***. The literature discusses the intricate connection between RHD and depression, suggesting a significant role of the right hemisphere in regulating mood.
6. ***Challenges in emotional processing and expression***. RHD can profoundly affect the ability to process and express emotions, leading to difficulties in recognizing emotional signals in facial expressions and language.

Overall, this personality profile paints a picture of significant and diverse changes brought about by RHD, affecting emotional regulation, social interaction, and personal behavior in complex ways. This will influence the personality traits this study hypothesises may have a significant relationship with ToM ability in the RHD experimental group. It is important to note, especially with findings around mood and brain injury, the distinction between primary and secondary deficits. These deficits in personality change following brain injury can be understood in terms of direct and indirect effects. Primary deficits arise directly from the damage to brain areas responsible for emotional regulation, social behavior, and personality traits. These can include changes in emotional responsiveness, social awareness, and impulse control. Secondary deficits, on the other hand, are indirect and may result from the individual's psychological response to the injury and its consequences. This might include depression, anxiety, or changes in self-esteem due to a new understanding of one's abilities and limitations post-injury (Schwarzbold, 2008).

RHD and Right Hemisphere Syndrome

The above review of personality and emotional changes makes up one part of Right Hemisphere Syndrome. Right Hemisphere Syndrome refers to a cluster of cognitive, emotional, and behavioral symptoms that may occur following damage to the right hemisphere of the brain. This syndrome is characterized by difficulties in attention, visual-spatial skills, and awareness of one's own physical and mental condition (Solms, 2002). People with Right Hemisphere Syndrome might exhibit impaired judgment, lack of insight, and may not recognize deficits in their own abilities. Emotional and behavioral changes, such as reduced empathy, inappropriate emotional responses, and a lack of awareness of social cues, are also common. This condition highlights the critical role of the right hemisphere in regulating various cognitive and emotional processes. The following section will explore the main symptoms of Right Hemisphere Syndrome that are related to RHD. This includes anosognosia, spatial cognition difficulties and hemi-neglect.

Anosognosia and Right Hemisphere Damage

Anosognosia, commonly associated with right hemisphere injuries, is a condition characterized by a denial of obvious impairments such as left hemiparesis. This disorder highlights the critical role of the right hemisphere in self-awareness and emotional regulation. The following discussion focuses on how frontal RH damage contributes to more severe forms of this condition, which can appear similar to psychotic symptoms.

Research has consistently demonstrated that anosognosia is most likely to develop from lesions in the right hemisphere, particularly when both frontal and parietal regions are affected. This suggests that anosognosia results from disruptions in a complex cortico-subcortical network involving these areas (Pia et al., 2004). Such disruptions impair the brain's capacity for self-monitoring and emotional regulation, leading to a faulty perspective mechanism where patients are unable to recognize their deficits.

The right frontal regions of the brain are pivotal in integrating cognitive and emotional responses. When these areas are damaged, patients may exhibit symptoms that border on psychotic, such as profound denial of reality and fabrication of elaborate explanations for their impairments (Feinberg, 1997; Ramachandran & Blakeslee, 1998). Studies such as those by Vocat et al. (2013) have shown that patients with frontal RHD and anosognosia display abnormal levels of confidence and an inability to feel doubt, suggesting a deep-seated disruption in the emotional regulation system.

Experimental treatments like caloric vestibular nerve stimulation have temporarily alleviated symptoms of anosognosia, underscoring the involvement of the right frontal and temporo-parietal cortices in this disorder (Levine et al., 2012). These findings support the hypothesis that anosognosia involves a significant emotional component, where right frontal damage leads to a disconnection from the emotional impacts of one's physical state.

Anosognosia not only reflects a neurological failure but also represents a psychological defense mechanism. This condition can be seen as an extreme form of denial, a primitive defense typically associated with the right frontal regions' regulatory roles over emotions and self-awareness. Patients with RHD may engage in denial to avoid the emotional distress associated with acknowledging their impairments, which can be exacerbated by the right frontal regions' damage (Turnbull et al., 2014).

Understanding anosognosia requires an integration of neurological and psychological perspectives. The right hemisphere's role in mediating emotional responses to self-awareness disruptions suggests that both emotional and cognitive processes are deeply intertwined in the manifestation of anosognosia. Studies have shown that even when confronted directly with evidence of their deficits, patients may only temporarily acknowledge their impairments, soon reverting to denial (Ramachandran, 1994; Marcel et al., 2004).

In summary, anosognosia in patients with RHD, particularly those with frontal damage, can be understood as a disorder of both perspective and emotion regulation. The frontal regions of the right hemisphere play a crucial role in integrating self-perception with emotional responses, and damage to these areas can lead to severe and sometimes psychotic-like manifestations of anosognosia. This complex interplay of cognitive and emotional disturbances highlights the need for a comprehensive approach in both the diagnosis and treatment of anosognosia.

Anosognosia and the spatiality of emotion. Marcel et al. (2005) provides a framework in the emotional spatiality and cognitive awareness in anosognosia cases. A significant aspect of their framework is the specificity and variability of anosognosia. The study finds that anosognosia can manifest in relation to specific deficits and vary in its expression. For example, a patient's recognition of their hemiplegia might change based on context, or they might overestimate their abilities in certain tasks despite being aware of other limitations. This challenges the notion of anosognosia as a uniform or global lack of awareness.

Marcel et al. (2005) also discuss the importance of integrating sensory and motor information in anosognosia. Impairments in this integration can lead to a fragmented or disjointed understanding of one's physical state, highlighting how patients might struggle to reconcile their immediate experiences of deficits with a coherent self-perception.

A central aspect of their study is the impact of emotional and motivational factors in anosognosia. The researchers suggest that emotions such as denial, fear, or frustration, potentially influenced by right hemisphere damage, significantly shape how patients perceive and accept their condition. These emotional attitudes influence cognitive processes like attention and perception and play a crucial role in shaping the patient's awareness of their physical limitations.

This framework discusses how emotions are not just psychological states but are deeply embedded in our physical experiences. This includes the spatial dimensions of emotions, where bodily states and interactions with the environment significantly shape emotional experiences. The rapid and automatic generation of emotions, referred to as the microgenesis of emotion states, involves the appraisal of events in relation to personal concerns, leading to physical and physiological changes that are spatial in nature.

Moreover, the study discusses the concept of Evaluative Description (ED) of emotions, which is the mental record of how an event impacts an individual’s concerns or self. This aspect is vital as it translates emotional experiences into a form that can be spatially understood and processed. For example, feeling diminished or augmented can have a spatial representation in one's mind.

The concept of Action Attitude (AA), referring to the readiness for physical action as a direct consequence of emotional appraisal, is also highlighted. This readiness is spatially oriented and prepares the body to move or react in physical space in response to emotional stimuli. The study proposes that emotions are experienced through an embodied self, meaning that emotions are felt both internally and through physical presence and interactions in the world. The spatial dynamics of emotions are thus grounded in our bodily experiences.

In conclusion, Marcel and colleagues' framework offers a comprehensive understanding of anosognosia for hemiplegia, emphasizing the multifactorial nature of the condition and the role of the right hemisphere in processing emotions and spatial information. This study provides essential insights into the spatiality of emotion and is instrumental in formulating holistic treatment strategies that consider the complex interplay of cognitive, emotional, and neurological factors in anosognosia. It will also inform my research hypotheses that personality changes and emotion are connected to spatial ability associated with the right hemisphere.

RHD and spatial cognition. Spatial cognition is the capacity to perceive, process and understand information regarding objects and their location in space (Klencklen et al., 2012). Evidence suggests that spatial cognition is one of the main functions of the right fronto-temporo-parietal area (Sack, 2009), with right hemisphere lesioned patients significantly more likely to have spatial location difficulties than left-hemisphere lesioned controls (Mennemeier et al., 1997).

From their investigations in primates, with spatial processing being bilateral, evolutionary researchers surmise that the right hemisphere may be the domain for spatial cognition in humans as a biproduct. They posit that as the left hemisphere developed and dominated language function, other cognitive functions (for example, spatial cognition) were shifted into the domain of the right hemisphere (Oleksiak et al., 2011).

From the information above, it appears that the right hemisphere is more adept at spatial cognition. Spatial cognition requires two separate, dissociable mechanisms to transform mental images: egocentric perspective transformation and object-based transformation (Zacks et al., 2003). Object-based transformation refers to the movement or rotation of an object without reference to the self. Egocentric transformation refers to imagining oneself rotating around fixed objects, or understanding spatial transformation in relation to the self (Zacks et al., 2003). Jeffery et al. (2013) state that object-based and egocentric spatial reasoning have separate neural substrates which are likely interconnected.

These two types of transformations both involve the updating of an observer's egocentric reference point, the environmental or outside reference point, and the intrinsic reference point of the objects in the environment (Zacks et al., 2003). For the egocentric transformation, the link between the object in the environment and the environment itself is static, but the egocentric perspective with reference to the object and the environment is updated (Zack et al., 2003). For the environmental transformation, the egocentric point of view remains static while the object's reference point's relationship to the environmental reference-point is updated. (Zack et al., 2003).

According to Zack et al. (2003), object-based and egocentric perspective transformations are performed by two separate neural networks. From fMRI imaging data in their study, they concluded that different parts of the posterior cortices are responsible for object-based and egocentric perspective transformations. In particular, posterior regions of the parietal lobe are associated with the position of the self in space (Zack et al., 2003). This was confirmed by Sack (2009), Marshall and Fink (2001) and by Nico and Daprati (2008) who found that patients with right parietal lesions suffered deficits relating to egocentric processing, that is, difficulty understanding their own body's position in the environment.

From the above, it is evident that different perspectives on space are subserved by different neural systems and visual processing of space is also linked to different pathways: the dorsal and ventral streams (Ungerleider & Mishkin, 1982). The dorsal route in the parietal cortex is responsible for locating where an object is in space relative to other objects and to the self. The ventral route concerns itself with identifying what the object is, giving it meaning (Sack, 2009).

The posterior parietal cortex is involved in the dorsal route (where the object is relative to the self). Research focused on mental rotation (that is, imagining the rotation of an object while the position of the self remains fixed) has linked this function to the posterior cortex (Kosslyn, 1994) in posterior parietal regions (Zacks, 2008). Some studies have suggested a specific lateralization to the right posterior cortex, but these studies are few and far between and no consensus has been reached. Studies have shown, though, that patients with right hemisphere lesions do suffer from visual mental rotation difficulties (Vromen et al., 2011). Hattemer et al. (2011) found right hemispheric involvement during mental rotation tasks with focused activation in the right hemisphere (such as the inferior gyrus and superior parietal lobe) and bilaterally in the frontal areas. This was found particularly in the male sample. Other studies have supported the conclusion that men show more right hemispheric specialization to mental rotation than do their female counterparts (Siegel-Hinson & McKeever, 2002).

Neurological substrates of ToM and spatial cognition overlap in the right hemisphere. For example, the right temporo-parietal junction is thought to be involved in ToM and left-sided hemineglect (Kerkhoff, 2001). Brunetti et al. (2014) illustrate how social and spatial cognition overlap at the rTPJ, for example when one points to an object in order to get the attention of another (declarative pointing).

Other areas subserving both spatial and social cognition include the right superior temporal sulcus, which is involved in ToM tasks and in the detection of movement (Frith & Frith, 1999). From this overlap of brain areas for spatial cognition and ToM, some have hypothesized that ToM has evolved from spatial ability (Kerkhoff, 2001).

Some studies have found a left hemispheric specialization. Patients with left-hemisphere damage show impairment when using a motor strategy (Tomasino & Rumiati, 2004). In copying figures (such as the Rey-Osterrieth Complex Figure), left-hemisphere patients struggle to copy details of figures, yet are still able to accurately discern and copy the gestalt of the figure. However, patients with RHD (particularly posterior lesions) show an inability to grasp the form of the figure (Stiles & Nass, 1991). This is a deficit that their left-hemisphere counterparts do not display (Stiles-Davis et al., 1985).

Theory Of Mind

ToM refers to the capacity to understand one's own and others' mental states (Baron-Cohen et al., 1985; Baron-Cohen, 1988; Leslie, 1987). This allows us to understand and predict another's behaviour (Premack & Woodruff, 1978). The goal of this section is to discuss the multidimensional aspects of ToM, distinguishing between its cognitive and affective components, and delves into the development and assessment of ToM skills. The nuances of implicit and explicit ToM will be presented and the connection between ToM with ABI.

ToM is multidimensional (Martín-Rodríguez & Leon-Carrion, 2010) and can be divided into two systems: the affective component and the cognitive component (Poletti et al., 2012). The affective component refers to being able to infer another's emotions and feelings, while the cognitive component refers to being able to infer another's beliefs and intentions (Poletti et al., 2012). There is then an overlap between the constructs of "cognitive empathy" and "affective empathy". It is helpful to treat ToM as a multi-faceted system that should be explored from both a cognitive and affective perspective, but I question the need for separate constructs with such overlap between them.

There are two dominant theories of how people make sense of how another is feeling and the intention behind their behaviour. These are the simulation-theory and the theory-theory (Perry & Shamay-Tsoory, 2013). The simulation-theory maintains that we use our own mental models to create a simulation of the others' mind and we experience the beliefs and emotions that we assume the other to believe and feel based on their behaviour and information.

The theory-theory of ToM rather suggests that people approach their ToM development similarly to scientists approaching their field. Children learn to infer others' beliefs and emotions based on their knowledge of people in the world and causal reasoning (Perry & Shamay-Tsoory, 2013). The simulation-theory is similar to our understanding of affective empathy, or the capacity to experience emotions based on observing others, while the theory-theory is similar to cognitive empathy, or ToM, which is the cognitive ability to take the perspective of the other and reason about their mental state.

A recent meta-analysis on ToM and ABI explored 28 studies grouping the findings into either support for the theory-theory of ToM or simulation theory of ToM (Lin et al. 2021). Some studies demonstrate a link between executive functions and ToM, supporting the Theory Theory model (Lin et al. 2021). Others show an association between ToM and emotional or affective variables, aligning with the Simulation Theory. This mix of findings from different research suggests that impairments in ToM following ABI could involve both cognitive strategies and emotional processing (Lin et al. 2021).

Much literature has noted the lack of consensus in ToM research (Schaafsma et al., 2015). They continue that ToM is treated homogenously by researchers and that the definition of ToM needs to be more precise, suggesting that distinctions need to be made beyond cognitive versus affective ToM to include implicit versus explicit ToM. In their understanding, implicit ToM is automatic, rapid and non-verbal while explicit ToM is slow, verbal and deliberative.

Development of ToM. ToM was originally tested based on the cognitive view that if one could understand that someone could have a false belief, (i.e. a belief different from one's own and from reality), they had a ToM. The initial research based on false-belief tasks assessments focused on the performance of children and it has been determined that usually by four years of age, children are able to conceive that others can have false beliefs (Leslie et al., 2004).

In the classic false-belief task, a story is told where Sally places a marble in a basket and leaves the room. Her friend, Anne, moves the marble to another location while Sally is not in the room. After being told this story, young children are then asked where Sally will think her marble is located, or what her belief will be (Leslie et al., 2004).

With this task pre-schoolers can struggle to infer that another's beliefs may be different from what is based in reality. They are unable to inhibit the true-belief default and tend to default to what is true or to the information that they have. Apperly et al. (2006) successfully utilized false belief tasks to understand whether belief reasoning was automatic in adults. They noted that presenting unexpected questions related to false-belief tasks about another person's beliefs took significantly longer to respond to than questions about the object's actual location in the false-belief task. They were able to conclude that adults do not ascribe others' beliefs automatically.

With these earlier assessment tasks, marked ceiling effects were found – healthy six-year-old children should easily be able to pass these test - and even adult patients with marked brain insults are able to pass these tests. This gives rise to one of the challenges facing ToM research being the choice of assessments tasks that are appropriate and sensitive to elicit true functioning. As a result more advanced ToM assessments have been developed that vary in complexity, from basic first-order and second-order tasks to more sophisticated tests like indirect speech and social faux pas recognition. Other advanced approaches that are widely used for assessing ToM abilities in older children and adults range from inferring the mental states of others from cartoons or short stories (Brunet et al., 2003; Gallagher et al. 2000) to inferring the emotional state of others by expressions in and around the eye (Baron-Cohen et al. 1999), from perceiving social embarrassment (Shamay-Troory et al., 2005) to ascertaining whether a person has said something hurtful unintentionally (Stone et al. 1998). The tiers of complexity in ToM assessment tasks mirror the natural progression of developing reasoning skills, as documented in studies by Avis and Harris (1991), Leslie (1987), and Wimmer and Perner (1983).

In the field of ToM research, there is an ongoing debate regarding young children's understanding of mental states. One perspective suggests that children inherently grasp mental state concepts but lack the requisite cognitive abilities, like attention focus or memory, to succeed in ToM tasks. This view interprets their failure as a gap between competence and performance. Alternatively, other researchers posit that children's conceptual understanding of mental states develops with age. This view is supported by evidence of a marked developmental shift around age 4 in understanding representational mental states, particularly false beliefs, indicating a qualitative change in their mental state reasoning. This shift is attributed to a deeper comprehension of mental states.

Advancements in ToM research have broadened the focus beyond the conventional age range of 3 to 5 years, encompassing studies on infants and adults. For infants, research methodologies have adapted to include simplified social scenarios with an emphasis on observing looking behavior rather than relying on verbal responses. In adult studies, researchers employ parametric measures across multiple trials to mitigate ceiling effects. These methodological advancements have uncovered early ToM abilities in children and more intricate ToM performance in adults. Consequently, these findings have spurred further discussion on the roles of language, executive function, and the differentiation between implicit and explicit ToM measures, thereby opening new avenues for research (Samson & Appelby, 2010).

In summary, while the interpretation of social information involves analyzing explicit and implicit social cues, ToM focuses on understanding the internal mental states behind these cues. Both are integral to successful social interaction but emphasize different elements of social understanding.

ToM and ABI. The relationship between ToM deficits and the broader neuropsychological profile in patients with severe ABI varies. Some studies have identified a positive correlation between cognitive functions like working memory, processing speed, inhibition, flexibility, and ToM performance (Bibby & McDonald, 2005, Dennis et al. 2009 and Henry et al. 2006). However, other research suggests a possible separation between cognitive impairments from ABI and deficits in social cognition (Tranel et al. 2002). Consequently, several researchers propose that ToM and other cognitive domains might operate as independent cognitive systems. The structured development of ToM suggests that assessment tasks of varying complexity and specificity can effectively measure ToM impairments in adults with ABI. This methodology, first proposed by Stone et al. (1998) and later supported by researchers like Shamay-Tsoory (2003) and Shaw (2004), has been instrumental in identifying various levels of ToM abilities in conditions like schizophrenia and autism spectrum disorders, as observed by Apperly, Samson, and Humphreys (2005).

A comprehensive meta-analysis encompassing 26 studies delved into the effects of ABI on ToM (Martin-Rodriguez & Leon-Carrion, 2010). This analysis evaluated ToM using diverse tasks, including first-order and second-order belief tasks, indirect speech, and the Faux Pas test. The findings revealed a strong association between impaired Faux Pas performance and ABI (effect size = .7), with the specific area of brain injury being a crucial determinant. Particularly, injuries to the frontal lobe and right hemisphere (RHD) were more frequently linked to substantial ToM impairments than left hemisphere damage (LHD).

There's a growing body of evidence in ABI research underscoring the challenges individuals face in social cognition following an injury. Studies have consistently shown that people with ABI often struggle with empathetic understanding, face difficulties in social engagement, and have trouble interpreting sarcasm and irony. Furthermore, there's documented evidence of diminished social skills, constrained conversational involvement, and issues with appropriate emotional expression. These social cognitive difficulties, primarily stemming from an impaired ability to process social information, can have a more debilitating effect than other cognitive challenges arising from ABI.

Interpreting social information involves understanding, evaluating, and responding to social cues and contexts. It includes recognizing and interpreting social signals such as facial expressions, body language, tone of voice, and social norms. This skill is crucial in discerning others' emotional states, intentions, and behaviors in various social situations. It primarily focuses on identifying the 'what' in social interactions – what is happening, what are the signals, and what they imply.

The ramifications of these impairments extend beyond the patients, significantly affecting their families and caregivers. Additionally, these social challenges present formidable hurdles in adjusting to life within the community post-injury and can impede the effectiveness of rehabilitation programs.

Studying ToM in ABI patients offers distinct benefits over functional neuroimaging methods. This approach, which involves analyzing brain lesions, provides a more precise understanding of the brain regions crucial for ToM. This method's effectiveness has been highlighted by Bird, Castelli, Malik, Frith, and Husain (2004). For accurate results, it's important to carefully select patients for research, ensuring their brain lesions are in clearly defined areas. In ToM research, including a diverse range of ABI patients, with different injury causes and severities, can lead to inconsistent results due to the variability in cognitive performance. This issue is particularly relevant in studies involving traumatic brain injury (TBI) patients, as they often have more extensive and severe brain damage, including diffuse axonal injuries, than those with other types of ABI (Martin-Rodriguez & Leon-Carrion, 2010).

In the assessment of pragmatic ToM in individuals with acquired brain injury (ABI), the identification of social faux pas, a concept introduced by Stone et al. (1998), is frequently used. This test requires patients to identify situations where someone unknowingly makes an inappropriate remark. It includes questions about the emotional reactions of the character who commits the social error, thereby evaluating both the cognitive and emotional aspects of ToM. Generally, children develop the skill to successfully complete this task around the ages of 9 to 11.

Samson and Michel (2013) point out that the cognitive and neural mechanisms which underpin ToM are still unclear. Given previous evidence that there is a neurological network of distinct areas associated with it and that lesions to different areas can lead to compromises in ToM functioning, ToM is not a unitary function (Samson & Michel, 2013). Samson and Michel (2013) saw being able to inhibit one's own perspective as the first cognitive requirement for ToM functioning. Samson et al. (2005) presented the case study of WBA, who suffered right lateral PFC damage following a stroke illustrates this. Their ToM tasks (reality-known and reality-unknown false belief tasks, Samson et al. 2005) used two conditions in the classic false belief task: one where the participant knows of the change of location (high self-perspective inhibition condition) and one where the participant does not know (low self-perspective inhibition condition).

Patient WBA made false belief errors only when he was aware of the locations but he was able to correctly ascribe false beliefs when he was not aware of them. From this case study, evidence of the right PFC's role in inhibiting one's perspective is the first stage of ToM. The first step of ToM is to inhibit our own belief/position. If there are problems with inhibition (a frontal function) then ToM performance would suffer (Samson, 2005).

Contrast this with PF, a patient suffering from left temporo-parietal damage. She performed better on tasks that required inhibition of self-perspective but failed at automatically tracking other people's mental states (Apperly et al., 2007). Samson and Michel (2013) encourage more acquired brain lesion studies to help understand the varying building blocks of ToM in addition to executive and memory functioning. Their current understanding involves four distinct processes. Firstly, a process to inhibit one's own perspective and secondly, to monitor the environment around oneself to perceive relevant information to have the relevant content for others' mental states. The last two processes involve short-term memory to temporarily hold others' mental states in one's own mind, and long-term memory to store ToM knowledge of others.

Samson and Michel (2013) agree that the biggest challenge in ToM research is the untangling of the representations of others' minds and its insight into the neural and functional understanding of ToM architecture. Both Samson and Michel (2013) and Koster-Hale and Saxe (2013) agree that a crucial method to understand this relationship between neural and ToM functional architecture is through studying patients with acquired brain damage.

Samson (2009) has done this and was able to identify the left TPJ as integral to ToM tasks. However, all their participants with RHD failed the control tasks, which means that they could not test ToM deficits in right hemisphere patients. This was likely due to the assessment being done in the acute phase following brain injury. In order to pass the higher level ToM task (specifically the *Faux Pas* task), the patient would need to be have relatively intact intelligence, inhibition and memory to pass the control tasks (Samson, 2009).

Samson (2009) and Samson and Michel (2013) made a compelling argument to explain the foundation of ToM architecture by discussing the building blocks, broken down into four separate processes. Firstly, the first building block is executive in nature and allows the participant to inhibit their own perspective. They use the work by Baron-Cohen et al. (1985) on first order False Belief tasks (the "Sally and Anne" story discussed earlier). In order to take the perspective of Sally, the participant must first inhibit their own, more detailed and accurate knowledge of the moved marble.

Samson and Michel's (2013) second building block is also executive in nature but its function is to monitor the environment or *track* the other person's belief. This involves being able to detect and integrate observations to give the participant information into being able to infer what they may be thinking. Samson et al. (2007) provided evidence of this in a case study, patient PF, who suffered from left TPJ damage. While she had strong ability to inhibit her own perspective, she performed poorly when having to infer what another person would do in an 'reality-unknown condition' where she was not reminded what the other person knew or that their perspective may be needed to correctly complete the task. These first two building blocks are executive in nature then (inhibition and tracking) and are necessary for perspective taking or mind reading to occur.

The third building block is also executive in nature and is tied to the second one. In order to hold information in our mind (the third building block), there needs to be inhibition of self and an ability to track or monitor the environment for cues.

Bukowski & Samson's (2017) newer research deals with narcissism and how we understand and interact with others. They illustrate that people vary in how they take on others' perspectives. This variation is based on two main factors: 1**.** *How well they distinguish between their own perspective and someone else's*: Some people are better at separating their own thoughts and feelings from those of others, while some find this more challenging; and 2. *How much attention they pay to themselves versus others:* Some individuals tend to focus more on their own viewpoint (referred to as "egocentric"), while others pay more attention to what others might be thinking or feeling (referred to as "altercentric"). Here, egocentricity is the mediator for ToM where egocentric people are “non-flexible” if they have difficulty in distinguishing between self and other perspectives, while others are "flexible" if they can do this more easily (Bukowski & Samson, 2021). This is a cognitive connection between perspective taking and narcissism.

Saxe’s (2006) work from functional imaging and ToM studies argues that the right hemisphere (particularly the right TPK) is specifically involved in the representation of the beliefs of other people. If this theory is valid, that the theoretical framework for understanding ToM is one of meta-representation, then the brain needs to be able to hold that information of another’s representation in order to process it. Working memory is therefore required. Evidence for this is provided by McDonald and Bibby (2005) in Samson and Michel (2013) in their study that showed that higher resources of working memory correlated with higher order false belief tasks than simple first order false belief tasks. The greater the complexity of the representation of the other, the more working memory resources are required. Work from Lin et al. (2010) shows that people with lower working memory spans were significantly less able to use ToM or mindreading abilities.

The last building block according to Samson’s work is based in long-term memory. This proposal dismisses that ToM is not a “folk’ theory but requires explicit knowledge about mentalizing: e.g. the knowledge that people’s beliefs can shift over time. For example, the ability to infer people’s mind from verbal tasks would require the memory of the semantic knowledge of the language itself. However, the participant would still be able to infer mental states if assessed non-verbally (Samson & Michel, 2013).

Saxe and Samson's work is the foundation for this research. In order to tease apart the mechanism and complexity of ToM, case studies involving acquired brain injury is necessary. Our current research addresses a notable gap in ToM studies, focusing on individuals with acquired brain injury (ABI) who demonstrate proficiency in the primary cognitive underpinnings of ToM—executive functions, including inhibition and working memory, alongside general intelligence. This investigation aims to contribute additional lesion studies to the ToM literature, elucidating how aspects beyond these foundational cognitive skills may influence ToM performance. The study's intention is to deepen our understanding of the multifaceted and complex nature of ToM, particularly in the context of ABI.

RHD and ToM. Patients with RHD show impaired ToM ability (Sabbagh, 1999; Winner et al. 1998). Kaplan, et al. (1990) and Winner et al. (1998) demonstrated that right hemisphere patients were unable to understand sarcasm, and typically inferred deceitful intentions. This was ascribed to an inability of right- hemisphere patients to infer the mental states of others. Specifically, this relates to the ability to accurately identify the speaker's intention in order to discern the difference between lies and irony. In the past decades, there has been increased research in the domain of social cognition in patients with acquired brain injury (Bibby & McDonald, 2005; Cicerone & Tanenbaum, 1997; Henry et al., 2006; Mah, Arnold & Grafman, 2014; Martin-Rodriguez & Leon-Carrion, 2010; McDonald & Flanagan, 2004; McDonald et al., 2011; Muller et al. 2010; Williams & Wood, 2009). Channon et al. (2005) studied the relationship between closed head injury, ToM and sarcasm, while Henry et al. (2006) explored the relationship between ToM and emotion recognition following traumatic brain injury. Shamay-Tsoory et al. (2004) have found links between basic empathy and acquired brain injury (specifically in prefrontal areas and right parietal areas), while Santoro and Spiers (1994) discovered maladjusted emotional expressions in cases of acquired brain injury.

Other authors have confirmed these findings, arguing that right hemisphere patients consistently show this inability (for example, Brownell et al. 1990; Happe et al., 1999; Kaplan et al., 1990; Stuss et al., 2001), and patients with right-sided hemispherectomies show more ToM problems than their left-sided hemispherectomy counterparts (Fournier et al., 2008). Happe et al. (1999) developed stories that create a conflict with regard to a character's motives or thoughts. They found that participants with RHD were worse at inferring the mental states of characters. Further evidence for this is studies showing that patients with left posterior lesions exhibit similar levels of ToM response to controls (Shamay-Tsoory et al. 2003). While a number of areas are implicated in ToM research, the right anterior and posterior areas are consistently identified and associated with ToM.

There is evidence from lesion studies that damage to the right hemisphere leads to ToM dysfunction. However contrary evidence exists also, showing the involvement of the left temporo-parietal junction (TPJ) in false belief tasks in children (Xiao et al. 2019), the left inferior frontal gyrus in an emotion inferring task (Schurz et al. 2020) and the left frontomarginal gyrus in cognitive perspective taking tasks (Molenberghs et al. 2016). Additionally, left-sided activation of the frontal structures is reported to be more marked in ToM tasks (Baron-Cohen et al. 1999; Calarge et al., 2003). There is therefore controversy concerning the role of left hemisphere structures in ToM, which suggests that the left hemisphere is not as integral to ToM as the right hemisphere and that ToM is *relatively* lateralised to the right.

While a few areas in the left hemisphere have been implicated in ToM, almost the entirety of the right hemisphere has been linked to it. For example, studies have agreed that ToM may be subserved by prefrontal and temporo-parietal areas (Fletcher et al., 1995; Mitchell et al., 2005; Santiesteban et al., 2012; Saxe & Kanwisher, 2003; Saxe & Wexler, 2005; Vogeley, et al. 2001) and the limbic system and temporal areas (Abu-Akel, 2003; Baron-Cohen et al., 1999, Frith & Frith, 2003; Gallagher & Frith, 2003; Gallagher et al. 2000). De Achaval's et al. (2012) work on schizophrenia and ToM found lowered activation in right hemisphere areas, such as the right temporoparietal junction and frontal areas, in participants with ToM difficulties (Gallagher et al. 2000). ToM is therefore related to large areas in the right hemisphere.

This creates a challenge for understanding the neural foundations of ToM. Happe et al. (2001) suggest that certain lesions, for example, in the connections between the orbito-frontal areas and the limbic system, may impair the ability to evaluate the mental states of others. A connectionist network, not entirely lateralized to the right hemisphere, may then be a better idea for understanding ToM, rather than focusing only on small, localised areas.

There are two neural areas that appear to have consensus among researchers: the right prefrontal cortex and the right TPJ. The following looks at the mechanism that ties these areas to ToM functioning.

Shamay-Tsoory et al. (2004) state that the right ventro-mesial area only appears to be involved in affective aspects of ToM and not cognitive components, as all adult patients in their study passed the false belief tasks. The right ventro-mesial prefrontal cortex might not be involved in the cognitive aspect of ToM. This claim should be treated with caution as the tasks they are referring to were developed for healthy four year old children. Kalbe et al. (2010) disagrees and argues that damage to the right prefrontal areas results in cognitive ToM deficits but not affective ToM deficits (Kalbe et al. 2010). Their evidence was based on using 1 Hz repetitive transcranial magnetic stimulation (rTMS) to interfere with the functioning of the right dorsolateral prefrontal cortex. Cognitive ToM was disrupted as a result, but not affective ToM. This does not necessarily mean that the right prefrontal cortex is the seat of ToM, though.

Schaafsma et al. (2015) broke down some of the underlying functions required for ToM. Emotion and feature processing need to be intact in order to infer mental states from facial expressions and gaze. Predicting behaviour based on attributed mental states requires the underlying ability to track intentions, an ability to separate belief from fact and an understanding of causality (Schaafsma et al. 2015). These underlying functions are necessary for ToM to occur, but are not themselves ToM. From the above information, we can see that ToM requires different abilities to be intact. This may require us to tease out the different functions of the right prefrontal cortex (e.g. executive function) and their role in ToM.

This makes ToM research difficult to do, as other cognitive domains are needed for ToM to function. Frith and Frith (1999) posit that the neural mechanisms that are necessary for ToM are related to functions of location and object tracking, language processing, and executive functioning. In developmental psychology, they have also been unable to parse out the causal roles of language, executive function and ToM in development. They are intrinsically inter-related. In order for ToM to be functional, a range of domains needs to be intact.

In attempting to understand the mechanisms of ToM, Leslie et al. (2004) used a belief-desire processing model. This model focuses on 'metarepresentation', a system that represents desires and beliefs. This system uses an inhibitory selection process: it is easier and quicker for us to assume that another's desires and beliefs are identical to our own (true-belief default). But what happens when this is not true, that is, when a false belief is in effect and another has a different desire or belief to one's own? It then becomes necessary to inhibit this true-belief default and to be able to select a more appropriate option (Leslie et al., 2004). The prefrontal cortex allows inhibition of one's own beliefs, then, in order for inference into others' minds to take place.

Besides the right prefrontal cortex, the right TPJ has been repeatedly identified as important for ToM processing. Saxe & Kanwisher's (2003) work in particular is instrumental in illustrating the role of this particular area of the right hemisphere. By utilizing false belief tasks with fMRI, they were able to show that the right TPJ is preferentially active when thinking of other minds. Later, multiple imaging studies have been published confirming the relationship between ToM and right hemisphere functioning (Balaban & Friedmann, 2015; Filmer & Fox, 2019; Nott et al. 2019; Saxe 2009; Saxe & Kanwisher, 2003; Saxe & Powell, 2006; Saxe et al., 2006). Saxe's (2006) imaging research using false-belief tasks also showed right lateralization in the prefrontal cortex as well as the right TPJ. She has further argued that the right TPJ is specifically involved in the representation of the beliefs of other people.

From the above sections, it is evident that right hemispheric structures are strongly implicated in ToM functioning. It is clear that distributed networks are implicated, as ToM is a higher order function. ToM appears to be dependent on several areas in the right hemisphere as well as subcortical structures. Research that looks broadly at the role of the right hemisphere may therefore be helpful in ToM research.

Research illustrates that ToM is not the sole purpose of the right TPJ (Karnath et al., 2002; Weed et al. 2010). The right TPJ is part of the attentional network and is related to orientation (Kraft et al., 2015; Luckmann et al., 2014, Petersen & Posner, 2012). Posner's attentional model (see Petersen & Posner, 2012 for an updated review) is crucial here in understanding that the brain's attentional system, particularly alertness, visual orientation and target detection is subserved by right posterior parietal areas. Rafal and Henik (1994) argued that the right TPJ is involved in endogenous orientation that is not reflexive. In other words, tasks where the individual must voluntarily direct their attention lead to activation in the right TPJ region (Corbetta & Shulman, 2002; Halligan et al. 2003). The right TPJ is also linked to spatial perspective taking (Blanke et al. 2005).

From the above, we can see that the same area in the right hemisphere is integral to mentally taking the perspective of another and spatially taking the perspective of the other. The question becomes why is this happening? Does one give rise to the other? Itier and Batty (2009) explained this overlap of social and spatial cognition as being the result of controlled eye movements and gaze processing that is facilitated by the right TPJ. They argued that the reason this area in the right hemisphere is linked to ToM is because the ability to gaze and orient one's eye movements is integral to mentalising. Processing gaze is fundamental to ToM because the eyes are one of the best sources of social information (Itier & Batty, 2009).

Reading the Mind in the Eyes is one of the most prominent ToM tasks (Baron-Cohen et al., 2001), using facial expressions reflective of higher order mental states or complex emotion. This is different from the basic ability of facial emotion recognition. The task rather requires participants to infer the complex emotional state of a person by a photograph of their eye expression. ToM impairment should then arise from an inability to gaze or orient one's eye movements. But there are other steps besides gaze and eye movement orientation in ToM.

Overlap Between Theory Of Mind and Spatial Cognition

Takeuchi et al. (2013) showed that the ability to empathize is related to increased density of white-matter tracts near the right temporo-parietal junction and inferior parietal lobule. They adopted Baron-Cohen et al.'s (2005) definition of ToM as the ability to understand that another's mental beliefs are different to one's own and that one can predict others' emotional states. They used Baron-Cohen and Wheelwright's (2004) The Empathy Questionnaire (EQ) to measure empathy, and they used the following definition of empathy: "Empathy is the drive or ability to attribute mental states to another person/animal, and entails an appropriate affective response in the observer to the other person's mental state"

(Baron-Cohen & Wheelwright, 2004: p.168). This definition was corroborated by six experimental psychologists working in the empathy field (Takeuchi et al. 2013).

Frith and de Vignemont (2005) showed interest in mentalising ability in patients with autism. Here, they treated mentalising as either egocentric, where the other person was described in relation to the Asperger's Syndrome patient, or allocentric, where the other was described as independent of the patient. In comparing spatial processing systems, patients with autism struggled more with allocentrism, which they treated as highly abstract, in comparison to egocentrism (Frith & de Vignemont, 2005). Their evidence shows that areas that subserve spatial cognition are involved also in social cognition. In addition, those with social cognitive deficits (that is, patients with autism) struggle with allocentrism in perspective taking. This all points to a link between one's spatial ability (particularly, allocentric spatial ability) and inferring what another may be thinking.

The argument that ToM relies on spatial ability is sensible. That is, the ability to mentally rotate objects and see how objects relate to self may subserve the ability to see things from another's point of view and acknowledge that another's mental life is separate from one's own. The ability to take a third-person perspective by imagining oneself literally from the perspective of another can actually improve ToM ability (Zwickel & Müller, 2010). This strengthens the argument that there are strong links between social and spatial cognition and strengthens the hypothesis that ToM incorporates existing spatial function to enhance mental perspective taking.

Hamilton et al. (2009) investigated visual perspective taking in children with social cognitive impairment. They agree that the precursor to social cognition was to be able to literally imagine oneself in another's shoes, before being able to do it metaphorically (Hamilton et al., 2009). They found that children who struggled with social cognitive tasks struggled with visual perspective taking more significantly, compared to other spatial tasks. From this example, spatial perspective taking and mental rotation would be necessary for social cognition and ToM to occur.

Frame of reference would then be crucial to our understanding of the relationship between spatial and social cognition (Sun & Wang, 2014). In terms of frame of reference in spatial cognition, Sun and Wang (2014) further differentiate between allocentric and egocentric references. They divide allocentric referencing into intrinsic and allocentric. Here, intrinsic indicates a reference point that is flexible whereas allocentric indicates a fixed reference point.

The former is susceptible to time-related changes, as the reference point may move. Sun and Wang (2014) argue that the same mechanisms used for predictive learning with reference to an intrinsic frame of reference, whereby one predicts where the object will move in space, is similar to the mechanisms of social cognition. This is congruent with Schaafsma's et al. (2015) description of prediction and tracking of another's mind as a component of ToM. The neural areas involved with predicting the movement of an object and its locational change in space, are the same areas associated with the predictive nature of ToM, where one predicts what a person may be thinking and may do next (Sun & Wang, 2014).

Other work sees perspective taking in ToM as a two-step process. Samson (2005) argues that the frontal lobe's role in ToM may involve holding one's own perspective and another's at the same time, and being able to disentangle the two (Gallagher & Frith, 2003 in Samson, 2005). Samson (2005) and Vogeley et al. (2001) continue that inferring another's perspective involves fronto-parietal activation and say that a problem with much research is separating the different functions of the frontal lobes and the temporo-parietal junction in ToM. Their argument is that ToM is a two-step process. The frontal lobes inhibit one's own perspective and the temporo-parietal region processes the perspective of the other.

Samson (2005) puts forward the most popular argument in the literature, which is that the frontal lobes support the ability to exercise a ToM. The frontal lobes' widely accepted role is that of executive control. The frontal lobes may then be providing assistance in managing complex reasoning in ToM (Samson, 2005; Samson et al., 2005; Samson et al., 2007). In ToM research, executive functioning, particularly inhibition, would need to be controlled. Following this logic, patients with hemineglect would be more likely to suffer from ToM deficits than those with intact spatial cognition. Patients with RHD with spatial cognition deficits would then be more likely to develop ToM deficits.

There appears to be a gap in the initial discussion regarding how neglect, particularly hemineglect associated with RH damage, relates to ToM deficits. Hemineglect, or the lack of awareness of one side of space, can provide a unique lens into the dysfunction of spatial awareness and its impact on social cognition. Patients with hemineglect often ignore stimuli on the affected side, which could metaphorically extend to a neglect of other people's perspectives or emotional states.

Samson's (2005) research suggests that the frontal lobes play a crucial role in managing the complex reasoning involved in ToM by helping to inhibit one's own perspective to consider another's viewpoint. This inhibition is crucial for patients with RH syndromes, including those with spatial cognition deficits, as they are more susceptible to ToM deficits. This connection underscores the intertwined nature of executive functions, spatial reasoning, and ToM abilities, clarifying why impairments in spatial awareness due to RH damage could exacerbate difficulties in understanding and relating to others' mental states.

By reorganizing the section to first emphasize the foundational links between spatial and social cognition and then addressing the specific concerns about neglect and RH syndrome, the revised narrative should provide a clearer, more logically connected argument that aligns with developmental evidence and addresses the reviewer's concerns about the theoretical justifications.

Overview and Rationale

This research embarks on a nuanced exploration of the intersections between ToM spatial cognition, and personality changes related to ABI. The right hemisphere's role in social and emotional behavior is a focal point, suggesting an intricate relationship between spatial cognition, personality changes (notably egocentrism) and ToM functionalities. This research aims to scrutinize the correlations between RHD and changes in social cognition and personality, with a focus on traits akin to 'acquired narcissism' (Kaplan-Solms & Solms, 2000) and 'acquired sociopathy' (Saver & Damasio, 1991). The research hypothesizes that RHD-induced spatial cognitive deficits and personality changes substantially influence ToM capabilities. Additionally, the study aspires to bridge gaps in existing literature by employing a thematic analysis methodology to comprehensively examine how ABI patients with preserved intelligence, working memory, and inhibition, navigate ToM challenges.

The overarching goal is to add to the construct of a neuropsychological profile that illuminates the psychological architecture connected to ToM performance, offering insights into how patients with ABI interpret and navigate relationships, thereby contributing novel perspectives to the field.

The research aims to explore the intricate relationship between personality change, spatial cognition, and ToM. Individuals with RHD often exhibit emotional and behavioral dysregulation, social cognition difficulties, egocentrism, and traits associated with Cluster B personality disorders. These changes can profoundly affect mood regulation, emotional processing, and expression. The framework proposed by Marcel et al. (2005), highlighting the role of the right hemisphere in processing emotions and spatial information, informs this research by providing a neuropsychological link between emotion and spatial cognition.. Additionally, perspective taking in ToM, as discussed by Samson (2005), suggests a two-step process involving the frontal lobes and temporo-parietal region, indicating that patients with spatial cognition deficits might develop ToM deficits. Samson's (2005) research has noted the gap of lesion studies controlling for the initial steps of ToM to add to the complicated picture of the neuropsychology of ToM. She argues that lesion studies in particular help with the understanding of how the brain and cognition work together in reading minds. By looking at adults with brain damage, research can clarify how different processes involved in mind reading work and how they are connected to language and decision-making skills.

Newer research by Bukowski and Samson (2017) examines individual variations in perspective-taking, identifying two key factors influencing this ability. Firstly, they look at how effectively individuals can differentiate between their own perspective and that of others. Some people adeptly separate their thoughts and feelings from those of others, while some struggle with this differentiation. Secondly, they explore the degree of focus on self versus others, distinguishing between "egocentric" individuals who are more self-focused and "altercentric" individuals who are more attuned to others' thoughts and feelings.

They suggest that egocentricity plays a pivotal role in perspective-taking, categorizing individuals as "non-flexible" or "flexible" based on their ability to distinguish between self and other perspectives. This research also makes a cognitive connection between perspective-taking and narcissism, and the mediating role narcissism may provide in ToM. Our research will investigate these connections, focusing on how personality changes related to egocentricity and Cluster B qualities may link to spatial abilities in the right hemisphere (Bukowski & Samson, 2017). Our research aims to add to Samson’s work by providing lesion study evidence on the neuropsychological picture of ToM.

Aims

This research aims to explore the intricate relationships among spatial cognition, personality changes—specifically egocentrism—and Theory of Mind (ToM). It particularly focuses on the contributions of the right hemisphere, examining how damage to this area influences self-awareness and the ability to understand others' mental states (ToM). Clinical observations and prior studies suggest that right hemisphere damage often results in significant personality shifts and impaired social interactions, which may affect an individual's capacity for ToM (Happe et al., 1999; Shamay-Tsoory et al., 2005). This study will delve into right hemisphere syndrome deficits, including anosognosia and spatial neglect, to clarify how these impairments interact with ToM and personality changes following acquired brain injury (ABI).

Research Questions

1. **Clarifying the Relationship Between Visuo-Spatial and ToM Performance**:
    - Investigate how visuo-spatial capabilities relate to ToM, controlling for executive functioning and intelligence. It is hypothesized that individuals with right hemisphere damage (RHD) will exhibit poorer visuo-spatial performance compared to controls, which in turn, might correlate with weaker ToM abilities. This study will also examine if visuo-spatial abilities can predict ToM performance, exploring potential differences based on lesion location (anterior vs. posterior).

2. **Examining the Impact of ABI on Personality Changes and Their Relationship to ToM**:
   - Analyze how ABI influences personality, focusing on changes in Cluster B personality traits, such as egocentrism, and their relationship to ToM and spatial cognition. This question seeks to determine whether post-injury personality changes in individuals with RHD, particularly those related to egocentrism and narcissistic behaviors like empathy reduction and altered self-insight, predict ToM abilities.
3. **Analyzing ToM Task Performance in Individuals with RHD**:
   - Evaluate how individuals with RHD perform on ToM tasks, such as the Faux Pas test, controlling for executive function and intelligence. This question aims to determine if RHD is a significant predictor of ToM outcomes. A qualitative thematic analysis of task performance will be conducted to identify specific areas of difficulty and their potential links to changes in social cognition and personality post-injury.

Objective

By investigating these features of right hemisphere syndrome, this study aims to provide critical insights into how spatial cognition and personality changes from ABI are related to ToM. The ultimate goal is to enhance our understanding of the neural and cognitive mechanisms underlying social cognition impairments following right hemisphere damage.

Methods

The study was divided into two sections: acute (Study 1) and chronic (Study 2) phase investigations of the impact of RHD on the variables of interest. Conducting the study in two distinct phases – acute and chronic – was done for several reasons.

Firstly, understanding disease progression was necessary. By assessing patients shortly after injury (acute phase) and then again at a later stage (chronic phase), the study could track changes and developments in cognitive and personality traits over time, specifically spatial cognition. This method was especially important for patients with RHD. It let us see how their lasting problems with understanding space relate to their ToM and how their narcissistic traits might change or remain the same after injury.

Moreover, considering the detection of delayed effects, some cognitive changes, particularly in areas like visuo-spatial abilities and nuanced personality traits, might only become apparent or pronounced over time. An initial assessment could fail to capture these subtleties, which could emerge or intensify in the months following the injury. This longitudinal approach, therefore, provided a more comprehensive understanding of the impacts of RHD and LHD.

Lastly, the dual-phase approach enhanced the reliability of findings. Assessing patients at two different time points allowed for distinguishing between immediate effects of the brain injury and longer-term changes. This was crucial in the context of RHD, where certain symptoms or changes in social cognition and personality, such as those related to narcissistic behaviors, might not be immediately evident (Cascio et al. 2015). The chronic phase assessment provided a more robust and reliable understanding of these changes, reinforcing the findings from the acute phase with additional insights.

Behavioural assessments were conducted within a week of neurological insult (that is, acute phase) and at least 4 months post neurological injury (that is, chronic phase) for Study 1 and Study 2 respectively.

Study 1: Acute phase assessment

Research Design

For Study 1, a researcher-blind, quasi-experimental design was used to compare the RHD group with a control group of similarly acute LHD patients on negative mood, spatial cognition and ToM. We use the term “researcher-blind” to indicate that the administrator and scorer of the tasks in the study did not have knowledge as to which group the participants belong.

Sample

Study 1. The first study’s sample included 23 right-handed participants aged between 32 and 65 years in the acute phase post-stroke. The cut off point for the acute phase was one week post-neurological insult. Convenience sampling was used by including all consenting Right Hemisphere cerebrovascular infarction cases who were admitted at Groote Schuur Hospital’s neurology stroke ward during the first half of 2011. Consenting Left

Hemisphere cases who matched the Right Hemisphere cases were recruited during the same timeframe. The groups were matched by lesion size and location (for example, a RHD patient with an anterior lesion would be matched with a LHD patient with an anterior lesion of a similar size). This was done in consultation with a supervising neuropsychologist using neuroimaging to match patients by lesion size and localization. CT scans were rated as either anterior, posterior, both or neither, and lesions sizes were matched within 5 millimetres. These recruited and matched participants consisted of 13 RHD and 10 LHD patients.

While the primary criteria for matching were location and size of lesion, this study also matched for gender, age and education. Patients were not deliberately matched by language, but all participants in Study 1 identified themselves as bilingual (English and Afrikaans). The purpose of Study 1 was to investigate the social and spatial cognitive deficits in patients immediately post-stroke. This study wanted to examine the acute effects of brain damage. Therefore, a neurologically intact control group was not included, but did recruit a neurological deficit control group (acute LHD group). See Table 1 for more details on participants' demographic information. Regarding socioeconomic and sociodemographic status, all patients in Study 1 were patients at state hospitals, indicating low income.

Table 1
Demographic characteristics of the full sample of Study 1

	RHD	LHD	χ^2 / t	p
N	13	10		
Gender (Male:Female)	4:9	3:7	.02	.97
Age	48.46	49.00	.12	.91

	(9.62)	(11.53)		
Age Ranges	(18 – 77)	(23 – 71)		
Highest Level of Education	10.38	10.50	.08	.94
	(2.00)	(2.12)		

Note: Means presented with standard deviations in brackets for Age and Highest Level of Education.

Brain scans (CT or MRI) verified the size and location of the lesions in the clinical groups (See Appendix A and B for lesion details of each clinical participant). All participants were screened for multiple CNS insults and premorbid psychiatric and significant social difficulties. The LHD and RHD groups had focal and lateralised pathologies with no bilateral or generalised conditions, as I was trying to establish location-function correlations.

No participant with significant pre-morbid psychiatric and/or social dysfunction was eligible for the study because the research explored the impact of specific brain damage on these functions; for example, participants with a prior history of affective or psychotic disorders, previous gang membership or any social deviancy were immediately excluded. Aphasic patients with marked impairment of comprehension and/or production were also excluded, as a certain level of language functioning was necessary to understand consent and to engage with the tasks. See Appendix E for the full list of exclusion criteria.

Recruitment and Ethics. Recruitment progressed from September 2010 until October 2012. The University of Cape Town's Faculty of Health Sciences Human Research Ethics Committee granted ethical approval (HREC 121/2010, see Appendix C) and the Declaration of Helsinki's ethical codes were followed regarding the principles of working with research participants (Declaration of Helsinki, 2013). The university and hospital granted ethical approval for access to medical folders. Folders were kept on hospital premises and were not removed from the records offices.

Patient access. Relevant neurological and neurosurgical wards at Groote Schuur Hospital were used to find participants for Study 1. Only literate English or Afrikaans patients were approached as the ToM tasks required a basic level of reading ability. Potential patients were screened at the hospital.

Those who did not meet any of the exclusion criteria (described in Appendix D) were provided information regarding the study, gave written consent to participate in the initial assessment and were then administered Study 1's cognitive-behavioural assessment. Patients provided consent for later contact to participate in Study 2.

In order to keep this work researcher-blind, research assistants approached patients and obtained signed informed consent from all participants (see Appendix E for Consent and Information forms). Though none of the participants were under legal custodianship, given the potential cognitive compromise in the patient groups, family members were encouraged to be present for the initial assessment.

Risk of harm. Risk of harm was not present in this study. Fatigue from testing was the only possible harmful effect, but participants were given breaks and encouraged to take additional breaks whenever they wanted. Being provided with information on the effects of the neurological injury after the assessments was a possible benefit, given the positive feedback received from participants' close family members. For some, family members stated that they were relieved to hear that personality changes can be related to neurological injury.

Procedure

Participants in the acute post-neurological insult phase were assessed at their bedside at Groote Schuur Hospital. After written consent was obtained, a paper and pen behavioural assessment was conducted. Study 1's protocol consisted of assessment of spatial cognition, mood and social cognition.

Assessment tools. Before any of the assessment instruments were administered, patients were interviewed and were asked questions regarding their highest level of education and literacy ability. Patients with LHD were interviewed for longer to ascertain language impairment (specifically production and comprehension). All participants interviewed were literate, and two participants showed potential language impairment. This was discovered after screening and only picked up during assessment. For these two participants, the assessment was immediately ended.

For the tasks below (see Table 2), translations into Afrikaans were available. Assessments were conducted in either English or Afrikaans, depending on the requests of the participants. Questionnaires were read to the patient in either English or Afrikaans.

Table 2

Study 1. Assessment and domain: Acute phase

Anosognosia	Anosognosia task
Extinction	Extinction task
Mood	Beck Depression Inventory II
Spatial Cognition	Matches Spatial Cognition Task
Spatial Cognition	Rey Complex Figure
Spatial Cognition	Benton Judgment of Line Orientation
Theory of Mind	Faux Pas Task
Theory of Mind	First Order False Belief Task

Anosognosia. *Anosognosia for hemiplegia questionnaire.* This questionnaire was developed by Feinberg et al. (2000) as a clinical rating 3-point scale to ascertain the presence of a denial of deficit for patients with stroke. A score of 0 denotes no anosognosia where the patient demonstrates full awareness of their deficit. They accurately acknowledge functional limitations and have a realistic appraisal of any limitations. A score of 1 indicates partial awareness of their condition where they may not spontaneously acknowledge their deficit and may minimize the extent of their deficit. A score of 2 indicates a complete lack of awareness or denial of deficit. Patients fail to recognise any impairment and may repeatedly refute evidence of their limitations. Feinberg et al. (2000) has used this questionnaire in their clinical sample of patients with hemiplegia as the result of stroke. Orfei et al. (2007) review this questionnaire in their systematic review of anosognosia literature and liken it to other clinical rating scales by Bisiach et al. (1986) and Starkstein et al. (1992) which used their scales as an assessment of anosognosia following hemiplegia poststroke and traumatic brain injury. These included samples of over 80 patients.

Extinction. *Extinction task.* This task assesses extinction through three modalities (visual, auditory and tactile). Double simultaneous stimulation is used by simultaneously presenting a stimulus (visual, auditory or tactile) on both the left and right side of the patient's body. For visual extinction, the patient is asked to focus their eyes on a central point. Moving fingers are then presented in the peripheral visual fields. Either on one or both sides at the same time. If the patient does not report a stimulus on the contralateral side when both sides are visually stimulated, visual extinction is indicated.

Similar to the above visual testing, auditory stimuli are delivered to one ear and then both ears of the patient simultaneously. The inability of the patient to recognize a sound in the ear opposite the stimulated side during bilateral stimulation may indicate auditory extinction. Tactile testing requires the examiner to touch the patient's limbs while their eyes are closed. Lack of reporting touch to the contralateral side during bilateral stimulation indicates tactile extinction. Scoring is on a 3-point scale where for each of the three sensory modalities, extinction is either present (1) or not (0). This is a common clinical task and has been used in studies exploring stroke and traumatic brain injury (for example, Kaplan et al. 1995).

Spatial Cognition. *Rey Complex Figure Test.* Constructional praxis was assessed with the Rey Complex Figure Test (Rey, 1941; Osterrieth, 1944; Corwin & Bylsma, 1993). A poor performance on the copy drawing can be an indication of a visuospatial disorder. This test is widely used as a test of visuospatial ability, constructional praxis, executive functioning and memory (Lezak, 2004). For the purposes of this study, the Rey Complex Figure Test was used to ascertain visuospatial ability. This widely-used test has cross-cultural applicability as it has been successfully used in Spanish and African-American populations and patients following RHD (Patton et al. 2000, Pena-Casanova et al. 2012, Rosselli & Ardila, 1991, Wagner et al. 2007). This task was used in both Study 1 and Study 2. Participants were asked to complete the Copy trial, not the 3-minute immediate recall trial nor the 30-minute delayed recall trial. The construction component of the Rey Complex Figure is scored on a 36-point system. Normative scores are dependent on age and education level, though generally, scores below the 25th percentile (typically below 20) may indicate impairment.

Benton Judgment of Line Orientation Test. The Benton Judgment of Line Orientation Test (Benton, 1977) is a widely-used 30-item psychometric task of visuo-spatial perceptual reasoning. It requires the participant to visually match line segments to 11 numbered lines forming a semi-circle. Each correct response earns one point, and the total score is the sum of all points. The task has strong construct validity and test-retest reliability (Benton et al., 1978). This test has been used in patients with acquired brain injury where right hemisphere patients with visuo-spatial difficulties perform more poorly on this task than left hemisphere patients (Meador, Moore, et al., 1991). In terms of cross-cultural applicability, the test has been successfully used in African American populations (Lucas et al. 2005).

Mood. *The Beck Depression Inventory – Second Edition Manual (BDI-II)* (Beck et al., 1996). This widely-used inventory was used to ascertain levels of depression and negative mood in the three groups in Study 2. The first version of this inventory was developed by Beck et al. (1961). The inventory measures 21 different symptoms of depression by asking participants to choose between statements that reflect escalating levels of symptoms. Participants are presented with four to six statements for each symptom of depression. They choose the statement(s) which best reflect how they feel. In terms of clinical ranges, a total score of 0-13 is classified as minimal. Scores between 14 – 19 are rated as mild, 20 – 28 are moderate, and scores above 29 are classified as severe. Scoring is done by summing the scores for all 21 items and each item is scored on a Likert scale between 0 (no symptom) to 3 (symptom is severe).

The test-retest reliability of the depression scale ranges from 0.60 – 0.83. A meta-analysis confirmed that the inventory's average internal consistency coefficient was 0.86 for psychiatric patients and 0.81 for non-psychiatric patients, which indicates strong psychometric properties (Beck et al., 1988).

The inventory shows strong concurrent validity with clinical ratings, with coefficients ranging from 0.55 – 0.96. According to Beck et al. (1988), the inventory shows strong construct and discriminant validity. The Beck Inventory has been used in TBI populations (Green et al. 2001).

In terms of cross-cultural applicability, the inventory has been evaluated as appropriate for use in European, Japanese, Nigerian and Persian groups (Nuev et al., 2009; Masayo et al., 2002; Adewuya & Ola; 2007; Ghassemzadeh et al., 2005). Given its wide range of applicability (and especially in another African country), the inventory is appropriate for use in South Africa.

Theory of Mind. *Faux Pas Recognition Test. Faux Pas recognition test* (Stone et al., 1998). This test contains 20 stories: ten stories contain a faux pas, and ten are control stories. Participants are asked to read through the story and are then asked whether anyone in the story said something awkward or something they should not have said. Scoring of the Faux Pas task is typically based on several key components:

1. **Detection:** Participants receive a point if they correctly identify that a faux pas has occurred in the story. This involves recognizing that something inappropriate was said.
2. **Recognition of Distress:** Additional points are awarded if the participant can accurately identify why the statement was inappropriate and recognize the potential distress it caused to the listener in the story.
3. **Explanation:** Participants are also scored on their ability to explain the faux pas in their own words. This tests their understanding of the social context and the feelings of the characters involved.

4. **Specific Questions:** In some versions of the task, participants are asked specific follow-up questions to probe deeper into their understanding of the faux pas, such as asking how the faux pas made the listener feel, or why the speaker might not have realized the statement was inappropriate. Points are awarded based on the accuracy and relevance of their responses.
5. **Total Score:** The total score is calculated by summing the points from all components for each story. This score is then used to assess the participant's overall ability to understand and interpret social interactions and norms.

The Faux Pas test is able to discriminate between normal controls and patients with Asperger's syndrome (a mild form of autism) (Stone, et al, 1998). Scores significantly below the norm (typically less than 10 correct identifications) may suggest deficits in social cognition or ToM. The'Faux Pas' tests are frequently used in ToM research (Craig et al., 2004; Kettle et al., 2008; Lee et al., 2005; Muller et al., 2009; Peron et al. 2009; Savina & Beninger, 2007; Torralva et al., 2007; Varga et al., 2009) and in stroke patients (Nijsse et al. 2019). McGrath (2009) and Lindinger et al. (2016) demonstrated that the Faux Pas and Reading the Mind in the Eyes tasks were applicable in a South African population.

Data Analysis

Behavioural Analysis. Group differences on aspects of visuo-spatial and ToM, performances were investigated using SPSS 19 (IBM SPSS 2011). Parametric (independent group *t*-tests and mixed design ANOVA) and non-parametric (Chi-squared tests) analyses were used where appropriate to investigate significant differences and associations. Because of the specific predictions, linear contrasts were used rather than omnibus ANOVA for relevant parametric analyses (Schad et al., 2020). Group differences between RHD and LHD groups on tasks were explored while controlling for age, home language, and level of education.

As the sample sizes were quite small and the study was exploratory, a Type 2 error would be more likely and detrimental than a Type 1 error. As a result, significance levels were not adjusted, and the conventional alpha of 0.05 was used (Jaeger & Halliday, 1998). In all analyses, assumptions of normality and independence of observations were upheld.

Effect sizes are an estimate of the strength of the relationship between variables (Gignac & Szodorai, 2006). Cohen's d is the effect size used when reporting t-tests. A Cohen's d of 0.2 is considered small, 0.5 is considered a moderate effect size and 0.8 is considered large (Cohen, 1988 in Gignac & Szodorai, 2006). Eta squared and R-squared are measures of effect size that measures the proportion of total variance that is associated with the variation in the independent variable. For example, an effect size of 0.20 means that 20% of the total variation in the model can be explained by the group membership in the independent variable (Gignac & Szodorai, 2006). Because this is a low power clinical study, effect sizes are important to examine. For correlation size, a coefficient of < .20 is considered small, .20 to .30 is considered medium and >.30 is considered large, according to psychological study empirical guidelines (Hemphill, 2003).

Thematic analysis. This study employed NVivo 11 to analyse transcribed responses to the *Faux Pas* task for both Study 1 and 2. Braun and Clarke's (2006) thematic analysis methodology was used to analyse participants' responses to the Faux Pas task. This method is particularly effective for pinpointing and reporting patterns or themes within qualitative data. It also allows for a deeper engagement with the data, moving from mere description of patterns in the data to interpreting their significance (Braun & Clarke, 2006).

This study's analysis process in this research followed a six-step approach as outlined by Braun and Clarke (2006), iteratively applied to ensure thoroughness. The initial phase involves immersing oneself in the data through multiple readings of the transcripts of the participants' responses to the Faux Pas task. The subsequent phase is the generation of initial codes, where interesting data features are identified and grouped meaningfully, laying the groundwork for theme development.

The third phase involves developing themes by examining how these codes interconnect. Once themes are formulated, the fourth phase involves a meticulous review and refinement of these themes, ensuring they form coherent patterns and adjusting them as necessary. This may involve merging, dividing, or discarding themes based on their coherence and data support.

In the fifth phase, themes are precisely defined to capture their essence and align with the research questions, ensuring distinctiveness among themes and identifying subthemes for further clarity and structure. The final phase entails the detailed write-up of these themes, supplemented with direct quotes from the participants.

This methodology was applied to this study's *Faux Pas* data. Each participants transcript was read multiple times to fully engage with the content, noting preliminary patterns and meanings that aided subsequent coding and analysis. I grouped the initial readings through *error types*.

The coding process involved labeling segments of the transcripts with codes that encapsulated their core meanings. This led to a table of themes, organized by participant and theme, facilitating the write-up phase by easily referencing participant quotes to illustrate themes. For example, a recurring code initially was varied feelings (hurt, sad, pity). These were grouped by types of error and then grouped into core meanings (e.g. deliberate hostile attribution).

Study 2: Chronic phase assessment

Research Design

For Study 2, a researcher-blind, quasi-experimental design was used to compare the RHD group, with a brain-damaged control group (LHD) and a group of demographically matched (highest level of education, residential area, gender, age), neurologically intact controls on negative mood, social attachment, spatial cognition, executive function, intelligence and ToM performances. The outcome variables of interest are negative mood, social attachment, and ToM performance. Potential confounding variables to be controlled include executive function and intelligence. Executive functioning and intelligence affect almost all forms of cognition and could very well affect ToM ability. This was done by using psychometrically sound assessments discussed below (i.e. the Delis-Kaplan Executive Function System (D-KEFS) and Wechsler Abbreviated Scale of Intelligence which is discussed in more detail further in this chapter).

Sample

Study 2. The second study's sample included a clinical sample of literate English- or Afrikaans-speaking adults in the post-acute phase. For this study, post-acute phase was defined as at least four months post stroke, with the majority of participants falling in the 6 month – 1 year range. 59 right-handed participants aged between 16 and 71 years old took part in the study: 19 LHD participants, 20 RHD participants and 20 RHD-matched neurologically intact controls. Convenience sampling was used by including all consenting Right Hemisphere cases who were admitted in the neurology ward at Groote Schuur Hospital June 2011 – July 2012. Consenting Left Hemisphere cases who matched the Right Hemisphere cases were recruited during the same timeframe. See Table 3 for the demographic data of the participants and the matching properties of the RHD and controls. Controls included friends or family members of the participants, and staff at the University of Cape Town to case match the experimental groups on gender, age, education level, intelligence and executive functioning.

Table 3

Demographic characteristics of the full sample of Study 2

	RHD	LHD	Controls	χ^2 / F	p
N	20	19	20		
Gender (Male:Female)	9:11	10:9	9:11	.30	.86

Age	44.35	42.63	43.00	.09	.92
	(13.20)	(13.23)	(11.67)		
Age ranges	16 – 71	18 - 77	17 – 73		
Highest Level of Education	9.77	10.53	10.20	.74	.48
	(2.31)	(1.74)	(1.70)		
Intelligence	75.83	75.14	76.95	.55	.58
	(23.35)	(10.77)	(10.39)		
Executive Functioning	76.61	79.54	82.25	.36	.72
	(14.88)	(23.35)	(24.32)		

Note: Means presented with standard deviations in brackets for Age and Highest Level of Education.

The RHD and control groups were case matched on gender, age, race, socioeconomic status, occupation and residential location. The control group matched the LHD group on age, highest level of education, socioeconomic status and race. As the LHD group served as a clinical control group for the RHD group, the two groups were matched on lesion location, lesion size, and time since lesion.

Similar to Study 1, all patients from Study 2 were also at state hospitals, indicating low income. Additionally 90% of Study 2 participants resided in the Cape Flats area, a low to middle-low income area.

Ethics and Recruitment Study 2 received the same ethical approval as Study 1 and recruitment happened over the same period of time. The same steps were taken to ensure that Study 2 was researcher-blind.

In the case of patients who had also participated in Study 1 previously, consent was obtained for them to be contacted to be a part of Study 2. For patients who were recruited at the beginning of Study 2, consent was obtained at this time.

Participants in Study 2 were asked to bring a family member or close friend to fill in a questionnaire about any changes that they had noticed in the participants. Verbal consent was provided from both the participant and their family member/close friend for the informant questionnaire.

The same care was taken, as in Study 1, to explicitly assure patients that their confidentiality would be retained. Compensation and allowances for meals and transportation were provided, as was the offer of receiving a feedback report.

The risk of harm in Study 2 did not differ from Study 1

Procedure

Patient access. In addition to patients from Study 1 who were patients who were identified within the hospital ward, patients for Study 2 were identified by accessing files at Groote Schuur Hospital across the time period September 2010 to October 2012. As with Study 1, only literate English or Afrikaans patients were approached.

From twenty-three participants who agreed to participate in Study 1, ten consented to participate in Study 2. The further twenty-nine participants in Study 2 were then recruited from a pool of 137 patients sourced from the neurology and neurosurgery wards at Groote Schuur Hospital.

See Appendix E for the breakdown of the 108 participants who were unsuitable to participate or declined. The same inclusion criteria was used for Study 1. High rates of declining research participants are listed by Ejiogu et al. (2011) as a significant risk to clinical research, with participants from lower economic status populations being most likely to refuse to participate in research - especially neuropsychological testing - due to the time constraints of taking part (Marcantonio et al., 2008).

Study 2's protocol investigating the chronic phase effects consisted of additional tasks to Study 1 and assessed spatial cognition, personality, mood, attachment, social cognition and ToM. Table 4 sets out the assessment measures.

Additional participants who met the inclusion criteria and had been admitted at least four months ago were screened telephonically. Those who did not meet any of the exclusion criteria were asked to come in for the chronic-phase assessment. Before all the participants for Study 2 came in for an assessment, they were asked to bring along a close family member or friend who knew them very well before and after the brain injury. Their companion was then asked to fill in a behaviour change inventory while the participant was assessed.

These latter assessments were conducted at the Department of Psychology at the University of Cape Town. All participants were compensated with R300 for travel and meal costs

Compared to assessments used in Study 1, as seen in Table 2 above, some additional assessments were included as part of Study 2, as shown in Table 4 below.

Table 4

Study 2. Assessment and domain: Acute and Chronic phase

Anosognosia	Anosognosia task
Emotional Intelligence	Empathy Quotient (EQ) Scale
Executive functioning	Delis-Kaplan Executive Function System (D-KEFS): Sorting
Executive functioning	Delis-Kaplan Executive Function System (D-KEFS): Color – Word Interference
Extinction	Extinction task
Intelligence	Weschler Abbreviated Scale of Intelligence (WASI)
Mood	The Beck Depression Inventory
Personality	Affective Neuroscience Personality Scales (ANPS)
Personality Change	Iowa Ratings Scale for Personality Change (IRSPC)
Spatial Cognition	Matches Spatial Cognition Task
Spatial Cognition	Rey Complex Figure
Spatial Cognition	Weschler Abbreviated Scale of Intelligence (WASI) Blocks
Theory of Mind	Faux Pas Task
Theory of Mind	Reading the Mind in the Eyes

Spatial Cognition. *Stick Test.* A sensitive task for constructional praxis, the Stick Test (Butters & Barton, 1970) requires the patient to copy patterns constructed with matchsticks. Patients are required to rotate their patterns as if from the perspective of their examiner, who is sitting directly opposite them. This rotation task is a very sensitive test of constructional ability (Butters et al., 1970). This task has been successfully used in a Serbian population (Maćešić-Petrović, 2003) and in patients with TBI (Laeng, 2006).

Mood and Personality tasks. *The Beck Depression Inventory – Second Edition Manual (BDI-II)* (Beck et al., 1996). This widely-used inventory was used to ascertain levels of depression and negative mood in the three groups in Study 2. The first version of this inventory was developed by Beck et al. (1961). The inventory measures 21 different symptoms of depression by asking participants to choose between statements that reflect escalating levels of symptoms. Participants are presented with four to six statements for each symptom of depression. They choose the statement(s) which best reflect how they feel. In terms of clinical ranges, a total score of 0-13 is classified as minimal. Scores between 14 – 19 are rated as mild, 20 – 28 are moderate, and scores above 29 are classified as severe. Scoring is done by summing the scores for all 21 items and each item is scored on a Likert scale between 0 (no symptom) to 3 (symptom is severe).

The test-retest reliability of the depression scale ranges from 0.60 – 0.83. A meta-analysis confirmed that the inventory's average internal consistency coefficient was 0.86 for psychiatric patients and 0.81 for non-psychiatric patients, which indicates strong psychometric properties (Beck et al., 1988).

The inventory shows strong concurrent validity with clinical ratings, with coefficients ranging from 0.55 – 0.96. According to Beck et al. (1988), the inventory shows strong construct and discriminant validity. The Beck Inventory has been used in TBI populations (Green et al. 2001).

In terms of cross-cultural applicability, the inventory has been evaluated as appropriate for use in European, Japanese, Nigerian and Persian groups (Nuev et al., 2009; Masayo et al., 2002; Adewuya & Ola; 2007; Ghassemzadeh et al., 2005). Given its wide range of applicability (and especially in another African country), the inventory is appropriate for use in South Africa.

Affective Neuroscience Personality Scale (ANPS) (Davis et al., 2003). The Affective Neuroscience Personality Scale assesses personality in terms of the brain's affective systems. There are six core emotional command systems, labelled PLAY, SEEK, CARE, FEAR, ANGER, and SEPARATION DISTRESS (Davis et al., 2003). These sub-cortical emotional systems help explain personality structures and affective temperaments.

The scale provides three positive and three negative emotions which can be grouped in two clusters (that is, the positive emotion category and the negative emotion category). Together, the scale is comprised of 36 items related to emotion and each item is scored /4 point Likert (scored from 1 to 4). The scale has subscales for each of the six emotions and ones for positive (PLAY, SEEK, CARE) and negative (FEAR, ANGER, SEPARATION DISTRESS). Each emotion subscale comprises of 6 questions, while the positive and negative emotion subscales comprise of 18 questions each.

Internal consistency for the scale ranges from .65 – .86 (Davis et al., 2003). The SEPARATION DISTRESS component showed moderately strong discriminant validity with

Emotional Stability from the Five Factor Model scale ($r = -.68$, $p < .001$). All three negative emotions on the scale inter-correlate strongly ($r = .73$, $p < .001$).

In terms of cross-cultural applicability, the ANPS has been used successfully in Spanish populations (Abella et al., 2011) and in populations with chronic TBI (Juengst et al. 2014).

The Iowa Rating Scale for Personality Change (IRSPC) (Barrash et al., 2000)**.** The Iowa Rating Scale for Personality Change measures the change from premorbid personality characteristics to current behaviour and personality traits by assessing 30 behavioural, emotional and cognitive traits (Barrash et al., 2000). An informant who knows the patient very well (both pre- and post-insult) is asked to rate the patient's present personality characteristics and level of change in comparing their traits pre- and post-neurological insult. Item responses are scored on a Likert scale. This ranges from 0 (no change) to 3 (severe change). Items for specific personality traits are totalled where higher scores indicate more significant changes. This study specifically looked at change scores (pre- vs post- ratings) associated with Narcissism and other Cluster B personality traits. These included: Egocentricity, Emotional Lability, Irritability, Social Withdrawal and Inappropriate Behaviour (Barrash et al., 2000).

The scale's inter-rater reliability is high, ranging from .80 to .96 (Malloy & Grace 2005). This scale has been successfully used by Swiss researchers (Annoni et al., 2005). This scale has been used in research with populations with focal brain damage (Barrash et al. 2011).

Emotional Intelligence. *Empathy Quotient Scale* (Baron-Cohen & Wheelwright, 2004)**.** The Empathy Quotient (EQ) Scale was developed by Baron-Cohen and Wheelwright (2004) to measure empathy, defined as "… the drive or ability to attribute mental states to another person/animal, and entails an appropriate affective response in the observer to the other person's mental state" (Baron-Cohen & Wheelwright, 2004, p.168). The scale consists of 40 questions with a 4-point Likert self-report format. Muncer and Ling (2006) argue that its measurement of empathy can be further broken down into three domains: cognitive empathy, emotional reactivity and social skills. The scale comprises of a mix of positively and negatively phrased items. Responses are given on a 4-point scale (strongly agree, slightly agree, slightly disagree, strongly disagree). Positively phrased items receive scores of 2 (strongly agree) or 1 (slightly agree), while negatively phrased items are scored in the reverse manner. The total EQ score is the sum of these points, with the highest possible score being 80, which is achieved by earning 2 points on each of the 40 key empathy questions.

Strong concurrent validity and test-retest reliability has been found for this task (Lawrence et al., 2004). In Allison et al. (2011), reliability coefficients were found to be higher than .90. In terms of cross-cultural applicability, the task has successfully been used in Chinese, French-Canadian, Italian and Turkish populations (Quan et al., 2012; Berthoz et al., 2008; Preti et al. 2011; Bora & Baysen, 2009). The task has been used in populations with traumatic brain injury (see Zuban et al. 2018).

Theory of Mind. *Reading the Mind in the Eyes (Baron-Cohen, et al., 2001).* 'Reading the Mind in the Eyes' is a cognitive empathy task that is used to measure mentalising in adults (Baron-Cohen et al., 2001). The task consists of 36 photographs of the eye region of males and females. Each photograph is accompanied by four mental-state descriptors. Participants are asked to choose the mental state which best describes how or what the person in the photograph is feeling or thinking.

The test has been able to discriminate between controls and those with autism-spectrum disorders (Baron-Cohen et al., 2001) and has been tested in ABI populations (Hamilton et al. 2017). For each correct identification of the emotion, a point is given where 36 is the total possible score (that is, a point for each correctly identified emotional expression). According to Sato et al. (2017), neurotypical populations typically score between 23 and 30.

Intelligence and executive functioning. *Wechsler Abbreviated Scale of Intelligence* (WASI, Psychological Corporation, 1999). The Verbal Intelligence Quotient (VIQ) subscale on the WASI is scored out of 160. The VIQ combines the scores of verbal subtests, and the total raw scores from these subtests are converted into a scaled score using normative data. The VIQ provides a measure of verbal reasoning and comprehension abilities. The WASI has excellent reliability ($r = .87$) and stability ($r = .82$) with moderately strong convergent validity ($r = .62$) (Parker et al., 1988). This widely-used intelligence battery has been applied in South African and Arab populations (Abu-Hilal et al., 2011; Ferret et al., 2010) and in ABI populations (Ryan et al. 2005). The scale consists of both Verbal Intelligence Quotient (VIQ) and Performance Intelligence Quotient (PIQ) subscales.

The Delis-Kaplan Executive Function System (D-KEFS, Pearson Corporation, 2001). The D-KEFS is a widely used executive functioning battery. This battery of executive tasks has been used in African-American populations (Wagner et al. 2007) and in stroke populations (Tiznado et al. 2021). As no local norms are available for these tasks, it is important to administer them with caution and not to use them for diagnostic purposes.

From the D-KEFS, two subtests in particular were used: the Color-Word Interference Test and the Sorting Test. The former assesses inhibition and set-shifting and involves four test conditions. Each score is based on the time taken to complete the task and the number of errors made. The Sorting Test requires participants to sort cards according to different rules. Scoring is based on the number of correct sorts, description quality, and errors to assess abstraction and problem-solving ability. These tasks provide a good indication of the executive functioning of participants. Raw scores were used. The scoring of the Color-Word Interference takes into account both time take to complete the task and how many errors were completed. Normative scores are then derived from accuracy and speed.

Data Analysis

Behavioural Analysis. Statistical analyses were performed with the same software package (SPSS) as Study 1**.** Additionally, for Study 2, this research also controlled for intelligence and executive function by matching LHD and RHD participants on these dimensions. To study how visual-spatial skills and ToM are related, the research compared raw scores of attention problems, visual-spatial thinking, and building skills with tests like Faux Pas, Reading the Mind in the Eyes, and individual social ability measures using ANOVA analysis. If meaningful differences were discovered, posthoc analyses were performed to see if there was a significant the relationship between task performance and lesion location (anterior vs posterior and cortical vs subcortical).

Related to the second research question, ISPC's sub measures raw scores related to self-insight, manipulativeness and empathy as related to narcissism were used to determine if a relationship existed between RHD changes in visuo-spatial and ToM performances.

Where tests of homogeneity of variance were violated in ANOVA in Study 2, analyses continued as sample sizes were equal and ANOVA is robust under these circumstances (Howell, 2007).

Thematic analysis. Study 2 employed the same software and technique for analysing Faux Pas test responses as Study 1.

Data Transformation. In our methods section, for data reduction or transformation, we utilized the 56-item Affective Neuroscience Personality Scales (ANPS) to evaluate positive and negative emotional tendencies. Each of the six emotional systems (SEEKING, FEAR, ANGER, SADNESS, CARE, PLAY) was scored by summing the responses to its respective items. Positive emotionality was assessed by summing scores from CARE and PLAY scales, indicative of positive emotions. Negative emotionality was measured by aggregating scores from the FEAR and SADNESS scales. This approach enabled us to quantify participants' propensities towards positive and negative emotional states, essential for our study's objectives.

Similarly for the Reading the Mind in the Eyes task, scores were recoded into a positive emotion and negative emotion sub scores. Harkness's (2005) study on validating the valence sub scores was used (12 items were identified as negative (e.g. “hostile) and 8 items were identified as positive (e.g. “friendly). The remaining 16 were treated as neutral (e.g. “reflective”). Scores remained on a 1-4 Likert scale.

Results

Study 1: Acute phase assessment

Overall analyses

LHD and RHD groups were matched on age, gender, language, and education level. Any differences detected between groups are therefore not due to the above controlled variables.

Acute phase assessment

This study's hypotheses were that the RHD group would perform worse on all visuo-spatial cognition and ToM tasks relative to the LHD group. Furthermore, this study hypothesised that the RHD group would express significantly fewer symptoms of depression than the control group. See Table 5 below for descriptive statistics.

Table 5

Group means for the Visuo-spatial tasks

	RHD *(n = 13)*	LHD *(n = 10)*	t/χ	p
Rey Complex Figure	22.00	32.13	3.46	.01
	(7.29)	(5.64)		
Judgment of Line Orientation	13.62	22.00	2.69	.01
	(7.43)	(7.29)		

Block Design	14.85	22.50	2.43	.03
	(9.16)	(3.46)		
Anosognosia	1.00	0.00	5.5	.01
	(1.08)	(0.00)		
Extinction	6.79	9.00	4.53	.01
	(2.67)	(0.00		

Note: Means presented with standard deviations in brackets.

Research Question 1: The Relationship Between Visuo-Spatial and ToM Performance

In addressing the first research question related to the relationship between ToM performance and visuo-spatial cognition, the acute phase study revealed the following:

Spatial Cognition: The RHD group's performance in spatial cognition tasks was significantly lower compared to the LHD control group. This was evidenced by their scores on the Rey-Osterrieth Complex Figure ($t(21) = 3.46$, $p = .01$, $r2 = .32$), Benton Judgment of Line Orientation ($t(21) = 2.69$, $p = .01$, $R2 = .27$), and the Block Design task from the Wechsler Abbreviated Intelligence Scale ($t(21) = 2.43$, $p = .03$, $R2 = .23$). These results align with the hypothesis predicting poorer performance in the RHD group on spatial cognition tasks.

Anosognosia: Addressing the prediction about the RHD group's visuo-spatial performance, the results indicate a pronounced anosognosia in the RHD group, as demonstrated by a higher frequency of denial of deficit compared to the control group (X^2 (1, N = 20) = 5.5, $p < .05$). This supports the hypothesis that the RHD group would perform worse in areas like anosognosia.

Extinction: Similarly, in assessing visuo-spatial abilities, the RHD group reported significantly lower scores on the Extinction task (M = 6.79, SD = 2.67), t(21) = 4.53, p < .01, d = .83, indicating a more severe presence of extinction, again aligning with the predicted visuo-spatial impairments in the RHD group.

Relationship between Visuo-Spatial and ToM performance. Pearson correlation analyses were conducted to assess relationships among scores on the Faux Pas task, Total Judgment of Orientation, Block Design, and Rey-Osterrieth Complex Figure Test. The analysis revealed no significant correlation between Faux Pas total scores and Total Judgment of Orientation, r(20) = -.077, p = .367, Block Design, r(20) = -.008, p = .486, or Rey-Osterrieth scores, r(19) = -.066, p = .389. A significant positive correlation was found between Total Judgment of Orientation and Block Design, r(20) = .586, p = .002, and Rey-Osterrieth scores, r(19) = .714, p < .001. These results suggest that while there is no significant relationship between the ability to detect faux pas and measures of spatial cognition, there are strong positive associations among the measures of spatial orientation, visual-spatial construction, and complex figure recall.

Research Question 2: Examining the Impact of ABI on Personality Change

Mood. *The Beck Depression Inventory – Second Edition Manual (BDI-II).* To assess changes in personality following ABI, mood was utilized as a proxy, specifically through the administration of the Beck Depression Inventory – Second Edition (BDI-II). This inventory measures the presence and degree of depressive symptoms, with higher scores indicating greater severity (Beck, Steer, & Brown, 1996). Although mood and personality are distinct constructs, in the context of brain injury, changes in mood can reflect alterations in affective disposition, which is a key component of personality. Depressive symptoms often include changes in self-perception, motivation, and emotional responsiveness, aspects closely tied to personality.

While the ideal approach would involve a multifaceted assessment of personality changes directly, the BDI-II was chosen for its sensitivity to the affective symptoms that can indicate broader changes in an individual's personality post-injury. This approach aligns with research suggesting that mood disorders following brain injuries, particularly in the right hemisphere, can manifest changes in the patient's affective makeup, which can be reflective of underlying personality changes (Robinson & Jorge, 2016).

Contrary to the hypothesis predicting lower depression scores in the RHD group compared to the LHD group, the Independent Sample t-test showed no significant differences, $t(21) = 1.02$, $p = .32$, $d = .45$. This suggests similar levels of depressive symptoms between the two groups. However, a trend was noted where the LHD group's scores fell into the Mild Depression range ($M = 17.00$, $SD = 11.07$, Range = 0 - 42), while the RHD group scored in the Minimal Depression range (M = 12.79, SD = 8.20, Range = 2 - 52). Despite the non-significant results, the moderate effect size (Cohen's d = .45) suggests a practical significance that warrants consideration.

Given the small sample size, post hoc power analysis was conducted, revealing a power of 0.27. This indicates a 73% probability of Type II error — failing to reject a false null hypothesis. This suggests that the study may be underpowered to detect small but potentially meaningful differences in mood that could reflect underlying personality changes.

Research Question 3: Analyzing ToM Task Performance and RHD

ToM quantitative analysis. Regarding the impact of RHD on ToM task performance, the results from the First Order False Belief task showed no significant difference between the RHD and control groups, t(21) = .55, p = .46, d = .03. Both groups performed similarly on this basic ToM task (RHD group M = 9.69, SD = 1.11; control group M = 10.00, SD = 0.00), suggesting that RHD may not significantly impact performance on elementary ToM tasks. The *Faux Pas* task also showed no significant differences between the groups. An independent sample t-test was used, t(21) = .55, p =.46, with the RHD group (M = 21.21, SD = 6.52)scoring similarly to the LHD (M = 19.38, SD= 7.35) group. The group means indicate that both groups performed quite poorly on the task (the maximum possible score for this task is 60). Power was calculated as 0.14. Therefore, there is an 86% chance of incorrectly retaining the null hypothesis when it is in fact false.

ToM qualitative analysis. A thematic analysis delves into the qualitative responses of individuals with RHD and LHD during a Faux Pas task. The focus is on identifying and comparing the key themes in their interpretations of social scenarios, highlighting how left or right hemispheric brain damage influences social cognition. While there was no significant quantitative difference between the LHD and RHD performance on the *Faux Pas* task, the qualitative differences were marked. When the LHD group failed on the task, it was a result of not reporting a faux pas and appearing apathetic about the social interaction (6 of the 10 participants). The RHD group, however, failed differently. They highlighted faux pas that did not exist (5 of the 10 participants). As a result of these marked qualitative differences, a thematic analysis was performed on the transcripts of the *Faux Pas* task. Results are organized by two themes which emerged from the interview data analysis (see Table 6). Please note that all participants passed the control questions ascertaining that participants comprehended the story.

Table 6

Themes of Faux Pas RHD and LHD responses

Participant group	Theme	Subthemes
RHD	1. Misinterpretation	• Neutral and Faux Pas stories • Attention seeking • Over-interpretation • Negative

Participant group	**Theme**	**Subthemes**
	2. Attribution of Malice	• Negative intent to faux pas • Benign interaction • Paranoia • Deliberate • Exhibitionism, arrogance • Hurtful comments towards characters
LHD	3. Apathy towards Social Cues	• Disinterest • Non-recognition • Under-interpretation

Study 1 Themes in RHD Participants' Responses

Misinterpretation of Social Cues and Attribution of Malice. RHD participants frequently misinterpreted social interactions, often perceiving a faux pas where none existed and interpreting a faux pas as malicious and deliberate. A notable example is Patient DP's response to a benign introduction at a party. Here is the story read to DP:

Vicky was at a party at her friend Oliver's house. She was talking to Oliver when another woman came up to them. She was one of Oliver's neighbours. The woman said, "Hello," then turned to Vicky and said, "I don't think we've met. I'm Maria, *what's your name?" "I'm Vicky." "Would anyone like something to drink?" Oliver asked. Did anyone say something they shouldn't have said or something awkward?*

DP inferred a faux pas and ascribed a desire for attention to Maria:

*Probably because she **want**s to be **noticed**... that **she's been around**... been to Oliver's house before, and that people must know that she has Oliver by the olives.*

In another instance involving a child's mistaken gender, DP was read the following story:

Sally is a three-year-old girl with a round face and short blonde hair. She was at her Aunt Carol's house. The doorbell rang and her Aunt Carol answered it. It was Mary, a neighbour. "Hi," Aunt Carol said, "Nice of you to stop by." Mary said, "Hello," then looked at Sally and said, "Oh, I don't think I've met this little boy. What's your name? Did anyone say something they shouldn't have said or something awkward?

DP again attributes negative intent, stating, "She is a **mean** little girl, I think." Such responses indicate a propensity among RHD participants to attribute malice to ordinary interactions.

From the thematic analysis, not only is malicious intent ascribed to characters but characters are treated quite maliciously by the RHD. In their narrative, toddlers are mean, a stranger at a party is promiscuous. The patients think of the characters how they fear the characters are thinking of them or others.

The tendency to perceive negativity where it might not exist is further illustrated by Patient JJ's interpretation of Jake's comment in a story competition as a deliberate act of spite: “**He did it to** flash it in her face.” This response underscores the heightened sensitivity of RHD participants to perceived social slights.

The following story was read to participants:

> *Eleanor was waiting at the bus stop. The bus was late and she had been standing there a long time. She was 65 and it made her tired to stand for so long. When the bus finally came, it was crowded and there were no seats left. She saw a neighbour, Paul, standing in the aisle of the bus. "Hello, Eleanor," he said. "Were you waiting there long?" "About 20 minutes," she replied. A young man who was sitting down got up. "Ma'am, would you like my seat?" Did anyone say something they shouldn't have said or something awkward?*

Patient ML incorrectly identified Paul as the culprit of a *faux pas.* ML thought Paul was insensitive in asking Eleanor if she had been waiting long. She further said that he *must have known* that the bus was running late since he was on the bus that was late, and that there was no need to ask such a question. When asked how Eleanor may have felt following the interaction, ML surmised that Eleanor must have been “*disgusted and hurt*” by Paul’s question.

Themes in LHD Participants' Responses.

Apathy. In this study, apathy is defined as a diminished emotional engagement and a lack of proactive interaction with the given task, particularly in the context of recognizing and interpreting social cues such as faux pas. This definition is crucial in understanding the differential behaviors observed between the left hemisphere-damaged (LH) and right hemisphere-damaged (RHD) participants.

LH patients, unlike their RHD counterparts who actively misinterpret social cues, often fail to acknowledge these cues entirely. This was exemplified in responses to the vignettes presented, where LH participants frequently stated that no faux pas occurred, demonstrating a notable disengagement from the social intricacies of the scenarios. For instance, when presented with a story involving a clear faux pas of misgendering a child, Patient AD's response was dismissively flat, stating, "Seems fine," and "It's fine." This lack of recognition and emotional response is characteristic of apathy as conceptualized in our study.

The observed behavior aligns with existing neuroscientific research which suggests that damage to specific regions of the left hemisphere can result in impairments in emotional processing and social cognition. These regions are instrumental in generating appropriate emotional responses and engaging with complex social interactions. The LH patients' failure to detect faux pas and their generally flat affect—speaking in short, clipped sentences without emotional intonation—provides a clear manifestation of apathy. Such responses are not merely due to a misunderstanding of the social situation but are indicative of a deeper inability to engage emotionally and cognitively with the scenario.

This contrast in engagement levels between LH and RHD groups underscores the specific impact of left hemisphere impairment on the patients' ability to process and react to social and emotional content.

Comparative Analysis

A striking difference emerges in how RHD and LHD participants interpret social cues. RHD participants often over-interpret these cues, frequently ascribing negative intentions, whereas LHD participants tend to under-interpret or show disinterest in the social dynamics presented in the stories. This disparity highlights the varied impact of hemisphere damage on social cognition and the interpretation of social interactions.

The thematic analysis reveals significant differences in how patients with RHD and LHD process and interpret social scenarios presented in the Faux Pas task. RHD participants are prone to misinterpretations, often with a negative slant, suggesting an altered or disrupted social cognition. They tend to attribute exhibitionism, arrogance and sadism in others, yet this paranoia is paralleled on their thoughts on the characters themselves. In contrast, LHD participants display a form of social apathy, showing less engagement in interpreting social cues. These findings illuminate the nuanced effects of brain damage on social perception and interaction, contributing to our understanding of the cognitive and emotional ramifications of RHD and LHD.

Integration of Quantitative and Qualitative Findings

The integration of quantitative and qualitative findings reveals a complex picture of ToM abilities in individuals with RHD and LHD. Although the quantitative data did not show significant differences in ToM task performance, the qualitative data highlighted significant differences in the interpretation of social cues. The RHD group's tendency to over-interpret and ascribe negative intentions could reflect a specific impairment in social cognition that is not captured by traditional ToM tasks. Conversely, the LHD group's apathy towards social cues might indicate a different kind of social cognitive deficit. These findings underscore the importance of using both quantitative and qualitative methods to fully understand the cognitive and emotional ramifications of brain injuries.

Summary of Study 1 Findings in Relation to Research Questions

1. The findings support the hypothesis that the RHD group would exhibit worse visuo-spatial performances, specifically in anosognosia and extinction.
2. Data concerning the impact of RHD on narcissistic personality traits post-injury were not presented in Study 1. However, trends showed that LHD participants tended to report more depressive symptoms than RHD.
3. The lack of significant difference in ToM task performance between RHD and control groups suggests that very basic ToM abilities may remain intact in RHD individually. There was also a lack of significant difference in the *Faux Pas* task performance with LHD incorrectly stating no faux pas occurred, unlike the RHD. This may suggest a language problem in LHD impacting their performance.

Study 2: Chronic phase assessment

The aims and research hypotheses for the chronic phase of this research were to investigate the relationship between ToM and visuo-spatial cognition. My hypothesis was that only the RHD group would demonstrate a significant relationship between visuo-spatial cognition and ToM. However, before examining this, the relationship between the RHD group and the control groups on spatial cognition and ToM tasks required exploration. Importantly, these performances were controlled for intelligence and executive functioning, as the control groups had very similar performances on these domains as the RHD group. This research hypothesised that the RHD group would perform significantly worse than the control groups on these tasks and on tasks related to right hemisphere function, such as extinction and anosognosia. See Table 7 for descriptive statistics.

Table 7

Group means for the Visuo-spatial tasks

	RHD *(n = 20)*	LHD *(n =20)*	Healthy Controls (n = 20)
Matches test (Rotation)	25.50	30.58	40.50
	(9.34)	(10.29)	(5.57)
Matches test (Construction)	36.00	39.45	40.00
	(5.92)	(1.57)	(0.00)
Rey Complex Figure (Copy)	30.18	32.90	35.36
	(8.56)	(7.90)	(1.12)

Note: Means presented with standard deviations in brackets.

Research Question 1: The Relationship Between Visuo-Spatial and ToM Performance

Right hemisphere tasks. ***Spatial cognition*****.** I assessed visuo-spatial ability with the Rey-Osterrieth Complex Figure and Stick test (construction and rotation subtests) with higher scores indicating better spatial cognition. I predicted that the RHD group would perform worse on these tasks than the control groups (LHD and healthy controls). Because I had specific predictions a priori, I was able to use linear contrasts for ANOVAs (Schad et al. 2020). ANOVA with weighted linear contrast found a significant effect for the Rey-Osterrieth Complex Figure, $F(2,56) = 4.41$, $p = .04$, *partial* $eta^2 = .08$. A significant difference was found between the RHD group ($M = 31.30$, $SD = 6.01$) and the healthy controls (*M* = 35.20, *SD* = 1.54), with the RHD group significantly worse. No significant statistical difference was detected between the LHD (*M* = 32.90, *SD* = 7.90) and healthy control (*M* = 35.20, *SD* = 1.54), group (*t*(37) = 1.28, *p* = .21).

ANOVA with linear contrasts found a significant effect for the Matches rotation task, *F*(2,56) = 15.67, *p* = .01, *partial* eta^2 = .37, where each group differed significantly from the other two groups; the RHD group performed the worst (*M* = 25.50, *SD* = 9.34), followed by the LHD group (*M* = 30.58, *SD* = 10.29) and then the healthy control group (*M* = 40.50, *SD* = 5.57).

Correlations were then conducted on the RHD group to see if Matches Rotation scores correlated with anterior versus posterior lesion location, and whether Matches Rotation scores correlated with cortical versus subcortical lesion location. This was specifically done for Matches Rotation as it is a purely spatial cognitive task, that does not require executive functioning, like the Rey Complex Figure. No significant relationships were found for either anterior versus posterior, r(57) = -.16, p = .33 or cortical versus subcortical, r(57) = -.23, p = .16. While technically not significant, there appears to be a small effect in the correlations between Matches Rotations scores and cortical versus subcortical lesion location (r = -.23), with low Matches performance associated with subcortical lesions.

Anosognosia test. I predicted that the RHD group would perform worse on this task than the LHD group. Chi-squared analyses found a significant association for the Anosognosia test, $\underline{X}^2$(1, N = 40) = 3.58, *p* <.05, with the RHD group more likely to exhibit significantly more denial of deficit than the LHD group. Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior and cortical versus subcortical) was related to these results. Lesion location was not related to RH patients' anosognosia score for either anterior/posterior and Anosognosia performance (r(57) = .07, p = .66), or cortical/subcortical and Anosognosia performance (r(57) = .04, p = .80).

Extinction test. The extinction test identifies the inability to perceive bilateral stimulation in the visual, auditory and tactile domains. I predicted that the RHD group would perform worse on this task than the LHD group. An independent t-test found a significant difference for the Extinction test, $T(38) = 1.86$, $p < .05$, with the RHD group ($M = 0.50$, $SD = 0.95$) exhibiting more extinction signs than the LHD group ($M = 0.05$, $SD = 0.23$, Cohen's D = .65). Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior and cortical versus subcortical) was related to these results. Meaningful relationships were between posterior lesions and Extinction performance (r(39) = .28, p = .06), and cortical lesions and Extinction performance (r(39) = .21, p = .17) with small effects evident. Participants with symptoms of Extinction were more likely to have cortical and posterior lesions.

Given how close the probability value related to anterior versus posterior involvement is to achieving significance at the 0.05 level, there may be a meaningful association. The low sample sizes contribute to very low power, and these results show an association, albeit not statistically significant, with posterior and cortical areas correlated with poor Extinction performance. With a correlation coefficient of ~.25 and a significance level of 5%, in order to increase power to .90, I would need a sample size of 160. My clinical sample is 40, so it is likely that I have insufficient power due to low sample size.

Table 8

Relationships between Theory of Mind tasks and Right Hemisphere Syndrome symptoms in RHD group

	Anosognosia	Extinction	Matches construction	Matches rotation	Rey Complex Figure
Reading the Mind in the Eyes	-.23*	-.25*	.33**	.29*	.07
Faux Pas	-.19	-.08	.21	.18	.13
Emotional Quotient	-.22*	-.18	.36**	.14	.12

*p<0.05 **p<0.01

Note: A low Anosognosia and Extinction score refers to little presence of Anosognosia and Extinction. Meaning, the negative relationship between ToM tasks and these measures indicates that a good performance on ToM is associated with a healthy performance on Anosognosia and Extinction.

Table 9

Relationships between Theory of Mind tasks and Right Hemisphere Syndrome symptoms in LHD group

	Anosognosia	Extinction	Matches construction	Matches rotation	Rey Complex Figure
Reading the Mind in the Eyes	-.17	-.12	.22	.05	-.32
Faux Pas	.10	.12	-.01	.08	.18
Emotional Quotient	.40*	.16	.16	.17	-.09

*p<0.05 **p<0.01

Note: A low Anosognosia and Extinction score refers to little presence of Anosognosia and Extinction. Meaning, the negative relationship between ToM tasks and these measures indicates that a good performance on ToM is associated with a healthy performance on Anosognosia and Extinction.

Table 10

Relationships between Theory of Mind and Personality Changes in RHD group

	Lack of Insight	Inappropriate affect	Apathy	Irritability	Poor Judgment	Manipulativeness
Reading the Mind in the Eyes	-.29*	-.29*	.01	-.29*	-.33**	-.19
Faux Pas	-.14	-.37**	-.20	-.25*	-.32**	-.27*
Empathy Quotient	-.10	-.03	-.10	-.14	-.07	-.10

*p<0.05 **p<0.01

Relationships between Right Hemisphere Syndrome and ToM. The main purpose of this research is to investigate the relationship between the ToM performances with visuo-spatial performances, personality changes, extinction and anosognosia in the RHD group. Note that even though the sample sizes are small, the magnitude of the relationship is significant between RH tasks and ToM tasks. A correlation in the range of .3 is generally considered to reflect a distinct and moderate relationship (Hemphill, 2003). These results provide evidence for the hypothesis that ToM requires spatial cognition. Significantly, the visual cognitive ToM task is found to be significantly correlated with all symptoms Right Hemisphere Syndrome (see Table 8). The significant positive relationships between Matches Construction and Rotation with ToM tasks indicate that better performances on Matches are related to better performances on ToM tasks. The significant negative relationships between ToM tasks with anosognosia and extinction indicate that the more evidence of anosognosia and extinction, the worse the ToM performance. The next step is to repeat the correlations in the LHD group to assess whether these are also evident in these patients.

See Table 9 for details. The ToM tasks in the RHD group showed some significant correlations where the higher the spatial ability, the higher the ToM ability. Similarly, the presence of extinction and anosognosia was negatively correlated with ToM ability, as in the lower the ToM ability, the more likely the presence of extinction and anosognosia. This was found only in the RHD group and not in the LHD group. Note the lack of significant relationships between pure spatial tasks and ToM tasks in the LHD group. The Emotional

Quotient was the only ToM task that was correlated to a right hemisphere task (i.e. anosognosia) in the LHD group. The Emotional Quotient task is also a ToM task that is heavily reliant on language skills, a left hemisphere function.

Next, correlations between ToM tasks and personality changes reported by close family members were examined in Table 10

Table 11
Relationships between ToM and Personality Changes in LHD group

	Lack of Insight	Inappropriate affect	Apathy	Irritability	Poor Judgment	Manipulativeness
Reading the Mind in the Eyes	.07	-.56**	.17	.18	.03	-.00
Faux Pas	.10	-.42**	.03	.09	-.14	-.01
Empathy Quotient	.20	.06	.03	.13	.11	-.00

*p<0.05 **p<0.01

Research Question 2: Examining the Impact of ABI on Personality Change and Mood

Table 12

Group means on the Beck Depression Inventory

RHD *(n = 20)*	LHD *(n = 19)*	Healthy Controls *(n = 20)*
20.75	15.47	12.70
(12.81)	(11.12)	(9.35)
2 - 52	0 - 42	0 - 30

Note: Means presented with standard deviations in brackets and ranges.

Depression and personality change. Given that one of the aims was to describe the personality and mood presentation of the RHD, this study used both mood and personality assessments. This research hypothesised that mood symptoms would be more pronounced in the LHD group, with the RHD group demonstrating significantly more avoidant attachment behaviour. If this hypothesis was upheld, the relationship between attachment and mood in the RHD group would be explored.

The Beck Depression Inventory – Second Edition (BDI-II). This research predicted that the RHD group would score significantly lower on depression scores than the LHD and healthy control groups. This hypothesis was not supported, as the RHD group scored significantly higher on depression scores than the healthy controls, as evidenced by ANOVA with linear contrast, $F(2,56) = 5.18$, $p = .03$, *partial* $eta^2 = .09$. The RHD group's scores fell into the Moderate Depression range, while the control groups' scores did not fall into the

Depression range and the LHD group fell in the Mild Depression range (see Table 12 for more details).

Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior and cortical versus subcortical) was related to their BDI results Lesion location was not related to BDI scores for either anterior/posterior, $r(57) = .04$, $p = .77$ or cortical/subcortical, $r(57) = .05$, $p = .73$.

However, there was high variability particularly in the RHD group, showing that while the RHD group did score on average in the Moderate Depression range, this does not mean that all participants in this group have Moderate Depression but rather indicates a large range of no depressive to severe depressive symptoms.

Affective Neuroscience Personality Scale (ANPS). This task measures personality from the six core affective systems identified by Panksepp (that is, SEEKING, FEAR, CARE, ANGER, PLAY, SEPARATION DISTRESS). This research predicted that the RHD group would score lower on CARE, SEPARATION DISTRESS and FEAR than the LHD and healthy control groups. A lower score indicates a lower presence of the affect. ANOVA with linear contrast did not show a significant effect for any of these subscales (see Table 13 for inferential and descriptive statistics). Given the lack of meaningful relationships, posthoc analyses exploring the relationship between these scores and lesion location were not performed.

Table 13

Group means and ANOVA for the ANPS subscales

	RHD *(n = 20)*	LHD *(n = 20)*	Controls *(n = 20)*	df	F	p	η_p^2
SEEKING	8.80	8.63	6.46	2,49	2.57	.09	.09
	(3.17)	(2.69)	(3.60)				
FEAR	11.30	11.37	11.23	2,49	.01	.99	.00
	(2.72)	(2.67)	(4.29)				
CARE	7.90	6.95	5.69	2,49	1.53	.23	.05
	(3.74)	(3.33)	(3.55)				
ANGER	10.80	10.21	10.92	2,49	.15	.86	.01
	(4.79)	(2.51)	(4.57)				
PLAY	13.20	11.74	11.92	2,49	1.04	.36	.03
	(3.40)	(2.42)	(4.46)				
SEPARATION-	9.60	11.00	9.31	2,49	1.13	.33	.02
DISTRESS	(3.80)	(3.40)	(3.30)				

Note: Means presented with standard deviations in brackets.

Iowa Rating Scale of Personality Change (IRSPC). Personality change following injury could only be assessed in the RHD and LHD groups. This research predicted that family members of RHD participants would report greater post-morbid change reflecting

Lack of Insight. Higher scores would indicate higher post-morbid presence of these constructs. ANOVA with linear contrast found a significant effect for all these personality characteristics. The RHD group reportedly evidenced more difficulties with Lack of Insight, Inappropriate Affect, Apathy Irritability, Lability, Poor Judgment, and Social Withdrawal. No significant changes were found for Manipulativeness between LHD and RHD. However, Manipulativeness was significantly correlated with the Faux Pas task, specifically in the RHD group. See Table 14 for details.

Table 14

Group means of the change in IRSPC personality characteristics

	LHD *(n = 20)*	RHD *(n = 20)*	DF	F	P	η_p^2
Lack of Insight	0.16	0.37	2,56	8.89	.01	.25
	(0.96)	(2.00)				
Inappropriate Affect	0.20	0.58	2,56	6.26	.01	.17
	(1.31)	(2.29)				
Apathy	-0.21	1.79	2,56	5.81	.01	.16
	(2.20)	(2.70)				
Irritability	0.42	2.32	2,56	13.37	.01	.32
	(1.58)	(2.00)				
Lability	-0.16	1.63	2,56	6.49	.01	.19
	(2.01)	(2.19)				

Poor Judgment	0.55	0.32	2,56	9.58	.01	.26
	(1.42)	(2.08)				
Manipulativeness	0.25	0.75	2.56	1.21	.19	.05
	(0.79)	(2.27)				
Social Withdrawal	2,56	0.42	1.95	9.98	.01	.27
	(1.26)	(2.15)				

Note: Means presented with standard deviations in brackets.

Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior or cortical versus subcortical) was related to these results. Please see Table 15 for details. Subcortical lesion location was associated with changes related to Apathy (r = -.20).

Table 15

Relationships between Personality Changes and Lesion Location for RHD Group

	Lack of Insight	Inappropriate Affect	Apathy	Irritability	Poor Judgment	Manipulativeness
Anterior/Posterior	.06	-.02	.01	-.03	-.02	.06
Cortical/Subcortical	-.04	.05	-.20**	-.06	.07	-.03

*p<0.05 **p<0.01

Note: r values reported

For all these characteristics above, family members of RHD participants consistently rated greater changes, reflected in higher scores, than their LHD counterparts.

Research Question 3: Analyzing ToM Task Performance in RHD Individuals

Theory of Mind tasks.

The Empathy Quotient (EQ). On this self-report questionnaire of empathy, I predicted that the RHD group would score significantly lower on EQ than the control groups, with lower scores indicating lower EQ ability. The maximum score possible for the task is 60. ANOVA with linear contrast found a significant effect, $F(2,56) = 6.04$, $p = .02$, *partial* $eta^2 = .11$, with the RHD group ($M = 41.65$, $SD = 14.71$) scoring significantly lower than the healthy control group ($M = 51.20$, $SD = 11.38$). However, *post hoc* Tukey's analyses did not show a significant difference between the RHD group and LHD group ($M = 45.05$, $SD = 10.24$, $p > 0.05$). This suggests that having a brain injury is a significant predictor of lower EQ performance, though not laterality of lesion. As these results are non-significant, power was calculated *post hoc* as 0.11. Therefore, there is an 89% chance of incorrectly retaining the null hypothesis when it is in fact false.

Reading the Mind in the Eyes. This ToM task measures the ability to accurately infer emotion based on facial expression as reflected in the eye region, with a higher score indicating greater ability to infer complex mental states. The maximum score possible on this task is 36. In this task, I predicted that the RHD group would perform worse than the LHD and healthy control groups. ANOVA with linear contrast upheld this prediction, $F(2,56) = 10.67$, $p < .01$, *partial* $eta^2 = .30$, with the RHD group ($M = 17.45$, $SD = 4.71$) performing significantly worse than the LHD ($M = 20.00$, $SD = 4.18$) and healthy control ($M = 24.30$, $SD = 5.24$) groups. When I specifically looked at performances inferring positive emotions (e.g. comforting, happy, relaxed), participants with RHD were significantly worse at accurately identifying *positive* emotions than the left hemisphere ($p < .01$ with a medium to large effect size, with a Cohen's D of .7). No differences between LHD and RHD performance were detected in identifying *negative* emotion ($p > .05$).

Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior and cortical versus subcortical) was related to these results. No significant correlations were found between ToM score and cortical/subcortical location, $r(57) = -.09$, $p = .48$, though a meaningful relationship was detected between ToM score and anterior/posterior location in terms of the size of the correlation coefficient ($r(57) = .20$, $p = .14$), with posterior lesions more strongly associated with lower performance on Reading the Mind in the Eyes.

Faux Pas recognition test. I predicted that in this ToM task, the RHD group would perform worse than the LHD and healthy control groups with lower scores. The Faux Pas task showed significant differences between the RHD group and the two control groups. ANOVA with linear contrast showed a significant effect, $F(2,56) = 5.17$, $p = .02$, *partial* $eta^2 = .14$, with the RHD group ($M = 48.95$, $SD = 8.43$) scoring significantly lower than the LHD

(*M* = 59.16, *SD* = 11.62, $p < .05$) and healthy control (*M* = 59.85, *SD* = 20.59, $p < .05$) groups. Correlations were then conducted on the RHD group to see if lesion location (anterior versus posterior and cortical versus subcortical) was related to these results. No significant correlations were found for either anterior versus posterior, $r(57) = .18$, $p = .18$, or cortical versus subcortical, $r(57) = -.01$, $p = .92$.

ToM and personality change. A correlation matrix between ToM performance and personality were run by experimental condition. Significant negative correlations were noted between ToM tasks and personality characteristics in the RHD group, showing that the more pronounced the personality change, the lower the ToM performance. Changes leading to increased Lack of Insight, Poor Judgment, Social Withdrawal, Inappropriate Affect and Irritability were significantly negatively correlated with ToM performance. This was not found with the LHD group where only a change in Inappropriate affect post-neurological injury was negatively correlated with the Reading the Mind in the Eyes and Faux Pas tasks. Only in the RHD group, Manipulativeness was negatively correlated to the Faux Pas task. See Table 16 for details

Lack of Insight predicting self-reported measures. A regression was conducted to investigate why there were minimal findings in self-reported measures like mood and Empathy Quotient (EQ), utilizing the 'Lack of Insight' aspect from the Iowa Scales of Personality Change. This reassessment aimed to explore if the initial insignificant results might be due to issues with self-awareness. Although this reevaluation did not confirm the hypothesis for the EQ questionnaire, it did reveal a significant link at the 5% level for predicting self-reported levels of depression. For depression, linear regression results indicated that Lack of Insight was a significant predictor of BDI measures, ($F(1,38) = 4.82$, $p = .03$, $R2 = .1$). For EQ, linear regression results indicated that Lack of Insight was not a significant predictor of EQ ($F(1,38) = .54$, $p > .05$, $R2 = .01$).

Predicting Theory of Mind performance from spatial cognition ability. Hierarchical multiple regression analysis was used to test if RHD and spatial cognition tasks significantly predicted participants' ToM performance. Two models were performed, one for each outcome variable. The outcome variables were ToM performance, measured by Reading the Mind in the Eyes (Model 1) and Faux Pas tasks (Model 2).

For the first block of in Model 1, the predictor variable Group (LHD, RHD, and control group) was analysed. The results of this first block hierarchical regression analysis's model was statistically significant ($p < .01$). In addition, the R^2 value of from this model indicates that the Group predictor explains 0.52 of the variation in Reading the Mind in the Eyes, which means that 52% of the variation in Reading the Mind in the Eyes can be explained alone by Group (LHD, RHD, and control group). For the second block analysis the predictor variable of Matches spatial rotation was added to the analysis. The results of this second block indicates 26% of the variation in Reading the Mind in the Eyes can be explained by spatial cognition. See Table 17 for details on the model.

For Model 2, hierarchical multiple regression analysis was also used to test if RHD and spatial cognition tasks significantly predicted participants' Faux Pas performance. The results of the second regression indicated Group explained 15% of the variance in *Faux Pas* performance. While RHD group membership impacted *Faux Pas* performance, spatial cognition did not. See Table 18 for details on the model.

Table 16

Summary of Hierarchical Regression Analysis for Variables Predicting Reading in the Mind in the Eyes Ability (N = 59)

Model 1 Variables	Unstandardized *B*	Coefficients SE	Beta (ß)	*t*	*p*
Block 1					
Group (RHD, LHD, Healthy Control)	13.31	3.87	.75	4.96*	0.0001**
Block 2					
Spatial Cognition (Matches)	12.47	12.76	.55	2.29	0.02*

Note R^2 =.55 for Model 1, p <.001; $R^2\Delta$=.11 for Model 2, p<.05; Total R^2 =.66, p<.001.

Table 17

Summary of Hierarchical Regression Analysis for Variables Predicting Faux Pas Ability (N = 59)

Model 2 Variables	Unstandardized *B*	Coefficients SE	Beta (ß)	*t*	*p*
Block 1					
Group (RHD, LHD, Healthy Control)	8.41	1.69	.28	1.80	0.08
Block 2					
Spatial Cognition (Matches)	14.70	6.43	.20	1.43	0.16

Note R^2 =.15 for Model 1, p >.05; $R^2\Delta$=.0.08 for Model 2, p>.05; Total R^2 =.23, p>.05.

Faux Pas thematic analysis for Chronic Phase Study 2. When looking at the raw sub scores, the RHD group struggled with either identifying whether a *faux pas* occurred and/or understanding why a *faux pas* occurred. For example, some RHD participants were able to correctly identify that a *faux pas* had occurred but had problems ascribing the reason behind it. Often they would accuse a character in the story vignette of deliberately trying to hurt the other person, ignoring other interpretations for the *faux pas.* See Table 19 for details on themes that emerged from the thematic analysis.

Similarly, other RHD participants consistently reported that there were no *faux pas* occurrences in any of the stories. This shows that while RHD participants generally perform badly in this task, they do so in different ways. Some consistently could not recognise social awkwardness, while other RHD participants found slights in the stories yet ascribed vindictiveness to characters in the stories as deliberately trying to hurt those around them. Of the 20 RHD participants, six consistently ascribed malice to story characters, and six demonstrated indifference, denying that any *faux pas* had occurred.

Conducting a thematic analysis on the text of participants who incorrectly identified a faux pas involved identifying and interpreting recurring themes related to the patients' ability to understand and interpret social cues in faux pas tasks. This analysis focuses on several key themes emerging from the patients' responses, supported by direct quotations from the text. Negative subthemes refer to specific patterns or themes within the overall negative interpretation or perception of social interactions exhibited by participants. These subthemes could include beliefs or attributions of malicious intent, hostility, envy, or superiority in others' behavior or comments. In the context of the study, these negative subthemes highlight variations in how participants with RHD participants interpret social situations, often attributing negative motives or intentions to others' actions or statements.

Table 18

Themes in Participants' Responses to Faux Pas task

Participant group	Theme	Subthemes
RHD	1. Hostile Attribution	• Negative intent to neutral vignette • Feelings – Surprise, Hurt, Self-pity • Sadism - Mean, Vindictive, Punishment • Paranoia
	2. Envy	• Negative intent to faux pas • Feelings – Surprise, Hurt, Sad, Self-pity • Bystander pity
	3. Superiority	• Other thinks they are better • Other wants me to know they think they're better • Knowing/certainty of envy, hostility, arrogance, power • Arrogance

Table 20

Summary of Faux Pas Task Responses by RHD and LHD Patients

Patient ID	Group	Story Context	Correct Identification	Incorrect Identification	Attribution of Malice	Notes
DP	RHD	Office Joke	Yes	No	Yes	Attributed vindictiveness to character making inappropriate joke at sensitive time.
ML	RHD	Coffee Spill	No	Yes	Yes	Misinterpreted customer's request as arrogant and deliberate.
CM	RHD	Lawyer Comment	Yes	No	Yes	Perceived negative intent towards lawyers as deliberate, despite casual context.
MM	RHD	Card Declined	No	Yes	Yes	Incorrectly saw malice in cashier’s

Patient ID	Group	Story Context	Correct Identification	Incorrect Identification	Attribution of Malice	Notes
						notification that the card was declined.
LP	RHD	Wedding Gift	Yes	No	Yes	Believed that the friend's negative comment on the gift was intentionally hurtful.
AM	RHD	Apartment Decor	Yes	No	Yes	Saw friend's critique of curtains as a deliberate personal attack due to jealousy.
SD	LHD	Party Introduction	No	Yes	No	Misunderstood social protocol; saw introduction as a breach of etiquette.
CL	Control	Story Competition	Yes	No	Yes	Believed competition winner displayed arrogance deliberately to upset peers.

Notes:

- **Correct Identification**: Whether the patient correctly identified if a faux pas occurred.
- **Incorrect Identification**: Whether the patient incorrectly perceived a situation as containing a faux pas when there was none.
- **Attribution of Malice**: Whether the patient attributed negative intentions or malice to the characters involved in the faux pas.
- **Group**: Distinguishes between Right Hemisphere Damage (RHD), Left Hemisphere Damage (LHD), and controls.
- **Story Context**: Brief description of the faux pas scenario to provide context for the responses.

Table 20 helps illustrate the types of errors and interpretations made by patients with RHD compared to LHD and control groups, focusing on their ability to perceive and interpret social cues correctly or incorrectly, and their tendency to ascribe negative intentions where none may exist.

Misinterpreting Neutral and Faux Pas vignettes as Deliberate Punishment: Patients often misunderstood social interactions in the stories, either failing to recognize a faux pas or incorrectly identifying one. Patient DP was read the following *faux pas* story:

> *Jean West, a manager at ABCO Software Design, called a meeting for all of the staff. "I have something to tell you," she said. "John Morehouse, one of*

our accountants, is very sick with cancer and he's in the hospital." Everyone was quiet, absorbing the news, when Robert, a software engineer, arrived late. "Hey, I heard this great joke last night!" Robert said. "What did the terminally ill patient say to his doctor?" Jean said, "Okay, let's get down to business in the meeting. Did anyone say something they shouldn't have said or something awkward?

Patient DP correctly identified the faux pas, but ascribed vindictiveness to the character, Robert. When DP was asked why Robert had made a joke, DP responded that,

it was a way of him ***punishing*** *the manager or maybe the team member who was sick.*

Similarly in response was Patient LP who was read the following:

Jeanette bought her friend, Anne, a crystal bowl for a wedding gift. Anne had a big wedding and there were a lot of presents to keep track of. About a year later, Jeanette was over one night at Anne's for dinner. Jeanette dropped a wine bottle by accident on the crystal bowl and the bowl shattered. "I'm really sorry. I've broken the bowl," said Jeanette. "Don't worry," said Anne. "I never liked it anyway. Someone gave it to me for my wedding. Did anyone say something they shouldn't have said or something awkward?

LP correctly identified that a *faux pas* had occurred but was sure that Anne had known that LP had given her the crystal bowl. As LP states:

She deliberately bought a gift she knew she would not like to ***punish*** *her.*

Belief that Others are Envious. Based on the quotes provided, we can identify examples where participants suspected envy or malice in others, a tendency that can be reflective of narcissistic traits. Here are a few instances from the quotes where this theme is evident. Patient AM was told the following story:

Jill had just moved into a new apartment. Jill went shopping and bought some new curtains for her bedroom. When she had just finished decorating the apartment, her best friend, Lisa, came over. Jill gave her a tour of the apartment and asked, "How do you like my bedroom?" "Those curtains are horrible," Lisa said. "I hope you're going to get some new ones!" Did anyone say something they shouldn't have said or something awkward?

AM correctly identified the *faux pas* of Lisa insulting Jill's new curtains, but was convinced that it was done deliberately to hurt Jill's feelings. When asked why she wanted to hurt Jill, AM responded that Lisa was jealous of her friend's new apartment. Here AM perceived envy in Lisa's behaviour, attributing negative intentions to a likely benign comment.

LP had a similar response to the following story:

Imagine your husband was throwing a surprise party for your birthday. He invited Sarah, a friend of yours, and said, "Don't tell anyone, especially <insert name>." The day before the party, you were over at Sarah's and Sarah spilled some coffee on a new dress that was hanging over her chair. "Oh!" said Sarah, "I was going to wear this to your party!" "What party?" you asked. "Come on," said

Sarah, "Let's go see if we can get the stain out. Did anyone say something they shouldn't have said or something awkward?

LP correctly identified that a *faux pas* had taken place. But LP understood Sarah's *faux pas* as deliberate and driven by envy. When asked why Sarah made the *faux pas*, LP said, "She wanted to take the surprise **away from me**."

Belief that Others Feel Superior. ML was read the following story:

> *Tim was in a restaurant. He spilled some coffee on the floor by accident. "I'll get you another cup of coffee," said the waiter. The waiter was gone for a while. You were another customer in the restaurant, standing by the cashier waiting to pay. Tim went up to you and said, "I spilled coffee over by my table. Can you mop it up? Did anyone say something they shouldn't have said or something awkward?*

ML correctly identified that a *faux pas* had taken place but when ML was asked why the customer requested that she mop up his spilled coffee, she responded with, "I don't work there! He was trying to be difficult… **arrogant.** He thinks he's **better** than me." She was adamant that he knew that she was a fellow customer.

The story competition story with Jake was a common story for RHD participants to detect superiority in others. Two participants used the words "**arrogant**" and another described him as thinking he is better than him.

For example, when told about the restaurant story, where a customer asks another customer to clean up their mess, CL correctly identified the *faux pas.*

However, even though she surmised that the fellow customer had asked her to clean up the mess because she may look like a cleaner or be close to the counter, she continued to believe that they treated her like a waiter deliberately. She thought that they knew that she was a fellow customer.

The thematic analysis of RHD patients' responses in the faux pas tasks reveals significant challenges in their social cognition, particularly in interpreting intentions and recognizing social norms. This variability in response highlights the complex impact of RHD on social understanding and emotional interpretation.

Attribution of Malicious Hostility. ML was read the following story:

Louise went to the butcher to buy some meat. It was crowded and noisy in the shop. She asked the butcher, "Do you have any free-range chickens?" He nodded and started to wrap up a roasted chicken for her. "Excuse me," she said, "I must not have spoken clearly. I asked if you had any free-range chickens." "Oh, sorry," the butcher said, "we're all out of them". Did anyone say something they shouldn't have said or something awkward?

ML incorrectly ascribes a *faux pas* to the butcher, stating that he was "trying to be difficult" and upset Louise. When asked if she was sure that the butcher heard Louise correctly, ML was adamant that he definitely had. Here we see again the belief that behavior that negative impacts another must be deliberate.

Similarly, CL was read the following story:

Roger had just started work at a new office. One day, in the coffee room, he was talking to a new friend, Andrew. "What does your wife do?" Andrew asked. "She's a lawyer," answered Roger. A few minutes later, Claire came into the coffee room looking irritated. "I just had the worst phone call," she told them. "Lawyers *are all so arrogant and greedy. I can't stand them." "Do you want to come look over these reports?" Andrew asked Claire. "Not now," she replied, "I need my coffee." Did anyone say something they shouldn't have said or something awkward?*

CM correctly identified that a *faux pas* had taken place. However, when asked why the new employee complained about attorneys, CM responded with, "Oh, she **knew** his wife was a lawyer. She **knew somehow**." Another RHD patient, MM, was told the following story:

John stopped off at the gas station on the way home to fill up his car. He gave the cashier his credit card. The cashier ran it through the machine at the counter. "I'm sorry," she said, "the machine won't accept your card." "Hmmm, that's funny," John said. "Well, I'll just pay in cash." He gave her twenty dollars and said, "I filled up the tank with unleaded." Did anyone say something they shouldn't have said or something awkward?

MM incorrectly identified that a *faux pas* had occurred. When MM was asked if anyone had made a faux pas, he replied that the cashier was the culprit. The cashier's *faux pas* was telling the man that his card did not work. When MM was asked why the cashier said that, MM said, "*He (the cashier) **knew** it would bounce. He must have **known***." LP used similar language in responding to hearing the story about a new employee making a negative comment about lawyers: "*She must have **known** his wife was a lawyer. She doesn't like the wife*."

AM also correctly identified a *faux pas* in the story of the team leader telling the group that one of their members was very sick with cancer, and Robert arriving late to the meeting and making a joke about terminally ill patients. AM could not explain why Robert had made the joke. However, he was sure that Robert had done it **deliberately** and "*must have known".*

To summarise, six of the twenty RHD participants demonstrated consistent suspiciousness in the *Faux Pas task,* compared to only one LHD participant and one healthy control. The most common lesions in the six RHD participants were anterior (four participants) and cortical (four participants). The LHD participant presented with an anterior, subcortical stroke.

Summary of Study 2 Findings in Relation to Research Questions

Research Question 1: The Relationship Between Visuo-Spatial and ToM Performance. RHD group performed worse on visuo-spatial tasks (Rey-Osterrieth Complex Figure, Matches Rotation) than healthy controls. No significant difference between LHD and healthy controls in Rey-Osterrieth Complex Figure task. All groups differed significantly in the Matches Rotation task, with RHD performing the worst.

No significant correlations between lesion location (anterior vs. posterior, cortical vs. subcortical) and spatial cognition tasks in the RHD group. No significant correlations between lesion location and anosognosia scores in the RHD group. RHD group exhibited more denial of deficit (anosognosia) and more signs of extinction than the LHD group.

Research Question 2: Examining the Impact of ABI on Personality Change and Mood. RHD group scored higher on depression scales compared to healthy controls, falling into the Moderate Depression range. No significant correlation between lesion location and depression scores in the RHD group.

ANOVA showed no significant effect for the Affective Neuroscience Personality Scale (ANPS) subscales in the RHD group. RHD participants showed more pronounced personality changes reported by family members, such as lack of insight, inappropriate affect, apathy, irritability, lability, poor judgment, and social withdrawal.

Research Question 3: Analyzing ToM Task Performance in RHD Individuals.

RHD group scored significantly lower than the healthy controls in the Empathy Quotient, indicating lower empathy ability. The RHD group scored lower in the Faux Pas recognition test compared to both control groups and the RHD group performed significantly worse than both LHD and healthy controls in the "Reading the Mind in the Eyes" task.

No significant correlation was found between lesion location and ToM performance in the RHD group.

Negative correlations were found between ToM tasks and personality characteristics in the RHD group, indicating that pronounced personality changes were associated with lower ToM performance. Thematic analysis revealed paranoia, hostile attribution and egocentricity in the qualitative performance of RHD participants. Group membership (RHD, LHD, Healthy Control) significantly predicted ToM performance, with membership in the RHD group specifically affecting performance on the *Faux Pas* task. However, spatial cognition ability did not significantly predict performance on the *Faux Pas* task. Contrarily, spatial cognition ability, as measured by the Matches task, did significantly predict overall ToM performance.

Discussion

This research examines the personality and interpersonal changes in patients with acquired ToM deficits, focusing on the psychological elements that effects ToM. The study investigates how damage to the right hemisphere, resulting in spatial cognitive deficits, impacts ToM, contrasting with left hemisphere damage and healthy controls. It particularly looks at the association between spatial deficits, ToM performance, and personality changes before and after illness, with an emphasis on traits like egocentricity and Cluster B personality disorder traits in right hemisphere patients. The study offers new insights into how patients with acquired brain injury interpret and manage relationships, particularly in cases where inhibition and intelligence are relatively unaffected. It uniquely contributes to understanding the neuropsychological aspects of ToM in patients with right hemisphere damage. Relationships between these factors were explored to identify a theoretical framework explaining behavioral changes. For both studies, significant relationships were detected between spatial cognition, anosognosia, extinction, and ToM tasks in the RHD group but not the LHD group, reinforcing the need for ToM frameworks to consider these functions.

For Study 2, the finding of significant relationships between visuo-spatial functions and ToM only in the RHD quasi-experimental group, but not in the LHD group or healthy controls, suggests a specific involvement of the RH in integrating spatial cognition and social understanding. This aligns with neuroscientific research indicating the RH's crucial role in processing spatial, visual, and social information, essential for ToM. The lack of significant findings in the LH group and controls may indicate that these aspects of cognition are less dependent on the specialized functions of the LH or are already well-developed in healthy individuals, making any correlation less apparent in these groups.

Performances in these domains were contrasted with patients having left hemisphere damage (LHD) and neurologically intact controls. While some hypotheses, particularly regarding mood, were not supported, profound personality changes in the right hemisphere group were found. Moreover, relationships between ToM, spatial cognition, extinction, and anosognosia tasks were demonstrated. Close family members of RHD participants reported personality changes different from those reported by family members of LHD participants.

These personality changes in the RHD group showed significant correlations with both visual and verbal ToM tasks, and with spatial cognition tasks. The study highlights the importance of considering dynamic responses to deficits in understanding social cognition deficits in right hemisphere patients. The following considers how current understanding of ToM and psychological developmental theories can provide a framework for interpreting both qualitative and quantitative observations in these participants, relating to their spatial and ToM performances.

Research Aim 1: Clarifying the Relationship Between Visuo-Spatial and Theory of Mind Performance

The analysis of both Study 1 and 2 participants reveals a persistent connection between spatial cognition and ToM deficits in those with RHD. This suggests that these impairments are not only interconnected but also enduring over time. For both stages post neurological insult, the right hemisphere groups unsurprisingly performed worse than the left hemisphere and control groups on visuo-spatial tasks (that is, the Rey-Osterrieth Complex Figure, Benton Judgment of Line Orientation, and Block Design task). This was to be expected, as visuo-spatial tasks are related to right hemisphere functioning more than left hemisphere functioning (Amorapanth et al., 2010; Karnath & Rorden, 2012, Kerkhoff, 2001, Mosidze et al., 1994).

Other right hemisphere tasks such as the Anosognosia and Extinction tests also elicited worse performances in the right hemisphere group than the left hemisphere group. Anosognosia, in particular, is a well-known possible effect of right hemisphere injury (in almost any part of the right hemisphere) and attention is one of the dominant functions of the right hemisphere (Rafal & Henik, 1994). Extinction is a result of inattention and is also a well-known effect of right hemisphere injury. The results are consistent with the literature, that is, that patients with RHD would show more signs of denial of deficit and inattention, than the LHD and neurologically intact controls.

In addressing the limitations of the measurement tools used to assess anosognosia, it is essential to acknowledge that many of the broadly applied scales lack the sensitivity required to discern impairment-specific nuances. These general tools often fail to capture the complex and varied manifestations of anosognosia across different types of impairments, leading to potentially oversimplified conclusions about a patient's awareness of their cognitive deficits. In contrast, more specialized instruments like the Self-Awareness of Deficits Interview (SADI) offer a refined approach.

The SADI specifically tailors its assessment to the particular deficits experienced by an individual, thereby providing a more accurate measure of self-awareness. Given these advantages, incorporating tools such as the SADI into future research could enhance the precision of our measurements and deepen our understanding of the intricacies of anosognosia, paving the way for more targeted therapeutic interventions.

The persistence of anosognosia after a focal lesion months after injury is rare, with only a handful of case studies provided in the literature (Venneri & Shanks, 2004 point out four case studies between 1996 and 2004), with few published since then. Persistent anosognosia is more commonly found in patients with dementing syndromes or severe mental illness, like schizophrenia (Orfei et al. 2007).

The significant correlation between anosognosia and spatial cognition, as reinforced by the research of Fotopoulou (2014) and Besharati et al. (2016), highlights a deeper connection between anosognosia and perspective-taking abilities. Specifically, Besharati et al. (2016) demonstrated that patients with anosognosia can adopt a third-person perspective but face challenges in mentalizing others from an allocentric viewpoint. Their studies, which involved reading short stories to discern mental states, revealed that anosognosic patients struggled with mentalizing others unless they were included as characters in the story. This finding is crucial in understanding the relationship between allocentric perspective-taking and mentalizing others.

Furthering this line of inquiry, Besharati et al. (2021) investigated the impact of perspective-taking on the awareness of motor deficits. Their findings indicate that anosognosic patients with hemiparalysis can acknowledge their paralysis when considering their deficits from a third-person perspective rather than a first-person viewpoint.

The works of Fotopoulou et al. (2009) and Besharati et al. (2015) employed perspective-altering experiments that effectively shifted anosognosia in patients. Notably, a patient with left-sided paralysis and anosognosia would deny their paralysis when oriented to a first-person or subjective perspective. However, providing video feedback which offered a third-person perspective significantly altered their awareness of the deficit.

Besharati et al. (2016) also explored the role of spatial cognition in third-person perspective taking. Their research with right-hemisphere stroke patients showed that anosognosics performed worse in third-person perspective taking than those without anosognosia. The severity of anosognosia correlated with the impairment in third-person perspective taking, highlighting a connection between self-awareness and social cognition.

Importantly, the manifestation of anosognosia, characterized by a decline in self-awareness and ego functions, echoes Freud's (1961) notion of denial as a primitive defense mechanism, a concept reflective of early brain and ego development stages. The ego, as a mediator between personal perception and external reality (Hinsie & Campbell, 1963), suggests that significant damage to the right hemisphere could result in fundamental defense reactions like denial or delusional paranoia (Feinberg, 2011). This psychoanalytic view sheds light on the psychological roots of anosognosia.

Extinction and Inattention

The Extinction test used in the study assessed neglect across auditory, tactile, and visual modalities, revealing significant signs of extinction in patients with RHD in both acute and chronic phases. This finding aligns with existing research indicating RHD patients' propensity for neglect, particularly inattention to the left spatial field. The study observed that those with extinction symptoms often had right posterior strokes, and these symptoms correlated with impaired performance in the ToM task, Reading the Mind in the Eyes. However, neglect is not a singular syndrome but may result from various attentional deficits, often stemming from right posterior lesions and subcortical damage. This research also highlights the intersection of attention and social cognition, evidenced by the importance of interpreting eye gaze in social interactions. Similarly, attentional challenges are central in autism spectrum disorders, underlining the integral role of attention in social cognition.

To further detail the role of attentional impairments in right hemisphere damage (RHD) and their impact on outcomes in this study, it's critical to explore how these deficits specifically interact with the cognitive processes being examined. Patients with RHD often exhibit attentional impairments that extend beyond simple neglect; these can include difficulties in sustained attention, selective attention, and the allocation of attentional resources across multiple stimuli. Such impairments could significantly influence the relationships studied, particularly in tasks requiring the integration of complex social cues.

One hypothesis could be that attentional impairments in RHD patients lead to a decreased ability to process and respond to social stimuli effectively, as evidenced in tasks like the Theory of Mind (ToM) task, Reading the Mind in the Eyes. This task requires not only the recognition of subtle eye gaze directions but also the integration of this information to infer emotional states or intentions. Attentional impairments might hinder the ability to maintain focus on these critical social cues, leading to poorer performance on this task. Additionally, the propensity for inattention to the left spatial field could mean that any stimuli presented on this side are less likely to be incorporated into social judgments, potentially skewing the interaction dynamics observed in these patients.

Further research could utilize more nuanced assessments of attention to determine which specific aspects of attentional control are most predictive of difficulties in social cognition tasks. This could not only clarify the pathways through which RHD impacts social interactions but also guide the development of targeted interventions to improve outcomes for these patients.

Spatial Cognition

In Study 1, the spatial cognition tasks used were the Rey-Osterrieth Complex Figure, Benton Judgment of Line Orientation, and the Block Design from the Weschler Abbreviated Intelligent Scale. As predicted, the group with RHD performed significantly worse than the left hemisphere group on all three tasks. These diminished abilities of spatial cognition in the right hemisphere group were expected, given the strong relationship between spatial skills and the right hemisphere (Brunetti et al. 2014; Frith & Frith, 1999; Kerkhoff, 2001). For example, the R TPJ is strongly associated with social cognitive tasks, attention and orientation of space (Blanke et al. 2005). Given the acuteness of the symptoms in participants from Study 1, this research focused the investigation on Study 2, where participants had experienced neurological injury at least four months prior.

The spatial cognition tasks used in Study 2 assessed construction (Rey-Osterrieth Complex Figure) and mental rotation (Stick Test) with right hemisphere groups performing significantly worse on the mental rotation task than both the left hemisphere and healthy control groups. The right hemisphere group performed significantly worse on the construction test than the healthy control group. These results are expected and unremarkable (see Mennemeier, et al., 1997; Oleksiak et al. 2011). The reason we wanted to assess spatial cognition and, in particular, mental rotation, was to explore the relationship between performance on spatial cognition and the performance on ToM tasks by both clinical groups in my study. We hypothesised that given the overlap between the neural correlates of spatial cognition and ToM, the mental perspective taking of ToM arises from spatial cognitive ability to separate self from other (Nico & Daprati, 2009).

The concept of spatial and social cognition as a unified system is supported by minimal evidence. However, a study by Hamilton et al. (2009) suggested that children could better understand others' perspectives metaphorically when they physically put themselves in someone else's place. This study reinforces the idea that social cognition might rely on spatial cognition, as evidenced by significant correlations found between social cognitive tasks (like Reading the Mind in the Eyes) and spatial tasks (such as mental rotation) in the right hemisphere damaged group. My findings showed a significant relationship between spatial tasks and ToM tasks but more importantly, detected the mental rotation task (Stick Test) as a significant predictor of ToM performance. This is meaningful to the literature on lesion studies exploring spatial cognition and ToM.

Developmental and Psychoanalytic Lens on Spatial and Social Cognition Overlap

There are different frameworks to make sense of this finding. Below, we discuss how developmental psychology and psychoanalytic theory work well together in providing understanding.

From a psychoanalytical viewpoint, Object Relations Theory states that infants initially view the world around them as part of themselves (Klein, 1946/1984). As development continues, the infant realizes that the world and their caregiver is separate from themselves. A further emotional milestone for the infant is to realize that their love object consists of both positive and negative qualities which reside in the same person. If the infant successfully accepts this, psychoanalytic theory says that the infant has moved from the paranoid-schizoid to the depressive position. In essence, the child is accepting reality. But in order for the child to accept that reality exists, they must be able to perceive reality. The internal self, or the ego, develops because of its relationship to the internalised object of the other and because of feedback from reality.

From a neurocognitive point of view, we can understand the same process as the infant being cognitively unable to accept that objects are separate from themselves until their cognitive abilities are able to perceive the environment and the relationships between objects in space. Therefore, social cognition can only develop if spatial cognition is present. We cannot understand that other people have separate mental lives from ours if we cannot yet perceive that they are separate from us, in a very concrete sense.

Furthering the psychoanalytic train of thought, Klein (1946/1984) argues that infants are in a primary narcissistic position. They focus on themselves, with little concern for those around them. As the child develops, it is able to shift to a depressive position by holding the realization that what they want (e.g., their mother, sustenance) is separate from them. They reconcile that not only is their primary caregiver separate from them and cannot be completely controlled, and that their primary caregiver can consist in both positive and negative aspects. The same caregiver can provide comfort and nurturing (the good mother) and yet can also not be there when the child wants attention and sustenance.

Developmental psychology supports this, indicating that young children exhibit egocentric thinking as described by Piaget (Gruber & Vonèche, 1977). As cognitive development progresses, the child begins to recognize the separateness of objects and people, a crucial milestone in both spatial and social understanding.

In parallel, Piaget's theory of cognitive development posits that during the sensorimotor stage, infants learn about the world through their actions and sensory experiences. This stage is critical for developing a concept of object permanence, which is foundational for understanding the permanence and separateness of people and objects in their environment. This cognitive skill is a precursor to understanding social relationships and forming a realistic view of the world, akin to Klein's concept of moving from the paranoid-schizoid to the depressive position.

In terms of spatial cognition, developmental psychologists like Piaget have emphasized the role of spatial awareness in cognitive development. The ability to perceive and understand spatial relationships is fundamental in the child's ability to categorize and make sense of their environment, which is intricately linked to their social understanding. This notion aligns with neurocognitive perspectives that suggest social cognition can only develop if spatial cognition is present. Without the ability to discern the physical separateness of others, understanding that they possess separate mental lives becomes a challenge (Gruber & Vonèche, 1977). The innate drive in human children to seek proximity to caregivers during distress or danger, as highlighted by Vrticka and Vuilleumier (2012), underscores the survival importance of these early relationships. This instinctual behavior forms the basis of the child's emotional and social development, influencing how they will engage in relationships and perceive the world as adults.

Autism research aligns with the idea that discerning the physical separateness of others is crucial for the development of social cognition. Just as Piaget highlighted the importance of object permanence in realizing the constancy and separateness of people and objects, Frith and de Vignemont (2005) underscore the necessity of differentiating and transitioning between one's own perspective and others' for ToM development. This allocentric spatial development—understanding from an other-centric point of view—is presented as foundational for ToM. Integrating this framework, we might ponder the implications for adults who, due to brain injury, face compromised spatial cognition and, subsequently, challenges in maintaining a clear separation of self and others, potentially impacting social relationships and reinforcing the profound significance of spatial awareness in both developmental psychology and neurocognitive science.

The results from my study are a tentative indication of the relationship between the two constructs and that spatial ability is the foundation of being able to accurately perceive the environment. And from this ability, ToM can develop: the ability to perceive others as separate objects with separate motivations. This ability to see others as separate minds shifts infants beyond self-centred, narcissistic positions (Klein, 1946/1984). If the spatial skills were to fail, then ToM deficits and narcissistic personality characteristics may emerge. These narcissistic personality characteristics would manifest in primitive defence mechanisms, such as paranoia and splitting. Then, not only would the individual be unable to represent the other in their mind, they would also replace that now unknown other with a paranoid fantasy.

The paranoid-schizoid and depressive positions described above are not limited to infancy but are ways of being throughout the developmental lifecycle (Klein, 1935). She maintained that these positions alternate and shift throughout the lifecycle, with paranoid-schizoid positions triggered by stress, crisis, or loss. This means that even adults with integrated self-concepts and whole object relationships can resort to defense mechanisms under times of stress, like splitting. This has been connected to changes in the prefrontal cortex and the limbic system (Arnsten, 2015). Klein (1935) describes how during these moments of crisis, an adult can shift from these primitive defense mechanisms to the more integrated depressive position through a supportive environment that partners with the adult to hold and acknowledge the pain. There is a corollary here to the multiple clinical cases (Fotopoulou et al., 2009; Kaplan-Solms & Solms, 2001; Ramachandran, 1994) where clinicians were able to support anosognosia patients through their denial of deficit (albeit briefly) to acknowledge their loss of limb function.

The development of mental representation in adults requires two core systems: the ability to differentiate and integrate (Kernberg, 1984). According to Kernberg (1984), psychological boundaries are created by the ability of the self to differentiate between one's internal world and the external one. This differentiation between oneself and others is what allows adults to function independently. This independence can only arise if the individual's representation of the self is separate from others' as that means their feelings about themselves are not defined or dependent on the feelings of those around them.

While differentiation is necessary for autonomy, integration is necessary for a balanced understanding of oneself and others. To integrate means to connect seemingly contradictory emotions together. For example, we can love someone who hurts us. That same person can induce anger and frustration, but also love and compassion. Without this ability to hold these contradictions, adults who cannot integrate that an object can contain contradictions can approach the world in extremes: the world is comprised of heroes who are perfect or villains who are deliberately trying to hurt them (Kernberg, 1984).

This connects to Bowlby's (1969/1982) theory of attachment. The experience of emotion underpins the representation of the self, and one's attachment to primary caregivers as infants informs that representational self (Kernberg, 1984). Therefore, a disruption of attachment leads to profound unregulated emotions. Early attachment is central here to whether the adult can differentiate themselves from others and accept those contradictory qualities in themselves and others. If a child was rejected when attempting closeness with their primary caregiver, they may have marked emotional reactions to closeness with others as adults. This unconscious emotional response to avoid closeness protects the adult from feelings of vulnerability and rejection. These working models of ourselves and relationships with others are powerful.

According to Object Relations Theory, it is through this internal representation of the other or the object, and the emotion it elicits, that the infant's internal representation of their self comes into being. For example, if the caregiver is perceived as threatening, unsafe, and strong, that internal representation of the caregiver would give rise to the infant constructing their self-concept in relation to that. So, in this example, the child might develop internal concepts of being weak, vulnerable, and afraid in relation to that internal representation of the object. While these internal relationships are based on interactions between the infant and the other, they are not necessarily based in reality. They are based on both impressions from interactions and fantasized interactions. What ties these actual interactions and fantasies together is the dominant emotion that is attached to the object and its relation to the self. These object relations are then self-other dyads (Kernberg, 1984) that will inform how the grown adult will relate to others.

As these are the foundational building blocks, the ways that adults relate to and perceive others will be triggered by these basic emotions. However, in healthy adult development, the adult will be capable of nuance and complexity, unlike the infant. Kernberg (1984) further maintains that the emotion tied to the object is integral to the representation, and that the initial building blocks cannot house both positive and negative emotions. Positive emotions can be formed in a single object (e.g., trust and love) but not a mixture like suspiciousness and love. By this logic, if the neurological areas that subserve this ability are compromised, the adult may regress to a primitive ability to relate to others in extreme terms: heroes or villains.

The next section looks at Cluster B traits as a link to Bukowski and Samson's (2017) research which delves into individual differences in perspective-taking, highlighting two key aspects: the ability to distinguish one's own thoughts from others' (self-other distinction) and the degree of focus on self versus others (egocentric vs. altercentric tendencies). They found that people vary in their capacity to separate their perspective from others', with some individuals being more egocentric and others more altercentric. This research suggests that egocentrism plays a role in ToM where those with difficulty in distinguishing perspectives are less flexible in understanding others' mental states, linking to cognitive aspects of narcissism.

Research Aim 2: Examining the Impact of ABI on Egocentrism and Cluster B traits and its Relationship to Theory of Mind.

No significant difference was observed between the right and left hemisphere groups in regard to depression, with the left hemisphere group reporting more symptoms descriptively. The right hemisphere group’s scores indicated a moderate level of depression. Despite no significant differences on the ANPS subscales, there were correlations between ToM tasks and personality changes as per the IRSPC, particularly in the right hemisphere group. These correlations suggest an interplay between personality changes and ToM impairments, likely stemming from spatial skill disintegration.

We posited that the lack of significant findings regarding mood might stem from using self-report methods and participants' potential lack of self-awareness. A multiple regression analysis using the Beck Depression Index as the outcome variable, with the 'Lack of Insight' factor from the Iowa Rating Scale of Personality Change, indicated that 'Lack of Insight' significantly predicted results. This supports the theory that self-report measures might obscure true mood states due to insight issues. The findings suggest using caregiver-rated mood inventories might offer more reliable insights, highlighting a methodological limitation in this study's approach.

The study also aimed to investigate personality differences between the right hemisphere and control groups. However, contrary to expectations, the ANPS results showed no significant differences, except a trend towards higher levels of SEEKING, PLAY, and CARE in the right hemisphere group. The Iowa Rating Scale of Personality Change (IRSPC) indicated that family members of right hemisphere patients noted significant changes in personality traits related to manipulativeness, lability, irritability, apathy, inappropriate affect, judgment, insight, and social interaction.

Significant correlations were observed between ToM tasks and personality changes as per the IRSPC. Notably, in the RHD, lower scores on ToM tasks were associated with higher ratings of Lack of Insight, Inappropriate Affect, Irritability, Poor Judgment and Manipulativeness by family members. Lack of Insight negatively correlated with Reading the Mind in the Eyes only, while Manipulativeness only correlated with the Faux Pas task.

In the LHD group, personality changes showed a notable correlation with ToM performance. Specifically, an increase in 'Inappropriate Affect' was negatively associated with performance on both the Reading The Mind in the Eyes and the Faux Pas tasks. This aligns with the thematic analysis findings, which indicated a prevalent display of apathy in incorrect responses to the Faux Pas task by the LHD group. The observation of increased inappropriate affect post-neurological injury, as noted by caregivers, further reinforces the prevalence of apathy in the LHD group.

Significant relationships were detected between personality changes and non-self-reported ToM tasks (Faux Pas and Reading the Mind in the Eyes) in the right hemisphere group. Most of the changes related to ToM fall under the **Disturbed Social Behavior** dimension of personality disturbance (Inappropriate Affect, Lack of Insight, Aggression/Irritability, Manipulativeness) with Poor Judgment falling under the Executive Deficit dimension and Social Withdrawal under the Hypo-emotionality dimension (Barrash et al. 2011). The previous term for this dimension was "Interpersonal Disturbance". These traits reflect aspects of Cluster B personality disorders. These disorders are known for intersocial difficulties characterized by dramatic, overly emotional, or unpredictable egocentric thinking or behavior (American Psychiatric Association, 2013).

Personality Changes and Spatial Cognition. The next step in the analysis was to look at the personality changes reported by close family members in the clinical groups and to explore the relationship between personality changes and spatial cognition. From the above section, this study was specifically looking for personality changes related to the RHD personality profile which includes egocentrism and emotional dysregulation. To do this, correlations were run between the IRSPC personality changes and the ToM tasks separately for the left and right hemisphere groups. Significant relationships were detected between personality changes and ToM tasks that were not self-reported (*Faux Pas* and Reading in the Mind in the Eyes task). Particularly, Lack of Judgment, Manipulativeness, Inappropriate Affect, Lack of Insight and Irritability significantly correlated with the *Faux Pas* and Reading the Mind in the Eyes task in the RHD group, but not in the LHD.

It was unsurprising, then, to see that the self-reported empathy questionnaire was not significantly correlated with any personality changes, since the RHD was rated by family members as having a significant lack of insight. To explore this, we reran the EQ questionnaire in a multiple regression model with Lack of Insight as a predictor. It was not a significant predictor which does not support the hypothesis that a lack of findings was due to it being a self-reported measure. This means that our study's interpretation is incorrect. This strengthens the argument that the EQ is not measuring elements of ToM that are required by the right hemisphere but not the left hemisphere.

This links to a limitation of this research which is the reductionist approach. By classifying clinical groups as having left or right hemisphere damage is to greatly simplify the immense complexity of the neural systems that result in ToM deficit. Numerous brain regions in both the left and right hemisphere have been implicated in ToM and exploring the results from a brain hemisphere compromised will do little to tease apart the neural architecture at play (see for example Perner et al. 2006).

Secondly, these findings may indicate that the empathy the EQ captures is not related to personality changes in the participants. While the Reading the Mind in the Eyes and Faux Pas tasks are cognitive ToM tasks that are impacted by personality changes, the EQ task is predominantly an affective ToM (Preti et al. 2010). Our research then indicates that cognitive ToM can be impacted in RHD patients with intact executive and intelligence functioning and is significantly related to personality change that are related to egocentric and social disturbance behaviour, whereas affective ToM is not necessarily affected by these personality changes.

Personality Changes and Right Hemisphere Damage. Egocentric or narcissistic, sociopathic changes and emotional dysregulation are the two of the most pronounced behavioural changes in right hemisphere patients described in the literature (see Barrash et al., 1994; Cummings, 1997; Kaplan-Solms & Solms, 2000; Saver & Damasio, 1991; Saxe & Wexler, 2005; Sundram et al. 2012; Weed et al. 2010). Because of this, our study predicted that there would be significant differences in personality between the right hemisphere and control groups in this study.

Looking at the results on Panksepp's (2003) ANPS (Affective Neuroscience Personality Scale), I did not find any significant differences between groups, though I detected one meaningful trend (at the 10% significance level). Specifically those in the right hemisphere group showed higher levels of SEEKING, PLAY, and CARE ($p > 0.1$).

No meaningful differences were found in the ANGER, FEAR or SEPARATION DISTRESS subscales, but there were detectible trends on the positive personality traits of SEEKING, PLAY and CARE. There are two likely reasons for this from the literature.

The first is in support of the dated Valence effect theory of emotion (Atchley et al. 2007). Higher exhibitions of positive traits (that is, SEEKING, PLAY and CARE) make sense, according to the Valence effect.

Furthermore, according to the Valence effect, we would not expect to see higher increases of ANGER, as it is also an approach-based emotion, where the right hemisphere is avoidance-based and the left hemisphere is approach-based (Cummings, 1997). This research did not find that participants in the right hemisphere groups were more likely to report higher self-ratings of ANGER.

In fact, there was no significant difference on the ANGER subscale of the ANPS across all groups, with the right hemisphere group self-reporting lower ANGER than even the control group. From the literature, anger is related to the subcortical and orbito-prefrontal cortical areas (Blair, 2016, Besterher et al. 2017), with studies which do find evidence of lateralization noting the role of the left hemisphere in irritability (Kim et al. 1999).

The Valence effect is very simplistic in its argument of the neural bases of emotion and behaviour and the ANGER ratings not coinciding with the Valence effect theory, one would expect positive behaviours to be detected in other measures, too, not only self-reported ratings.

PLAY, SEEKING and CARE are socially desirable. If RHD is tied to less reality testing (Feinberg, 2011), it is likely that this is how patients with RHD want to be portrayed. As the right hemisphere is tied to sociopathic and narcissistic tendencies, it is likely that these participants are not reliable narrators of their behaviour and are likely to have defences that protect them in thinking of themselves in more of a positive light, than a realistic one. Indeed, the problem with assessing personality in patients who have decreased levels of insight and increased denial, is that self-reported information may be misleading. A more accurate understanding of personality changes in this group would be found by asking people who know them well to rate them on personality traits.

Critique of the Affective Neuroscience Personality Scale (ANPS). The use of the ANPS in our study was initially driven by its purported ability to capture core personality traits that are theoretically linked to specific brain functions. Panksepp's (2003) model provides a biologically-informed perspective that is appealing for studies like ours, where neurological impairments are a central concern. However, our findings, along with a broader critique in the field, suggest several areas where the ANPS may not fully align with the needs of our research or the complexities of right hemisphere damage (RHD).

1. **Theoretical Alignment**: While the ANPS is grounded in affective neuroscience, which should theoretically resonate with the neurobiological emphasis of our study, the scale's broad categories (SEEKING, PLAY, CARE, FEAR, ANGER, and SADNESS) may oversimplify the complex alterations in personality traits following RHD. The right hemisphere's involvement in processing emotional and social information is nuanced, affecting more than just discrete emotional reactions; it influences social interaction, empathy, and decision-making. This complexity is inadequately captured by the ANPS, which is designed more for capturing baseline affective dispositions rather than changes due to neurological conditions.
2. **Interpretation Challenges**: The results indicating higher levels of SEEKING, PLAY, and CARE in the right hemisphere group, and lower levels of ANGER, contradict some typical expectations of RHD impacts based on the literature suggesting increased negativity or apathy (Barrash et al., 1994; Cummings, 1997). This discrepancy raises questions about the scale's

sensitivity and specificity in a neurological population. The socially desirable nature of certain traits measured by the ANPS could lead to biased self-reports, particularly in patients with reduced insight—a common consequence of RHD. As Feinberg (2011) notes, the compromised reality testing in RHD patients can skew self-assessments, making them overly positive and less reflective of actual behavior.

3. **Empathy and Apathy**: Concerning empathy and apathy, the ANPS does not directly measure these constructs, which are critical in understanding the social and emotional deficits often seen in RHD. Empathy involves not only the emotional responses akin to those captured by the ANPS but also cognitive empathy, which includes perspective-taking and empathic accuracy, areas likely to be impaired in RHD. The lack of a direct measure for cognitive empathy in the ANPS may lead to incomplete interpretations of how RHD affects social cognition.

Alternative Measures and Recommendations. Given these considerations, our study highlights the need for using additional or alternative measures that are better suited to the specific deficits associated with RHD. Instruments like the Interpersonal Reactivity Index (IRI), which includes scales for both cognitive and affective components of empathy, might provide a more comprehensive understanding of how RHD impacts social interactions (Davis, 1980). Additionally, employing informant reports rather than self-reports could mitigate the biases introduced by impaired self-awareness in RHD patients. Additionally, while the psychometric properties of the ANPS generally show good reliability, improvements are still needed, particularly in refining the scale's latent factor structure. Moreover, Montag et al. (2021) emphasizes the need for more extensive biological validation studies to firmly establish the connections between the ANPS scales, brain functions, and proposed molecular mechanisms. The IRSPC was a more valuable assessment for this study because it did not rely on the participants self-report of themselves, especially when compromised self-awareness is linked to RHD. The IRSPC also provided a difference score taking into account the personality traits of the participants pre-morbidity.

Pre- to Post-morbid Personality Change. The Iowa Rating Scale of Personality Change (IRSPC) provided such information as it requires family members of patients to rate changes in the personality of the patients. Because of previous research referenced earlier between personality change and the RHD as well as personality disorders, this study was specifically interested in personality traits related to egocentricity and Cluster B personality traits: altered affect, altered judgment, lack of insight and challenges around social interaction. Lack of Insight, Inappropriate Affect, Apathy, Irritability, Lability, Manipulativeness, Poor Judgment and Social Withdrawal from the IRSPC were then explored. Close family members of right hemisphere patients rated significantly larger changes in all these personality characteristics. This was not noted as being profound in patients with LHD, except for Manipulativeness which was included because of its significant correlation to ToM in the RHD.

Personality ratings fell into three categories: Insight (Lack of Insight and Poor Judgement), Mood (Irritability, Inappropriate Affect and Lability), and Withdrawal (Apathy and Social Withdrawal). Family members of RHD participants not only rated participants as being less insightful than did family members of left hemisphere participants, but also rated a significant decline in insight following their stroke. From this, we can interpret any changes in insight to be directly related to RHD.

This is consistent with previous literature into the right hemisphere and insight. Indeed, one of the most well-known symptoms linked with the right hemisphere is that of anosognosia, or a denial of self-awareness. This makes sense as RHD is associated with anosognosia where patients lack insight into their deficits (Schulze et al. 2013).

Pre-morbid functioning is a significant predictor of neurological performance and this study is exploring personality traits. Having baselines and detailed information on the personality, attachment, mood and behavioural information about patients before they experience neurological injury would strengthen the science and provide a more accurate picture of the true impact of the neurological injury. Building off this research, we would recommend recruiting patients at hypertensive and diabetes clinics as they would be more likely to experience strokes than the general population. By following them longitudinally from before stroke to the acute and chronic phase post-stroke, we would have a better understanding on how RHD affects personality and behaviour as pre-morbid functioning is essential to understanding the mechanism of neurological injury and personality changes.

Indeed, Shaw et al. (2018) in their study of social cognition task in healthy participants, looked for personality differences in the healthy population and found that certain personality traits, specifically adaptability and flexibility were associated with better social cognition performance.

Inappropriate Affect and Right Hemisphere Damage. Inappropriate Affect may be explained in a number of ways. Firstly, RHD leads to problems with processing and perceiving emotion (Collins & Cooke, 2005; Gainotti, 2012; Starkstein & Tranel, 2012; Straube & Miltner, 2011). If the patient is unable to accurately perceive emotion in others, they may respond inappropriately. Turnbull et al. (2014) suggested in addition that the right hemisphere's role in emotion is primarily that of *regulation*. Tondowski et al. (2007) supported this claim by showing that patients with RHD presenting with anosognosia are able to experience and convey both positive and negative emotions. Anosognosia then emerges from poor or inappropriate emotional *regulation*, rather than a *lack* of emotion. Interestingly for this study, this was found in patients with right hemisphere lesions independent of lesion size and location, similar to the findings by Tondowski et al. (2007).

In this study, inappropriate affect tended to cluster with irritability and lability. This directly contradicts research which argues that emotional inappropriateness in right hemisphere patients is due to lack of negative emotions (see Gainotti, 1997; Jorge & Robinson, 2002). Our findings rather support the work utilizing psycholoanalytic theory like Kaplan-Solms and Solms (2000), Tondowski, Kovacs et al. (2007) and Turnbull, et al. (2014) to the effect that patients with right hemisphere deficits and anosognosia feel and can express profound negative emotions and depression. These authors argue that the experience of loss and pain is so intolerable that the patients with RHD rely on primitive defence mechanisms to deny it, though they are still able to be aware of it.

The difference in how right hemisphere participants in the study rated themselves on the depression inventory and how their family members rated them on mood, lability and irritability is also marked. Family members of right hemisphere participants would often note significant increases in irritability and lability, and a significant lowering of mood, while the right hemisphere participants would not self-rate themselves as depressed on the *Beck Depression Inventory.* Not only are there indications of a difficulty in affect regulation, but this is compounded by a denial of symptoms in the right hemisphere participants. The neuropsychological fallout from neurological injury is then further compounded by the mind's attempt at compensating for the injury. This reinforces a neuropsychoanalytic understanding: if the neurological structures that allow participants to connect to and hold reality are compromised, the individual is reduced to narcissistic, egocentric defence mechanisms, as support outside of themselves does not exist for them. This also explains why Lack of Insight was a significant predictor of the *Beck Depression Inventory*.

The next section explores the right hemisphere participants and how they make sense of the other or of interactions with others. The ToM task, the *Faux Pas* task, provided us with verbatim quotes from these participants regarding how they understood others' behaviours and how they attributed meaning and intention to these interactions. A common theme emerged from these qualitative insights that reinforced the defence mechanisms on display when these participants were asked to imagine another.

Research Aim 3: Analyzing ToM Task Performance in RHD Individuals

Qualitative insights from the *Faux Pas* task

This study has demonstrated a significant relationship between spatial and ToM skills, and their connection to personality changes. So far, this research supports the view that social cognition relies on spatial cognition and perspective-taking. The most salient and novel findings of this research are contained in the qualitative insights from the Faux Pas task. Unlike its typical use as a pass/fail test of higher-order ToM in academic literature, we delved into the verbatim responses of participants with right hemisphere damage (RHD) to understand how they failed and what insights this might provide into the subjective experience of those with chronic RHD. For a subset of this group, six participants often assumed malintent in characters and were suspicious of their motives.

Among the sixty participants, eight consistently ascribed malice to story characters. Of these, six had RHD, one had left hemisphere damage (LHD), and one was a healthy control. The RHD participants who ascribed malice often had large strokes, typically anterior rather than posterior, and more cortical than subcortical. While twelve out of twenty RHD participants performed poorly on the Faux Pas task, six of them consistently failed to recognize a faux pas or social awkwardness that had clearly occurred.

Assuming Ill-Intent in Others. In our study, a stark contrast was observed between the interpretations of healthy controls and participants with RHD. While the majority of healthy controls tended to perceive ambiguous situations as misunderstandings with either positive or neutral intent, a notable subset of six RHD participants consistently inferred that the characters in the stories possessed the same level of knowledge as themselves. This inference led these participants to attribute hostile intentions to the story characters, a pattern indicative of paranoia.

This finding is in line with existing literature on perspective-taking and ToM in brain injury cases. Specifically, it echoes the suggestions put forth in Samson's research, which emphasizes the importance of lesion studies where patients maintain intact executive functioning. The ability to inhibit one's own perspective is crucial for successful perspective-taking in ToM tasks. Studies that incorporate participants with this level of executive function intact are essential for a nuanced understanding of perspective-taking abilities post brain injury.

Our study aligns with this research imperative. The six RHD participants who exhibited signs of paranoia in attributing ill-intent to others met the criterion of having intact executive functioning, particularly the aspect of inhibition. This is a critical point, as it suggests that their perspective-taking deficits and subsequent paranoia are not simply due to a generalized impairment in executive function. Instead, these symptoms might be more specifically related to the right hemisphere damage. Therefore, our findings contribute to the nuanced discussion of how specific brain lesions, particularly in the right hemisphere, impact ToM and perspective-taking abilities, underlining the significance of intact executive function in these processes.

For instance, in a *Faux Pas* story vignette about a mistaken gender of a child named Sally, healthy controls recognized the faux pas as unintentional. They understood that the neighbor lacked specific knowledge about Sally. In contrast, the six RHD participants acknowledged the faux pas but interpreted it as deliberately hurtful. Common phrases from these participants were “They were trying to be mean” or “She wanted to hurt her neighbor”. This inability to inhibit their own knowledge and to assume positive or neutral intentions was notable. When asked about their feelings if they were to find out about a surprise party planned for them, these participants expressed feelings of being ‘hurt’, ‘sad’, or ‘punished’.

Interestingly, these participants described feeling punished as if the other character had authority and power to inflict harm, suggesting a perception of retribution. They often attributed characters' actions to "arrogance" or a desire to "show their power".

Belief in Others' Envy and Feelings of Superiority. For the six participants with RHD, they tended to believe others feel envious or superior, often interpreting social interactions negatively. This tendency is evident in their responses to the Faux Pas task, where neutral or benign comments are perceived as jealousy or arrogance, suggesting a default assumption of negativity in social interactions.

This theme led me to revisit another non-self-reporting ToM task, the Reading the Mind in the Eyes test, to investigate whether these participants' performance varied depending on the type of facial expression conveyed. Notably, RHD participants were significantly worse at accurately identifying positive emotions compared to the LHD or healthy control groups, reinforcing the complexity of ToM deficits in RHD beyond issues of inhibition and perspective-taking.

Parallels between RHD ToM findings and Borderline Personality Disorder (BPD). In the context of this study, the notion of internal representations as posited by psychoanalytic theory provides a crucial lens through which to view the cognitive and personality changes observed in individuals with right hemisphere damage (RHD). Psychoanalytic frameworks, such as Object Relations Theory, emphasize that our early relationships fundamentally shape the internal schemas or "objects" that represent our perceptions of ourselves and others. These internalized images are not static but evolve with ongoing experiences and significantly influence how individuals interpret social cues and relationships throughout their lives.

For patients with RHD, impairments in spatial and social cognition could disrupt these internal representations, leading to altered perceptions and responses to social interactions. This disruption can manifest as a regression to more primitive defense mechanisms, such as splitting and projection, where individuals may rigidly categorize others as all good or all bad without the nuanced understanding that people can possess both positive and negative qualities simultaneously. This black-and-white thinking is notably similar to what is observed in individuals with Borderline Personality Disorder (BPD), suggesting a shared mechanism of disrupted internal representations impacting social cognition and interpersonal relationships.

In cognitive models, these internal representations are akin to the mental models or schemas that are employed to process and predict social behavior. In Theory of Mind (ToM), which refers to the ability to attribute mental states—beliefs, intents, desires, emotions—to oneself and others, these schemas are crucial for interpreting and predicting others' actions accurately. The qualitative findings from the Faux Pas task in our study highlight how RHD patients often misinterpret neutral or benign intentions as hostile, a pattern that may result from a fundamental distortion in these cognitive schemas. Such distortions could stem from the neurological impact on areas of the brain integral to empathy, emotional regulation, and social processing—functions typically associated with the right hemisphere.

Moreover, the intense emotional responses and distorted perceptions common in BPD—and mirrored in our findings with RHD—can be conceptualized within cognitive models as a result of a hyperactivation of the mental state attribution network. Neuroimaging studies in BPD have shown increased activity in regions like the right temporo-parietal junction and the right dorsolateral prefrontal cortex, areas implicated in the processing of social information and emotional regulation. This overactivation may lead to what is termed 'hypermentalizing,' where individuals attribute complex intentions and emotions to others that are not grounded in reality. Similarly, RHD patients may exhibit a form of cognitive bias where their damaged neural circuits misinterpret or exaggerate social signals, leading to misattributions similar to those observed in BPD.

By drawing parallels between the psychoanalytic concept of internal representations and cognitive models of ToM, we can better understand the underlying mechanisms contributing to the personality changes and social cognition deficits observed in RHD. This linkage not only deepens our theoretical understanding but also suggests therapeutic interventions. For instance, therapies that aim to reconstruct healthier internal representations and improve mentalization abilities, such as Mentalization-Based Treatment (MBT), might be adapted for individuals with brain injuries to help mitigate these distortions and improve their social interactions and self-perception.

There are distinct similarities in the findings of this study and literature on BPD and these conditions impact ToM and the construction of self-image. Individuals with Borderline Personality Disorder (BPD) often interpret social cues in a negative light and attribute malicious intentions to others due to a combination of factors. These include heightened emotional sensitivity, difficulty in regulating emotions, and potential past experiences of trauma or invalidation. Their intense emotional responses can distort their perception of social interactions, leading to a tendency to perceive benign actions or comments as hostile or threatening. This hypersensitivity and fear of abandonment or rejection often stem from deep-seated insecurity and unstable self-image, characteristic of BPD (De Meulemeester, Lowyck & Luyten, 2021).

The unstable self-image in Borderline Personality Disorder (BPD) often arises from a combination of genetic, biological, and environmental factors. Early traumatic experiences, such as abuse, neglect, or abandonment during childhood, can profoundly impact a person's self-image and self-esteem. These experiences can lead to feelings of emptiness, insecurity, and identity disturbance. Furthermore, there may be a biological predisposition that makes certain individuals more sensitive to environmental stressors, contributing to the development of an unstable self-image. The interplay between these factors can vary widely among individuals with BPD.

This study's thematic analysis of the *Faux Pas* test emphasizes that individuals with RHD often misinterpret social cues, attributing malice where none exists. This pattern echoes the tendencies in BPD, where individuals are *hypersensitive* to negative stimuli and prone to perceive benign or neutral actions as hostile. Such misinterpretations in both RHD and BPD can be understood through the lens of Object Relations Theory and Developmental Psychology.

Future studies should build on the qualitative work on how patients fail the *Faux Pas* task and what it can tell us about how these patients interact with the world. The above interpretations are speculative and a future mixed-methods approach would be an advantage to further our understanding of the subjective experience of these patients and what it is like to encounter their world. Further work should focus on expanding the ToM tasks to right hemisphere participants while having detailed interviews with the close family members of participants. Given the lack of insight displayed by participants, case studies should involve detailed interviews with the family members who know them best to unpack examples of changed behaviour and emotion in this group.

Object Relations Theory, a framework within psychoanalysis, posits that our early relationships with primary caregivers shape our internal representations of ourselves and others. These internalized images, or "objects", form the basis of our adult self-concept and interpersonal interactions. In the context of our study, individuals with RHD, facing a sudden impairment in spatial and social cognition, may regress to more primitive forms of relating to others. They might rely on defense mechanisms like splitting, projecting negative qualities onto others, and creating a dichotomy of all-good or all-bad objects. This regression is akin to the paranoid-schizoid position described by Melanie Klein, where individuals are unable to integrate the good and bad aspects of themselves and others.

Similarly, individuals with BPD often exhibit unstable self-images and relationships, stemming from their early attachment experiences. Their heightened emotional vigilance and difficulty in integrating contradictory aspects of self and others mirror the dynamics observed in RHD patients. This commonality suggests a shared developmental disruption, albeit arising from different causes: early relational trauma in BPD and acquired brain injury in RHD. In both RHD and BPD, we see a breakdown in this developmental trajectory, leading to distorted perceptions of social interactions and unstable self-images.

The insights into RHD, particularly the patterns observed in the Faux Pas task and Reading the Mind in the Eyes, suggest that the deficits in spatial cognition following brain injury could undermine the foundational ability to perceive others as separate entities with distinct motivations. The inability to recognize positive emotions in others can lead to a skewed internal representation of social interactions, where negative perceptions are amplified. This mirrors the phenomenon in BPD, where early relational traumas contribute to unstable self-images and hypersensitivity to negative social stimuli. In fact, more than one study has shown that individuals with Borderline Personality Disorder displayed a markedly reduced ability to identify positive emotions in the Reading the Mind in the Eyes Test, compared to control groups. This observation was noted in the studies conducted by Anupama et al. (2018) and Unoka et al. (2015).

The neural underpinnings of BPD through neuroimaging identifies increased activity in the right hemisphere including the right temporo-parietal junction, right dorsolateral prefrontal cortex, right anterior cingulate cortex and right medial prefrontal cortex (Bozzatello et al. 2019; Beeney et al. 2016). This pattern indicates an overactive mental state attribution (MSA) network, which paradoxically did not improve task performance. Instead, it was linked with challenges in maintaining self-other distinctions over time and identity issues. This overactivation suggests that BPD patients might engage in hypermentalizing, a process of overly analytical and detached mentalizing, disconnected from real-life experiences. This hypermentalizing, especially in difficult social contexts, is considered a characteristic trait of BPD. This is similar to the qualitative performances of the RHD group. The hypersensitivity to criticism and interpreting neutral social interactions as deliberately hostile.

Here, RHD and BPD experience a regression to more primitive, narcissistic ways of relating, characterized by paranoia and splitting. Such a regression has striking parallels with the defensive strategies seen in BPD, where fear of abandonment and identity disturbance lead to similar patterns of idealization and devaluation in relationships. From a cognitive perspective, the struggle with egocentric bias (focus on self and have trouble understanding others' perspectives) in RHD patients may lead them to assume others feel or think the same way they do, without recognizing the differences in others' mental states. Whereas BPD may include altercentric bias which occurs when they are overly focused on others' mental states and find it difficult to separate their own feelings and thoughts from those of others. As a result, they might feel overwhelmed by others' emotions, mistakenly believing these emotions are their own.

Further evidence for this comes from the thematic analysis. The participants who displayed conviction that characters were mean and vindicative, displayed mean thoughts themselves, e.g. calling a toddler mean or a neighbour offering their seat on the bus as arrogant and hurtful.

Theory of Mind

Acute Phase Performance Comparison. The acute phase of Study 1 demonstrated no significant difference in Theory of Mind (ToM) performance between the right hemisphere group and the control left hemisphere group. Despite established associations between right hemisphere damage (RHD) and ToM performance in existing literature (De Achaval et al., 2012; Fournier et al., 2008; Happe et al., 1999; Modinos et al., 2010; Poletti et al., 2012; Sabbagh, 1999; Shamay-Tsoory et al., 2005; Winner et al., 1998), our findings were inconclusive. This may be attributed to the limited ToM tasks utilized: the First Order Belief Task, which has a low ceiling effect, and the Faux Pas test, which is heavily reliant on language comprehension. Although both acute clinical groups exhibited poor performance on the Faux Pas task, the underlying reasons for their difficulties varied, potentially due to subtle language issues impacting the left hemisphere group despite the absence of overt language difficulties.

Theory of Mind as a Higher Order Function. ToM encompasses a variety of subtypes that may involve separate neural pathways, with tasks ranging from inferring mental states from gaze to predicting behavior (Schaafsma et al., 2015). The Faux Pas test, used in our study, does not fully capture all aspects of ToM. Less language-dependent tasks such as the Reading the Mind in the Eyes test might have been more appropriate for our aims. Despite efforts to control for executive ability and intelligence, and including a comprehension section in the Faux Pas task, it remains uncertain how effectively these measures mitigate the impact of potential language difficulties on ToM performance. Koster-Hale and Saxe (2013) suggest that future research should include more verbal ToM tasks that allow for open-ended responses, which could reveal more about the feelings and thoughts of story characters.

Two dominant theories, simulation theory and theory-theory, provide frameworks for how individuals comprehend others' emotions and intentions (Perry & Shamay-Tsoory, 2013). Simulation theory proposes that individuals use mental models to simulate another's mind, experiencing presumed beliefs and emotions based on observed behaviors. Conversely, theory-theory likens ToM development to a scientific method where children infer others' beliefs and emotions through acquired knowledge and causal reasoning. These frameworks do not fully explain the behaviors observed in Study 1 and 2 among participants with RHD, who consistently believed others had malicious intentions and were intent on causing harm.

Implications for Understanding Borderline Personality Disorder (BPD). Borderline Personality Disorder (BPD) is characterized by unstable moods, behaviors, and relationships, with significant symptom overlap related to impairments in social cognition, akin to those observed in our RHD cohort. This comparison is pertinent as both groups face challenges in perspective-taking, emotional regulation, and maintaining a stable self-image. One critical element in BPD is egocentrism, where the difficulty in appreciating others' perspectives can lead to intense and unstable relationships. Our findings suggest that similar mechanisms might be disrupted in RHD patients, evidenced by significant deficits in ToM tasks. This may lead RHD patients to misinterpret social cues and attribute hostile intentions where none exist, a pattern also prevalent in BPD. Enhancing perspective-taking and empathy through interventions could therefore be beneficial for both groups.

Suitability of BPD as a Comparison Group. BPD's broad clinical presentations provide a unique opportunity to explore the spectrum of social cognition impairments, despite the inherent challenges posed by its heterogeneity. Including BPD patients in future studies could enhance our understanding of the specific cognitive deficits associated with RHD that overlap with BPD, potentially leading to more personalized treatment approaches. Comparative analysis could validate the use of RHD as a model for examining complex interpersonal interactions in psychiatric populations, thereby informing therapeutic strategies. For instance, therapies effective for one group, such as Dialectical Behavior Therapy (DBT), which focuses on improving emotional regulation and enhancing social skills, might be adapted for the other group.

Integrating Studies. For Study 2, unlike Study 1, quantitative analyses showed that the right hemisphere group struggled with the ToM tasks significantly more than the left hemisphere group (for both the *Faux Pas* task and the Reading the Mind in the Eyes test). This is consistent with previous literature which repeatedly shows that patients with RHD perform badly on these tasks (see De Achaval et al. 2012; Fournier et al. 2008; Happe et al. 1999; Modinos et al. 2010; Poletti et al. 2012; Sabbagh, 1999; Shamay-Tsoory et al., 2005; Winner et al. 1998).

Koster-Hale and Saxe (2013) linked ToM to the right TPJ through TMS studies disrupting this area. When disrupted, the moral judgments of participants are unchanged but their ability to consider another's thoughts and beliefs in their moral judgments is affected. Secondly, disruption to the right TPJ slowed down the ability of participants to perform a simple, first order false belief task (Cosa et al., 2013).

Koster-Hale and Saxe's (2013) hypothesis of the rTPJ is that these regions specifically function as meta-representation: the representation of other people's mental representations. Sabbagh (2013) provides an overview of the small number of event-related potential (ERP) technique studies in ToM. ERP refers to an encephalographic recording (EEG) being time-locked with a particular stimulus (precise moment that a question requiring inferring mental states is asked).

These studies have a similar limitation to imaging studies of trying to capture *when* a participant is inferring the state of mind of another. Other cognitive functions may be activated (e.g., memory, spatial reasoning, inhibition). Sabbagh's (2013) approach was to repeat the studies with 40 trials to maximize the benefit of signal averaging. His findings showed right frontal lobe activation. This fits with Saxe and Powell's (2006) argument that the frontal lobes may be critical for the representation of mental states and the parietal lobes are required for reasoning about the specific belief.

In the second study, both left hemisphere damage (LHD) and right hemisphere damage (RHD) groups showed similar results on the Emotion Quotient (EQ) inventory, which is a self-reported measure of affective empathy. The EQ inventory is known for its strong validity and reliability (Baron-Cohen & Wheelwright, 2004; Muncer & Ling, 2006). This may explain why the LHD group outperformed the RHD group in all ToM tasks except the EQ scale, suggesting that RHD impacts cognitive aspects of ToM more than affective ToM.

The profound ToM deficits detected in the right hemisphere group was surprising given the wide range of cortical brain regions affected in the right hemisphere group. This study was unable to detect any differences between ToM performance and lesion location in the right hemisphere group, where participants with anterior, posterior, cortical and subcortical lesions all presented with ToM difficulties.

Work by Samson and Michel (2013) make sense of this by acknowledging that the literature shows wide-ranging lesion locations including: lesions to the right hemisphere, frontal lobes, temporo-parietal junctions and even the amygdala and basal ganglia (Samson & Michel, 2013). This shows that the impairment of basic neuropsychological functions of the RH can compromise ToM in different ways with damage to rPFC lesions compromising perspective taking due to inhibitory failure and posterior RH lesions due to spatial problems (Samson & Michel, 2013).

Koster-Hale and Saxe (2013) posited that the consensus of the specific roles of both the anterior medial PFC and posterior TPJ in ToM is one of human neuroimaging's most remarkable findings. The testing materials also included the *Faux Pa*s tests and rotational tasks. What makes this finding so remarkable is that studies with different methodologies, types of participants and testing material have found the same two areas to be involved.

Koster-Hale and Saxe (2013) pointed out the difficulties in linking behaviour to brain regions. They suggested the best way is to include participants with focal brain damage, and to provide them with controlled cognitive tasks (ranging from memory, intelligence) and ToM tasks and to identify the regions of damage in those who passed the control tasks but failed the ToM tasks.

Samson (2009) did this and was able to identify the left TPJ as integral to ToM tasks. However, all the participants with RHD failed the control tasks, which means that they could not test ToM deficits in right hemisphere patients.

This study looks at right hemisphere patients in the chronic stage of their brain injury, which means that they are able to pass the control tasks (intelligence, inhibition) but were still unable to pass higher level ToM tasks (specifically the *Faux Pas* tasks). Our most significant findings besides the qualitative presentations from LHD and RHD participants is the hierarchical model we were able to build.

RHD and spatial cognition abilities could predict ToM performance. Two outcome variables were assessed: ToM performance in the 'Reading the Mind in the Eyes' test (Model 1) and the 'Faux Pas' task (Model 2). In Model 1, the 'Group' variable (comprising LHD, RHD, and control group) significantly predicted ToM performance, accounting for 52% of variance in 'Reading the Mind in the Eyes'. Adding spatial cognition to the model explained an additional 26% of variance. When controlling for intelligence and executive functioning, we can see the direct impact of spatial cognition on cognitive ToM. This is a remarkable finding in psychological research as it is rare that a single variable can account for this much variation in a model.

Integration of Affect and Cognition. The integration of affect and cognition in the context of theory of mind (ToM) and right hemisphere damage (RHD) presents distinct challenges, primarily due to the complex and sometimes counterintuitive ways in which these brain functions interact. Our study's findings indicate a pronounced discrepancy between affective empathy, as measured by the Emotion Quotient (EQ) inventory, and cognitive ToM abilities, as assessed through tasks like the Faux Pas test and the Reading the Mind in the Eyes test. Notably, while the EQ results did not differ significantly between groups, RHD participants showed considerable deficits in cognitive ToM tasks. This suggests that RHD predominantly impacts cognitive components of ToM rather than affective empathy, underscoring a crucial separation between affect and cognition in these patients.

Theoretically, this separation aligns with neuroscientific models that posit different neural substrates for affective and cognitive components of empathy and ToM. The right temporo-parietal junction (rTPJ), implicated in our findings and highlighted in studies by Koster-Hale and Saxe (2013), is known for its role in cognitive perspective-taking. The unexpected lack of performance variability in ToM tasks across different lesion locations within the right hemisphere, however, poses a significant challenge. It suggests a more distributed network affecting ToM, which contradicts some traditional models that assign discrete cognitive functions to specific brain areas.

One inconsistency in our data is the observation that despite similar EQ scores across groups, the profound deficits in cognitive ToM tasks were specific to RHD participants. This divergence might be due to the methodological limitations of self-reported measures like the EQ, which could fail to capture subtler aspects of affective empathy altered by RHD. Furthermore, the lack of correlation between ToM performance and specific lesion sites within the right hemisphere suggests a more complex interaction between brain damage and ToM abilities than previously understood. This complexity is partly attributed to the multifaceted nature of ToM, which involves various cognitive processes such as memory, spatial reasoning, and inhibition—functions that can be variably affected by RHD.

Addressing these gaps, future research should consider more nuanced approaches to measuring both affective and cognitive components of ToM. For instance, employing neuroimaging techniques during ToM tasks could provide real-time insights into how different brain regions are activated or disrupted in RHD patients compared to controls. Additionally, enhancing the sensitivity of affective measures to better differentiate between genuine empathetic responses and the ability to understand and report on such responses could clarify the impact of RHD on affective processes.

This study highlights the critical need for integrating affective and cognitive dimensions in the study of ToM and brain injury. By refining our methods and theoretical frameworks, we can better map the intricate ways in which the brain's affective and cognitive systems interact, particularly in the context of neurological damage. Such advancements will not only deepen our understanding of brain-behavior relationships but also inform more targeted interventions for individuals with brain injuries affecting social cognition.

Significance of Theory of Mind Findings. This is the biggest contribution this research provides, by focusing on patients with chronic damage who have passed control tasks of intelligence and executive functioning. Similarly to Study 1, of particular interest was not only the quantifiable differences in the right hemisphere group's responses to the *Faux Pas* task but also the qualitative performances. The right hemisphere group in Study 1 did not perform well on the *Faux Pas* task either, but they did not fail in the same way. Participants across all three groups failed on the tasks due to two possible reasons.

They either failed to identify that a *faux pas* had occurred, or they incorrectly asserted that a *faux pas* had taken place. Of the seven participants with LHD (from ten) who failed *Faux Pas* tasks, six consistently failed to identify that a *faux pas* had occurred. In comparison, only three participants with RHD failed to identify that a *faux pas* had occurred when it had. Of the eight participants with RHD who failed the *Faux Pas* task, six incorrectly ascribed malice during the *Faux Pas* task, whereas only one participant with LHD attributed hostility in any task.

Implications

There are fundamental shifts in how patients with RHD encounter and make meaning of the world around them, which are not seen on the same scale and severity in their left hemisphere and healthy control counterparts. This study has been able to show that their assumptions about the world profoundly affect their ability to correctly infer the minds of others, and this likely has real world implications for the patients who suffer from these changes. Nine (out of thirty) right hemisphere patients in the two studies displayed significant and consistent paranoia and hostile attribution when making judgments about social interactions and characters' intentions. These varied in lesion location, showing that anterior, posterior, cortical and subcortical damage to the right hemisphere can lead to profound shifts in social interacting with the world. These patients' affective changes compounded their cognitive ToM.

ToM research focuses on disentangling the neural and cognitive architecture to understand if there is a ToM-specific network and to understand which cognitive domains are part of that network or are foundational for mind reading to take place. Samson's (2005) seminal work has shown the use of neuropsychological studies of patients with acquired brain damage. This work has shown that inhibiting one's own perspective requires executive functioning in the prefrontal cortex and requires posterior right hemisphere perspective taking which relies on spatial cognition. What the research seems to have ignored is the powerful psychological projections that the mind creates in response to right hemisphere brain damage. For a significant proportion of participants in the study, their lens is clouded by a belief that the outside world is hostile and that other people's deliberate intentions are to hurt.

The significant correlations between ToM tasks and spatial cognition performance for the clinical group with RHD, but not in the LHD group, supports the view that ToM performance is subserved by spatial cognition.

This research added to the framework of how boundaries and relationships to objects in spatial cognition give rise to boundaries and relationships to the mental representations we have of others. This research has also for the first time presented the paranoia, hostile attributions and personality changes observed in these right hemisphere participants, as a result of the disintegration of spatial and cognitive ToM.

It is crucial to note that the observed patterns of assuming ill-intent in others were not uniform across the entire group. This specific change was prominent in a subset of six RHD participants, which is less than half of the total RHD group. This distinction raises important questions about the heterogeneity within the RHD population and the factors contributing to these differences.

This variation within the RHD group suggests that the impact of right hemisphere damage on ToM and personality traits is not monolithic but rather subject to individual differences, possibly influenced by factors such as the extent and specific location of the brain damage. Therefore, while our study highlights a significant finding in a specific subgroup of RHD patients for the first time, it also underscores the need for a more nuanced understanding of the variations within the RHD group in future studies. Such an understanding can help in tailoring rehabilitation approaches and in furthering our knowledge of the intricate ways in which different brain lesions affect cognitive and social functioning.

From this, future studies could build on this knowledge to focus on the treatment options to support these patients with profound difficulties in their lives.

For example, treatments for Borderline Personality Disorder (BPD) to patients experiencing personality changes due to brain injury could be tested and adapted. These would include therapeutic techniques such as Dialectical Behavior Therapy (DBT) or Mentalization-Based Treatment (MBT), which have been effective in managing BPD symptoms, to address the unique challenges faced by brain injury patients (American Psychiatric Association, 2013). This research could explore how these therapies might be tailored to assist with emotional regulation, impulsivity, and interpersonal difficulties that often arise post-brain injury.

Additionally, investigating the effectiveness of these adapted treatments could provide valuable insights into the neurobiological underpinnings of personality changes following brain injury and contribute to developing more comprehensive rehabilitation programs. This research would not only advance our understanding of brain injury but also potentially offer new, effective treatment pathways for those affected.

In discussing the findings of this study, it is crucial to balance our interpretation to consider both the positive outcomes and the areas where expected results were not observed. Notably, the study did not find significant differences in certain personality traits between the right hemisphere and control groups as anticipated, which prompts a critical evaluation of our theoretical framework and measurement tools. Such discrepancies suggest that the manifestations of right hemisphere damage might not always align straightforwardly with predicted theoretical outcomes, indicating potential resilience or compensatory mechanisms at play.

Further, the absence of expected negative associations, particularly in the domains of anger and social withdrawal, challenges some prevailing assumptions about the impact of right hemisphere damage. This could suggest a more complex interplay of neural functions or a limitation in the sensitivity of the tools used to measure these constructs. The implications of these findings are significant, suggesting that our understanding of the neural underpinnings of personality changes post-stroke may need to be revised or expanded. It also underscores the need for employing a broader range of diagnostic tools or more sensitive measures in future research to capture subtle changes not detected in the current study.

These unexpected results highlight an opportunity to explore new hypotheses about the adaptive or compensatory responses in individuals with right hemisphere damage, potentially leading to innovative therapeutic interventions or strategies to support these individuals. By integrating these findings into our theoretical models, we can enhance our understanding of brain-behavior relationships and refine our approaches to treating and supporting individuals affected by right hemisphere damage.

Conclusion

Clinical and research experience with patients suffering from RHD indicates that these patients can present with profound changes in their social relationships, spatial cognition and personality traits associated with egocentricity. The goal of this research was to explore this by conducting neuropsychological studies of patients with acquired brain damage.

The unique contribution of this research was to provide both qualitative and quantitative data on patients with RHD and LHD. These groups were able to pass first order false belief tasks, executive functions and intelligence, that are often confounding variables in other research. This has allowed a pure exploration of *how* these patients infer others' mental states and how this relates to compromise of spatial cognition. This study seeks to bridge a gap in ToM research, particularly in the context of cognitive changes following neurological impairment. By incorporating psychoanalysis, developmental and abnormal psychology, the research integrates ToM concepts with how patients adapt to brain injuries affecting their social and spatial cognitive functions. This blended approach provides a deeper understanding of ToM performance post-neurological trauma. And to understand the neuropsychology of ToM, research needs to understand these compensatory psychological mechanisms that are not *directly* related to the neurological damage resulting in ToM deficit, but are part of the integrated whole of the clinical presentation following RHD.

This research provides evidence that future ToM research consider the impact of spatial cognition and personality traits, such as egocentrism, paranoia, and hostile attribution. This compounds the loss of cognitive ToM abilities leading to significant changes in patients' relationships with others and the way they view the world. Without this connection to understanding others, these patients experience profound changes in their ways of relating to others and to their self.

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Appendix A

Lesion Details of Each Clinical Participant for Acute Sample

Lesion details of each clinical participant

Acute study

Participant	Group	Lesion details
1	RHD	Acute Right Middle Cerebral Artery infarct
2	RHD	Acute Right Middle Cerebral Artery infarct
3	LHD	Left head of caudate and Left posterior limb internal
4	RHD	capsule
5	RHD	Acute RightMiddle Cerebral Artery infarct
6	LHD	Acute R Middle Cerebral Artery infarct
7	RHD	Acute L Middle Cerebral Artery infarct
8	LHD	Acute R Middle Cerebral Artery infarct
9	RHD	L posterior limb of internal capsule
10	RHD	Acute R Middle Cerebral Artery infarct
11	LHD	Acute R Middle Cerebral Artery infarct
12	RHD	L hyperacute infarct
13	RHD	Acute R Middle Cerebral Artery infarct
14	LHD	Acute R Middle Cerebral Artery infarct
15	RHD	L lentiform nucleus
16	RHD	Acute R Middle Cerebral Artery infarct
17	RHD	Acute R Middle Cerebral Artery infarct
18	LHD	Acute R Middle Cerebral Artery infarct
19	LHD	Acute L Middle Cerebral Artery infarct
20	LHD	Acute L Middle Cerebral Artery infarct

21	RHD	Acute L Middle Cerebral Artery infarct
22	RHD	Acute R Middle Cerebral Artery infarct
		Acute R Middle Cerebral Artery infarct

Appendix B

Lesion Details of Each Clinical Participant for Chronic Sample

Lesion details of each clinical participant

Chronic study

Participant	Group	Lesion details
1	LHD	L post fossa bleed
2	LHD	L Middle Cerebral Artery infarct
3	LHD	L frontal brain tumour
4	LHD	L Middle Cerebral Artery infarcts
5	LHD	L cortical infarct (suspected)
6	LHD	L temporal lobe infarct
7	LHD	L BG infarct
8	LHD	L temporo-parietal bleed
9	LHD	L PACI (suspected)
10	LHD	L fronto-temporal-parietal subdural bleed
11	LHD	L frontal extra-axial bleed
12	LHD	L temporo-parietal intracerebral bleed
13	LHD	L PCA subacute infarct
14	LHD	Coiled aneurysm left
15	LHD	Left posterior limb of internal capsule subacutelacune
16	LHD	L thalamic haemorrhage
17	LHD	L Middle Cerebral Artery infarct
18	LHD	L Middle Cerebral Artery infarct
19	LHD	L Middle Cerebral Artery infarct
20	LHD	R parietal bleed

21	RHD	R Middle Cerebral Artery infarct
22	RHD	R Middle Cerebral Artery infarct
23	RHD	R fronto-parietal and BG infarcts
24	RHD	R thalamic infarcts
25	RHD	R frontal ICH and SAH
26	RHD	R fronto-parietal intracerebral bleed
27	RHD	R Middle Cerebral Artery infarct
28	RHD	R fronto-temporal meningioma
29	RHD	R frontal intracranial bleed
30	RHD	R pontine low densities
31	RHD	R Middle Cerebral Artery infarct
32	RHD	R Middle Cerebral Artery infarct
33	RHD	R CVA
34	RHD	R haematoma
35	RHD	R Middle Cerebral Artery territory infarct
36	RHD	R Middle Cerebral Artery
37	RHD	R Middle Cerebral Artery infarct
38	RHD	R Middle Cerebral Artery
39	RHD	R Middle Cerebral Artery
40	RHD	R Middle Cerebral Artery

Appendix C

Human Ethics Approval

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6626 • **Facsimile** [021] 406 6411
e-mail: lamees.emjedi@uct.ac.za

08 September 2010

HREC REF: 121/2010

Prof M Solms
Psychology
Upper Campus

Dear Prof Solms

PROJECT TITLE: THE ROLE OF THE RIGHT HEMISPHERE IN NEGATIVE MOOD & AFFECTIVE SOCIAL BONDING

Thank you for submitting your response to the queries raised relating to your new study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the FHS HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until 15 September 2011.

Please send us an annual progress report (website form FHS 016) if your research continues beyond the approval period. Alternatively, please send us a brief summary of your findings so that we can close the research file.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

Lesley Henley

pp **PROFESSOR M BLOCKMAN**
CHAIRPERSON, HSF HUMAN ETHICS

lemjedi

Appendix D

Consent Forms for Study Participants

University of Cape Town

Consent to participate in a medical research study: Paper and pencil assessment

The role of the right hemisphere in negative mood and affective social bonding

Study Purpose

We, UCT neuropsychology, are currently researching the effects of brain damage on some aspects of real life function, focusing particularly on social perception and personality. We are trying to document how damage to different regions of the brain can have very different results: sometimes it changes how a person relates to others, and behaves in the world. Sometimes these changes do not occur.

Study Procedure

If you consent to participate in this study, you will be involved in two cognitive assessment sessions (each about an hour long), where aspects such as social perception, mood and personality will be assessed. These abilities are assessed by asking you to complete several straightforward pencil and paper tasks. We will also ask you about your experiences after your injury/surgery. If you agree, we will also ask a person who knows you very well to provide information about any changes they may have noticed since your brain injury/surgery. We will need to look at your scans to determine exactly which area of the brain was involved.

We will compensate you for travel and meal costs for each session you attend (R100 per session), and provide a completion bonus for attending both sessions (an additional R100), so by the time you have completed the study you will have received R300).

Voluntary participation

Participation in this study is completely voluntary. You can discontinue participation at any point and this will not affect your present or future medical care in any way.

Possible risks

Participating in the cognitive assessment may bring on uncomfortable feelings. In our experience, these are slight and do not bother you after you have left. If you need to talk to someone about this experience, we can refer you to a qualified clinician.

Confidentiality

Your information from this study will be kept confidential. All your identifying information such as your name will be kept separate from your task results. Your identifying information and consent form will be kept in a separate, locked filing cabinet. The information you give us will not form part of your medical record, nor will it be placed in your medical folder.

The data gathered from this research may be published, but your contribution will remain anonymous. If excerpts from your responses are quoted, you will not be identified – only a random number will be used (eg. Participant 5).

NB: Your decision to participate or not participate will in no way impact on your ongoing medical care and treatment.

Should you have any questions or queries about the research or your participation, please do not hesitate to contact the investigators, Jill Mosdell: (ph) 021 685 1922 (email) Jill.Mosdell@uct.ac.za

Susan Malcolm-Smith (ph) 021 650 4605 (email) Susan.Malcolm-Smith@uct.ac.za

Professor Mark Solms (ph) 021 650 3437 (email) Mark.Solms@uct.ac.za

Questions about your rights as a study participant, comments or complaints about the study also may be presented to the Research Ethics Committee, Faculty of Health Sciences, University of Cape Town, Rondebosch, 7700, telephone 021-406-6492.

Consent Form

The study has been explained to me, and my questions have been answered.

I understand that participation in this study is voluntary, and that I may withdraw at any point.

I understand that I will not be identified except by a random number, and that this anonymity will be maintained throughout the study and when the research is published.

I consent to participate in this research.

I consent that the researchers of this study may approach a family member/close friend to participate in the research and provide information about me.

I have been offered copies of this consent form and of the Information Sheet.

Name ____

Signature ____

Date ____________________________

I have explained the study to the participant, and in my opinion s/he understands that participation is voluntary and is able to give informed consent.

Researcher ____

Signature ____

Date ______________________________

Declaration by interpreter

I *(name)* …………………………………………… declare that:

- I assisted the investigator (*name*) …………………….to explain the information in this document to (*name of participant*) ………………..…………………….. using the language medium of Afrikaans.
- We encouraged him/her to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was related to me.
- I am satisfied that the participant fully understands the content of this informed consent document and has had all his/her question satisfactorily answered.

…………………………………………………………………

Signature of interpreter

Appendix E

Exclusion Information

Study 1: Exclusion Criteria

Left handedness
Any psychiatric disorder, including affective and psychotic disorders
Psychoactive medication
Serious systemic condition (e.g. lung disease, kidney disease)
Any previous brain injury in addition to current one
Severe language impairment
Epilepsy
Multiple Sclerosis
Parkinson’s Disease
Dementia
Substance or alcohol abuse
Premorbid social deviance (e.g. gang membership)

Study 2: Exclusion information during screening phase (N = 108)

Reason	Number	Percentage
Uncontactable	41	37.96
Unsuitable infarction[1]	21	19.44
Not interested	10	9.26
Deceased	10	9.26
Aphasic	7	6.48

Incorrect/incomplete details in folder	6	5.56
Left-handed	4	3.70
Dementia/frailty	4	3.70
Psychiatric diagnosis	3	2.78
HIV diagnosis	1	0.93
Epilepsy	1	0.93

[1] I defined an unsuitable infarction as one that led to a lesion(s) that involved both hemispheres of the brain.

Appendix F

Anosognosia Assessment

Anosognosia assessment

Anosognosia		
Unawareness of deficit or consequences of deficit, or unconcern about		
deficit (anosodiaphoria)		
Somatoparaphrenia – psychotic thoughts about the body		
Misoplegia – hatred of paretic limb		
Tests:		
During assessment of orientation, look for **spontaneous report of deficit.**		
(a) Ask patient: Please describe all your current symptoms/deficits		
(Spontaneous report of all motor and sensory	**0/3**	=
impairments)		
(b) Ask patient: What about your legs/arms/hands/eyes, etc.	**1/3**	=
(where applicable), are they all functioning normally?		
(Accurate acknowledgement of all deficits)		
(c) Demonstrate deficit to patient by physical examination, then	**2/3**	=
ask: Do you still think your … is functioning normally?		
(Accurate admission of all demonstrated deficits)		
(d) Still denies deficit.	**3/3**	=