Theory of Mind following Paediatric Traumatic Brain Injury:

A Comparative Study of South African Children

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COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

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Abstract

'Theory of mind' (ToM) refers to the ability to understand and make inferences about other people's intentions, feelings and beliefs. The fact that previous research shows an impairment in social competence following traumatic brain injury (TBI) alludes to a potential relationship between TBI and ToM. Although the relationship between paediatric TBI (pTBI) and ToM ability is relatively unexplored, especially within a South African context, previous research on TBI and ToM suggests social impairment following TBI. The current research project was aimed to investigate exactly that. The study reported here investigated this relationship, and specifically focused on the effects of pTBI on ToM ability in 9-15 year old children. Twenty mild and 10 moderate pTBI participants were compared to 20 typically developing (TD) children matched on socio-economic status (SES), home language and age. Due to a lack of South African norms and in consideration of a potential cultural or language influence on ToM development, the performance of the typically developing participants functioned as the norm against which the pTBI participants were compared. The three groups were assessed on ToM ability using the NEPSY-II ToM subtest and a developmentally sensitive ToM battery. General intelligence and executive functioning were also assessed as potential confounding variables. Statistical analysis showed no statistical significant differences in ToM ability across the three groups. However, a general trend was observed in the performance on the developmental sensitive battery, where mild TBI and TD participants performed at a similar level and moderate TBI participants performed worse than both of these groups. It was found that with greater power the trends observed may well prove to be significant. The results also suggest that the measures used to assess ToM ability and cognitive functioning need to be further adapted for use with a non Western population. Potential critical factors impacting on the insignificance of the results are discussed, paying special attention to the effect of language and the administration of Westernised test batteries in non Western populations.

Keywords: theory of mind, paediatric traumatic brain injury, social impairment, NEPSY-II, ToM tests, neuropsychological testing in the South African context, Western norms, effects of language, adaptation and translation of Western test batteries.

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Humans are social beings governed by social interactions and relationships in daily life. Even successfully navigating through a simple conversation requires some understanding of social appropriateness as one needs a certain basic mental skills to nod at the right time, give a suitable response or make an empathetic gesture. Although such simplistic responses appear to come naturally to most people and we do them without conscious thought, some people are incompetent or clumsy when it comes to social interactions. This is because they lack the cognitive skills required to successfully engage socially with other people (Baron-Cohen, Leslie, & Frith, 1985). Individuals who have suffered a traumatic brain injury (TBI) often experience negative changes in their social behaviour such as having inadequate social judgement. Deficits in social behaviour following TBI can have potentially serious consequences not only for the patient but also for their friends and family. TBI patience may become socially awkward or inappropriate leading to loss of jobs and meaningful relationships.

The ability to (a) attribute mental states, (b) understand the beliefs and intents and (c) predict the behaviour of others is known as Theory of Mind (ToM). Therefore, deficits in social behaviour have been attributed to impairments in ToM ability. The underlying neuropsychological deficits causing impairments in ToM have been investigated in numerous research studies Although a relationship appears to exist between TBI and difficulties in ToM the exact effects of TBI on ToM are still relatively unexplored. The majority of the existing research on ToM post TBI has mainly investigated this relationship in adult populations. Even though evidence suggests that children and adolescents suffer greater social deficits following TBI than adults (McKinlay, Dalrymple-Alford, Horwood, & Fergusson, 2002), very little is known about the consequences of paediatric TBI (pTBI) on ToM ability. There is an ongoing debate as to whether social deficits result from (a) a primary deficit in ToM, (b) generalised cognitive impairment or (c) related impairments in executive functioning, all of which are common after a TBI (Milders, Fuchs, & Crawford, 2003). Investigating the affected underlying neuropsychological components of ToM is crucial for our understanding of the causes of deficits in social behaviour. For this reason, the current study was designed to investigate the effects of pTBI on social behaviour or more specifically ToM ability.

Theory of Mind Overview

The cognitive capacity to recognise and understand the mental state of others and to predict their behaviour is often referred to as Theory of Mind (Baron-Cohen et al., 1994; Milders, Ietswaart, Crawford, & Currie, 2006). This ability is considered a crucial component for effective social communication (Channon & Crawford, 2000; Happé, Malhi, & Checkley, 2001) as social interaction requires complex and flexible behaviour (Adolphs, 2001; Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999). The ability to make social inferences contributes to the ability to understand social situations and facilitates building and sustaining relationships with others. The processes underlying ToM are characterised by two types of inferences, (a) epistemic inferences, which are made about the knowledge and beliefs of others, and (b) affective inferences, which allow the interpretation and understanding of emotional states of others (Stone, Baron-Cohen, & Knight, 1998). The interaction of these two processes is crucial for the display of adequate ToM ability.

Some research suggests that ToM exists as a separate cognitive module independent of general intelligence (Adolphs, 2001; Baron-Cohen et al., 1994; Baron-Cohen et al., 1985; Happé, 1999; Happé et al., 2001; Happé, 1993). Therefore, whereas other cognitive aspects such as language may remain intact, ToM can be selectively impaired (Stone et al., 1998). Thus, an individual with normal intelligence may exhibit impaired social behaviour due to a deficit in ToM. Many patients with frontal lobe damage, for example, show impaired social cognition while showing only minimal impairment in other cognitive domains (Rowe, Bullock, Polkey, & Morris, 2001).

An array of tasks is used to measure ToM performance and ultimately ToM ability. Such tasks tap into the ability to make different mental state attributions that need to be intact for successful social cognition. A critical tool employed in ToM research is the false-belief task, which assesses the ability to infer epistemic mental states, such as beliefs. Briefly, the task is designed to determine a person's ability to understand that somebody else's belief may not resemble the reality of a given situation (Bibby & McDonald, 2005). A famous example of a false-belief task is the Sally-Anne test. In this story, there are two doll protagonists, namely Sally and Anne. Sally places a marble into a basket and then leaves the room. Then Anne moves the marble and puts into a box. The child is then asked where Sally will look for the marble. If the child correctly suggests that Sally will look in the basket (i.e. where *she* had put it) the child has successfully predicted someone else's behaviour based on that person's belief and not their own knowledge. The correct prediction is dependent on making the inference that the person has a false belief, thus, the task demonstrates ToM ability (Baron-Cohen, Leslie, & Frith, 1985).

There are two levels of complexity to false-belief comprehension. The less complex level, known as first-order false-belief, is the understanding that others can have mental states that differ from reality (e.g. the Sally-Anne task). The more complex level, known as second-order false-belief, is the ability to conceptualise what another person thinks a second person thinks (i.e., having a belief about someone else's belief). This is the traditional approach in assessing ToM ability and the method most often employed when investigating young children. The ability to make first-order and second-order false-belief inferences develops fairly early during childhood, by four and six years of age, respectively. Initially a child's ToM ability was reduced to simply passing a false-belief test and children who passed this test were considered to have reached the developmental milestone of ToM ability. But ToM ability constitutes more than just the understanding of false-belief and thus inferring that ToM has fully developed based on a single task, is fallacious. Also, a meta-analysis (Wellman, Cross, & Watson, 2001) showed a main effect for age on false-belief tasks suggesting that the older a child gets the better they get at mastering the false-belief task. This finding demonstrates that ToM ability continues to develop as the child matures. It also implies that ToM ability goes beyond the scope of understanding false-beliefs and that other more complex aspects of ToM need to be explored too.

Therefore, further tests were developed targeting older children and a wider range of mental concepts such as desires and intentions, and understanding of more complex social interactions. A typical ToM test aimed at older children between the ages of seven and eleven is the faux-pas test, which involves the ability to recognize socially awkward situation (Baron-Cohen et al., 1999). The faux-pas test is extremely valuable as it is designed to detect ToM deficits at a higher level than first or second-order false belief. Also, it investigates the ability to make both affective and epistemic inferences rather than only epistemic inferences as is the case in the false-belief task.

Another ToM task was developed by Happé (1994) and is known as the *Strange Stories* task. These stories are simple accounts of everyday scenarios aimed at investigating the motivation behind responses that are not literally true, like contrary emotions, irony, lies, pretend, appearance-reality distinction, persuasion, double-bluff, white lies, misunderstanding, jokes, figure of speech and forgetting. The preceding context of a story affects how the story or situation is interpreted (i.e., why the protagonist acted in a specific way). Thus, the stories were set out in such a way that the motivation behind why the protagonist gave a certain response was clear and could only be interpreted in one specific way. Therefore, this test does not only look at *if* individuals are able to correctly interpret a social situation but also considers the explanation that they give as to *why* the protagonist said something. This is important as different individuals may come to the same conclusion about a social situation but may have different underlying reasons or interpretations of the situation. Most ToM research is based on using tasks that only measure single aspects of ToM.

However, ToM is a very complex mental construct that needs to be measured in a comprehensive way and intact ToM ability should not be reduced to the mastering of false-belief tasks as this is too simplistic a measurement. ToM comprises far more than just that concept, and therefore, comprehensive measures need to be employed which explore multiple components and aspects of ToM.

Development of Theory of Mind

There is a general consensus that ToM is a mental process that develops during post-natal maturation. The question of whether ToM is definitely due to a biological maturation or instead from a process affected by environmental influences consistent across cultures, or perhaps both, remains unanswered. In attempting to answer this question, the onset of ToM has often been reduced to the ability of children to pass false-belief tasks (Callaghan et al., 2005). Such false-belief testing has become a major research tool in the assessment of ToM ability and has lead to the notion that ToM follows specific developmental stages. Research seems to suggest that the shift in the understanding of mental states is consistent across cultures (Kobayashi, Glover, & Temple, 2006) and that its onset in typically developing children is generally between three to five years of age in Western cultures (Stone et al., 1998; Wellmann, Cross, & Watson, 2001). Whether ToM ability develops on a biological level, such as through brain maturation during early childhood and whether it is possibly triggered by universal childhood experiences is still under investigation. Therefore, knowing whether this transition can be generalised across various cultures is key to understanding the causes underlying its development (Callaghan et al., 2005).

Typical developmental trajectory. Despite not knowing for certain what underlies ToM development, research has been able to establish a typical developmental trajectory;

from early, basic abilities starting during infancy to the understanding of complex mental inferences around 11 years of age. Early development of ToM first becomes apparent in the expression of joint attention (looking at an object another person is looking at) and proto-declarative pointing (using pointing to draw attention of parent to an object); generally at around 18 months of age (Baron-Cohen, 1997).

The next stage in ToM development occurs around 18-24 months when the child engages in pretend play (is able to distinguish pretend from reality; Leslie, 1987). At around two years of age a child is able to grasp the concept of 'desire' (e.g., "Peter wants a cookie"; Wellman & Woolley, 1990), which precedes understanding the concept of 'belief' (other peoples' beliefs about the world). From three to five years of age, children develop the ability to understand others' false beliefs, their own previous false beliefs, and to make appearance-reality dissociations (Bibby & McDonald, 2005; Bright-Paul, Jarrold, & Wright, 2008; Wellman, 1990).

Between ages five and seven, children begin to comprehend second-order beliefs (i.e., the ability to understand that a person can have beliefs about another person's beliefs; Perner & Wimmer, 1985). The ability to distinguish between jokes and lies and the appreciation of metaphors, sarcasm and irony generally develops by six to seven years (Brüne & Brüne-Cohrs, 2006). Between 9 and 11 years, children begin to recognize social faux pas, which occur when a person says something that they should not have said without knowing that they should not have said it (Stone et al., 1998). Understanding a faux pas is a rather complex process as one needs to be able to represent two mental states, namely that of the person unknowingly committing the faux pas as well as the feelings of the receiver of the faux pas (Baron-Cohen et al., 1999).

ToM is likely to continue to mature throughout the lifespan but can break down at any of the developmental stages. However, no research exists that explores ToM development after the age of 11. Therefore, while ToM research in children has in recent years been expanded to include children up to the age of 11, ToM ability in adolescence has thus far been neglected. A possible reason for this may be that because it is generally accepted that the most crucial and basic ToM abilities have, under typical conditions, already developed by this age, ToM is not further explored in this age range. Research into ToM does, however, exist in adult populations. In this context, ToM development has generally been investigated retrospectively or the focus has been on examining, for example, the effects of adult TBI on ToM (Bibby & McDonald, 2005).

Theories of Theory of Mind. In general, researchers have come to agree that children and adults have a universal ability with which they reason about other people's mental states, making use of inferred beliefs and emotions. Despite this general agreement regarding ToM's developmental trajectory there are several theories that claim to explain its development: (a) the nativist or modularity theory, (b) the 'theory' theory, (c) the simulation theory, and (d) the social constructivist theory.

Modularity theory. Modular theorists propose that because children are able to reason about mental states although they cannot touch them, hear them or see them, there must be an innate ability that allows for ToM. According to the modularity theory, ToM ability takes the form of a specific module, or more specifically, a neural module, which is dependent on the biological maturation of certain cognitive structures in the brain during early childhood. ToM is considered independent of the child's social environmental factors, which are merely regarded as a trigger of ToM development (Scholl & Leslie, 1999). Environmental factors such as language and socio-economic status (SES) are seen to affect the timeframe within which the ToM module develops but its manifestation is culturally consistent. This view supports the notion that modules can be selectively impaired by neurological damage of the congenital or acquired type. For example, children with William's syndrome have intact social functioning but impaired intelligence, whereas children with high-functioning autism, where intelligence is normal, often fail false-belief tasks (Baron-Cohen et al., 1985).

'Theory' theory. The 'theory' theory suggests that ToM development results from developing a theory-like knowledge about the mind. This knowledge contains causal or explanatory laws that govern external stimuli and relate them to mental states (Lillard, 1999). This 'theory' acquirement is described as a paradigm shift (i.e. a child's dramatic shift in his/her conception of others) that occurs around the age of four when the child is able to pass first-order false belief tasks (Meristo, 2007). Under the view of this model, the social experiences of the child are the building blocks on which this knowledge base is acquired. Therefore, specific cultural environments will define the manner in which mental states are understood and may thus differ across cultures (Hughes & Leekam, 2004).

Simulation theory. The simulation theory stipulates that we learn to understand other people's actions and intentions by directly adopting their perspective with the help of mirror neurons. The mirror neuron system (MNS) is self activated when executing or observing actions. It may also be the mechanism that initiates and governs many social behaviours including understanding and prediction of intentions (Gallese & Goldman, 1998; Ramachandran & Oberman, 2007; Rizzolatti & Craighero, 2004). The MNS directly relates the external actions of others with our own past related experiences on a sensory and motor level and integrates them on a higher order cognitive level. The outcome of the action, which is known to us due to our own past experiences, then helps us to understand the mental state of the person performing the action (Hamilton & Grafton, 2008; Gallese & Goldman, 1998; Iacobonhl et al., 2005). With regards to ToM, this theory implies that the basis of ToM ability occurs at a subconscious neuronal level and is influenced by our past experiences as these feed our knowledge of social interaction.

Social-constructivist theory. Social constructivist Lev Vygotsky's (1978) view on human development suggests that it needs to be regarded in the context of the social system and interpersonal relationships. The social-constructivist theory suggests that children's mental states are constructed by their social interactions and are thus a direct result of their social environment. In this regard, communication and interaction with others is regarded as key to the development of social processes as conversation helps the child to internalise ways of thinking. With regards to ToM, this theory suggests that ToM ability develops solely based on our social environment; the richer our social interactions and communication with others, the more sophisticated our ToM ability becomes.

Theory of Mind and cultural consistency. Accepting that ToM development is due to biological maturation (modularity theory) would suggest that different cultural environments have little impact on this process. A similar concept is that of learning to walk, where universally, independent of culture, children begin walking around the age of one (Callaghan et al., 2005). Observations from autism research seem to suggest that ToM deficits develop due to a delay in biological mechanisms, which is the case in autism. Autistic children with a mental age of six years continue to fail false-belief tasks (Baron-Cohen, 1997), which suggests a link between the development of ToM and cerebral maturation. The argument for the biological maturation process, in light of findings showing a synchronised onset of ToM across cultures in typically developing children, seems to be fairly strong.

Several ToM studies that focused their research outside of Western cultures (see e.g., Kobayashi et al., 2006, 2008) and considered cultural and linguistic factors, have obtained mixed results. For example, Kobayashi and colleagues (2006) studied Japanese bilinguals and propose that ToM has brain functions that are both independent and dependent on language and culture (i.e., depending on your culture or language, some areas of the brain associated with ToM may develop differently). This suggests that the way ToM develops is not entirely universal. However, a meta-analysis (Wellman et al., 2001) concluded that a typical trajectory of ToM development consistent across cultures does appear to exist.

A fairly recent meta-analysis (Liu, Wellman, Tardif & Sabbagh, 2008) on non Western cultures demonstrated parallel developmental trajectories in false belief tasks in Chinese children and Western populations. However, the developmental timing was shown to vary considerably within the non Western population itself. This finding challenges the idea that the onset of ToM is consistent across cultures (Callaghan et al., 2005). Instead this seems to suggest that among different communities within the same cultural group, developmental timetables may vary by up to two years. Therefore, ToM appears to develop along a universal trajectory where ToM abilities seem to develop in the same sequential order across cultures. However, the timing at which this development occurs may be influenced by multiple sociocultural and linguistic variables.

Demonstrating whether there is a universal ToM developmental trajectory across cultures is imperative to understanding what causes its development. It seems that, generally, in literate cultures, the major shift of understanding that other people have beliefs too and act according to these beliefs occurs around the same age (Callaghan et al., 2005). Mixed findings have suggested that various cultural factors such as the lack of mental state verbs (Vinden, 1996) or cultural attribution styles (Naito, 2003) create variability in ToM development across cultures. How language can affect ToM performance was demonstrated in Liu and colleagues (2008) research on ToM in a Chinese population. In Chinese the word 'think' has two meanings. It can either be neutral or it can denote a false belief. It was shown that when the 'think falsely' meaning of the word was employed as opposed to the neutral think word, Chinese children's performance improved significantly (Liu et al., 2008). Another example exists, in the Junin Quechua language, where concepts such as "thought" and "belief" are not referred to directly but rather circumscribed by other phrases (Vinden, 1996). However, this is an extreme and isolated case and findings suggesting a culturally variable development of ToM have been suggested to be the product of the administration of non-standardised, culturally- and linguistically insensitive methods (Callaghan et al., 2005).

Other sources of variability in ToM performance. Various cultural and ethnic aspects have been said to affect the performance on ToM tasks. Many socio-cultural factors such as language and family circumstances have been suggested to explain the variability in ToM performance across cultures. Specifically, differences surrounding language and conversation styles within a family have been shown to influence ToM performance. Children coming from families where emotions are spoken about regularly, for example, often demonstrate a more refined understanding of belief and false belief at a young age (Hughes & Leekam, 2004). In contrast, late-signing deaf children who rarely engage in conversation appear to have greater difficulty on false-belief tasks (Peterson & Siegal, 1998). Similarly, authoritarian parenting style may result in less conversation and may thus hinder ToM development. This has been argued to account for the delayed performance in ToM in Cameroonian children(Chasiotis, Kiessling, Hofer, & Campos, 2006).

The size of a family has also been suggested to impact ToM ability, where children from larger families generally demonstrate better ability in false-belief understanding than children from smaller families (Perner, Ruffman, & Leekam, 1994). Here, the interaction with siblings is said to have a beneficial impact on understanding false-belief. At the same time, larger families also give greater opportunity for pretend play, which has been suggested to promote the development of false-belief reasoning (Hughes & Leekam, 2004).

Measurement of ToM. As previously mentioned, a major flaw in the reviewed literature is that many researchers have investigated ToM by equating it to passing false-belief tasks. ToM is a complex and comprehensive mental construct, and drawing conclusions based only on an individual's false-belief reasoning is a gross oversimplification and an inadequate measure of ToM. Only a few studies have explored ToM development more comprehensively by applying test batteries that examine a variety of ToM abilities. Steele, Joseph and Tager-Flusberg (2003), for example, constructed a developmentally sequenced battery designed for an age range of 18 months to early adolescence. This wide-ranging approach taps into a variety of ToM abilities, including representational understanding of mind and moral judgement. Administration of a battery that consists of a range of developmentally sensitive ToM tasks is the methodological approach that needs to be taken in order to comprehensively track ToM development within its full complexity.

In an attempt to develop a standardised battery that comprehensively measures ToM, a subtest was recently introduced in *A Developmental Neuropsychological Assessment, second edition* (NEPSY-II; Korkman, Kirk, & Kemp, 2007) that is said to measure ToM. However, this subtest appears not to be comprehensive enough as it is failing to address crucial aspects of ToM such as moral judgment.

The administration sequence of the ToM tasks in the NEPSY-II is also of concern. The second-order false belief task, which assesses a more advanced ToM ability, is presented early on in the battery (item 2) and before the first-order false belief task (item 7). The understanding of a first-order false belief situation is a mental construct said to develop prior to more advanced second-order false belief comprehension. Thus, it is questionable why (a) the more advanced task would be administered before the less advanced task and (b) in consideration of the known developmental trajectory of ToM ability, why the more advanced task is administered to a younger participants rather than older individuals. As a result, given the format of the battery, which stipulates administration starting points dependent on the age of the participant, older children passing the first few items of their age-appropriate starting point, will not be exposed to the more advanced second-order false-belief task at all. Similarly, younger children are, thus, firstly exposed to the more advanced task before encountering its less advanced relative further along in the battery and are not necessarily expected to pass the more advanced test based on stage of their ToM development. The NEPSY-II ToM subtest, thus, while attempting to consider the developmental trajectory ToM, fails to follow a developmentally sensitive sequence.

ToM ability also relies on other cognitive skills such as memory and ability to understand implicit language. Deficits in these domains are sometimes said to be the underlying reason for a poor performance on tasks that measure ToM ability, although these domains appear unrelated to ToM ability as such (Bibby & McDonald, 2005; Channon & Crawford, 2000; Stone et al., 1998). For example, poor task performance may arise due to an inability to remember the task's content or to understand the task- related questions rather than due to a ToM deficit. Thus, potential confounding variables such as executive dysfunction, memory and deficits in general intellectual ability need to be controlled for.

No matter how ToM develops and regardless of the potential cultural influences that exist and independent of its measurement, the fact is that ToM develops over time. While the debate on sociocultural influences continues, ToM is considered to follow a universal trajectory to some extent. If ToM development is indeed to some degree universal (Liu et al., 2008; Wellman et al., 2001) then South African children should display similar developmental patterns to children from other countries. Although various studies have been conducted exploring ToM in non Western populations (Liu et al., 2008; Naito, 2003; Wellman et al., 2001), no ToM development studies have been conducted in South Africa until recently. Van Staden (2010) compared native signing, late-signing and orally trained deaf children's ToM ability in a South African province. However, no ToM studies have yet been conducted in South Africa on individuals with traumatic brain injury (TBI). Before further exploring ToM in relation to TBI, an overview of TBI in general needs to be presented.

Traumatic Brain Injury

Traumatic brain injury (TBI) refers to damage to the brain caused by physical forces being placed on the neurons (Bauer & Fritz, 2004). This damage to the brain can occur either through (a) the penetration of the brain by an object, referred to as a open head injury; or (b) from a blow to the head or a sudden, violent motion causing the brain to knock against the skull, known as closed head injury. The Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) is generally used to assess the severity of brain damage and determines whether it is mild, moderate or severe. The scale classifies a score of 13-15 as indicating a mild head injury, a score of 9-12 as indicating a moderate head injury and a score between 3 – 8 as indicating a severe head injury. This classification is frequently employed by researchers in order to assign participants into groups based on their severity of their injuries. However, the GCS is not the ideal manner by which to classify head injury. Many other factors such as (a) the duration of unconsciousness, (b) post-surgical complications and (c) the length of post-traumatic amnesia, impact on the outcome of the injury and are considered far better indicators and predictors of severity of the head injury. However, because this information is difficult to standardise and is not always available to researchers, the GCS is frequently used as a tool of classification within the research environment.

It has been well established that closed head TBIs frequently result in diffuse neuroanatomical disruptions causing a broad range of cognitive impairments (Anderson & Pentland, 1998). If a physical force placed on a neuron is strong enough it can damage the cell and ultimately lead to cell death. Such physical changes at the cellular level result in or are associated with cognitive deficits as neuronal connections are interrupted. Given the physical force placed on the internal structures of the brain following a closed head injury, numerous studies have investigated the array of deficits that accompany this type of TBI. Commonly, research on neuropsychological impairments following TBI focuses on the neurobehavioural domains of attention, memory and executive function (Ewing-Cobbs, Prasad, Landry, Kramer, & DeLeon, 2004; Levin et al., 1993, 2002; Limond & Leeke, 2005). The context of the current research and its specific aims in light of specific consequences of TBI, in particular that of paediatric TBI (pTBI), will be presented as the existing literature is explored below.

Previously, the immaturity of young developing brains was considered to be more beneficial than the maturity of older, developed brains in the case of cortical insult due to a greater ability for repair (Dennis & Barnes, 2000). Thus, TBI in childhood was thought to be less severe in terms of outcome than brain damage in adulthood, due to the developing brain's potential to recover. However, the current popular view holds that children are actually more vulnerable to the consequences of head trauma than adults specifically due to immaturity of the brain. Therefore, the developing brain's plasticity is no longer considered a protective factor (Gil, 2003). Under consideration of the vulnerability of the maturing brain and the implications of TBI sustained during childhood, the cognitive outcomes following pTBI are now further explored.

Outcomes following pTBI. Developmental Neuropsychologists now suggest that the immaturity of the developing brain should no longer be considered a protective factor in the context of pTBI (Gil, 2003). PTBI often results in diffuse neuroanatomical interruptions affecting the normal developmental of the maturing cortex causing generalised neurobehavioural deficits (Anderson & Pentland, 1998). Cerebral regions, and thus associated cognitive functions, that develop throughout childhood are considered most vulnerable to cortical damage. The younger the child at the time of injury, the more abilities still need to be acquired, and therefore the impact of early brain injury may only become apparent many years post- injury when skills that should have become functional have not emerged because they are lacking the necessary foundations.

Children with TBI, therefore, appear to "grow into" their cognitive impairments with early injury having a cumulative effect as new deficits develop as a result of other non-functioning skills (Anderson, 1998). Considering the overall effects of cognitive impairment on everyday life, TBI research has most commonly addressed "more apparent" cognitive deficits such as memory, attention and executive function, which are crucial cognitive skills required in our daily lives (e.g., Ewing-Cobbs et al., 2004; Lowther & Mayfield, 2004).

In this regard, the age of the child at the time of injury has been recognized as a significant contributing factor to the severity of the incurred injury (Segalowitz & Brown, 1991). In other words, the neurocognitive outcome of pTBI depends on the interaction of various endogenous factors such as age at injury and injury severity and exogenous factors such as the child's support system and other environmental factors. Therefore, cortical damage can have different effects on neurocognitive development depending on (a) the developmental stage and (b) the degree of specialisation of the affected area in combination with the developmental milestones already reached prior to injury (Barnes, Dennis, & Wilkinson, 1999; Chapman, Levin, Wanek, Weyrauch, & Kufera, 1998; Levin, Song, Ewing-Cobbs, Chapman, & Mendelsohn, 2001; Slomine et al., 2002). This difference originates from the fact that pTBI occurs concurrently with the development of the cerebral cortex and learning. A disruption of developing skills may, therefore result in an incomplete or defective collection of cognitive abilities (Levin, 1991). Measurable cognitive outcomes have been shown to differ for children compared to adolescents or adults (Lord-Maes & Obrzut, 1996), and children sustaining a TBI at a younger age are said to perform worse on cognitive assessments than children sustaining a TBI at an older age (Gil, 2003).

Theory of Mind and Traumatic Brain Injury

It has been widely recognised that various domains of executive function, including motor skills and goal management, are frequently impaired following TBI in children (e.g., Ewing-Cobbs, Prasad, Landry, Kramer, & DeLeon, 2004; Levin, Culhane, Mendelsohn, et al., 1993; Levin, Hanten, Chang, et al., 2002). TBI is generally considered to result in lifelong interrelated deficits in academic and emotional functioning (Lord-Maes & Obrzut, 1996). Although limited within the paediatric population, recent research has begun documenting potential social cognitive deficits following TBI, especially in children (Taylor et al., 2002).

Social cognition, which encompasses the ability to understand the thoughts, beliefs, desires, and intentions of others, is a crucial factor in the socialisation of children and the development of peer relations (Levin & Hanten, 2005). The overlap between observations of social impairments resulting from TBI when considering the social deficits associated with ToM impairment, suggest that the social impairment in TBI may arise due to a ToM deficit directly related to the TBI itself. Indeed, individuals with TBI have been shown to be significantly impaired on epistemic and affective inference tasks when compared to typically developing controls (Turkstra, McDonald, & DePompei, 2001; Turkstra, Dixon, & Baker, 2004).

In consideration of what is known about the developmental trajectory of ToM and the interruption of developing cognitive processes following TBI at a young age, current knowledge seems to suggest a potential for deficits in ToM as a result of pTBI. However, while severe impairments in ToM have been well documented among individuals with autism, Asperger's syndrome and schizophrenia (e.g., Baron-Cohen, Leslie, & Frith, 1986; Corcoran, Cahill, & Frith, 1997; Happé, 1993; Happé, 1994; Joseph & Tager–Flusberg, 2004), substantially less research has been conducted on potential ToM deficits following TBI in general. Although some studies have investigated a potential relationship between adult TBI and impaired ToM ability (Bibby & McDonald, 2005; Channon, Pellijeff & Rule, 2005; McDonald & Flanagan, 2004) this research is limited and lacks the ability to make any significant inferences about ToM deficits related to pTBI specifically.

The relationship between other cognitive domains and ToM performance. Any cognitive task requires conceptual understanding and other non-focal cognitive skills to solve the presented problem. Performance on a false-belief task, for example, requires the ability to represent other people's mental states (conceptual understanding); while at the same time important information about the situation needs to be remembered and attention needs to be focused on the problem at hand in order to comprehend the scenario.

Because numerous studies have documented the array of deficits that accompany a brain injury (Conklin, Salorio, & Slomine, 2008; Ewing-Cobbs et al., 2004; Fuentes, McKay, & Hay, 2010; Maas, Stocchetti, & Bullock, 2008), it has been suggested that poor performance on ToM tasks in individuals who have sustained a TBI at a young age may be related to deficits in other cognitive domains, such as executive function and memory, rather than due to a specific deficit in ToM ability. Some research suggests that the demands ToM tasks place on cognitive abilities such as memory may affect the performance of ToM tasks (Keenan, 1998). Executive functioning and working memory have also been said to be crucial for social cognition. More than one perspective needs to be held in mind, requiring intact working memory, while at the same time suppressing any other irrelevant perspectives with the help of inhibitory control (Carlson et al., 2004). Therefore, executive function deficits, such as problem-solving and inhibition resulting from TBI, have been suggested to impact on ToM performance as well (Carlson, Mandell, & Williams, 2004; Henry, Phillips, Crawford, Ietswaart, & Summers, 2006). Some researchers argue that deficits on ToM measures are a consequence of difficulties in executive function as ToM tasks require intact flexibility and inhibition responses (Hughes & Russell, 1993). So far, however, the literature has not been able to clearly investigate the relationship between ToM ability and executive functioning. Since executive function incorporates planning ability, flexibility, inhibition and working memory it appears that a relationship between executive dysfunction and deficits in ToM ability may exist. In this regard, executive dysfunction may diminish social interaction and thus affect a child's developing understanding of the mind. On the other hand, social interactions provide a platform through which to improve and extend executive functioning skills. Thus, executive functions and ToM may be related and both governed by the quality and quantity of a child's social interaction (Hughes, White, Sharpen, & Dunn, 2000). In an attempt to examine the relationship between ToM and executive functioning, some researchers have demonstrated a high correlation between ToM and executive function in adult populations (Bibby & McDonald, 2005; Channon & S. Crawford, 2000; Henry et al., 2006; Hughes & Ensor, 2007). On the other hand, some researchers have suggested that ToM deficits are independent of executive function impairments (Bach, Happe, Fleminger, & Powell, 2000; Rowe et al., 2001).

While the controversial investigation of the relationship between executive dysfunction and ToM performance continues, no study has thus far investigated this matter within a South Africa context and in a paediatric TBI population. Embarking on the quest of examining the effect of executive functioning on ToM forms an imperative and integral component in developing interventions that facilitate the social functioning of pTBI patients. In order to develop interventions that specifically target deficits in social judgement and interaction (i.e. components of ToM), the role that other cognitive domains play in ToM ability need to be understood and taken into consideration. If it is established that ToM ability is dependent on aspects of executive functioning such as problem-solving and inhibition, these functions need to be targeted specifically. In other words, although somewhat oversimplified, the intervention would then primarily focus on resolving the executive function deficits, which would then ultimately benefit ToM ability as a result of the improved executive function. On the other hand, if executive functioning does not exert a major impact on ToM ability, the intervention would need to target other cognitive domains or cortical structures shown to be crucial to intact ToM.

Limitations of Previous Research

Whereas ToM research appears fairly well established in developmental disorders such as Autism and Asperger's syndrome (see e.g., Joseph & Tager–Flusberg, 2004; Kaland, Smith & Mortensen, 2007), the acquired impairment of ToM has less frequently been addressed in TBI patients. As previously outlined, ToM follows a distinct paediatric developmental pattern. Following the established developmental trajectory of ToM many aspects of ToM ability should be fully developed by adolescence. This begs the question as to the effect TBI has on ToM ability depending on (a) whether TBI occurred during the development of the ability (i.e. during childhood) and disrupted the process or (b) whether the TBI occurred once ToM ability has fully developed (i.e. during adulthood). In other words, what are the different outcomes on ToM ability following TBI versus pTBI?

The focus and nature of the existing research has predominantly been the investigation of the effects of TBI on ToM ability in adults (see e.g., Henry, Phillips, Crawford, Ietswaart & Summers, 2006; Milders, Ietswaart, Crawford & Currie, 2006) or they aimed at identifying a particular anatomical brain region to which ToM ability is localised (e.g. Tompkins, Scharp, Fassbinder, Meigh & Armstrong, 2006). The effect of TBI on ToM ability in children is relatively unexplored. Given that ToM develops during childhood one may infer that a disruption during the development of this mental concept, as opposed to damage of the mental concept once it has been fully developed, may result in a different set of deficits. Thus, one may expect a difference in the ToM impairment pattern following TBI in comparison to pTBI, which disrupts the developmental process of ToM.

Milders, Ietswaart and Currie (2006), for example, examined whether ToM impairments following TBI change over time. The selected research participants were adults who had incurred brain injury during their adult life. Similarly, a further study on ToM and TBI (Henry et al., 2006) investigated the relationship between ToM impairment, emotion recognition and executive function and suggested that deficits in some aspects of executive function may impact on ToM ability to some extent. While the examination of the existence of such potential associations is important, the presence of ToM deficits following TBIwere once again assessed within an adult TBI population.

In their research on ToM after TBI, Bibby and McDonald (2005) focused on proving that ToM exists as a separate cognitive construct. The TBI participants in this study had all suffered severe TBI, which typically results in deficits of working memory and language too. The effects of severe cognitive deficits on the performance of ToM tasks cannot completely be controlled for, thus making it difficult to determine what causes the difficulty in ToM ability. Also, in this study ToM was investigated in an adult population using only first-and second-order ToM tasks (i.e. early childhood developmental abilities), failing to address other crucial components of ToM ability such as Faux-Pas. Although controlling for potential deficits in working memory due to the severity of the TBI, this study ultimately investigated whether ToM ability is lost and impaired as a consequence of severe TBI. Although this research is important, it has little relevance for the paediatric population. The question regarding the consequences of a disruption in the development of ToM ability cannot be answered as the study deals with a population where it is assumed that prior to the sustained TBI, ToM ability was previously intact and fully developed as the participants were all adults.

It thus appears that the effect of pTBI on ToM has been left somewhat neglected as while some studies have verified the existence of ToM deficits following TBI in adults, only a few have investigated this in children. Research addressing ToM deficits under consideration of the developmental trajectory of ToM (i.e. assessing ToM within the context of pTBI) is scarce as only a few have set out to examine the notion that ToM deficits may result from pTBI (Schmidt, Hanten, Li, Orsten & Levin, 2010; Schmitt & Wodrich, 2004).

A recent study (Schmidt et al., 2010) has set out to investigate emotion recognition within the paediatric context, which is a more basic ability necessary for ToM to function. It was found that pTBI appears to affect performance on emotion recognition (reading physical signs such as facial expressions) and that other demographic factors, such as SES and age, as well as developmental factors may additionally influence the observed social deficits. However, this recent research has dealt with a more basic concept related to ToM but is not considered part of the ToM construct, as no mental state inferences are made.

A key study in this fairly unexplored field is that of Snodgrass and Knott (2006) who investigated advanced and basic ToM abilities following pTBI. Identifying the gap in the paediatric literature they found that childhood TBI, particularly in relation to frontal brain regions, may disrupt the development of social adaptation and thus affect advanced ToM and as well as more basic abilities such as emotion recognition (Snodgrass & Knott, 2006). However, such investigations have not been conducted within the South African context. In order to further the knowledge of ToM development in non Western cultures like South Africa and considering the high prevalence of pTBI in this country due to its high rate of violence and motor vehicle accidents (Levin, 2004) research in this domain is imperative.

Rationale for Research

The literature reviewed above demonstrates that little is known about the effects of TBI on ToM ability within the paediatric population and that nothing is known about this relationship in a South African context. In addition, it is clear that there are a number of variables that need to be considered when designing studies in this area, which have not previously been taken into account. The current study, which looked at the effects of mild and moderate TBI on ToM ability in a low SES South African paediatric population, addressed some of the limitations present in previously conducted studies and provided insight into ToM research in non-Western populations. The following variables were considered in the design and implementation of the current research:

1) The central aim of the current investigation was to examine ToM abilities following pTBI in a low SES group in South Africa. Although a few recent studies have emerged to investigate ToM within a paediatric context, ToM development within a South African pTBI setting has yet to be explored. There are many cultures in South Africa, and every culture or even social group has their unique social environment. Because previous research has shown that social environment and culture may affect ToM ability, it was important to take the heterogeneity of the South African population into account and particular care was taken to ensure that the neuropsychological tests employed were fair to the particular low SES group reviewed.

2) The literature on the developmental trajectory of ToM (Stone, Baron-Cohen, & Knight, 1998) suggests that the disruption of ToM development at a specific stage will result in the impairment of ToM abilities yet to be acquired. Therefore, the age of onset, in other words at what age the TBI was acquired, was be taken into consideration in the current research, as different levels of ToM ability are said to develop at different ages.

3) The severity of the brain injury was also considered. Given the generalised nature of cognitive sequelae following severe TBI, the current research study compared ToM performance of individuals who had sustained a mild or moderate pTBI only.

4) The selection of ToM measurements presents a further crucial factor to be considered. Although existing ToM assessment tools from previous ToM research can be adapted for pTBI research it is imperative to be aware of the threat of potential confounding variables such as working memory demands on ToM task performance. The focus of the current study was on the administration of a carefully selected spectrum of classical basic and advanced ToM tasks aimed at examining the effects of pTBI on ToM ability. These tasks were selected and adapted for the South African context based on previous research on ToM within a clinical paediatric environment such as Autism (Happé, 1994; Joseph & Tager–Flusberg, 2004). A range of ToM tasks formed part of the battery and included first- and second-order false belief tasks, Faux-Pas tasks and a set of stories (titled *strange stories*) aimed at assessing the child's understanding of others' thoughts and feelings. Although ToM may be a universal ability, the tasks created to measure ToM ability may be culturally bound. In order to ensure that the ToM tasks presented were not culturally biased towards the population for which they were initially created, existing ToM tasks were adapted for the low SES cohort under investigation; and thus ensuring better test interpretation.

5) Because differences in language and language skill between the participant and test-giver may also affect test performance, in the current study participants were assessed in their home language (i.e. English or Afrikaans); the tasks were administered by an examiner proficient in the chosen language. Also, when tests are not adequately translated the participant's performance may be compromised. Although it is often difficult to consider all the aspects that make a specific subculture unique, all measures were taken to translate and adapt the tasks in a culturally-appropriate manner (more detail to follow in the *materials* section).

6) A second, Western standardised ToM battery, the NEPSY-II, was also administered. This lead to the secondary goal of the current study, namely to evaluate to some degree the usefulness of the recently introduced ToM subtests contained in the NEPSY-II within a non-Western population. The interest was to compare the overall performance of the participant groups to their overall performance on the developmentally sensitive battery. The suspicion here was that the NEPSY-II ToM test battery is not sensitive enough to pick up specific ToM deficits. The

administration sequence and comprehensiveness of the battery in consideration of ToM's complexity and developmental trajectory will also be explored.

7) As outlined above, other cognitive dysfunctions have been shown to confound the performance of ToM tasks. It has been shown that individuals with TBI have deficits in general intellectual ability and executive functioning (Levin & Hanten, 2005; Slaughter, Dennis, & Pritchard, 2002). When investigating ToM ability, it is thus imperative to control the potential effect executive function and general intelligence may exert on the assessment of ToM ability. Addressing these issues and thus identifying the type of deficit accounting for poor ToM performance, has vast implications in the development and implementation of interventions designed to help pTBI function better within society. Therefore, in order to investigate the presence and potential confound of other cognitive dysfunctions, the current research included measures of general intellectual ability and executive functioning.

Investigation of ToM within this low SES South African pTBI population will ultimately not only shed light on the nature of the population's social difficulties but also contribute to improving their quality of life and that of those surrounding them. Considering the high prevalence of pTBI in South Africa, especially among low SES communities, and the devastating consequences inappropriate social understanding and behaviour have on the child, his/her family and his/her future within society, any knowledge regarding this mental concept may help to lessen the burden of such individuals in future.

Summary of Aims and Hypotheses

Specifically the proposed study will address two main questions:

(1) Do young adolescents with mild and moderate pTBI demonstrate impairment on ToM tasks in comparison to matched healthy controls?

(2) How does the NEPSY –II ToM subtest compare to a developmentally sensitive ToM test battery in assessing ToM performance?

Given the overall rationale and the specific aims of the current study, the two research hypotheses that will be under review in the currently proposed research study are:

(1) Moderate pTBI patients will perform worse on ToM tasks compared to mild pTBI patients who will perform worse than typically developing individuals.

(2) The NEPSY-II ToM subtest is less sensitive in assessing ToM performance compared to a developmentally sensitive ToM test battery.

Methods

Design and Setting

The reported study consisted of a cross-sectional comparison of three groups: a mild TBI group, a moderate TBI group and a typically developing (TD) group. The groups were compared on ToM ability, executive functioning and IQ. A quasi-experimental design was employed as the participants were divided into groups according to the pre-existing criterion of TBI being present. Convenience sampling was used to obtain participants for this study. Testing took place in a quiet room free of distractions at the Red Cross Children's Hospital or Groote Schuur Hospital.

Participants

This study adhered to the University of Cape Town (UCT) Codes for Research as well as to the ethical guidelines for research with human subjects as set out by the Health Professions Council of South Africa (HPCSA). Ethical approval for this study was obtained from the UCT ethics committees of both the Department of Psychology and the Faculty of Health Sciences. Permission was granted by the Western Cape Education Department to recruit participants from schools in this region. Informed consent and assent were obtained from parents or legal guardians and participants respectively before testing began (see Appendix A for a copy of all ethics approval documents).

Thirty children with TBI were recruited through the Red Cross Children's Hospital medical records as well as through personal referral. Of these children, 20 had sustained a mild TBI and 10 had sustained a moderate TBI (see Table 1). During the recruitment phase of the research it was discovered that suitable candidates from this clinical population are scarce. It proved very difficult to find the intended number of participants although recruitment took place over a two year period. Unfortunately, at the end of this period only half the anticipated number of moderate TBI participants had been recruited. The challenges and difficulties encountered in recruiting participants for this study are discussed in more detail in the limitations section.

Severe TBI cases were not included in the study as such individuals generally show global cognitive impairment making it difficult to examine ToM specifically (Fontaine, Azouvi, Remy, Bussel, & Samson, 1999; Moore & Stambrook, 1995; Tate, Fenelon, Manning, & Hunter, 1991). For the purpose of this study the Glascow Coma Scale (Teasdale

& Jennett, 1974) was used to classify each participant's injury as a mild or moderate TBI. A GCS score of 13-15 or 9-12 recorded in the patients' medical file assigned each participant into the mild or moderate group, respectively.

As no South African norms exist against which ToM performance could be compared TD children participated in the study as controls. It was planned to recruit the TD group through demographically matched schools. However, due to various obstacles, discussed below, this was not possible. Therefore, the TD participants were recruited through local low SES communities instead. Ideally, the controls should have been matched to the TBI group on SES, language and age as these have been found to be important predictors of performance on neuropsychological tests. However, due to the reality of working with a clinical population, which revealed itself as being less available than originally assumed, participants were eventually matched primarily on ethnicity and SES. For the purpose of matching participants as closely as possible a total of 33 available TD participants were tested, from which, based on their demographic variables, the most closely matched 20 individuals were selected.

The final groups were investigated for significant group differences on the demographic variables taken into consideration. These were language, age, SES and gender. The analysis showed that there were no significant group differences between the two TBI groups and the TD group with regards to SES, language and gender. However, a significant group age difference was shown between the mild and moderate TBI groups, where the mean age of the mild TBI groups (M = 13.54, SD = 1.44) was significantly higher, $F(2, 47) = 3.43$, $p = .041$, $\eta^2 = .13$, than that of the moderate TBI group (M = 11.95, SD = 2.03). No significant group age differences were found between the TD group and the TBI groups. The significant age difference between the clinical groups is not ideal and must be taken into consideration when interpreting the results. Although the researchers were aware of the ramifications this age difference was likely to have, due to (a) the difficulty in recruiting the clinical population, (b) the restricted timeline governing this study and (c) the exhaustion of the available clinical participants, age matched clinical groups were just not attainable.

Table 1

Demographic Characteristics of the TBI and Typically Developing (TD) Groups

Demographic information	Mild (*n* = 20)	Moderate (*n* = 10)	TD (*n* = 20)	F/χ^2	*p*	η^2
Age range						
(Years : Months)	11:0-15:4	9:1-14:10	9:8-15:7			
Age (Years)						
Mean (SD)	13.54 (1.44)	11.95 (2.03)	12.59 (1.68)	3.43	.041	0.13
Sex						
Male : Female	14: 6	9: 1	12: 8	2.86	.240	.06
Home Language						
English : Afrikaans	18: 2	7: 3	14: 6	2.78	.247	.06
Ethnicity						
Coloured : White	18:2	10:0	18:2	1.09	.581	.02
Socio-economic status						
Medium : Low	3: 17	3: 7	2: 18	1.67	.435	.04

Note. Means are presented with standard deviations in parentheses.

Inclusion and exclusion criteria

Exclusion criteria included the presence of any developmental disorder (such as autism; developmental delay; etc), a history of infantile meningitis, or any neurological condition impacting on the central nervous system. Additionally, control candidates with any history of head injury were excluded from the study. Mild and moderate cases were included if they were at least three months post-injury, which is the timeframe within which post-concussive symptoms are thought to resolve in the majority of cases (Anderson & Pentland, 1998).

Any individuals with a history of any serious social deficits, such as conduct disorder or oppositional defiant disorder, were not included in the study. Fluency in either English or Afrikaans was essential and the tests were administered in the participant’s home language (i.e., the language in which they were considered to be most fluent). Each participant was screened to identify the presence of any of the above mentioned exclusion criteria in an initial assessment prior to the administration of any neuropsychological tasks.

Measures

Theory of Mind. In order to characterise or unravel potential impairments in ToM a broad selection of established ToM tasks were chosen for implementation in this study. Firstly, ToM ability was assessed using the ToM the NEPSY-II (Korkman, Kirk, & Kemp, 2007), which was designed to assess the ability to understand mental functions. Secondly, in order to evaluate the performance on specific ToM tasks a three-level (early, basic and advanced) ToM test battery was compiled (by the Autism Research Group of UCT's Psychology department) containing adapted versions of various established and well-known ToM tasks commonly used in ToM research (Baron-Cohen et al., 1999; Happé, 1994).

It has been shown that children who pass a more advanced ToM task also pass all easier tasks (Wellman & Liu, 2004) thus a three-level design was constructed. Under consideration of the age range of this study's participants, the advanced battery was primarily administered. Only if a participant failed the advanced battery (i.e., scored less than 50% on the test items) was a less advanced battery (i.e., a lower level ToM test) administered. Based on the research of Wellman and Liu (2004), not administering the easier test batteries when a more advanced battery has been passed should not affect the validity of the results. Similarly, the NEPSY-II ToM subtests were commenced at the age-appropriate starting point, as indicated by the battery's administration manual. Less advanced ToM tasks were only administered if required and were implemented according to the NEPSY-II's reverse administration and discontinue rules. Adhering to the standardized administration rules the entire *Contextual* task battery was always administered irrespective of performance on the *Verbal* tasks.

Adapted ToM battery. To enhance the fairness in assessing a non Western population, existing ToM tasks were adapted to make the measures more applicable to the South African context. Once adapted these items were then translated into Afrikaans while retaining their culturally-adapted meaning. The adapted ToM test battery administered in this study is an adaptation from that used by Steele, Joseph and Tager-Flusberg (2003) and consists of three developmentally sequenced batteries, namely for early, basic and advanced ToM. The adapted ToM test battery differs from the Steele et al. (2003) battery in the following ways: (a) the *Perception- Knowledge* task was moved from the basic to the early battery as this ability develops somewhat earlier than false belief reasoning, (b) the basic battery was expanded to include the *explanation of action* task, and (c) the *Traits and Moral Responsibility* tasks in the advanced battery, which simply establish performance on factors associated with ToM, were replaced with a *Strange Stories* and a *Faux Pas* task as these tests measure ToM directly.

The adapted early battery thus contained three tasks aimed at demonstrating the emergence of simple mental concepts: (a) *Desire*, (b) *Pretend/ Attributing Agency* and (c) *Perception- Knowledge*. The adapted basic battery contained four tasks aimed at demonstrating a representational understanding of mental concepts: (a) *Explanation of Action*, (b) *Location-Change False Belief* (Sally-Anne task), (c) *Unexpected-Contents False Belief* (Smarties task) and (d) *Sticker-hiding*. The adapted advanced battery contained four tasks aimed at demonstrating the understanding of more socially complex mental concepts: (a) *Second-order False Belief*, (b) *Lies and Jokes*, (c) *Strange Stories* (Happé, 1994) and (d) *Faux Pas* (Baron-Cohen et al., 1999). Except for the *Pretend* and *Sticker Hiding* tasks all the tasks had both test and control questions. To minimise linguistic and memory demands, which may otherwise affect the task performance, most tasks were accompanied by pictures and participants were be able to refer to materials while answering questions.

ToM task performance was evaluated by the distribution of a certain number of points depending on the number of test questions the child answered correctly. Typically developing children of three years, four to six years and seven years and above are expected to pass the early, basic and advanced battery, respectively.

Early Battery. The *Desire* task (Steele et al., 2003) tests the child’s ability to predict action based on a character’s stated desire. During the task the child was presented with two picture stories where a protagonist is looking for an object that is in one of two possible named locations but fails to find the object in the first location. The child was then asked whether the character will continue searching for the object and why.

The *Pretend* task, specifically adapted for this study, tested the child’s ability to use a doll as an independent agent in a pretend situation. The original *Pretend* task (Kavanaugh, Eizenman, & Harris, 1997; Steele et al., 2003) is inappropriately female-gender stereotyped as it involves a mother and a baby. As such the stories were adjusted to portray more gender-neutral situations by presenting the child with four stories and for each one asking to act out the next logical event using a doll as a prop.

The *Perception-Knowledge* task (Pratt & Bryant, 1990; Steele et al., 2003) tested the child's ability to understand that a character can obtain knowledge from perceptual (e.g., visual access). During this task the child observes one doll looking into a box and another doll pushing the box. The child is then asked to identify the doll who knows what is inside the box.

Basic Battery. The *Location-Change False Belief* task (Baron-Cohen et al., 1985; Steele et al., 2003; Wimmer & Perner, 1983) includes two picture stories in which an object is moved while the main character is not present. The child is then asked (a) whether the previously absent character will know where the object is, (b) where the character will look for the object, and (c) why the character will look there.

The *Unexpected-Contents False Belief* task (Perner, Leekman & Wimmer, 1987) tests the child's ability to understand representational change and false belief. During this task the child will is shown four different familiar containers that hold unexpected contents. The child is then asked (a) what s/he thought was in the closed box when s/he first saw it and (b) what another person would think was in the box if they saw the closed box.

The *Explanation of Action* task contains 12 stories in which an action is described based on either an emotion, a desire, a cognitive process such as thinking, knowing or forgetting, or a non-mental state. The child is then asked about why the story character is performing the specific action and what is going on in the character's head at that moment (Tager-Flusberg, personal communication, March 14, 2008).

The *Sticker Hiding* task (Devries, 1970; Steele et al., 2003) tests the child's ability to engage in deceptive strategies. During this task the child is asked to hide a sticker from the researcher. The task involves six practice trials wherein the researcher hides a sticker in one, both or neither hand so that the child will guess the correct location of the sticker at least once and incorrectly at least once. Then the child hides the sticker from the researcher for 10 trials of which only the last 5 trials are scored. Point allocation depends on whether the child hides both hands behind the back (1 point), brings both hands to the front (2 points), keeps both hands closed until the researcher has made a guess (3 points) or keeping the sticker completely invisible in the hand (4 points).

Advanced Battery. The *Second-Order False Belief* task (Sullivan, Zaitchik, & Tager-Flusberg, 1994) tests the child's ability to conceptualise what a character thinks/knows about what a second character thinks/knows. During this task the child is presented with two picture stories followed by an ignorance question ("Does the character think/know what the second character thinks/knows?"), a belief question ("What does the character think/know about what the second character thinks/knows?") and justification question ("Why does the character do that?"). Two content questions are also included as a control measure to ensure that the participant was actually paying attention and knew what was happening in the story. The various questions yielded three measures: *second-order false belief control* (consisting of the scores obtained on the content questions), *second-order false belief recognition* (whether or not the participant correctly identified the belief) and *second-order false belief comprehension* (whether the participant justified the belief correctly).

The *Lies and Jokes* (Steele et al., 2003; Sullivan, Winner, & Hopfield, 1995) task tests the child's ability to distinguish between lies and jokes. During the task the child is presented with two picture stories, one containing a lie and one containing a joke. In each story, a child character says something that a parent character knows to be false. In the joke version, the child is aware that the parent knows the truth whereas in the lie version the child is unaware that the parent knows the truth. The participant is then asked whether the child character's statement was a lie or a joke and to justify their answer.

The *Strange Stories* task (Happé, 1994) tests the child's ability to distinguish between a variety of communicative intents. During this task the child is be presented with 18 stories (12 ToM and 6 control stories) of 12 different types: contrary emotions, irony, lie, pretend , appearance-reality, persuasion, double-bluff, white lie, misunderstanding, joke, figure of speech and forgetting. On the 12 test stories (referred to as *ToM strange stories*) the participant is required to make an inference based on a mental state, whereas the control stories (referred to as *control strange stories*) require a physical inference. ToM ability is assessed by asking the participant to explain the protagonists' behaviour based on their beliefs, desires and feelings. The *control strange stories* are a control measure which helps to demonstrate that a ToM deficit as shown by the *ToM strange stories* is genuine. If a participant fails the *ToM strange stories* but passes the *control strange stories* this is proof that the participant does not have problems with inference making in general but only with inferences of mental states (Happé, 1994).

The adapted *Faux Pas* task (Stone et al., 1998) tests the child's ability to recognise a social faux pas, in other words someone saying something awkward or inappropriate or something they should not have said. During this task the child is presented with five normal social event stories (control questions) and five awkward or embarrassing social situations (test questions). Following each story the child is questioned to test (1) the detection of the faux pas ("Did someone say something they shouldn't have said?") referred to as *faux-pas detection*, (2) the understanding of the faux pas ("Who said something they shouldn't have said?"), (3) the understanding of mental state of the listener character (" Why shouldn't they have said it?"), (4) the understanding of the mental state the speaker character ("Why did they say it?") collectively referred to as *faux-pas comprehension*. Two control questions asking about some detail contained in the story are presented initially in both the faux-pas stories containing a faux-pas (referred to as *faux-pas control questions*) and those not containing a faux-pas. The faux-pas detection question contained in the control stories is referred to as *faux-pas control detection.* With this test Stone, Baron-Cohen and Knight (1998) aimed to not only test the participant's ability to understand/infer the mental state of another person but also whether at the same time the participant developed an empathetic understanding of the character's possible emotional reaction in the given situation.

NEPSY-II ToM battery. The NEPSY-II (Korkman, Kirk, & Kemp, 2007) is a standardized measure that provides reliable and flexible assessment of neuropsychological functioning in children aged three to sixteen. It is divided according to different functional domains containing various subtests. The most recent version contains an additional sixth functional domain, *Social Perception*. In total the NEPSY-II consists of 32 subtests, which can be administered in various combinations. The subtest of interest in the current study was the most recent addition, that of *Social Perception*, specifically the subtest labelled ToM.

The tasks contained in the NEPSY-II ToM subtest were not for the current research adapted but were applied in their standardised form as they occur in the test battery. This subtest is part of a standardised psychometric test battery (the NEPSY-II) and must, thus be administered in the given format. The ToM tasks in the developmentally sensitive ToM battery, on the other hand, are not standardised and could thus easily be adapted, without having to norm and validate the tasks. The ToM subtest is divided into two components, namely *Verbal* tasks and *Contextual* tasks. The *Verbal* tasks are further divided according to three age-appropriate starting points: ages 3-6, ages 7-8 and ages 9-16, whereas the

Contextual tasks are administered to all ages. During the *Verbal* tasks participants are read various scenarios or shown pictures and which were followed by questions testing their ability to predict another individual's belief or mental state. During the *Contextual* task non-verbal pictorial items are administered and aimed at testing the ability to understand the relationship between emotions and the appropriate affect that would follow that emotion in various social contexts.

Ages 3 to 6. The *NEPSY early battery* consists of three items: (a) a *Seeing Leads to Knowing* task, (b) a *Second-Order False Belief* task and (c) a *Recognizing Mental States* task all of which are prompted with pictures. The *Seeing Leads to Knowing* (item 1) task tests the ability to understand that if one person sees the contents of a box and another only sees or touches the outside of the box, the latter will not know what is in the box while/although the first person does (Pratt & Bryant, 1990). The *Second-Order False Belief* (item 2) task tests the ability to recognize what one person infers about a second person's mental state (e.g.What does Mom think that Maya is thinking about buying?). The *Recognizing Mental States* (item 3) task tests the ability to recognize mental state words such as thinking or wondering. In this task the participant is shown a picture of a person in a thought-consumed pose and is asked to describe what the person is doing.

Ages 7 to 8. The *NEPSY basic battery* consists of two items: (a) *Imitation/Pretending* task and (b) *Mental-Physical Distinction* task, which are prompted with pictures or pictures and movement. The *Imitation/Pretending* (item 4) task tests the ability to engage in pretend play, which should be well established in typically developing individuals by three years of age. The imitation component of this item tests the participant's gross ability to imitate. The *Mental-Physical Distinction* (Wellman & Estes, 1986) task tests the ability to understand that if one person is thinking about engaging in a specific action and another is engaging in that specific action, only the latter will have a physical experience.

Ages 9-16. The *NEPSY advanced battery* is the most extensive battery and consists of ten items: (a) a *Seeing Leads to Knowing* tasks (using pictorial stimuli), (b) a *Seeing Leads to Knowing* tasks (using tangible objects), (c) a *First-Order False Belief* task, (d) an *Imitation/Pretending* task (item 9), (e) a *Bluff* task, (f) a *Double Bluff* task, (g) an *Appearance- Reality* task and (h) three *Understanding Figurative Language* tasks. The *First-*

Order False Belief task (item 7) tests the ability to make inferences about another person's mental state. The *Bluff* (item 10) and the *Double Bluff* (item 14) task both test the ability to understand deception. The *Appearance- Reality* task (item 11) tests the ability to distinguish ambiguous items. The *Understanding Figurative Language* (items 12, 13, & 15) tasks test the ability to move beyond the literal level of interpretation e.g. understanding the figurative meaning in the saying "I have butterflies in my tummy".

Contextual tasks. Once the *Verbal task* component of the NEPSY-II ToM subtest has been completed, the *Contextual* tasks are administered. These are aimed at establishing ToM using non-verbal items so as to eliminate the effect that language may have on the task performance. The *Contextual* task consists of six items all aimed at testing the ability to make inferences about another person's feelings.

Cognitive ability. General intellectual ability and executive functioning of the TBI and TD groups were determined by the following three tests: the *Wechsler Abbreviated Scale of Intelligence* (WASI), the fourth United Kingdom (UK) edition of the *Wechsler Intelligence Scale for Children* (WISC-IV^{UK}) and the *Delis-Kaplan Executive Function System* (D-KEFS).

The WASI is a valid and reliable well-established measure that has been normed for individuals between the ages of 6 and 89 years (Wechsler, 1999). All four subtests were administered to assess general intellectual functioning by obtaining verbal IQ (VIQ) and performance IQ (PIQ) scores as well as a combined full scale IQ (FSIQ).

The WISC-IV^{UK} (Wechsler, 2004) is a well-established standardized measure of childhood intelligence (Watkins, Wilson, Kotze & Carbone, 2006) and extensive validity and reliability evidence has also been shown (Prifitera, Saklofske, & Weiss, 2005). To obtain a measure of working memory and processing speed four different subtests were administered. Specifically, the Digit Span and Letter-Number Sequencing subtests were used to get a measure of working memory (WMI), while the Coding and Symbol Search subtests were employed to attain a measure of processing speed (PSI). Working memory is a crucial cognitive domain necessary to perform almost any cognitive task and processing speed determines the speed at which the task can be completed. Deficits in either of these domains may thus affect task performance and need to be controlled for.

Furthermore, key components of executive function (EF) were measured using the standardised D-KEFS (Delis, Kaplan, & Kramer, 2001). This EF measure has been normed for individuals between the ages of 8 and 89 years and has been shown to have a high content validity for the assessment of EF. For the purpose of this study the Verbal Fluency and Colour-Word Interference subtests were administered. The Verbal Fluency subtest measures both lexic and semantic generativity, whereas the Colour-Word Inference subtest, which is based on the Stroop (1935/1992) test, measures an individual's ability to inhibit an overlearned response. These particular subtests have been specifically selected for this study as it has been shown that both verbal ability and the ability to inhibit pre-potent responses may impact on ToM (Hill, 2004).

It is a known fact that language is one of the most important single moderators affecting performance on psychometric measures (Nell, 1994). In an attempt to minimise the effect language may have had on the task performance, all the measures were translated from their original English format into Afrikaans. During this process great caution was taken not to change the measures' original meanings. In the case of the WASI, however, an already translated and South African adapted version was utilised (obtained through personal communication with Helen Ferret, Stellenbosch University). The working memory and processing speed subtests of the WISC-IV^{UK} were non-verbal and thus simply the instructions were translated and the test conducted in the appropriate language. Similarly, the stimuli and instructions for the D-KEFS were translated into Afrikaans. With regards to the letter fluency component, a letterset shown to be more suitable for the Afrikaans language was chosen. The original English letterset consisting of the letters 'F', 'A' and 'S', was replaced with the letters 'B', 'L' and 'S'. These letters have been shown to be more valid for the assessment of verbal fluency in the Afrikaans language (unpublished PhD thesis, H. Ferret). The tests that were specifically translated for the current study (i.e. WISC-IV^{UK}, D-KEFS, NEPSY-II ToM subtest and the adapted ToM battery) were forward translated and then checked by fluent bilinguals to ensure that the meaning was exactly the same.

Procedure

Prior to arranging a testing date informed consent was acquired from the participant's parent or legal guardian over the phone. At the same time, the parent or legal guardian was then interviewed to assess the participant's social, medical and developmental history. If the participant met all the inclusion criteria a testing date was arranged with the parent or legal guardian. On the arranged testing day written informed consent and assent were obtained before administering any of the tasks in the test battery (see Appendix B). At the same time, the parent or legal guardian was also required to fill out a questionnaire that confirmed the participant's demographic information and SES status. This questionnaire also aimed at identifying any possible exclusion criteria (see Appendix B).

In order to minimize memory and linguistic demands, the stories and accompanying pictures were printed out and left in front of the child for the duration of the questions. In addition to the established English versions of the cognitive ability and theory of mind test batteries, reliable Afrikaans versions of all tests were developed to minimise the impact of potential language effects on the participant's performance. The assessment was conducted in the participant's home language, thus either the complete English or the complete Afrikaans battery were administered.

Testing was completed in one session which lasted approximately two and a half hours. The participant was encouraged to take breaks as often as possible to control for fatigue effects. A mandatory break was taken just over halfway through the testing session. Drinks and snacks were provided during the breaks. The cognitive ability and ToM subtests were counterbalanced prior to the commencement of testing to further control for fatigue effects and the counterbalance order was applied consistently across all participants. Once the testing was completed, the participants were debriefed and any questions they may have had about the testing procedure were answered. At this stage, participants also received compensation for any incurred travel costs.

Statistical Analysis

For the purpose of this study the performance of the TD group was considered representative of typical ToM ability against which the performances of the pTBI groups were compared. Detailed descriptive statistics were analyzed first to characterise the performance of the TD and TBI groups on the various ToM subtests of both the NEPSY- II and the adapted ToM battery. To compare the performance of the different groups on the various tasks the analysis included a series of one-way analysis of variances (ANOVAs) and mixed factorial ANOVAs. Differences in cognitive ability, specifically full scale IQ, working memory, processing speed and executive functioning, were determined through the use of several one-way ANOVAs. All the statistical analyses were conducted on the IBM SPSS Statistics software package version 19 (IBM, 2011).

As an initial exploration, the data was examined for normality and homogeneity of variance. All assumptions underlying the various tests were upheld. There was an increased possibility of making a Type 1 error due to the number of analyses that were run. But given the small sample size and the data's poor power the significance level was left at $\alpha = 0.05$.

Results

Confounding Variables

General intellectual ability and executive function as measured by subtests of the WISC-IV[UK], the WASI and subtests of the D-KEFS, were examined to rule out these factors as potential confounding variables (i.e., to ascertain whether the deficits are primarily of ToM, or whether poor ToM performance was simply the result of deficits in other cognitive domains). To analyse performance on executive function the scaled scores of the various executive function tasks were used to account for any effect the age difference between TBI groups may have. A series of one-way ANOVAs were conducted to investigate differences between the groups on the various tasks. The analysis of the confounding variables was approached first in order to identify any group differences on these measures so that these could then, if necessary, be statistically controlled for on any significant ToM measures.

Working memory and processing speed. Administration of the WISC-IV[UK] results in three types of scores. A raw score which can be converted into a standard scaled score and factor indexes or IQ. Each subtest produces a scaled score having a mean of 10 and standard deviation of three and ranging from 1-19. The factor indices and IQ have a mean of 100 and standard deviation of 15. The WMI and the PSI have a standard score of 50 to 150. In the general population, 68% of children score within 1 standard deviation below and above the mean (Flanagan & Kaufman, 2004). As means of a standardised comparison the obtained raw scores of the current study were converted into factor indices (WMI and PSI, see Figure 1) and the mild and moderate pTBI groups' performance was compared to the matched TD group as well as to the standardised Western norms. A one-way ANOVA indicated that there were no significant group differences on working memory (WMI) and processing speed (PSI; see Table 2). Therefore, the TD, mild and moderate TBI groups did not differ significantly from one another on WMI. As there was no significant group difference on WMI, $F(2, 47) = 0.17$, $p = .842$, $\eta^2 < .01$, or PSI $F(2, 47) = 2.28$, $p = .076$, $\eta^2 < .01$, these variables were not controlled for statistically.

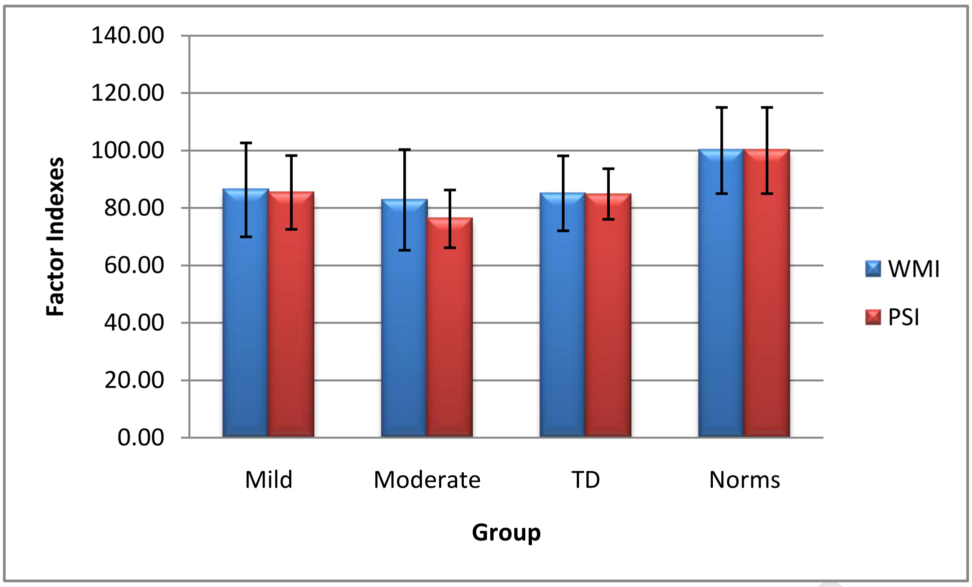

Figure 1. WMI and PSI group performances for the mild and moderate TBI, TD and normative group. Error bars indicate standard deviation of each group.

Table 2

Performance and Means of IQ, Processing Speed, and Working Memory Between the Typically Developing (TD) and TBI Groups

Measure	Mild (n=20)	Moderate (n=10)	TD (n=20)	*F*	*p*	η^2
WASI						
FSIQ	80.30 (17.15)	78.70 (9.13)	79.90 (12.01)	0.05	.956	.00
VIQ	77.85 (16.69)	75.70 (13.80)	78.05 (13.42)	0.09	.912	.00
PIQ	86.25 (19.09)	85.40 (8.54)	84.85 (11.61)	0.05	.955	.00
WISC-IV						
Working memory index (WMI)	86.30 (16.35)	85.12 (15.10)	85.10 (13.05)	0.17	.842	.00
Processing speed index (PSI)	85.40 (12.84)	76.20 (10.05)	84.85 (8.82)	2.28	.076	.10

Note. Means are presented with standard deviations in parentheses.

General intellectual ability. Administration of the WASI results in various types of scores. An initial raw score can be converted into a standard *T*- score. These *T*-scores can then be converted into a verbal (VIQ), performance (PIQ), a four-subtest full scale (FSIQ) and two-subtest full scale score. The WASI subtests generate an age-corrected *T*-score with a mean of 50 and standard deviation of 10. The IQ scores range from 50 to 160 with a mean of 100 and standard deviation of 15 based on the western population on which the subtest are normed (Kaufman & Lichtenberger, 2006). For a standardised comparison the obtained raw scores of the current study were converted into factor indices (four-subtest FSIQ, VIQ and PIQ, see Figure 2) and the mild and moderate pTBI groups' performance was compared to the matched TD group as well as to the standardised western norms.

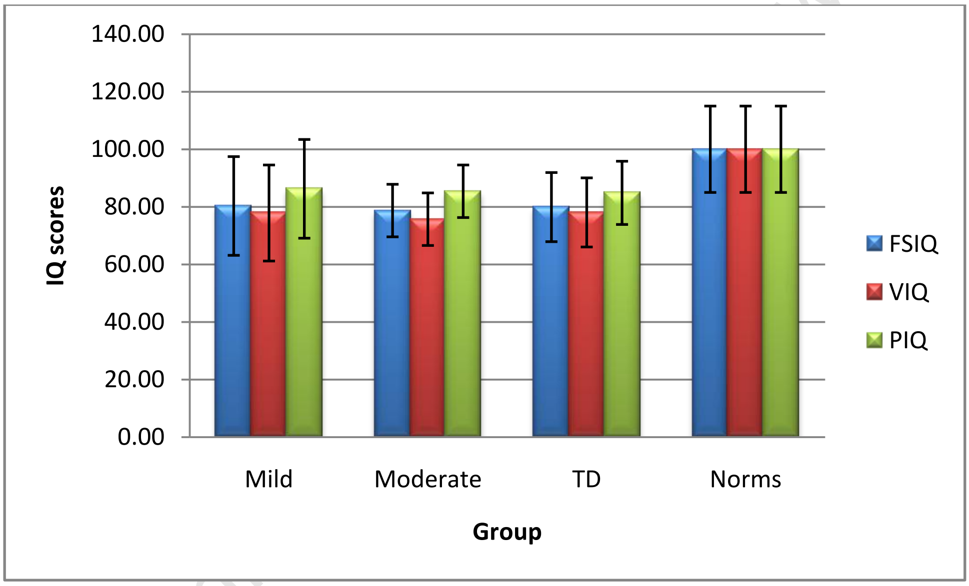

Figure 2. FSIQ, VIQ and PIQ group performances for the mild and moderate TBI, TD and normative group. Error bars indicate standard deviation of each group.

Full scale IQ. As anticipated within the South African low SES context, the full scale IQ of the TD group fell outside of established Western norms. A one-way ANOVA indicated that there was no significant effect for participant group (see Table 2). In other words, mild and moderate TBI and TD groups did not differ significantly from one another on FSIQ. As there was no statistically significant group difference on FSIQ, this variable was not controlled for statistically, $F(2, 47) = 0.05$, $p = .956$, $\eta^2 < .01$.

Verbal and performance IQ. Similarly, one-way ANOVAs indicated that there was no significant effect for participant group on VIQ and PIQ (see Table 2). Therefore, the TD, mild and moderate TBI groups did not differ statistically significantly from one another on VIQ or PIQ. As there was no significant group difference on VIQ, $F(2, 47) = 0.09$, $p = .912$, $\eta^2 < .01$, or PIQ $F(2, 47) = 0.05$, $p = .955$, $\eta^2 < .01$, these variables were not controlled for statistically.

South African WASI norms. When evaluating the participant's performance on the WASI with respects to the standardised Western norms, it is not surprising to see the South African population is performing fairly poorly in relation to the Western norms. In order to obtain a better representation, given the South African (non Western) context within which the WASI was applied, the IQ scores were re-evaluated using South African norms). The new IQ indexes are presented below (see Table 3). W-FSIQ, W-VIQ and W-PIQ refer to the indices that were normed using the Western standardisation and conversion tables. SA-FSIQ, SA-VIQ and SA-PIQ refer to the indexes that were normed using the South African standardisation and conversion tables.

The South African norms are based on the performance of 286 South African English and Afrikaans speaking TD individuals with a disadvantaged quality of education (unpublished PhD thesis, H. Ferret, Stellenbosch University). The normative population is representative of the participants included in the current study. However, unfortunately these norms only exist for 12-15 year old individuals. Thus, evaluation of performance of the mild and moderate TBI and TD groups on the WASI, within the South African context, was only possible for individuals falling within the stipulated age range. No meaningful group comparison can thus be drawn. However, in order to demonstrate that the participants of the current research perform better when evaluated against a representative population, the performance of these participants was re-evaluated within the South African context, nonetheless (see Figures 3, 4 & 5). Excluding cases below the age of 12 lead to a reduced sample size for the mild TBI ($n = 17$), the moderate TBI ($n = 5$) and the TD group ($n = 13$) giving a new dataset where $n = 35$. When evaluating the performance of the participants using the South African norms, converting the raw scores into standardised scores requires a different set of scaled scores. Thus, the results were re-scored and different values were obtained for the South African norms in comparison to the Western norms (see Table 3).

Table 3

Performance and Means of Full Scale IQ, Verbal IQ and Performance IQ of 12-15 year old participants of the current study standardised on Western (W-FSIQ, W-VIQ &W-PIQ) and South African norms (SA-FSIQ, SA-VIQ & SA-PIQ)

Measure	Participants (n=35)
WASI	
W-FSIQ	79.69 (15.03)
SA-FSIQ	91.86 (18.20)
W-VIQ	78.03 (16.00)
SA-VIQ	87.46 (18.56)
W-PIQ	84.54 (15.18)
SA-PIQ	98.57 (19.44)

Note. Means are presented with standard deviations in parentheses

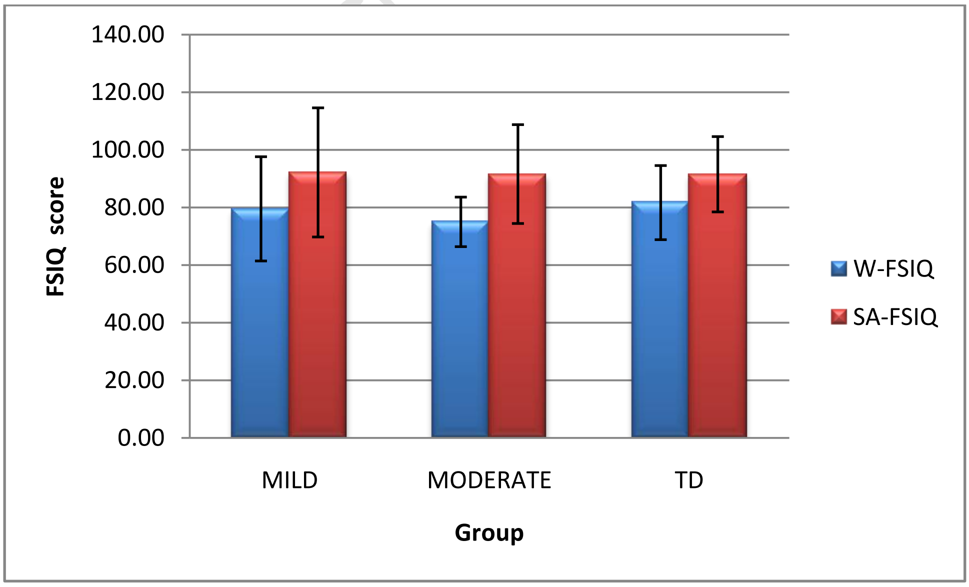

Figure 3. W-FSIQ and SA-FSIQ comparison for 12-15 year old participants of the mild and moderate TBI and TD group. Error bars indicate standard deviation of each group.

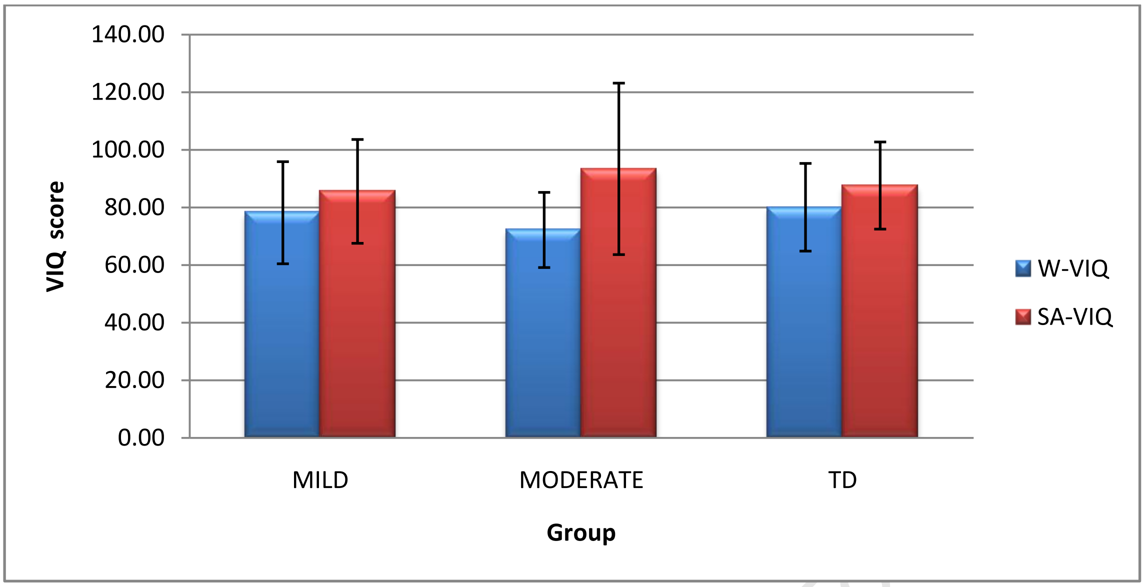

Figure 4. W-VIQ and SA-VIQ comparison for 12-15 year old participants of the mild and moderate TBI and TD group. Error bars indicate standard deviation of each group.

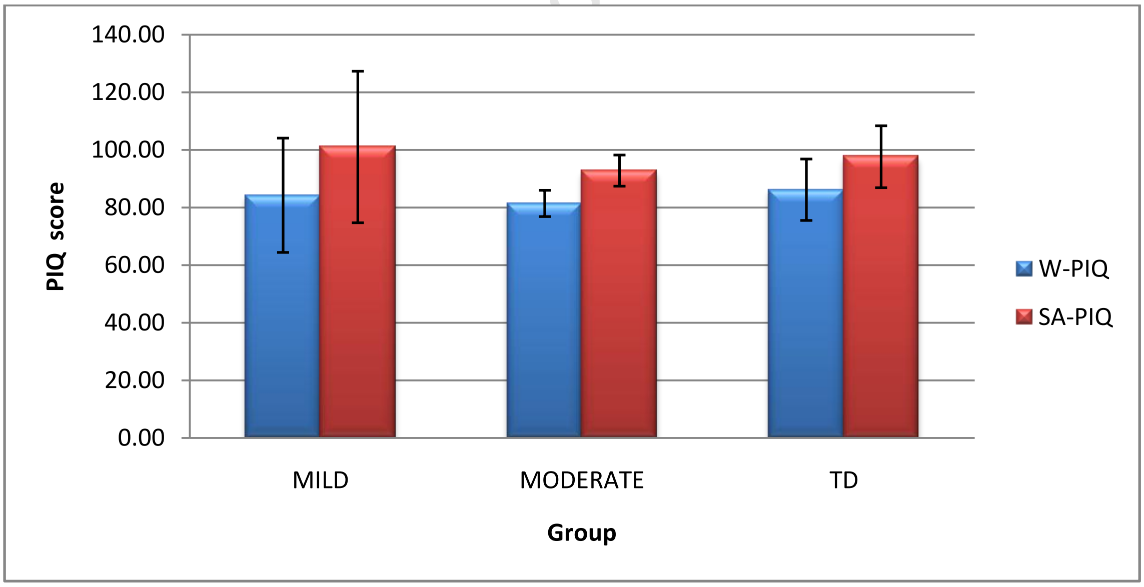

Figure 5. W-PIQ and SA-PIQ comparison for 12-15 year old participants of the mild and moderate TBI and TD group. Error bars indicate standard deviation of each group.

The graphical representation of the three IQ indices measured on the Western norms (W-FSIQ, W-VIQ and W-PIQ) and the South African norms (SA-FSIQ, SA-VIQ and SA-PIQ) suggests that when standardised on the South African norms, all participants do indeed perform much better on all three IQ measures than when standardised using the Western norms. An analysis was run to investigate whether there were any group differences between the mild TBI, moderate TBI or TD groups on the WASI when standardised using the South African norms. No significant group differences were found between the three participant groups on SA-FSIQ, $F(2, 32) = 0.01$, $p = .995$, $\eta^2 = .00$, SA-VIQ, $F(2, 32) = 0.33$, $p = .722$, $\eta^2 = .02$, or SA-PIQ, $F(2, 32) = 0.36$, $p = .704$, $\eta^2 = .02$.

Executive functioning. The D-KEFS Verbal Fluency and Colour-Word Interference subtests are two of the eight individual tests contained in the executive functioning battery. As each subtest is scored and interpreted separately there are no overall composite scores. Raw scores can be converted into scaled scores with a mean of 10 and standard deviation of 3 (Miller, 2009). Analysis of the current data was done on scaled scores (see Table 4). For a standardised comparison of *Verbal Fluency* (see Figure 6) and *Colour-Word Interference* (see Figure 7) the scaled scores were used. This was done to illustrate the performance of the mild and moderate pTBI groups in comparison to both the matched TD group and the standardised Western norms.

D-KEFS verbal fluency. In the domain of verbal fluency the following tasks were analysed: *Letter Fluency*, *Category Fluency* and *Total Correct Responses*. A one-way ANOVA (see Table 4) indicated that there was a significant effect for participant group on *Category Fluency* and *Total Correct Responses*, $F(2, 47) = 4.97$, $p = .01$, $\eta^2 = 0.18$ and $F(2, 47) = 3.20$, $p = .05$, $\eta^2 = .12$. No significant difference was found on *Letter Fluency*. Therefore, the TD, mild and moderate TBI groups differed significantly on their performance of *Category Fluency* and overall on *Total Correct Responses* but not on *Letter Fluency*.

Table 4

Performance and Means of Raw Scores of the D-KEFS Verbal Fluency and Colour-Word Interference subtests Between the Typically Developing (TD) and TBI Groups

Measure	Mild (n=20)	Moderate (n=10)	TD (n=20)	*F*	*p*	η^2
D-KEFS Verbal Fluency						
Letter Fluency [a]	25.85 (9.66)	17.50 (9.81)	23.40 (9.85)	2.44	.098	.09
Category Fluency [a]	27.60 (7.80)	23.20 (8.27)	32.10 (6.73)	4.97	.011	.18
Total Correct Responses [a]	62.80 (16.98)	50.40 (18.88)	67.45 (17.23)	3.20	.050	.12
D-KEFS Colour-Word Interference						
Inhibition [b]	7.35 (3.95)	7.40 (3.53)	8.25 (2.55)	0.41	.664	.02
Inhibition/Switching [b]	6.95 (3.24)	6.80 (4.07)	8.25 (2.45)	1.12	.335	.05
Total Errors: Inhibition [b]	6.25 (3.73)	6.20 (4.24)	6.05 (3.71)	0.01	.986	.00
Total Errors: Inhibition/Switching [b]	7.15 (4.12)	8.10 (4.56)	6.10 (4.39)	0.76	.472	.03

Note. Means are presented with standard deviations in parentheses.

[a] Better performance on the task is represented by a larger mean.

[b] Better performance on the task is represented by a smaller mean.

Post-hoc analysis of the *Category Fluency* data revealed that there was a significant difference between the TD and moderate TBI group. Here, the score of the TD participant group (*M* = 32.10, *SD* = 6.73) was significantly higher (*p* = .01) than that of the moderate participant group (*M* = 23.20, *SD* = 8.27), indicating that the moderate TBI participants performed worse. No significant group differences were found on *Category Fluency* between the mild TBI group and the moderate TBI group (*p* = .292) and the TD group (*p* = .149).

Similarly, post-hoc analysis of the *Total Correct Responses* data revealed that there was a significant difference between the TD and moderate TBI group. Here, the score of the TD participant group (*M* = 67.45, *SD* = 17.23) was significantly (*p* = .039) higher than that of the moderate participant group (*M* = 50.40, *SD* = 18.88), indicative of a better performance. No significant group differences were found between the mild and moderate TBI group (*p* = .170) and the TD group (*p* = .679).

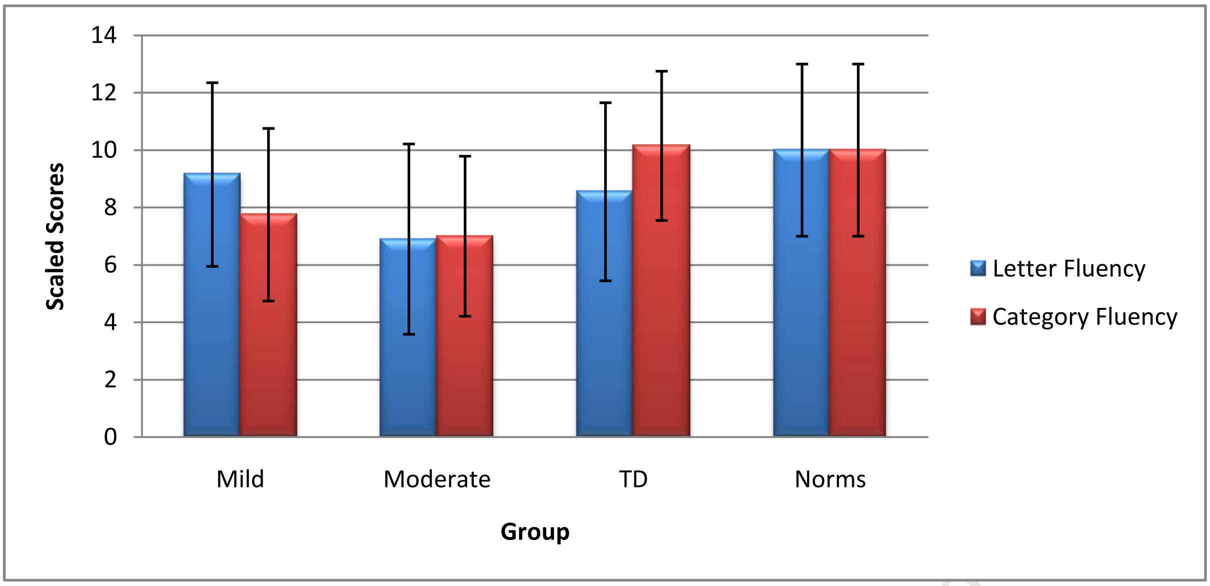

Figure 6. Scaled scores of Letter Fluency and Category Fluency of the Verbal Fluency subtest for the mild and moderate TBI, TD and normative group. Error bars indicate standard deviation of each group.

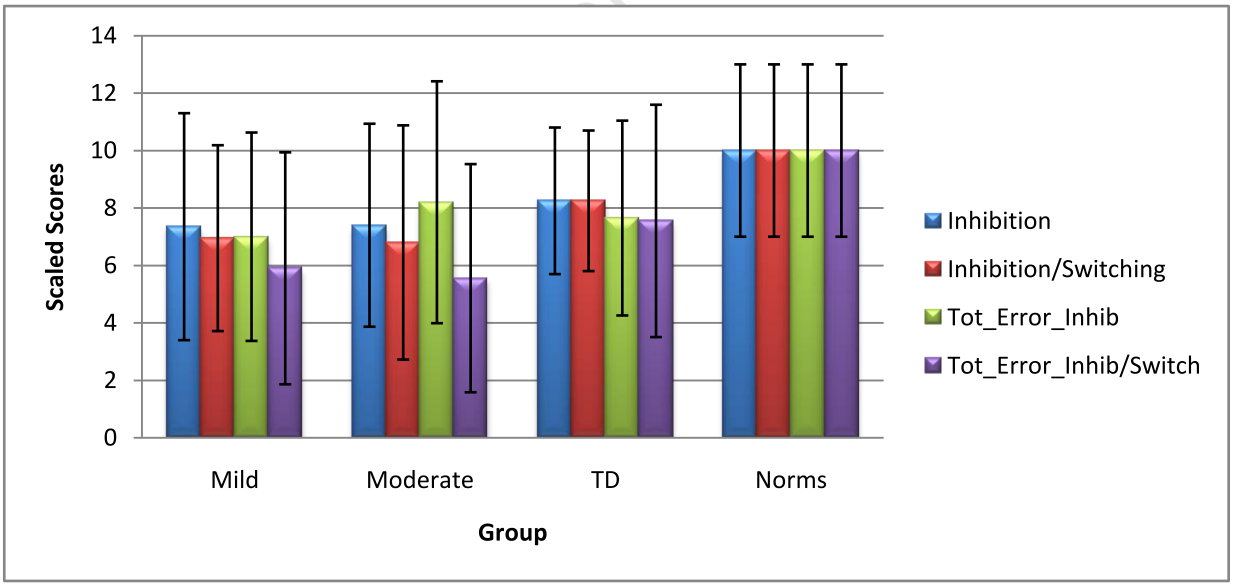

Figure 7. Scaled scores on Inhibition, Inhibition/Switching, Total Errors Inhibition and Total Errors Inhibition/Switching of the Colour-Word Interference subtest for the mild and moderate TBI, TD and normative group. Error bars indicate standard deviation of each group.

D-KEFS colour-word interference. In the domain of colour-word interference the following tasks were analysed: Inhibition, Inhibition/Switching, Total Errors Inhibition and Total Errors Inhibition/Switching. A series of one-way ANOVAs indicated that there was no significant effect for participant group on Inhibition, Inhibition/Switching, Total Errors Inhibition and Total Errors Inhibition/Switching was non-significant (see Table 4). Therefore, the TD, mild and moderate TBI groups did not differ significantly on colour-word interference. As there was no significant group difference on *Inhibition*, $F(2, 47) = 0.41$, $p = .664$, $\eta^2 = .02$, *Inhibition/Switching*, $F(2, 47) = 1.12$, $p = .335$, $\eta^2 = .05$, *Total Errors Inhibition*, $F(2, 47) = 0.01$, $p = .986$, $\eta^2 < .01$, or *Total Errors Inhibition/Switching*, $F(2, 47) = 0.76$, $p = .472$, $\eta^2 = .03$, these variables were not controlled for statistically

The NEPSY-II Theory of Mind tests

Raw scores were used for the comparison of the three groups on ToM ability as measured by the NEPSY-II. Given the age difference of the TBI participants, ideally scaled scores should have been used. However, the NEPSY-II ToM subtest offers standardised scores only in the form of percentile ranks and not scaled scores, which makes interpretation in a non Western population difficult. The highest score that can be obtained on the verbal subtest is 22 and on the contextual subtest 6. A total of 28 points can therefore be scored on the entire NEPSY-II ToM battery (see Table 5). Performance on the NEPSY-II ToM tasks was examined by analysing the verbal and contextual subtests separately and then also examining the TM total score in order to identify possible group differences between the two subtests. The overall performance (i.e. the total score) of the individual groups on the NEPSY-II ToM subtest is illustrated in Figure 8.

Failing the first or second item of the age-appropriate starting point of the NEPSY-II ToM subtest requires the administration of previous items (i.e. administer battery in reverse until two consecutive items are passed, then proceed forward again). This reverse-rule came into effect for three mild TBI, two moderate TBI and three TD participants. However, each participant managed to score two consecutive items correct before the discontinue rule came into effect (the test is discontinued after four consecutive items are failed) and thus the test was then completed.

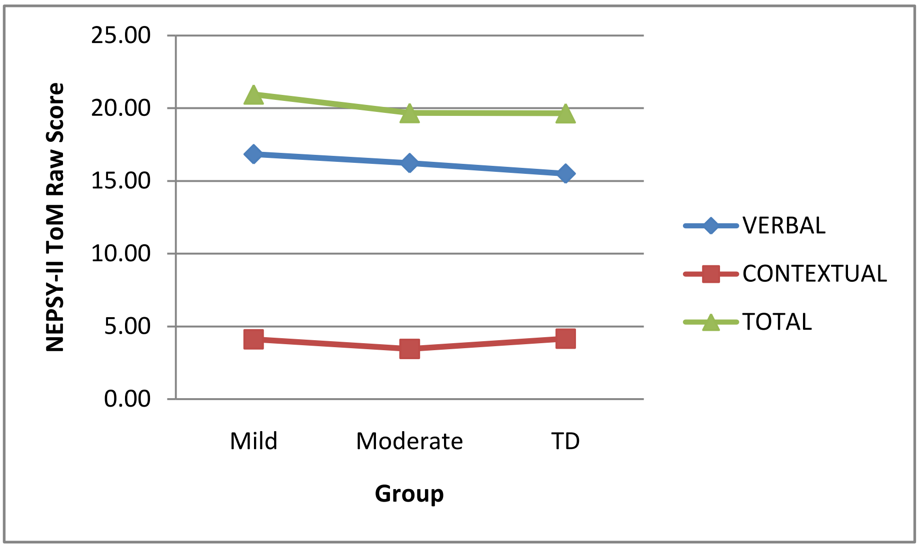

Figure 8. NEPSY-II ToM Verbal, Contextual and Total test score of the mild and moderate TBI and TD group.

A one-way ANOVA with TBI as the independent variable indicated that the effect for type of TBI group on the NEPSY –II TM verbal and contextual task were non-significant, $F(2, 44) = 0.72$, $p = .494$, $\eta^2 = .03$ and $F(2, 44) = 1.11$, $p = .340$, $\eta^2 = .05$, respectively. In other words, the TD, mild and moderate TBI groups did not differ significantly from each other on ToM ability as measured by the NEPSY-II's verbal and contextual subtests. A one-way ANOVA on the NEPSY-II Total score confirmed that the effect for type of TBI group was non-significant, $F(2, 44) = 0.53$, $p = .595$, $\eta^2 = .02$. Therefore, the TD, mild and moderate TBI groups did not differ significantly from each other on ToM ability as measured by the NEPSY-II.

The adapted Theory of Mind Test Battery

The administration rules of the ToM battery stipulated that only if a participant failed the advanced battery (i.e., score less than 50% on the entire advanced battery) was the basic battery administered. All participants of the TD group passed the ToM battery, whereas two mild TBI and one moderate TBI participant failed the battery. Both mild TBI participants failed the advanced battery based on a poor performance on the second-order false belief test and the Faux-Pas test. The moderate participant performed poorly on the Faux-Pas test only.

Due to the small number of participants required to be tested on the basic battery, only the performance on the advanced battery was considered for the analysis. Here, raw scores were used for the comparison of the three groups on ToM ability, as measured by the adapted ToM battery, as no scaled scores exist for these measures. Each of the individual subtests (*Second-order false-belief, Lies & Jokes, Strange Stories and Faux-Pas*) of the advanced battery were analysed to investigate performance of each group on the different ToM components separately (see Table 5).

Second-order false belief. A one-way ANOVA indicated that the effect for participant group on *second-order false belief recognition*, $F(2, 47) = 0.13$, $p = .879$, $\eta^2 < .01$, and *second-order false belief comprehension*, $F(2, 47) = 0.16$, $p = .855$, $\eta^2 < .01$, was non-significant. Therefore, neither of TD, mild and moderate TBI groups was better at correctly identifying the belief or justifying the belief. There was also no significant group difference on the *second-order false belief control* measure, $F(2, 47) = 1.16$, $p = .324$, $\eta^2 = .05$. Therefore, none of the participant groups was significantly better at answering the content questions correctly.

Considering the mean scores (see Table 5) obtained for the test questions of this task, individuals of all three groups were able to grasp the concept of second-order false-belief more than half of the time but not all the time and no group was significantly better than the other. However, on all three measures of second-order false belief, the moderate TBI group had the lowest mean.

Table 5

Performance and Means of Adapted ToM battery and NEPSY-II ToM subtests between the Typically Developing (TD) and TBI Groups

Measure	Mild (n=20)	Moderate (n=10)	TD (n=20)	*F*	*p*	η^2
Adapted ToM Battery						
2nd Order False Belief Control questions (max=8)	6.70 (2.25)	5.70 (2.41)	6.80 (1.32)	1.16	.324	.05
2nd Order False Belief Recognition (max=4)	2.70 (1.49)	2.40 (1.43)	2.60 (1.60)	0.13	.879	.00
2nd Order False Belief Comprehension (max=4)	2.30 (1.53)	2.10 (0.88)	2.40 (1.43)	0.16	.855	.00
Lies & Jokes Control questions (max=16)	15.65 (0.75)	15.56 (0.88)	15.65 (0.99)	0.04	.958	.00
Lies & Jokes Test questions (max=16)	10.45 (2..21)	9.56 (1.51)	10.50 (1.88)	0.81	.453	.03
Strange Stories Control questions (max=48)	38.63 (7.66)	34.67 (5.10)	34.10 (7.96)	2.00	.147	.08
Strange Stories Test questions (max=48)	34.32 (6.63)	32.11 (6.77)	30.95 (6.77)	1.24	.298	.05
Faux-Pas Detection (max=5)	2.84 (1.95)	1.90 (1.52)	2.60 (1.47)	1.04	.361	.04
Faux-Pas Control Detection (max=5)	4.53 (0.61)	3.00 (2.12)	4.05 (1.05)	5.03	.011	.18
Faux-Pas Comprehension (max=15)	5.37 (4.68)	3.00 (3.16)	4.05 (3.10)	1.30	.284	.05
Faux-Pas Control questions (max=20)	16.10 (3.23)	14.22 (4.05)	16.30 (4.41)	0.95	.394	.04
Total ToM Control questions (max=112)	88.05 (20.37)	73.30 (24.67)	89.35 (11.84)	2.81	.071	.12
Total ToM Test questions (max=112)	72.95 (21.64)	58.40 (24.12)	71.30 (13.41)	2.05	.140	.08
NEPSY-II ToM Subtests						
TM Verbal (max=22)	16.83 (3.73)	16.22 (2.54)	15.50 (3.49)	0.72	.494	.03
TM Contextual (max=6)	4.11 (1.32)	3.44 (1.13)	4.15 (1.22)	1.11	.340	.05
TM Total (max=28)	20.94 (4.80)	19.67 (3.12)	19.65 (4.00)	0.53	.595	.02

Note. Means are presented with standard deviations in parentheses.

Lies and jokes. The highest score that could be obtained on the *Lies & Jokes* subtest was 16 points each for the control and test questions. A one-way ANOVA indicated that the effect for participant group on second-order false belief ability tasks was non-significant for both the test and control questions, $F(2, 46) = 0.81$, $p = .453$, $\eta^2 = .03$ and $F(2, 46) = 0.04$, $p = .958$, $\eta^2 < .01$respectively. Therefore, the TD, mild and moderate TBI groups did not differ significantly from each other on the test or control questions of the *Lies & Jokes* tasks.

Here, it was also of interest to see how the three groups compared in correctly identifying a *lie story* in contrast to a *joke story* (i.e. could the participant correctly identify whether the protagonist in the story was lying or joking). No significant group differences could be found for the lie or the joke stories, $F(2, 47) = 1.66$, $p = .201$, $\eta^2 = .066$ and $F(2, 47) = 0.86$, $p = .428$, $\eta^2 = .04$ (i.e., none of the groups identified the lie as a lie or the joke as a joke better than any other group).

However, all the groups were better at correctly identifying lies as lies than at correctly identifying jokes as jokes. All the participants of the TD groups correctly identified all the lies without a single error, whereas some participants of the TBI groups occasionally made a mistake (in 10% of the cases). Pearson's chi-square analysis showed that there was a significant association between participant group and correctly identifying lies as lies, $\chi^2(4) = 10.44$, $p = .034$, and the TD group identified lies as lies the most often. In contrast, the correct recognition of the *jokes* was poor for all three groups. Here, the TD, mild TBI and moderate TBI groups only correctly identified a joke as a joke in 17.5%, 25% and 10% of the cases, respectively. Pearson's chi-square analysis showed that there was no significant association between participant group and correctly identifying jokes as jokes, $\chi^2(4) = 5.67$, $p = .225$.

Strange stories. The highest score that could be obtained on the *Strange Stories* subtest was 48 points each for the *control strange stories* and the *ToM strange stories*. A mixed factorial ANOVA was performed to investigate whether there is a difference between the participant groups and between the two types of stories (i.e., control and ToM). Participant group was the between groups independent variable and has three levels: mild TBI, moderate TBI and TD. Story type was the within groups independent variable and consists of two levels: *ToM strange stories* and *control strange stories.*

The analysis showed no statistically significant interaction effect between story type and participant group, $F(2, 45) = 0.23$, $p = .793$. The main effects could thus be interpreted freely. The first main effect, namely story type was statistically significant $F(2, 45) = 9.45$, $p = .004$, $\omega^2 = .03$. The descriptive statistics indicate that all participants performed significantly better on the *control strange stories* ($M = 36$, $SD = 7.56$), in which the participants needs to make physical inferences, than on the *TOM strange stories* ($M = 32.5$, $SD = 6.75$), in which the participant needs to make inferences about people's mental states. In other words, collectively participants answered more control stories correct than ToM stories. The second main effect, namely participant group was not significant, $F(2,45) = 2.13$, $p = .130$, $\omega^2 = .04$. Therefore, there were no significant differences between the participant groups (i.e., none of the groups was better at correctly answering the question to the ToM stories).

An ANCOVA was run to control for *Category Fluency* and *Total Correct Responses* but the covariate did not affect the ANOVA result. There was still a statistically significant difference on story type even when *Category Fluency*, $F(14, 32) = 2.48$, $p = .017$, $\eta^2 = .02$, and *Total Correct Responses* were controlled for, $F(14, 32) = 2.17$, $p = .035$, $\eta^2 = .02$.

Faux-Pas. The faux-pas task consisted of two sets of stories: faux-pas stories and faux-pas control stories. Within these stories the different questions asked following each story addressed various aspects and ultimately yielded four measures: *faux-pas detection*, *faux-pas comprehension*, *faux-pas control questions* and *faux-pas control detection*.

A mixed factorial ANOVA was run to investigate whether there is a difference between the participant groups between *faux-pas detection* and *faux-pas control detection* values (i.e. to see whether there was a difference between faux-pas stories containing a faux-pas and stories not containing a faux-pas). Participant group was the between groups independent variable and has three levels: mild TBI, moderate TBI and TD. Story type was the within groups independent variable and consists of two levels: faux-pas story with faux-pas (*faux-pas detection*) and faux-pas story without faux-pas (*faux-pas control detection*).

The analysis showed no statistically significant interaction effect, $F(2, 45) = 0.53$, $p = .595$. The main effects could thus be interpreted freely. There was a significant main effect for 'story type' $F(2, 45) = 20.53$, $p = .000$, $\omega^2 = .06$. Descriptive statistics indicate that participants were better at correctly inferring that there was no faux-pas ($M = 4.04$, $SD = 1.29$) than at correctly identifying a faux-pas ($M = 2.60$, $SD = 1.66$). 'Participant group' also had a significant main effect, $F(2, 45) = 3.27$, $p = .047$, $\omega^2 = .02$. Post-hoc analysis showed that there was a significant difference between the mild and moderate TBI groups, *p* = .036. A one-way ANOVA was run to investigate the participant group differences further and a statistically significant effect was shown on *faux-pas control detection, F*(2, 45) = 5.03, *p* = .011, η^2= .18. Post-hoc analysis showed that there was a statistically significant difference between mild and moderate TBI participants, *p* = .008. Descriptive statistics indicated that mild TBI participants were better (*M* = 4.53, *SD* = 0.61) at correctly identifying that no faux-pas was present on the faux-pas detection control questions than the moderate TBI participants (*M* = 3.00, *SD* = 2.12).

An ANCOVA was run to control for *Category Fluency* and *Total Correct Responses* but the covariate did not affect the ANOVA result. There was still a significant difference on participant group even when *Category Fluency, F*(2, 44) = 4.72, *p* = .014, η^2= .07, and *Total Correct Responses* were controlled for, *F*(2, 44) = 3.47, *p* = .040, η^2= .07.

A one-way ANOVA indicated that there was no statistically significant difference between participant groups on *faux-pas comprehension* was not significant, *F*(2, 45) = 1.30, *p* = .284, η^2= .05. All groups were poor at explaining the faux-pas even when they had identified it. And although there is no statistically significant difference the moderate TBI group did have the lowest mean (see Table 2). Similarly, a one-way ANOVA on *faux-pas control questions* was not significant, *F*(2, 45) = 0.95, *p* = .394, η^2= .04.

Total ToM score. As a final investigation the total ToM scores of the adapted ToM battery were examined. Here, the total test and control question scores across all ToM subtests contained in this battery were examined. The overall performance of the individual groups on the adapted ToM battery is illustrated in Figure 9. A one-way ANOVA indicated that the effect for type of TBI group on the total control question and test question score was non-significant, *F(*2, 47) = 2.80, *p* = .071, η^2= .11 and *F*(2, 47) = 2.05, *p* = .140, η^2= .08.

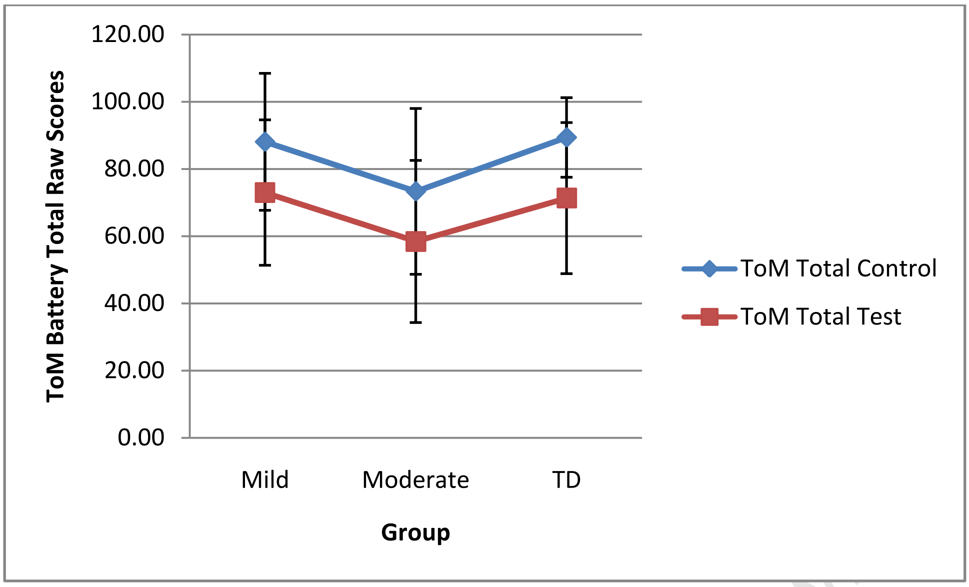

Figure 9. ToM Total Control Question and ToM Total Test Question score of the mild and moderate TBI and TD group. Error bars indicate the standard deviation of each group.

However, the group means of the ToM total test question and the ToM total control question score suggests a potential significant difference between the moderate TBI group and the TD and mild TBI groups. Considering the significance level of $\alpha = .05$, a group difference may have been present if a less stringent significance level of $\alpha = .1$ would have been applied. When accepting a lower alpha level, post-hoc analyses shows that there is a significant difference between the TD and moderate groups on the total control question score, $p = .074$ i.e. indicating that on average the TD participants ($M = 89.35$, $SD = 11.84$) and the mild TBI participants ($M = 88.05$, $SD = 20.37$) answered more control questions correct than the moderate participants ($M = 73.30$, $SD = 24.67$) did. On the graphical representation (Figure 9) it also appears that the TD and mild TBI groups performed better than moderate TBI groups on total control questions and total test questions, even if not statistically significantly better. A power analysis using G*Power (Faul, Erdfelder, Lang & Buchner, 2007) showed that the data of the total control question score and the total test question score had a power of 0.55 and 0.52, respectively. This indicates that a there was only a 55% and 52% chance of finding the suggested group differences significant. In other words, there seems to be a significant group difference on these measures but the dataset did not have enough power to demonstrate it.

Discussion

The main focus of this study was to compare the performance of children with mild or moderate pTBI to that of a language, SES and ethnicity matched control group on measures of ToM ability. I hypothesised that in comparison moderate pTBI patients would perform worse on ToM tasks than mild pTBI patients who would perform worse than typically developing healthy matched controls. Furthermore, the study aimed to investigate whether the NEPSY-II ToM subtest is less sensitive in assessing ToM performance compared to a developmentally sensitive ToM test battery. A discussion of the hypotheses in light of the obtained results follows below.

Measures of ToM

ToM ability was assessed using the NEPSY-II ToM subtest and an adapted ToM battery. The results obtained on each battery are interpreted below. Potential differences in battery utility are also discussed in an attempt to evaluate the strengths and weaknesses of each battery administered in the current study.

Performance on the NEPSY-II. Analysis of the results failed to demonstrate any significant results or potential trends on the NEPSY-II ToM subtest. Here all groups performed on a similar level. At first glance, this may either suggest that ToM ability is not affected by TBI or, more probable given the literature on the effects of TBI on ToM, that the NEPSY-II is not sensitive enough to pick up on ToM deficits. This idea and other factors are explored further below, in a comparison of the NEPSY-II ToM subtest and the adapted ToM battery.

Trends on ToM performance as measured by the adapted ToM battery. Few measures used were able to demonstrate the predicted group performances, namely that moderate TBI participants would perform worse than mild TBI participants, who would in turn perform worse than TD participants. The measures yielding insignificant results altogether (the *second-order false belief* and the *lies and jokes* task), documented in the results section above, will not be discussed in detail. The focus is instead on reviewing the measures that demonstrated certain group trends. Factors that may have impacted on not finding group differences on the ToM component are considered in a general discussion further below.

Strange stories. No group differences were found on the strange stories task suggesting that no participant group was better at interpreting the non-literal meaning of the scenarios than another. However, when investigating the performance on the *control strange stories* versus the *ToM strange stories* it was shown that in general all participants performed significantly better on the control stories than the ToM stories. As the control story's purpose is to ensure that the participant does not have a general deficit in inference making, they are easier than the ToM stories. This has been shown to be true for the current participants based on their better performance on the control stories. Therefore, if any group differences would have been present on the *ToM strange stories* this could have been considered to be a genuine ToM deficit as inference making in general had been shown to be intact. It is, however, unusual for TD participants to perform slightly more poorly on ToM tests than the clinical group. The reason for this may lie in the recruitment of the TD participants. Whereas the clinical participants were recruited through medical files and thus incidentally came from various random communities, the TD participants all come from the same community. Although, demographically speaking the control participants were also of a low SES background, there may be some unknown variable, such as poor schooling facility or parental control, within that community that affected their performance. Potentially, if the TD participants were also sourced from random low SES communities this effect would be mitigated.

Faux-pas. The faux-pas task yielded various measures, which were explored separately. As an initial investigation, I examined whether there was a tendency for participants to perform better on stories that did not contain a faux-pas compared to faux-pas stories that did contain a faux-pas. The effect for story type was shown to be significant. It was shown that in general, participants were better at correctly inferring that there was no faux-pas present than at identifying a faux-pas when it was indeed present. This was to be expected as the correct identification of a faux-pas when it is present is the aspect of ToM that is investigated by this task. In other words, the stories that contained no faux-pas are easier because they do not require a mental inference.

A significant group difference on this measure was also shown. Here, mild TBI participants were shown to be significantly better (*M* = 4.53, *SD* = 0.61) at correctly identifying that no faux-pas was present than the moderate TBI group (*M* = 3.00, *SD* = 2.12). Although not significant, the TD group was also performed better on this task (*M* = 4.05, *SD*

= 1.05) than the moderate group (*M* = 3.00, *SD* = 2.12). This trend appears to lean towards the right direction, where moderate TBI participants were predicted to perform worse on ToM measures than both the mild TBI and TD group.

When exploring group differences on *faux-pas comprehension* (i.e. the justification underlying the identification of a faux-pas being present), no group differences were found. Therefore, even though the mild TBI and TD groups were better at correctly detecting when no faux-pas was present, the groups were all equally poor at explaining the circumstances leading to the faux-pas when they did correctly indicate that one was present. This was to be expected as no group was shown to be better at detecting the faux-pas (i.e. *faux-pas detection*) in the first place, neither was any group better at responding to the content questions (*faux-pas control questions*). However, on both these measures the group means (Table 5) seem to show a trend, even if not significant, where the moderate TBI group performs worse on these measures than both the mild TBI and TD group.

Total ToM test question score. An overall ToM test question score was computed from the individual ToM components of the adapted ToM battery. When examined for group differences no significant differences could be demonstrated. However, although not significant the total ToM test question score followed the predicted trend where moderate TBI participants performed worse than both the mild TBI and TD group (see Table 5 for descriptive statistics). A power-analysis also indicated that there was only about a 50% chance of finding a significant group difference, thus the dataset did not have enough power. Therefore, with a greater sample size there is a good chance of demonstrating a significant group difference at the 5% level. However, considering that the moderate TBI group performed poorly on the control questions, a significant lower score on ToM questions would not indicate a specific deficit in ToM. Instead it would be indicative of a more general deficit as the control questions are supposed to be easier.

NEPSY-II versus the adapted ToM battery. The hypothesis that moderate pTBI participants would perform significantly worse on ToM tasks than mild pTBI participants who in turn perform significantly worse than TD participants was not supported by the results. On the contrary, the results indicate that there are no statistically significant group differences between the TD and the moderate and mild pTBI groups on ToM ability neither on the NEPSY-II ToM subtests or on any of the tasks of the adapted ToM test battery that was administered. However, on the adapted ToM battery the moderate TBI group appears to have performed more poorly than the mild TBI and TD groups; even if not significantly so, given the power limitations of the current sample.

Performance on individual aspects of ToM, measured by both batteries, was contrasted to investigate whether either of the battery found different results. When contrasting the graphical representation of the overall performance of the individual groups on the NEPSY-II (see Figure 8) compared to the adapted ToM battery (see Figure 9), it appears that the adapted ToM test battery may be picking up on some group differences that the NEPSY-II battery is not. This suggests that the adapted ToM battery may be more sensitive at detecting deficits in ToM ability within a pTBI population than the NEPSY-II. However, a bigger sample needs to be collected before drawing any final conclusions.

It is also imperative to note at this stage that the aspects of ToM that are measured by NEPSY-II are limited. The NEPSY-II measures far fewer aspects of ToM than does the comprehensive adapted ToM battery. Although neither of the batteries demonstrated any significant group differences, to conclude that administering either battery will yield the same results would be erroneous. The NEPSY-II fails to address certain key components of ToM altogether and is thus an incomplete measure of ToM. Therefore, when wanting a comprehensive and in-depth measure of ToM, the type of battery administered does indeed play a major role. The adapted ToM battery includes measures of ToM, or rather measures aspects of ToM that go beyond the scope of the NEPSY-II ToM subtest. The approach the NEPSY-II takes on attempting to measure ToM is too simplistic and key components of ToM are ignored altogether. Although considered a crucial component of ToM, comprehension of faux-pas and an individual's underlying understanding thereof, is not explored in the NEPSY-II at all. Apart from being an incomplete measure of ToM, the emphasis the NEPSY-II places on some aspect of ToM rather than on others is also imbalanced. For example, the NEPSY-II ToM subtest devotes three items to the understanding of figurative language, while aspects such as recognizing mental states and false belief are only assessed on a single item.

Also, the order of administration of the NEPSY-II ToM tasks does not simulate the known developmental trajectory of ToM. Whereas the adapted ToM battery follows a developmental sequence, presenting tasks at age-appropriate levels, the NEPSY-II fails to do this. An example is the second-order false belief task, which is item 2 on the battery and administered to children aged three to six, although it is known to develop between ages five to seven. The more basic ToM task, the first-order false belief task (item 7) is administered in the 9-16 age range, although it is known to develop between the ages of three and five. If following the developmental trajectory, first-order false belief reasoning develops prior to second-order false-belief reasoning and should, thus, also be assessed in that order.

Moreover, it seems that NEPSY-II ToM subtest in its current form is not suited for administration in a South African context. Adaptation or revision of the items is essential for use among a South African population to avoid the effects of cultural confounds as the wording in the NEPSY-II is more suited for the western population for which it was originally designed. For example, in item 12, the scenario is described using words such as ‘nursing home’ and ‘recess’. These are not commonly used in South African English and replacing them with words such as ‘old-age home’ and ‘break’ would suit the South African context better. Also, in the contextual tasks, there is a picture of a skunk. In order to correctly identify the correct facial expression related to the scenario, it is essential to understand that skunks are animals associated with bad smells or animals that stink. Skunks are not that common in South Africa, therefore, the child may not understand the scenario that is presented because it is based on a foreign concept.

It is understood that the aim of the NEPSY-II was to have a quick standardised measure of ToM. However, ToM is a complex mental construct consisting of the interplay of numerous mental aspects and reasoning processes that simply cannot all be comprehensively probed on a 21 item scale as is the NEPSY-II. In comparison, the strange stories task of the adapted ToM battery on its own consists of 18 items. It appears that the NEPSY-II is not comprehensive enough and attempts to assess too many crucial ToM skills in a rushed manner and is excluding domains that should form an integral part of any ToM assessment.

Factors influencing the measurement of ToM. Apart from exploring the usefulness of each battery, one of the main aims of the current research was to identify participant group differences despite which battery was used. As previously mentioned, no significant group differences were found on the NEPSY-II ToM subtests or on the adapted ToM test battery. It would, however, be hasty to simply conclude that pTBI, therefore, has no effect on the development of ToM skills. However, fact is that ToM ability reaches various milestones during its developmental stages. Thus in order to investigate the unique effect TBI severity has on ToM ability each group’s participants should be at the same developmental stage. If not, an incomplete ToM development may potentially be cause for any observed group differences. Given, that there was a significant age difference between the mild and moderate pTBI groups in the current study, and that no standardised scores were available for the ToM tasks administered, the results obtained need to be interpreted with caution. Apart from the problems with statistical power and age already mentioned, a few possible reasons may explain why the predictions of the research were not fulfilled.

NEPSY-II ToM subtest. To begin with, the insignificant results across the groups may have occurred due to the measures that were employed. Factors surrounding the development and administration of a psychometric test battery such as the NEPSY-II are increasingly accepted to impact the results of the neuropsychological tests. Variables such quality of education, SES as well as parental education level and socio-cultural factors have been shown to influence performance on standardised tests (Anderson, Catroppa, Haritou, Morse & Rosenfeld, 2005; Howie, Scherman & Venter, 2008; Magnuson & Duncan, 2006; O'Bryant, O'Jile & McCaffrey, 2004; Sherrill-Pattison, Donders & Thompson, 2000).

Despite several domains of the NEPSY (Korkman, Kirk, & Kemp, 1998) and the NEPSY-II being well researched (Brooks, Sherman & Iverson, 2010; Brooks, Sherman & Strauss, 2010; Davis & Matthews, 2010; Schmitt & Wodrich, 2004) the *Social Perception* domain and therefore the ToM subtest is a relatively new addition to the test battery and has received little attention in previous validations. The NEPSY-II was designed and normed based on a westernised population. Cultural differences and lack of normative data for non-western populations have been identified has problematic for the administration of Western-developed neuropsychological test batteries (Anderson et al., 2005; Mulenga, Ahonen, & Aro, 2001). In fact little or no normative data for neuropsychological testing with African populations exists, especially within the paediatric domain (Ruffieux et al., 2010).

The population on which the NEPSY-II ToM subtest has been normed is not representative of the typical demographics of the population used in this research. The current population is characterised by low SES and low and poor level and quality of education and low parental education levels. The sample on which the NEPSY-II was normed was matched to be representative of an U.S. population (Davis & Matthews, 2010) considering various demographic factors such as race distribution, gender and age. However, the South African sample of this study, being a non-western population, is significantly different to the U.S. sample. For example, the education levels of the parents of the sample on which the NEPSY-II was normed ranged from a minimum of 12 years to 16 years of education. In contrast, a parental education level of 12 years, for the population assessed in this study, is generally considered as the top level. Also, the current sample consisted mainly of low SES, Coloured individuals from a specific region of the country. Without culture-representative normative data it is impossible to evaluate the performance of an individual in relation to “what it should be”.

Generally, in order to adapt a cognitive test, developed for a Western population, to be suitable for a non-western population one can collect normative data within the specific culture in which it will be applied. The current research study addressed the potential sensitivity of neuropsychological tests in regards to the socio-demographic bias (O'Bryant et al., 2004) by collecting data of typically developing control participant against which the clinical groups’ performance was then evaluated. Therefore, instead of collecting normative data as such, a control group was used which was considered to be representative of a typical development and ability. When comparing performance on the NEPSY-II across all groups, all participants appeared to perform at the same level. This seems to suggest that the NEPSY-II ToM subtest is not sensitive enough to discern potential differences especially when considering that some trends had been shown within the adapted ToM battery, where moderate TBI participants performed more poorly than the other participants.

Luria himself believed that the mind is a product of our culture (Nell, 1999) and thus the concept that culture and demographics affect psychometric assessment is not new (O'Bryant et al., 2004; Ruffieux et al., 2010; Sherrill-Pattison et al., 2000). However, the culturally-biased content of the tasks administered in this study was not controlled. In order to eliminate the impact of cultural differences the tasks need to be redesigned for the South African context. Given that, in this study, the purpose of the administration of the NEPSY-II was to examine its application in a non-western setting, the tasks were kept in their original format. Therefore, socio-cultural differences between the NEPSY-II’s normative population and the South African population used in this study may have influenced the results in regards to the social scenarios portrayed in the tasks. Despite the opposing research which stirs the debate regarding whether ToM development is the same independent of culture or not (Callaghan et al., 2005; Naito, 2003), an individual’s background may affect his or her understanding and evaluation of a ToM task, which is based on a different cultural background and setting.

The graphical representation of the percentile ranks of the NEPSY-II ToM subtest (see Figure 10) is a great demonstration of how the South African sample performed in relation to a Western Population on which the percentiles are based. Apart from no significant group differences between the South African groups, this highlights how poorly this non-Western population performs on a standardised test constructed for a Western population. The majority of participants across all groups performed at a level at which less than 2% of their Western peers do. This may further suggest that the NEPSY-II ToM subtest in its original form is not suited for administration in a non-western setting.

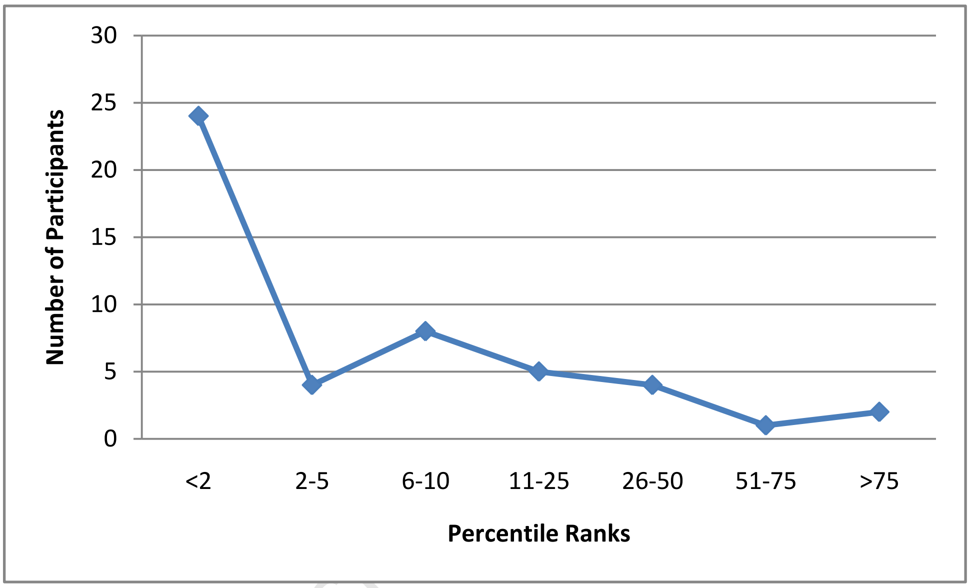

Figure 10. Percentile ranks of the NEPSY-II ToM Total test score of the mild and moderate TBI and TD group.

Additionally, although the NEPSY-II's subtests have been recently evaluated in terms of their validity and reliability (Brooks et al., 2010) no research could be found that investigates the NEPSY-II's ToM subtest's validity within a non-western population. It is, therefore, not altogether surprising that in the current study, the overall performance on the NEPSY-II subtest fell outside the established Western norms. These results support the initiative to further research the validity and reliability of the NEPSY-II ToM subtest and to possible re-develop versions that are more suited for the culture within which they are to be applied. Without this, research using the measure to examine the effects of pTBI on ToM within the South African context, or any non Western population, may not be valid. In general, it is thus cautioned to take cultural, language and personal demographics into account when interpreting results obtained from a western-standardised test battery (Mulenga et al., 2001).

The adapted ToM battery. Although the ToM tasks contained in the adapted ToM battery had been modified to suit the non-westernised South African context, the predicted group differences were not found to be significant. This is inconsistent with previous research, which is suggestive of social deficits following pTBI (Taylor et al., 2002) and TBI (Henry et al., 2006; Milders et al., 2003). However, it needs to be considered that the current study lacked the sufficient power to demonstrate significant results.

By modifying the content of these ToM tasks and by creating a more culturally suitable battery, the reasons relating to the cultural-sensitivity of these tests, were attempted to be avoided. Although no significant group differences were found on the ToM components of the subtests some significant differences were found on other components; for example, on the *control strange stories* and the *faux-pas control questions*. These significant results support the argument for the general trend that was seen overall to be genuine. The adapted ToM battery is significantly able to show expected results on the control components and with a greater power the observed trends (i.e. moderate TBI participants performing worse than mild TBI and TD participants on the ToM components) would have been significant. This suggests that the adaptations made to the battery were successful to some extent in eliminating cultural bias.

Even though I attempted to match the participant groups on language this was not entirely successful. Home language as indicated by each participant was chosen as the administration language. This may be problematic as home language, academic language and language of test administration may affect performance on standardised tests. Some research indicates that when tested in the language of academic instruction the participant will perform better than when assessed in their home language, which may indeed differ from their academic language (Biggs, 1990). In the current research, this was not considered and all participants were assessed in the indicated home language.

Considering that the tasks administered in the current research were all developed in English, they required translating into Afrikaans. Here, the method used to translate the tests may have affected the results. South Africa has a large, culturally rich population. Language, or in this context Afrikaans, varies from region to region and thus numerous variations of a single language exist even within a single province. The test instructions were translated into formal Afrikaans and not adapted to correspond with the type of ‘dialect’ spoken amongst the low SES sector from which the study participants were recruited. Although the participants were urged to ask for clarification if anything was unclear, this formal translation may have affected the results. However, this was of greater concern with regards to the translated intelligence test battery that was administered (see below).

A further factor influencing the results may be related to the clinical population under investigation. Solely mild and moderate pTBI participants were investigated in this study as individuals with severe pTBI were considered unsuitable as they commonly present with other severe cognitive deficits confounding the overall presentation (Havet-Thomassin, Allain, Etcharry-Bouyx & Le Gall, 2006). Previous research has, however, rarely examined mild pTBI participants in context of ToM ability. It may, thus, be that the NEPSY-II ToM and adapted ToM test battery are not sensitive to the severity of pTBI. Without further, extended research this question remains unanswered. However, research on mild TBI has shown that following mild TBI individuals often show acute cognitive injuries, which resolve within the first year post-injury (Binder, Rohling & Larrabee,1997; Frencham, Fox & Mayberry, 2005; Hessen, Nestvold & Anderson, 2007). Even though it has also been shown that subtle cognitive deficits may prevail for months and years post-injury these may be difficult to detect with conventional neuropsychological tests (Belanger, Curtiss, Demery, Lebowitz & Vanderploeg, 2005; Vanderploeg, Curtiss, Belanger, 2005). Picking up on certain deficits may thus be difficult. Such findings may help to explain why on some ToM tasks the general pattern seems to suggest that moderate TBI participants perform worse than the mild TBI and TD participants, but that the latter seem to perform equally well. Although the mild TBI participants may have deficits in certain domains, as suggested by the aforementioned research, formal testing with traditional neuropsychological measures may not be able to detect these as they are too subtle or may have already resolved. Thus, as has been shown in the current study, it appears that mild TBI and TD participants may indeed perform on a similar level on ToM tasks and significant group differences cannot be shown.

Investigation of the measured potential confounding variables

The results showed no differences in general intellectual ability across the three groups. Similarly, the analysis of the executive functioning data revealed no significant difference among the groups on these tasks except for on the *Category Fluency* and *Total*

Correct Responses components of the D-KEFS Verbal Fluency subtest. As with the ToM tasks the results obtained in the cognitive assessment may have been affected by various factors such language and the measures employed. Also, because age-sensitive scaled scores were used for comparison across groups, the significant age difference between the pTBI groups was not of concern.

General intellectual functioning. As illustrated above, the administration of neuropsychological tests designed for and normed on a specific Western population is somewhat problematic within a non-western context. With respect to the above discussion it was also not too surprising that both the clinical groups and the TD groups' fell outside the WASI's established norms. Once the results were interpreted within the South African norms, however, overall participants performed significantly better when compared to the South African norms; although, due to age restricted South African normative data, not all the cases could be included.

It was, however, not expected that the TD group's performance would lie so close to that of the moderate TBI participants. Factors such as sample size and practice effects may explain the TD group's poor performance. During the data collection process, it was discovered that the moderate participants had encountered the WASI before in other research projects through which they were recruited. Although I made every effort to attain the original data, I was unable to retrieve all the information. In trying to identify whether possible practice effects had occurred I compared the original WASI results to the results collected in the present research. However, this analysis was somewhat inconclusive as some participants did perform better and others did not. Therefore, the WASI data should be interpreted was caution.

Additionally, perhaps if a larger moderate pTBI sample had been used the final results may have looked different. Therefore, the unequal sample sizes together with possible practice effects may have influenced the outcome of the results. Nonetheless, the fact that all groups are below the normal range suggests that the WASI in its original Westernised form is not suitable for administration within a South African context.

A further problem, despite the Western context and standardisation of the WASI is its administration language. The WASI is designed for an English speaking sample. The majority of the participants in the current study are, however, first language Afrikaans. This required the creation of an Afrikaans version of the WASI. The non-verbal tasks i.e. *Block*

Design and *Matrix Reasoning*, only required their instructions to be translated. The real trouble starts when attempting to translate the verbal subtests, i.e. *Similarities* and especially *Vocabulary*.

I managed to source a recently-developed Afrikaans version of the WASI, which had been adapted and was in the process of being normed at the University of Stellenbosch (unpublished PhD thesis, H. Ferret). However, it later transpired that the level of Afrikaans that was utilised for the translation was once again more suited for a higher SES population. For example, in the vocabulary subtest numerous participants were unable to explain the meaning of words as they did not know that word despite it appearing early on in the test (the words increase with difficulty as the test progresses). If the same word was then given in English the participants were able to explain the meaning without hesitation. This is understandable as the participants sampled in this study speak a version of Afrikaans that is frequently dominated by English words (where the English word replaces the proper Afrikaans word altogether and the proper Afrikaans word is never learnt). An example, thereof, was the word *herstel*, which in English means either repair or restore but was unknown to the current population in Afrikaans. Also, the current study showed that participants of this demographic consistently give short and vague explanations, which is reflective of their manner of expression in general.

Therefore, it seems that even though the WASI has been translated into Afrikaans it may need to be further adapted to meet the abilities of specific cultural groups. On the other hand, norms that are developed for the Afrikaans version need to take the type of Afrikaans spoken into consideration.

As mentioned above, for the administration of the non-verbal subtests of the WASI, the corresponding instructions were merely translated into Afrikaans for administration of these tests in the said language. However, although non-verbal tasks are often considered to be culture-free (Rosselli & Ardila, 2003), difficulties on such tests as Block Design have been shown in non-western children (Skuy, M. Taylor, O'Carroll, Fridjhon, & Rosenthal, 2000). Unfamiliarity of the materials used has been said to be the cause of this. Whereas as Western children are used to playing with blocks non-western children may be less familiar with this kind of material (Ruffieux et al., 2010). Similarly, this may also be applicable in the current non-western population and may further account for the rather poor performance on the WASI *Block Design* subtest in comparison to Western populations. Thus, when employing non-verbal neuropsychological tests in a culture different from that for which the normative data was developed, great caution needs to be exercised (Rosselli & Ardila, 2003).

Processing speed. The scores on processing speed (PSI) showed that even if not significantly so, the moderate TBI participants scored lower on this measure than the mild TBI and TD group. Also, with a greater power this effect could be shown to be significant. Given the literature, this was to be expected. However, even though the moderate TBI participants were shown to have a slower processing speed, this would not disadvantage them on any ToM tests, as none of the ToM tasks were timed.

Executive functioning. Research suggests that that TBI, especially more severe forms thereof, may negatively influence executive functioning and general intelligence (Carlson et al., 2004; Henry et al., 2006). Therefore, one may expect that a more severe head injury would result in more severe deficits. However, the only group differences found in this study with regards to executive functioning was between the control group and moderate TBI group on *Category Fluency* and *Total Correct Responses*. Here, the TD group generated significantly more category words in the given time limit than participants of the moderate pTBI group. Similarly, the TD group scored more correct answers than the moderate pTBI group, overall on the D-KEFS' verbal fluency subtest. This is, however, a function of the greater total score obtained on *Category Fluency* which directly affects the *Total Correct Responses* score. It appears that at least in this domain the results are consistent with the suggestions made in the literature. However, as the hypothesised effects were not obtained, it was not possible to establish whether *Category Fluency* and *Total Correct Responses* are related to ToM ability within the pTBI context.

Limitations

Participants. Various factors of the current study have been identified that may have impacted on the results obtained. Initially, it was planned to recruit participants to fit an age range of 12-15 years, as research suggests (e.g. Stone et al., 1998) that typically many critical components of ToM should be fully developed by the age of 11. The age range was thus chosen to ensure that the trajectory by which typical development of ToM ability takes place would have been completed and therefore potential deficits in ToM abilities could be associated to the TBI and not stage of typical development.

However, given that this required the recruitment and availability of a clinical population, this in itself posed a bigger obstacle than expected. Initially, i.e. in the planning stage of the study, the clinical records that were available from the Red Cross Children's Hospital misleadingly gave the impression that there were 100s of potentially suitable candidates for use in the study. Unfortunately, once the recruitment process had commenced this was not the case. The number of suitable candidates on record reduced dramatically once I realised that injuries such as "had object stuck in ear/nose" or "knocked head on door" were listed under the general term head injury, which is not the same as an traumatic brain injury. Adding to this the further participation criteria such as age, SES, updated contact details and willingness to participate the initial extensive list shrunk dramatically. Also, I only discovered at this stage that in the paediatric population there are less incidences of moderate TBI than there are mild cases, 80% of TBI cases worldwide are mild (Hessen, Nestvold & Anderson, 2007), and that there were no moderate TBI cases that could be indentified on the Red Cross list. Therefore, moderate participants had to be recruited elsewhere and all the moderate TBI participants assessed in the present research had already previously taken part in other research studies. Due to their previous exposure to the testing environment and setting, the moderate TBI participants were potentially more at ease and may have thus had an unfair advantage over the other participant groups.

Practice effects. Although the moderate pTBI group may have been familiar with the WASI (see above), the ToM tasks administered in the current study were novel to all participant groups. Thus, the risk of retest effects was not present. Therefore, observed group differences in ToM would be genuine and one would expect to see performances consistent with the literature. And indeed, the current study has managed to demonstrate a trend in group performances on ToM as measured by the adapted ToM battery.

Time since injury. Ideally, participants should have also been at a stage 6 -12 months post-injury. This ensures that their deficits are more or less stable and chronic and prevents the typical ToM development from impacting with too great variability on ToM performance. But due to recruitment difficulties outlined above, finding participants who met all the ideal inclusion criteria was impossible. The mild TBI participants were all two to three years post-injury and the moderate TBI participants were all at least one year post-injury. Thus, due to the difficulty of recruiting from a clinical population, the clinical characteristics and age range of the participants used in the current study were not as ideal as they should have been.

This may have been a further impacting factor determining the insignificant results which are inconsistent with the suggestions of the existing literature.

Participant recruitment. Ultimately, the difficulty in recruiting the clinical population lead to the final unequal sample sizes. Initially, it was proposed to recruit 20 participants in each group. This was accomplished only in the mild pTBI and TD group. The moderate pTBI group was restricted to 10 as the researchers were not able to recruit further moderate participants in a two year time span. For a greater statistical validity equal sample sizes across all three groups would, however, be preferable.

Recruiting the TD group itself, posed another challenge. It was proposed to recruit TD participants through schools in the same area/SES as the clinical participants. Although permission to recruit participants from schools was submitted to the Western Cape Education Department within the first weeks (April 2009) after acceptance of the study's proposal, the permission letter was only received over a year later (May 2010). This delayed the recruitment of the TD group immensely. Once permission was granted, the selected schools were re-contacted and the relevant documents were delivered to be distributed among students within the given age range. However, although the study was explained in detail and compensation for incurred travelling costs was offered, the schools were somewhat uncooperative and not a single recruitment was able to be made through this route. As a result, the TD participants were recruited through a community liaison within a SES matched community.

Directions for Future Research

Selecting participants. Apart from considering and implementing the issues and factors highlighted investigating how age at injury affects ToM ability and the development thereof would be of great value. In this regard, children who sustain a TBI when they are older (i.e., once ToM ability has completely developed) have been shown to develop more social skills compared to children who sustain a TBI at a young age (Tukstra et al., 2000). It is, therefore, suggested that research needs to look at when the injury was incurred and investigate this as an additional impacting factor as interruption at different developmental stages, may indeed cause various outcomes in ToM ability.

Related to this, is the fact that some research suggests that ToM deficits are related to executive dysfunction as a consequence of TBI (Bibby & McDonald, 2005; Henry et al.,

2006) and thus implying that a link between ToM and frontal lobe structures, the origin of executive function; whereas other researchers found that ToM is independent of executive skills (Bach et al., 2000; Rowe et al., 2001). As long as the relationship between executive functioning and ToM remains unresolved, future research needs to consider the location of the head injury when selecting participants.

Separating participants into experimental groups not only according to their severity of their sustained TBI but also according to the location of the TBI along with age at injury may help to contribute towards characterising the relationship between ToM and executive function further.

Adaptation of research measures. On a different note, whereas great efforts were made to adapt the ToM tasks for the current population, some further changes may help to improve the batteries. During administration of the ToM tasks in the current study, some possibly problematic factors were observed that may have negatively impacted the performance of the participants. These suggestions are not aimed at improving the results but rather at improving the measure itself in order to obtain results that truly reflect the participants' ToM ability.

Only a few children were able to correctly identify the joke stories in the *Lies and Jokes* task, and most of them chose that the child lied in every story. I suggest that in order to minimise the memory aspect of the task, to enter another reminder into each story. In the one joke story (Appendix C) Patricia's mom tells Patricia not to eat any of the muffins when she leaves the house. During the story Patricia does eat some muffins and the mother, standing in front of the tray with the missing muffins, asks her, "Did you eat some of the muffins even though I told you not to?" and Patricia answers, "No, I would never do that," although Patricia knows that her mom saw her eating the Muffins. In this instance, before asking the participant whether Patricia lied to avoid getting caught or was joking to cover up her embarrassment, the examiner should add in a reminder stating, "And remember, Patricia knows that Mom sees the missing muffins on the tray". This ever so important fact, may have come across a little too subtle or the participant may have forgotten that the mom saw Patricia eating the muffins, although the story was accompanied by pictures. Adding that extra reminder will make sure that the participants is fully capable of grasping what has happened in the story and is able to make a judgement based on all facts.

Another problematic task was the *Faux-Pas* task (see Appendix C for an example).

Here, after each story the participants is asked, “Did anybody say something they shouldn’t have, or something awkward?” in order to get them to then explain who said something they shouldn’t have and why they shouldn’t have said it and why the participant thinks that they said it. In the current study, the impression was formed that all the participants figured out fairly quickly that if they answer that no-one said something they should not have said, they will move on to the next story faster and therefore they just always answered no. Here, it is suggested that instructions are added at the beginning stating that in every story there is someone who says something wrong and that the participant has to figure out what it is and why it is wrong. Therefore, the control stories need to be modified to contain something that is semantically or factually wrong so that in every story there is someone who said something they should not have. As a result, this measure will be improved and the participant’s will have less opportunity to avoid measurement. The suggested modified version of the *Faux-Pas* task is currently being piloted on a cohort of children with foetal-alcohol syndrome and the first impressions are that the modifications are taking the anticipated effect.

Conclusion

The cognitive capacity to recognise and understand the mental state of others and to predict their behaviour is considered a crucial component for effective social interaction. Suggestions have been made that the ability to infer mental states and other cognitive social processes are affected by TBI. The current study investigated this claim in the context of pTBI within a specific South African population by means of group comparison. The data collected was able to demonstrate some trends suggesting that moderate pTBI participants do indeed perform worse than mild pTBI and TD participants. Interestingly, it has also raised the issue that mild pTBI and TD participants may perform at a similar level. Further research is required to unravel the particular deficits that determine impairments in social functioning as a result of pTBI. However, the discussion above has outlined many contributing factors that may have affected the outcome of the study. Furthermore, although the research hypotheses could not be satisfyingly evaluated, the current research study seems to have provided a good platform on which to build future ToM and pTBI research in non-western populations. Some valuable considerations regarding potential confounding variables have been highlighted. These emphasize crucial factors that need to be taken into account when engaging in neuropsychological investigations within the South African context.

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Appendix A

Faculty of Health Sciences 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: shuretta.thomas@uct.ac.za

13 July 2009

REC REF: 143/2009

Ms S Malcolm-Smith
Dept of Psychology

Dear Ms Malcolm-Smith

PROJECT TITLE: THEORY OF MIND FOLLOWING PAEDIATRIC TRAUMATIC BRAIN INJURY: A COMPARATIVE STUDY OF SOUTH AFRICAN CHILDREN.

Thank you for submitting your request to the Research Ethics Committee for review.

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

Approval is granted for one year till the 20th July 2010.

Please submit an annual progress report if the research continues beyond the expiry date. Please submit a brief summary of findings if you complete the study within the approval period so that we can close our 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,

<u>PROFESSOR M BLOCKMAN</u>
<u>CHAIRPERSON, FSH HUMAN ETHICS</u>

Federal Wide Assurance Number: FWA00001637
Institutional Review Board (IRB) number: IRB00001938

S Thomas

Department of Education Approval

Navrae / Enquiries / IMibuzo	Dr RS Cornelissen
Telefoon / Telephone / IFoni	(021) 467-2286
Faks / Fax / IFeksi	(021) 425-7445
Verwysing / Reference / ISalathiso	20090428-0001

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Miss Nadine Kilchenmann
Department of Psychology
University of Cape Town
Private Bag
RONDEBOSCH
7700

Dear Miss N. Kilchenmann

RESEARCH PROPOSAL: THEORY OF MIND FOLLOWING PAEDIATRIC TRAUMATIC BRAIN INJURY: A COMPARATIVE STUDY OF SOUTH AFRICAN CHILDREN.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **6th May 2009 to 31st September 2010**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr R. Cornelissen at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.

Signed: Ronald S. Cornelissen
for: **HEAD: EDUCATION**
DATE: 6th May 2009

MELD ASSEBLIEF VERWYSINGSNOMMERS IN ALLE KORRESPONDENSIE / PLEASE QUOTE REFERENCE NUMBERS IN ALL CORRESPONDENCE / NCEDA UBHALE IINOMBOLO ZESALATHISO KUYO YONKE IMBALELWANO

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GRAND CENTRAL TOWERS, LOWER PARLIAMENT STREET, PRIVATE BAG X9114, CAPE TOWN 8000

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Appendix B

Consent Form – English Version

UNIVERSITY OF CAPE TOWN

DEPARTMENT OF PSYCHOLOGY

Theory of mind following paediatric traumatic brain injury: A comparative study of South African children

Principal Researcher:

Susan Malcolm-Smith
Lecturer
Department of Psychology
University of Cape Town
021-650-4605

You are invited to take part in a research study looking at theory of mind development in children with traumatic brain injury and typically developing children. Theory of mind is the ability to understand what other people want, feel and believe, and being able to predict people's actions using this knowledge. Thus, theory of mind is very important for everyday social interactions. We know that people with traumatic brain injury may have problems with theory of mind abilities, as well as difficulties with social and communication skills.

This study will look at the differences in theory of mind ability between children with mild and moderate traumatic brain injury and healthy children, aged 12 to 15 years. Approximately 60 children will participate in the study.

Theory of mind has not been studied in South African children. This study will aid in the understanding of theory of mind development by seeing whether South African children develop these abilities at the same age as previously studied children from other countries. It will also increase our understanding of how theory of mind ability differs in children with traumatic brain injury compared to children who have not had head injuries. The research findings will be used to improve the treatment of children with traumatic brain injury in future.

If you consent to your child participating in this study, your child will be involved in two cognitive assessment sessions (each about 90 minutes long), where abilities like memory, language and social perception will be assessed. These abilities are assessed by completing several straightforward pencil and paper tasks. You, or another caregiver, may be present at the testing session. There are no risks involved in participating in this study. If your child becomes tired during the assessment, we will take a break. If at any time during the assessment you or your child finds any of the procedures uncomfortable, you are also free to discontinue participation without penalty. Once the study is complete, you will receive feedback about what we found out about theory of mind in the different groups of children. You will also have the opportunity to ask questions and therefore learn more about research in psychology.

We will take strict precautions throughout the study to keep your personal information safe and confidential. Your information will be kept without your name or other personal identifiers, only a code, in a locked file cabinet or on a password-protected, secure computer. The data gathered from this research may be published, but your child's contribution will remain anonymous.

Should you have any questions or queries about the research or your participation, please do not hesitate to contact:

Susan Malcolm-Smith: (Tel) 021 650 4605, (email) Susan.Malcolm-Smith@uct.ac.za

Nadine Kilchenmann: (cell) 076 216 1266, (email) Nadine.Kilchenmann@uct.ac.za

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 my child at any point.

I understand that my child will not be identified except by an initial, and that this anonymity will be maintained throughout the study and when the research is published.

I consent to allow my child to participate in this study.

Child's name ____

Signature of parent/guardian ___________________________

Date ____

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

Researcher ____

Signature ____

Date ____

Use of Samples/Data for Future Research

With your permission, we would like to store the unused parts of your child's tests for use in future research. Strict precautions will be taken to keep your personal information safe and confidential. This is your choice entirely and you are free to say no and your child will still be able to take part in the study. Please check the boxes that apply to your choice:

I do <u>not</u> want my child's samples to be used for any future research. ___

You may use my child's samples for any future research. ___

Please indicate below if you would like to be notified of future research projects conducted by our research group:

______________ (initial) Yes, I would like to be added to your research participation pool and be notified of research projects in which I or my child might participate in the future.

Method of contact:

Phone number: ___________________________________

Cell phone number: ___________________________________

E-mail address: ___________________________________

Mailing address: ___________________________________

____

____

Assent Form – English Version

UNIVERSITY OF CAPE TOWN

DEPARTMENT OF PSYCHOLOGY

Assent Form

Hello! We want to tell you about a research study we are doing. A research study is a way to learn more about something. We would like to find out more about how people understand how *other people* are feeling, and what they think. This is called theory of mind.

If you agree to join this study, you will be asked to listen to a few stories and look at some pictures. I will then ask you some questions about the stories. You will also be asked to do some tasks like drawing pictures, telling me about the meaning of some words, and building puzzles with blocks.

There will be two sessions, both about an hour and a half long. If you get tired, we can take a break at any time. You can also have a parent or guardian with you if you want.

If you do take part in this study, no-one else will know what you answered. Your answers will be kept 'anonymous' – that means that your name will not be linked to them in anything that is written about the study.

Any questions?

If you sign your name below, it means that you agree to take part in this research study.

________________	______________________________________
Date (MM/DD/YEAR)	Signature of Child/Adolescent Participant

Demographic Form

DEMOGRAPHIC QUESTIONNAIRE

A. Child's Information:

1. Name: ____________________
2. Age: ______
3. Date of Birth (dd/mm/yy): ___________
4. Sex (circle one): Male Female
5. Ethnicity: White Black Indian Coloured
   Asian Other If other please specify: ____________
6. Home Language: ___________
7. Handedness (circle one): Left Right Ambidextrous
8. Number of siblings: ___________
9. Has your child ever experienced a head injury? (e.g., being hit on the head with an object and losing consciousness as a result) YES NO

   If yes, please give details:

____

____

____

10. Has your child ever experienced any of the following medical conditions:

    a. Neurological problems YES NO

    If yes, please specify: ____

    b. Depression YES NO

    If yes, please specify: ____

    c. Memory problems YES NO

    If yes, please specify: ____

    d. Problems with your vision YES NO

    If yes, please specify: ____

    e. Problems with your hearing YES NO

    If yes, please specify: ____

f. Is he/she currently taking any prescription medication? YES NO

If yes, what medication(s)?____

11. Has your child ever been diagnosed with a social disorder such as conduct disorder or oppositional defiant disorder (ODD)? YES NO

If yes, please specify:____

12. Has your child ever had a communication disorder? (For example: Having problems with understanding or producing speech, slow vocabulary development, difficulties recalling words or problems with producing sentences appropriate for his/her age.) YES NO

If yes, please specify:____

13. Has your child ever been diagnosed with a pervasive developmental disorder such as autism, Asperger's syndrome, Rett's disorder or childhood disintegrative disorder? YES NO

If yes, please specify:____

14. Has your child ever experienced learning difficulties such as dyslexia or attention-deficit / hyperactivity disorder (ADD/ ADHD)? YES NO

If yes, please specify:____

B. Parent Information:

1. What is the total yearly income of the household in which you live? (Circle one):

[NOTE: This should be household income, not personal income.]

Less than R80 000	R80 001 - R130 000	R130 001 - R180 000
R180 001 - R230 000	R230 001 - R300 000	More than R300 001

2. Education (highest degree or grade completed) of mother: ________________________

3. Education (highest degree or grade completed) of father: __________________________

4. Highest occupational level of mother: (The best job you've had, not necessarily in terms of job satisfaction or pay, but rather in terms of things like prestige or social status attached to job.)

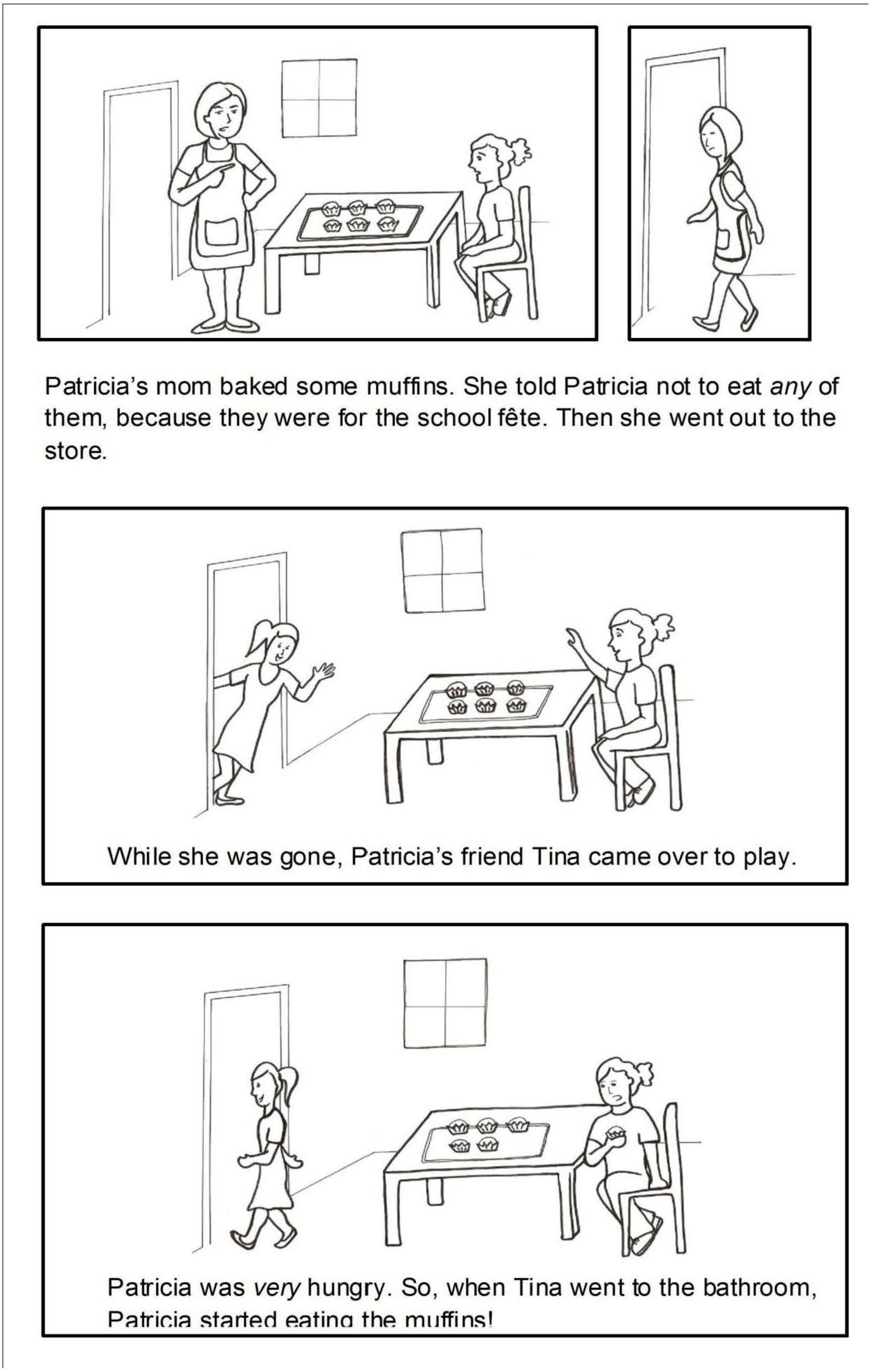
____

5. Highest occupational level of father: (The best job you've had, not necessarily in terms of job satisfaction or pay, but rather in terms of things like prestige or social status attached to job.)

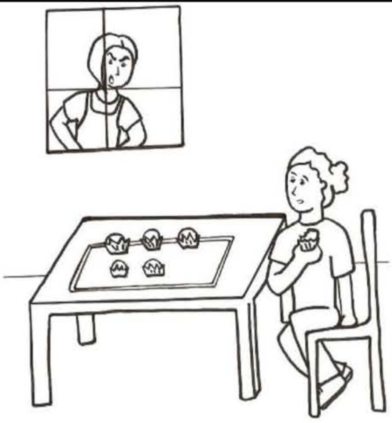
____

Appendix C

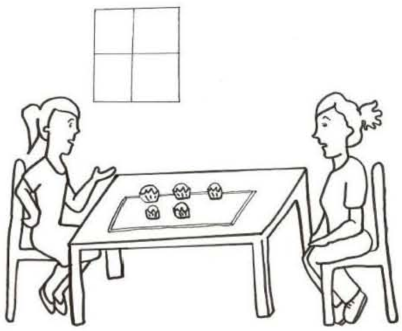
Lies and Jokes – Example of Joke story



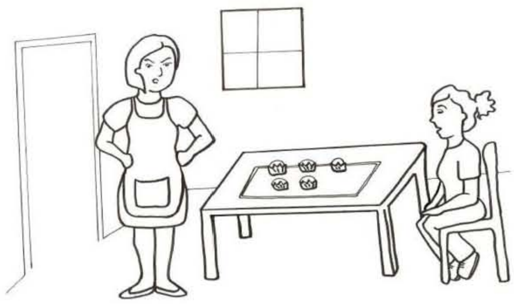
Meanwhile, Patricia's mom had forgotten something and came back home…



As she was about to open the door, she saw Patricia through the window eating the muffins! Patricia saw her mom looking angrily at her, but carried on eating the muffins.



Just then, Tina came back from the bathroom and asked Patricia, "Hey, does your mom know that you are eating the muffins for the school sale?"



Patricia's Mom came back into the kitchen. She asked Patricia, "Did you eat some of the muffins even though I told you not to?" Patricia says, "No, I would *never* do *that!*"

Example of a Faux-Pas Story

Robert had just started at a new school. He said to his new friend, Andrew, “My Mum is a secretary at this school” . Then Claire came over and said, “I hate secretaries. They’re horrible”. “Do you want to come and play soccer?” Andrew asked Claire. “No” she replied “I’m not feeling very well.”

What job does Robert’s Mum do?

Did Clare know that Robert’s Mum was a secretary?

Did anyone say something they shouldn't have said or something awkward?

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Firstly, I would like to thank my supervisor Susan Malcolm-Smith for her guidance and assistance throughout the entire thesis process, and especially for her incredibly fast and invaluable feedback on my drafts.

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I owe my deepest gratitude to my parents for their financial and moral support during this enduring process.

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