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Assessment of Post Traumatic Amnesia in Children Aged 4-7 Years

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Statement of Authentication

The work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

Signature:..... Date: .....

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Ax	Assessment
BIRP	Brain Injury Rehabilitation Program
CBCL	Child Behavior Checklist
CNC	Clinical Nurse Consultant
CNS	central nervous system
COAT	Children's Orientation and Amnesia Test
CT	computed tomography
D/C	discharge
GCS	Glasgow Coma Scale
GOAT	Galveston Orientation and Amnesia Test
GOS	Glasgow Outcome Scale
HC	healthy control / typically developing children
H-nonTBI	hospitalised children for non-neurological trauma,
Hx	history
IQ	intelligence quotient
IQR	interguartile range
KOSCHI	King's Outcome Scale for Childhood Head Injury
LC	length of coma
LOC	loss of consciousness
MOPTAS	Modified Oxford Post Traumatic Amnesia Scale
MRI	magnetic resonance imaging
N *or* n	number of participants
NEPSY	A Developmental Neuropsychological Assessment
NSLT	Nonverbal Selective Reminding Test
NSW	New South Wales
Oxford-C	Oxford Scale for Children
N/A *or* n/a	not applicable
ns	not significant
PGCS	Pediatric Glasgow Coma Scale
PTA	post traumatic amnesia
SCH	Sydney Children's Hospital
SCH-PTA Scale	Sydney Children's Hospital Post Traumatic Amnesia Scale
SD	standard deviation
TBI	traumatic brain injury
VSLT	Verbal Selective Reminding Test
vs.	versus/compared to
WISC-III	Wechsler Intelligence Scale for Children- Third Edition
WPTAS	Westmead Post Traumatic Amnesia Scale
WPTAS-C	Westmead Post Traumatic Amnesia Scale for Children

Abstract

Post traumatic amnesia (PTA) is a period of cerebral malfunction following brain injury during which a person is confused and unable to establish continuous memories. Several scales for assessment of PTA that have been developed for adults have been adopted for use with children and adolescents. Nevertheless, the use of these scales in children under 8 years of age is problematic, as they are developmentally inappropriate for this young population. Only few scales have been developed particularly for younger children (i.e. preschool and early school), however these pediatric scales have notable shortcomings and do not cover the entire 4-7 year old age range. Hence further research was necessary to establish whether a PTA scale can be developed to cover this age range, and whether such a scale would be predictive of children's outcome.

This dissertation had three aims: 1) to systematically review the psychometric properties of currently available PTA scales for children aged 4-7 years; 2) to evaluate the developmental validity and refine a 10-item Sydney Children's Hospital PTA (SCH-PTA) scale in a group of typically developing children; and 3) to establish concurrent and predictive validity of the refined scale in a cohort of children aged 4 to 7 years consecutively admitted to Sydney Children's Hospital between February 2008 – October 2012. Firstly, the systematic literature review identified five scales that have been used with children aged 4 to 7 years; but revealed that information about psychometric properties of these scales was often incomplete and very limited, with most scales lacking evidence of developmental validity. Secondly, the developmental validity of the 10-item SCH-PTA scale was examined in a sample of 52 typically developing children aged 4-7 years, the target group of the scale. This study identified a set of five items that are developmentally appropriate for the targeted age range. Thirdly, this 5-item PTA scale was evaluated in a retrospective study, using a clinical sample of 35 children consecutively admitted to Sydney Children's Hospital with traumatic brain injury (TBI). The 5-item scale was found to have good concurrent and predictive validity; correlating with initial Glasgow Coma Scale (GCS) scores, and being the strongest predictor of gross functional outcome compared to other indicators of TBI severity (initial GCS and clinical estimates of PTA duration) at discharge and outpatient follow-ups (approximately 6 and 20 weeks post discharge). Finally, suggestions were made regarding further improvements of this 5-item scale; proposing a 9-item PTA scale that has the potential to fulfill the clinical gap in the assessment of PTA in children aged 4-7 years.

Chapter 1: Introduction

Traumatic Brain Injury

Traumatic brain injury (TBI) occurs when an external force to the head causes transient or permanent neurological disruption. TBIs are typically classified as either an open or closed head injury, depending on whether the skull is penetrated. Closed head injuries are more common, and occur when an external force to the head (e.g. fall, whiplash) does not penetrate the skull, however the impact causes the brain to collide with the inside of the skull and consequently injure brain tissue. The resulting lesion/s may either be contained to a section of the brain (i.e. focal) or widespread (i.e. diffuse). Secondary injury may occur, such as further brain damage resulting from the restriction of blood and oxygen flow to the brain. As such, there is a varied spectrum of neurological sequelae that may occur following a TBI, depending on the type, location and severity of the damage.

It is estimated that every year, 10 million people worldwide sustain a TBI either requiring hospitalisation or resulting in death (Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007; Thurman, Coronado, & Selassie, 2007). Reported incidence rates are typically based on official statistics of hospital admissions. Since the majority of TBIs are of mild severity, and not all people that sustain a TBI present to a hospital, the reported incidence rates are likely to underestimate the true incidence of TBIs. With this in mind, crude annual incidence rates (based on hospitalisations) reported by Australian studies have varied between 100 to 470 per 100,000 of the population (O'Connor, 2002). In contrast, an incidence rate of 790 per 100,000 was found in a New Zealand population when non-hospitalised incidences were also captured (e.g. through health centres, family physicians, physiotherapists, schools, residential facilities, sports clubs, death registry) (Feigin et al., 2013). A bimodal distribution of TBIs across the age span has been consistently reported, with peak incidence rates occurring amongst the 15-19 years olds (approximately 276–300 per 100,000) and 80+ year olds (approximately 245–340 per 100,000) (O'Connor, 2002; Australian Institute of Health and Welfare, 2007). Males are also twice as likely to be hospitalised as females (O'Connor, 2002; Australian Institute of Health and Welfare, 2007). Based on the 1997-1998 Australian hospitalisation data (O'Connor, 2002), falls were the most frequent cause of TBI across the age groups, but especially amongst the 0-4 and 80+ year olds. Homicide was the

highest cause of TBI amongst those aged 20-44 years, whilst motor vehicle accidents were the highest cause of TBI amongst those aged 15-19 years.

With regard to young children, the population of interest to the current study, the 1997-1998 Australian hospitalisation data revealed the incidence rate of TBI in children aged 0-4 and 5-9 years, were 232 and 158 per 100,000 respectively; with falls being the main cause of injury for these young age groups (O'Connor, 2002). Again, when non-hospitalisations are considered, the true incidence rate is likely to significantly increase. Amongst children 0-16 years, 2 in every 10 emergency department presentations have been found to involve a TBI (Crowe, Babl, Anderson & Catroppa, 2009). Of this 0-16 year old sample, children aged 3-8 years comprised 32.1% of all TBI cases. This rate suggests the true incidence is likely higher than the rates reported based on hospital admission data.

Recovery and Outcome

TBI is one of the leading causes of death and disability, resulting in major changes in the patient's and family's life (Hyder et al., 2007). The neurocognitive sequelae following a TBI typically involve disruptions to cognitive, behavioural, psychological and/or adaptive functioning; however, the profile of specific deficits and impairments can vary immensely in nature and severity.

Recovery from a TBI may take weeks, months or years, depending on the severity of the damage. Premorbid functioning and age at injury have also been reported to predict outcome. Gains in recovery are typically rapid at first, particularly during the first two years. Thereafter, the speed of improvement tends to reduce and gains in recovery are slow and more subtle (Chadwick, Rutter, Brown, Shaffer, & Traub, 1981; Jaffe, Polissar, Fay, & Liao, 1995; Yeates et al., 2002).

Outcome Following TBI in Adults

There is a wide range of literature reporting on the various outcomes following a TBI in adults. A systematic review of the literature pertaining to cognitive outcome at least 6 months following a TBI revealed a dose-response relationship in terms of injury severity and outcome, a finding repeatedly reported in the literature (Dikmen, Corrigan, Levin, Machamer, Stiers, & Weisskopf, 2009). Studies revealed that long-term cognitive

deficits were evident following both moderate and severe TBIs, although such deficits were more reliably found in severe TBIs. Commonly reported in the reviewed studies were deficits in attention, speed of information processing, executive functioning, episodic memory, visuospatial skills, and language. Regarding mild TBI, there is controversy surrounding the extent of long-term sequelae. Nevertheless, the majority appear to demonstrate good long-term outcome. Moderate effects on cognitive performance may be evident in the first seven days post-injury, however only negligible effects, if any, would typically remain at three months or more post-injury (Levin et al., 1987; Schretlen & Shapiro, 2003; Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005). When residual cognitive deficits remain in the long-term, other factors are likely to have contributed to the poorer atypical recovery. Such factors may include previous head injury or neurological problems, chronic pain, previous psychiatric history, psychological distress post-injury, substance abuse, and litigation (Belanger et al., 2005; Vanderploeg, Belanger, & Curtiss, 2009; Hou, Moss-Morris, Peveler, Mogg, Bradley, & Belli, 2012; Ponsford, Cameron, Fitzgerald, Grant, Mikocka-Walus, Schönberger, 2012).

Reductions in functional capacities are commonly reported following a TBI, particularly amongst those suffering a moderate-severe TBI. A systematic review that involved TBIs of varying severities (i.e. mild to severe) revealed that approximately 41% of people with a TBI were able to return to work 1 to 2 years after injury (van Velzen, van Bennekom, Edelaar, Sluiter, & Frings-Dresen, 2009). Not only are occupational difficulties commonly reported; in severe cases, long-term assistance may be required with activities of daily living, community skills and transport (Ponsford, Olver, & Curran, 1995). Reduced functional and/or cognitive capacities can often lead to reduced participation in leisure activities and social isolation (Morton & Wehman, 1995).

Given the cognitive, social and functional deficits, difficulties and limitations one may experience after a TBI, it is no surprise that emotional disturbances and reductions in quality of life are commonly reported (Long & Webb, 1983; Morton & Wehman, 1995; Ponsford et al., 1995). Poor functional outcome has been shown to predict depression and anxiety at 12-months post TBI (Schönberger, Ponsford, Gould, & Johnston, 2011). In a sample of 559 consecutively hospitalised patients with complicated mild to severe TBI, 53.1% of the sample met criteria for major depression disorder when assessed between 1-12 months post injury (Bombardier et al., 2010). The impact of a TBI can be life-changing for both the individual and their families, particularly when a high burden of

care is involved. Caregivers of TBI survivors have been associated with poorer psychological well-being (Vangel, Rapport, & Hanks, 2011).

Age at injury has also been reported to influence outcome. Comparison studies have revealed poorer functional outcome in older adults than younger adults (Susman et al., 2002; Mosenthal et al., 2004; Leblanc, De Guise, Gosselin, & Feyz, 2006). Older adults are more likely to experience secondary injuries following a TBI, as a TBI may exert added impacts on pre-existing age-related cerebral changes that are more common in older adults, e.g. cerebral atrophy and loss of vascular elasticity (Thompson, McCormick, & Kagan, 2006). For example, subdural haematomas were 18.5 times more present in adults over the age of 65 years, than in adults under 65 years (Rathlev et al., 2006). Other pre-existing comorbid health conditions (e.g. cerebrovascular disease, stroke) may also influence the recovery following a TBI (Kinsella, 2011). Therefore the recovery of older adults following a TBI may be complicated by a range of health issues more common in older adults.

Outcome Following TBI in Children

Children's brains are developing and maturing during childhood and early adolescence (Giedd et al., 1999), and therefore a TBI may impose various effects and setbacks to a child's development. The developing nature of a child's brain also means there are less established skills to rely on following a TBI. An insult to a child's current development may consequently impede the typical developmental trajectory, as new learning is disrupted due to a range of cognitive deficits, leading to long-term effects that further web into complex difficulties. Impairments and difficulties are common in the cognitive, functional, behavioural and/or psychological domains. As a result, a child with a TBI may experience challenges in the home, school and community, due to a complex array of consequential disruptions in their intellectual, academic, social and independent functioning.

Children with a TBI have been associated with poorer intellectual functioning and academic performance (Massagli et al., 1996a; Kinsella et al., 1997; Rivara et al., 1994; Anderson, Catroppa, Morse, Haritou, & Rosenfold, 2000; Taylor et al., 2002; Ewing-Cobbs et al., 2004; Anderson, Morse, Catroppa, Haritou, & Rosenfeld (2004); Anderson, Catroppa, Haritou, Morse & Rosenfeld, 2005; Ewing-Cobbs et al., 2006). Additional cognitive deficits are also common following a TBI, including deficits in working

memory (Levin et al., 2004; Mandalis et al., 2007), attention and executive functioning (Slomine et al., 2002; Anderson et al., 2005; Nadebaum, Anderson, & Catroppa, 2007), information processing (Mathias et al., 2004; Nadebaum et al., 2007), memory (Lowther & Mayfield, 2004; Anderson et al., 2004; Anderson et al., 2005; Allen et al., 2010.) and language (Anderson et al., 2004; Sullivan & Riccio, 2010). Behavioural problems may also impact a child's ability to effectively learn in a classroom, as children with a TBI have been reported to display increased behavioural problems relative to typically developing children, including poorer attention/increased distractibility, impulsivity, and poor self–regulation (Goldstrohm & Arffa, 2005).

Children with a TBI are also reported to have poorer social outcomes, which may be associated with deficits in self-monitoring and -regulation (Ganesalingam, Sanson, Anderson, & Yeates, 2006; Ganesalingam, Yeates, Sanson, & Anderson, 2007), processing of social information (Walz, Yeates, Wade, & Mark, 2009), social judgment and problem-solving skills (Warschausky, Cohen, Parker, Levendosky, & Okun, 1997; Janusz, Kirkwood, Yeates, & Taylor, 2002; Yeates et al., 2004; Muscara, Catroppa, & Anderson, 2008), and communication (Yeates, et al., 2004; Sullivan & Riccio, 2010).

It is not uncommon for sufferers of a TBI to experience adjustment and coping difficulties due to the various impairments, difficulties and limitations that may result following a TBI. Adult survivors of severe childhood TBI have reported ongoing difficulties with education and employment (Anderson, Brown, Newitt, & Hoile, 2011). The web of difficulties one may encounter in the short- and long-term can have a significant impact on one's quality of life and mental well-being (Max et al., 1997; Bloom et al., 2001; Stancin et al., 2002; Pastore et al., 2011).

Similar to the adult literature, a dose-response relationship is also found in children. That is, the higher the TBI severity, the worse the outcome, slower the recovery and higher the risk of long term deficits (Massagli, Michaud, & Rivara, 1996b; Kinsella et al., 1997; Rivara et al., 2011; Anderson et al., 2012; Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2009; Catroppa, Anderson, Morse, Haritou, & Rosenfeld, 2008; Catroppa, Godfrey, Rosenfeld, Hearps, & Anderson, 2012; Max et al., 1998; Max et al., 2006). Additionally, over time, it appears that the discrepancy between the cognitive functioning of children with a severe TBI compared to control children tends to become larger, and occurs more so for children that sustain a TBI at a younger age (see review by Babikian & Asarnow, 2009). Even in moderate TBI, although children demonstrated cognitive

improvements two years following injury, they still fell behind their non-injured children peers (Babikian & Asarnow, 2009). These patterns highlight the long-term effects a moderate or severe TBI may impose on a young child's development. In comparison, majority of children that sustain a mild TBI tend to show significant improvements over time relative to those with moderate or severe injury, and tend to experience only few, if any, long term impairments (Ponsford et al., 1999; Anderson, Catroppa, Rosenfeld, Haritou, & Morse, 2000; Babikian & Asarnow, 2009; Babikian et al., 2011). However, several factors have been associated to increase the risk of ongoing problems in children that sustain a mild TBI, including previous neurological impairments or problems, learning difficulties, psychiatric problems, psychosocial problems, and family stressors (Ponsford et al., 1999; McCarthy et al., 2006).

Additionally, age at injury also appears to influence a child's recovery following a TBI. It has often been reported that sustaining a TBI earlier in age is associated with better outcome, due to greater neuroplasticity, and is therefore more able to reorganise and develop compensatory mechanisms. For example, when controlling for severity of injury, children with mild TBI have been demonstrated to have poorer outcome compared to adults with similar injury (i.e. mild TBI), suggesting that children are more susceptible to chronic neuropsychological dysfunction compared to adults (Hessen, Nestvold, & Anderson, 2007). However, research has been demonstrating that this view is oversimplistic. Children who sustain injuries during infancy and early childhood may be particularly vulnerable to residual cognitive impairment (Anderson et al., 1997; Anderson et al., 2005; Varier, Kaiser, & Forsyth, 2011). Studies have shown that post injury, younger children experience poorer outcomes compared to older children, suggesting that the growth curves of younger children may be more vulnerable to deceleration following a TBI (Levin et al., 1992; Anderson & Moore, 1995; Taylor & Alden, 1997). Risk is particularly increased when severe TBI is sustained in early childhood (Anderson & Moore, 1995; Anderson et al., 2000). However, failure to find differences in outcome post TBI between younger and older children has also been demonstrated (Kan, Saffari, & Khoo, 2009; Babikian & Asarnow, 2009).

Indicators of Injury Severity

Early prediction of outcome following a TBI is important in aiding clinical decisions, such as identifying treatment and rehabilitation needs, and appropriately

addressing them in order to maximise rehabilitation gains and recovery. As the outcome following a TBI is generally dependent on the severity of the injury, clinicians are interested in early indicators that may guide determination of the injury severity. TBI severity is typically classified either as mild, moderate, or severe. Two of the most classic indices of injury severity are depth of coma, and of most particular interest to the current study, duration of post traumatic amnesia (PTA).

Altered State of Consciousness

Following trauma to the head, a person may experience a loss of consciousness (LOC) for a brief period of time (seconds to minutes), or in severe cases, may remain unconscious or in a state of altered consciousness for days or weeks. The depth and duration of coma are commonly used measures of TBI severity, with higher severity associated with greater depth and longer duration of coma.

Measures of Consciousness

Glasgow Coma Scale. The most commonly used clinical scale to indicate a patient's level of consciousness is the Glasgow Coma Scale (GCS), developed by Teasdale and Jennett (1974). The GCS involves identifying and rating the patient's highest ability on three basic domains: 1) eye opening response, 2) verbal response, and 3) motor response. Eye opening responses are scored according to whether the patient is able to open their eyes spontaneously (4 points), to verbal command (3 points), to pain (2 points), or none/absent (1 point). Verbal response is rated according to whether the patient is oriented (5 points), confused but able to answer questions (4 points), provides inappropriate responses (3 points), produces incomprehensible speech (2 points), or no speech (1 point). Motor response is rated according to whether the patient is able to obey commands for movement (6 points), provide purposeful movement to painful stimuli (5 points), withdraws from pain (4 points), displays abnormal flexion (3 points), displays extensor posture (2 points), or no motor response (1 point). The points scored on the three domains are totaled, with a maximum of 15 points. The depth of coma is classified *mild* if total GCS is 13-15 points, *moderate* if 9-12, *severe* if less than 8. The person is considered to be in a *vegetative state* if the total GCS is less than 3; and if a vegetative state remains for over a month, the patient is considered to be in a *persistent vegetative state*. The ease of use, quick and standardized method, and numerical system makes the GCS practical to use and allows the scores to be plotted over time for easy monitoring of

one's consciousness level. It has become standard clinical practice to assess and monitor GCS in all patients admitted to hospital

Paediatric Glasgow Coma Scale. A paediatric version of the GCS (PGCS) has also been developed, in order to take into account the lower verbal and motor development of infants and young children. The pediatric version considers normal developmental milestones when scoring best verbal and motor response (Reilly, Simpson, Sprod, & Thomas, 1988). For example, infants aged 0-26 weeks can acquire a maximum verbal subscore by demonstrating vocalisations such as cries or laughs, a 52 week old infant would need to produce 2-3 words, children aged 1-5 years are required to utter age-appropriate words, and finally children aged 5 years and above would need to demonstrate a sense of orientation (i.e. state name and age). Best age-appropriate motor responses for infants aged 0-26 weeks would be the demonstration of flexion (e.g. selective movement of the pricked limb), whilst children above 2 years of age are expected to point to parts of the body.

Predictive Validity of GCS

Extensive research has been conducted to examine the predictive validity of GCS on TBI outcome. Child studies have not always detailed whether or how scoring of GCS was adapted for their pediatric sample. Therefore, in the following text, distinction between GCS and PGCS will not be made; GCS will be used to refer to both. Bearing this in mind, numerous studies have demonstrated the predictive validity of GCS in determining outcome.

In children and adolescents, initial GCS (i.e. on scene, admission) and/or lowest post-resuscitation GCS scores have been demonstrated to predict a range of outcomes approximately 1-12 months post injury, including gross outcome (Simpson, Cockington, Hanieh, Raftos, & Reilly, 1991; Levin et al., 1992; Kan et al., 2009; Prasad, Ewing-Cobbs, Swank, & Kramer, 2002), neurobehavioural and functional outcome (McDonald et al., 1994; Anderson et al., 2005), intellectual functioning (Anderson et al., 2000; Anderson et al., 2005; Babikian & Asarnow, 2009), cognitive functioning (Prasad et al., 2002; Anderson et al., 2004; Anderson et al., 2005; Babikian & Asarnow, 2009), motor outcome (Prasad et al., 2002), and level of family burden (Anderson et al., 2001; Anderson et al., 2005).

There is also evidence that GCS predicts outcome in the longer term. In children and adolescents aged 5-15 years, injury severity classified according to GCS, correlated with need for follow-up post-injury, need for therapy service, need for special education services, academic difficulties, personality changes, and gross functional outcome 1-6 years post injury (Hawley, Ward, Magnay, & Long, 2004).

In adults, correlations between early GCS measures and outcomes are generally found. However, there are variable findings as to whether it is one of the better predictors of outcome when compared to other indicators of injury severity, including PTA duration (see review by McNett, 2007).

Post Traumatic Amnesia

The indicator of injury severity that is of particular interest to the current study is the phenomenon of PTA. Once consciousness is regained after a TBI, the person may remain in a state of impaired consciousness, typically displaying confusion and disorientation, which may vary in duration and severity. The duration that a patient remains in PTA generally indicates the severity of the TBI.

The conceptual definition of PTA has been refined over the years since the term was first introduced by Symonds (1940; cited in Forrester, Encel & Geffen, 1994). PTA is now defined as the period following a TBI in which the person may be disoriented and unable to establish continuous day-to-day memories. The duration of PTA is typically calculated from the day of injury to resolution of one's basic orientation and memory, and includes any period of coma within this time (Forrester et al., 1994). In addition to disruptions to orientation and memory, a wide range of other symptoms are commonly present in persons with PTA, including aggression, agitation, distractibility, poor attention, impulsivity, wandering, incoherent verbalisation and other behaviours reflecting poor self-monitoring (e.g. inappropriate behaviours) (Corrigan, Mysiw, Gribble, & Chock, 1992; Weir, Doig, Fleming, Wiemers, & Zemljic, 2006). These behaviours are often confronting for families, as they are often uncharacteristic of the person, and at times, can be very challenging.

Measures of Post Traumatic Amnesia

Assessment of PTA in adults. Traditionally, PTA duration was assessed retrospectively by questioning the patient once confusion and disorientation subsided. The

patient would be questioned about events surrounding the injury and first memories, in order to determine the interval between the injury and return of his/her ability to establish continuous memory. However, retrospective assessments are subject to inaccurate and unreliable recall. This may be due to false memories, reconstruction of events based on others' accounts or memory fragments, or confabulation. As a result, unreliable recall of events when questioned retrospectively may make it difficult to accurately ascertain the interval between the date of injury and the return of continuous memory (Forrester et al., 1994).

A number of prospective tools for the assessment of PTA have therefore been developed. PTA assessments commence once the patient has regained consciousness to a level in which they are able to provide verbal or purposeful motor response. Assessment is achieved through daily administration of clinical scales that contain orientation and memory questions; thereby allowing depth of PTA and recovery to be monitored on a daily basis. The classification of injury severity using PTA duration is presented in Table 1 below. Table 2 presents the adult PTA scales to be discussed herein.

Table 1
Classification of Injury Severity Based on PTA Duration (Jennett & Teasdale, 1981)

PTA Duration	Injury Severity Classification
< 5 minutes	Very mild
5 - 60 minutes	Mild
1 - 24 hours	Moderate
1 - 7 days	Severe
1 - 4 weeks	Very severe
> 4 weeks	Extremely severe

Levin, O'Donnell and Grossman (1979) published the first standardised PTA scale, the Galveston Orientation and Amnesia Test (GOAT). The GOAT comprises of items that assess the major spheres of orientation, i.e. person, place, and time. In order to assess anterograde memory, the accuracy of the patient's recall of first memories after the accident is assessed, as well as the accuracy in identifying the date of admission to

hospital. The authors presume that patients learn the date of their admission from staff or family, thereby reflecting attainment of new information. Retrograde memory is also assessed, by determining the accuracy of last memories prior to the injury. The patient is considered out of PTA once he/she obtains two consecutive normal scores.

The Oxford Scale was described by Fortuny, Briggs, Newcombe, Ratcliff, and Thomas (1980), and comprises of questions that assess orientation to person, place and time. Similar to the GOAT, anterograde and retrograde memory is assessed by questioning the first memories after injury, and the last memories before injury. In addition, further assessment of anterograde memory is conducted by presenting the patient three coloured pictures that he/she is asked to name and remember. The patient is also asked to remember the examiner's face and first name. On subsequent days of testing, the patient's recall of this new information is assessed. If the patient is unable to freely recall the three pictures, a recognition procedure is administered, whereby the patient is presented with an array of pictures comprising of the target and distractor pictures. Different sets of distractor pictures are used each day for up to three weeks; thereafter the cycle is repeated (where required). PTA is considered resolved on the first of three consecutive days of obtaining a perfect score.

Extending on the Oxford Scale, the Westmead PTA Scale (WPTAS) was introduced in 1986 (Shores, Marosszeky, Sandaman, & Batchelor, 1986; Marosszeky, Ryan, Shores, Batchelor, & Marosszeky, 1997). In contrast to the GOAT and Oxford Scale, the WPTAS did not assess retrograde amnesia, and therefore eliminated recall of last memories preceding the injury. The recall of first memories after injury as a measure of anterograde memory was also eliminated. Following resolution of PTA, patients often experience difficulties or an inability to recall the events immediately prior or after the injury. Hence the failure to recall these memories is not a sensitive and specific criterion to establish presence of PTA. Rather, anterograde amnesia is assessed using the same face and name recall, and a similar three picture procedure, to that in the Oxford Scale. Similar to the Oxford Scale, a recognition format is administered if the patient does not freely recall all three pictures. In contrast to the Oxford Scale, an importance difference is the use of one pool of pictures that is repeatedly used on all consecutive days of testing. More specifically, once the patient correctly recalls or recognises the first three target pictures, three new target pictures are selected from the previous distractor pictures, and the previous target pictures become part of the new distractor set. This process is

continued until the patient obtains a full score on three consecutive days. Similar to the Oxford Scale, PTA is considered resolved on the first of three consecutive days of obtaining a perfect score. The WPTAS has become the most widely used PTA scale in the United Kingdom and Australia.

Concerns, however, have been raised about the picture administration method of the WPTAS, whereby target pictures become distractor pictures once all three pictures are correctly recognised/recalled, and previously presented distractor pictures become the new targets. Tate, Pfaff, and Jurjevic (2000) investigated whether the end-point of PTA varied according to the two different picture methods of the Oxford Scale and WPTAS. The results revealed variability in the number of days to emerge from PTA according to the picture administration procedure used to assess anterograde memory. Although not significant, the picture method of the WPTAS delayed emergence from PTA. Patients that were administered the WPTAS picture method "hovered" around the maximum score. More specifically, compared to those administered the Oxford picture format, they achieved the maximum score on more occasions before achieving three consecutive perfect scores. This suggested that swapping targets with previously presented distractors, and vice versa, made it more difficult to consistently remember the picture items over three consecutive days. Based on these findings, they developed the Modified Oxford Post Traumatic Amnesia Scale (MOPTAS) (Tate, Perdices, Pfaff, & Jurjevic, 2001), which involves the use of the same target pictures throughout testing, accompanied by a different set of distractors on each day of testing. In addition, Tate et al. (2000) also reported concerns about using recognition of the examiner's face as one of the anterograde memory items. Asking "Do you remember my face?" was critiqued to inherently provoke an affirmative response, making it difficult to ascertain whether the patient actually recalls the face. This item was subsequently modified in the MOPTAS: the patient is presented with a black and white portrait of a female and is asked to remember her face and name. When testing recall, the patient is asked to select the target picture amongst a selection of black and white photos. The final MOPTAS comprises 12 items: seven orientation and five memory items. As with the other scales, PTA is considered resolved on the first of three consecutive days of obtaining a perfect score. Tate et al. (2006) have suggested that for patients with a PTA duration exceeding four weeks, PTA may be considered resolved on the first occasion of obtaining a perfect score on either the MOPTAS or WPTAS.

Assessment of PTA in children. Although much research has been conducted on PTA assessment in adults, the literature pertaining to children is very limited. Whilst the WPTAS is the most widely used PTA scale for adults in the United Kingdom and Australia, it is not an appropriate scale to assess PTA in children aged 7 years and under (Marosszeky et al., 1993). Several scales have been developed for use in children, however the validity of these scales has not been adequately established. Assessment of PTA in children will be discussed in further detail in the next chapter.

Clinical Utility of PTA Identification and Monitoring

Management of Patients in PTA

Clinical presentations of PTA can vary widely. In addition to disruptions to orientation and memory, other typical symptoms commonly present during PTA include aggression, agitation, distractibility, poor attention, impulsivity, wandering, incoherent verbalisation and other behaviours reflecting poor self-monitoring (e.g. inappropriate behaviours) (Corrigan et al., 1992; Weir et al., 2006). Management of a patient in PTA can therefore be challenging and difficult. It is therefore important to recognise the environmental needs of a person in PTA. Common considerations include identifying the degree of structure and supervision required. Patients may be prone to wandering, aggression, or inappropriate behaviours, and therefore identification of the least restrictive practice to manage such behaviours is important. Avoiding over-stimulation is a common guideline to minimise agitation; this may include keeping instructions simple, and keeping visitors and noise to a minimum.

Monitoring Recovery via Assessment of PTA

PTA assessment allows clinicians to monitor a patient's recovery in the acute stage. As PTA is assessed on a daily basis, PTA assessment can aid in identifying deterioration in the patient, and also determine the patient's readiness for certain interventions. PTA monitoring aids clinicians in determining appropriate treatment programs, and the timing of assessments and interventions, that would be of optimum benefit to a patient. The disrupted ability to establish continuous memory of new information is a cardinal feature of PTA; therefore, it is believed that patients in PTA are not able to effectively benefit from certain active rehabilitation interventions, which demand the ability to consolidate and explicitly retrieve new learnt material. Learning that heavily relies on explicit memory of facts and events are therefore often commenced after resolution of PTA (Slifer et al., 1996; Weir et al., 2006).

Table 2

Item Description of PTA Scales for Adults

Scale	Orientation Items	Memory Items
Galveston Orientation and Amnesia Test (GOAT; Levin et al., 1979)	What is your name? When were you born? Where do you live? Where are you now? What time is it now? What day of the week is it? What day of the month is it? What is the month? What is the year?	Retrograde: Can you describe the last event you recall before the accident? Can you describe in detail (e.g. date, time, companions) the first event you can recall before the injury? Anterograde: On what date were you admitted to hospital? How did you get here? What is the first event you can remember after the injury? Can you describe in detail (e.g. date, time, companions) the first event you can recall after injury?
Oxford Scale (Fortuny et al., 1980)	Specific questions not detailed. "A simple questionnaire was used to ask the patient for personal details (for example, age, marital status, number of children, occupation) and to test his orientation in time and space" (p.377).	Retrograde: Questioned about last memories before the accident Anterograde: Questioned about first memories after the accident Recall picture 1 Recall picture 2 Recall picture 3 Remember examiner's face Recall examiner's name
Westmead PTA Scale (WPTAS; Shores et al., 1986; Marroszeky et al., 1997)	How old are you? What is your date of birth? What month are we in? What time of day is it? What day of the week is it? What year are we in? What is the name of this place?	Anterograde: Remember examiner's face Recall examiner's name Recall picture 1 Recall picture 2 Recall picture 3
Modified Oxford Post Traumatic Amnesia Scale (MOPTAS; Tate et al., 2001)	How old are you? What is your date of birth? What month are we in? What time of day is it? What day of the week is it? What year are we in? What is the name of this place?	Anterograde: Recall of face (picture) Recall name of face Recall picture 1 Recall picture 2 Recall picture 3

Rehabilitation of basic functional capacities such as activities of daily living, and gross and fine motor skills (i.e. walking, holding cutlery, chewing and swallowing), commence prior to emergence from PTA, as these interventions rely on procedural memory capacities which tend to be relatively preserved (Ward, Shum, Wallace, & Boon, 2002). Weir et al. (2006) found that patients in PTA are able to learn in functional situations (i.e. self-care tasks) and suggested that retraining of self-care tasks can commence once the patient is scoring 8-9 on the Westmead or Oxford PTA scale.

It is standard clinical practice for detailed speech and language, and neuropsychological assessments to be conducted after PTA has resolved. Test scores will be less influenced by the varying cognitive problems symptomatic and associated with PTA, which may be very transient and not representative of long-term sequelae (Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990). Assessment of neuropsychological functioning helps develop a profile of the person's functioning in the different cognitive domains, which further informs treatment and rehabilitation plans.

Predicting TBI Outcome via Assessment of PTA

Overall, early identification of prognosis following a TBI aids early clinical decisions and identification of treatment and rehabilitation needs. Failure to provide appropriate and timely treatment and rehabilitation services may result in greater long-term needs and inefficient allocation of services and finances.

Numerous studies have investigated the utility of different factors in predicting outcome. The predictive validity of PTA duration on TBI outcome has been widely established in adolescents and adults. PTA duration has been demonstrated to be a better predictor of various functional, cognitive and psychosocial outcomes, compared to other indicators of injury severity such as GCS, length of coma or time to follow commands, and duration of hospitalisation (Brooks, Aughton, Bond, Jones, & Rizvi, 1980; Bishara, Partridge, Godfrey, & Knight, 1992; Asikainen, Kaste, & Sarna, 1998; van der Naalt, Zomeren, Sluiter, & Minderhoud, 1999; Brown et al., 2005; Avesani, Salvi, Rigoli, & Gambini, 2005; De Guise, Leblanc, Feyz, & Lamoureux, 2005; Kosch, Browne, King, Fitzgerald, & Cameron, 2010; Zafonte et al., 1997; Tate, Broe, Cameron, Hodgkinson, & Soo, 2005; Hessen, Nestvold & Anderson, 2007). PTA duration has also been demonstrated to predict long-term cerebral atrophy in adult TBI survivors, measured by magnetic resonance imaging (MRI) at least 90 days post injury (mean post injury interval = 3.04 years, *SD* = 1.82 years). Each additional day of PTA duration was associated with

a 6% increase in the odds for developing abnormal ventricle-to-brain ratio, a measure of parenchymal atrophy and ventricular system dilation (Wilde, Bigler, Pedroza, & Ryser, 2006).

Although the utility of PTA duration as a predictor of outcome has been repeatedly demonstrated in adults, little research has been conducted with children. Discussion of the available scales to assess PTA in children and the predictive validity of PTA duration on outcome will be presented in the next chapter.

Chapter 2

Post Traumatic Amnesia Scales for Young Children: A Systematic Review

Whilst there has been vast research regarding PTA assessment, the data available for these scales primarily pertain to adults. The developmental level of children is clearly very different to that of adults, and therefore the assessment of PTA in children needs to take into consideration these cognitive and developmental differences. The maturational (cognitive, psychological and physiological) level of the child is likely to impact the content, quality and consistency of the responses provided. For example, infants and toddlers are unlikely to possess language skills that would allow them to understand and provide answers to various questions included in the adult scales. Furthermore, children who are of preschool and primary school age may have difficulties answering adult orientation questions relating to time, as their concept of time is not yet fully developed. In addition, children are more likely to be reluctant to engage in interaction with a person who is not known to them (examiner) than are adults, which is likely to impact the score on the scales.

For instance, Marosszeky et al. (1993) investigated the response patterns of hospitalised, non-neurologically injured children, aged 6-15 years, on the WPTAS. Results demonstrated that 6- and 7-year old children perform significantly different from the older age groups. Whilst 94% of children aged 8-15 years were able to meet the scale's criteria of obtaining three consecutive perfect scores, only 15% of 6- and 7-year old children were able to meet the criteria. As such, the WPTAS is not suitable for children aged 7 years and below.

Several PTA scales have been developed for use with children, however the research base demonstrating the psychometric properties of these scales appears to be lacking. It is important to establish the developmental validity of a PTA scale, otherwise failed items may be incorrectly misinterpreted to be disruptions to orientation or memory, where it may actually reflect skills that are still developing. Items comprising a PTA scale are expected to isolate and target the cardinal features of PTA, i.e. orientation and anterograde memory, and not be sensitive to other residual cognitive deficits that may be misinterpreted as PTA symptoms. Correlations between a PTA scale with other PTA scales and classic measures of injury severity respectively provides evidence that the PTA scale assesses the targeted construct of PTA, and is in fact a measure of TBI severity. It is

also important to establish the extent that a PTA scale predicts outcome following TBI, if clinicians are to consider a patient's PTA duration in early clinical decisions regarding treatment and rehabilitation. Lastly, the concordance of PTA scores obtained by different assessors using the same scale reflects the inter-rater reliability of the scale, subsequently reflecting the extent that the scale is standardized and objective.

As the WPTAS is appropriate for children aged 8 years and above, assessment of PTA in children 7 years and below requires particular attention. To address this need, the current authors conducted the following systematic review of the present literature pertaining to PTA scales for children aged 7 and below. The overall aim of this chapter was to identify and review scales that are available to assess PTA in children aged 7 and below and outline the psychometric properties of these scales. To achieve this, a search of the literature was conducted in order to collate the following psychometric properties pertaining to each scale: i) Validity: developmental, content, construct, concurrent, and predictive validity; and ii) reliability measures. A final evaluation of each scale is provided. This information was consequently used to propose suggestions that may guide future development of a PTA scale for use in children aged 7 and below.

Method

Search Strategy

Main search: A search was conducted on two databases, PsycINFO and Medline, using "post traumatic amnesia" as the key word. PsycINFO was searched for studies published from 1806 to June 2013; Medline was searched for studies published from 1948 to June 2013. The search was limited to articles (i) published in the English language, and (ii) involving children of preschool (2-5 years) or school (6-12 years) age.

First, all abstracts identified in the literature search were reviewed by the main investigator (PD) against the inclusion/exclusion criteria. Second, full texts of the manuscripts were reviewed. Third, the reference lists of the identified relevant studies were screened.

Scale search: To ensure that all relevant publications were considered, additional separate searches were conducted in PsycINFO and Medline in which the full name of each scale (where provided) was used as a search term. For PTA scales that are also used with adults (i.e. WPTAS), the search was limited to articles involving children of

preschool (2-5 years) or school (6-12 years) age. No limiters were entered for PTA scales specifically developed for children.

Inclusion/Exclusion Criteria

Studies were included in the review if (i) a specified PTA scale was administered to children, (ii) children were aged 7 years or younger, and (iii) empirical data on psychometric (validity or reliability) properties of the scale were reported.

Studies were excluded if they included only neurological or physiological measures of injury severity or outcome (e.g. PTA duration and its relation to CT pathology, serum measures, headache, pain, etc.).

Data Extraction and Synthesis

Studies that met inclusion criteria were reviewed in detail. Information relating to psychometric features were extracted and presented in Table 4. Specifically, the following validity and reliability indicators were examined:

Validity

Developmental Validity: the response patterns of typically developing, non-head injured children.

Content Validity: the extent that the PTA scale comprises items that adequately and validly measure the features of PTA (i.e. orientation and continuous/anterograde memory).

Construct Validity: the extent that the PTA scale correlates with other PTA measures.

Concurrent Validity: the extent that PTA duration correlates with other measures of injury severity.

Predictive Validity: the extent that PTA duration predicts outcome measures, i.e. cognitive, behavioural, functional and/or psychosocial outcomes.

Reliability

Inter-rater reliability: the concordance of the scores obtained by different assessors using the same PTA scale.

Results

Main search: The two database searches yielded a total of 45 articles, of which five were duplicates. Through the abstract review, 22 appeared to be of relevance to the current study, and 23 were not (see Figure 1. for exclusion details). On further evaluation of published manuscript, 15 more studies were excluded (see Figure 1. for exclusion details; see Appendix A.1 for list of excluded studies). Only seven studies met our inclusion criteria. Finally, screening of the reference lists identified four more studies relevant to the current review (see Appendix B for list of included studies), totaling to 11 identified studies in the initial main search. See Figure 1. for a flow chart of the search and selection process.

Review of the studies identified by the main search revealed five PTA scales that have been used to assess PTA in children aged 7 years and below:

1) Westmead PTA Scale (WPTAS) (Shores et al., 1986; Marosszeky, et al., 1997).

2) Children's Orientation and Amnesia Test (COAT) for children aged 3-15 years (Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990).

3) Unpublished Scale (not named) (Ruijs, Keyser, & Gabreels, 1992). For the purposes of this review, the scale from here on will be referred to as the Oxford PTA Scale for Children (Oxford-C).

4) Starship Posttraumatic Amnesia Scale (Starship PTA) for children aged 4-6 years (Fernando, Eaton, Faulkner, Moodley, & Setchell, 2002).

5) Westmead Post-Traumatic Amnesia Scale for Children (WPTAS-C) for children aged 4-5 years (Rocca, Wallen, & Batchelor, 2008).

Scale search: As there is no formal name for the scale introduced by Ruijs et al. (1992), an additional search could not be conducted. The scale search conducted on the remaining four scales totaled to eight additional scale searches and identified two relevant studies (McDonald et al., 1994; Goldstrohm & Arffa, 2005). See Figure 1 for a flow chart of the search results and selection process. See Appendix A.2 for list of excluded studies.

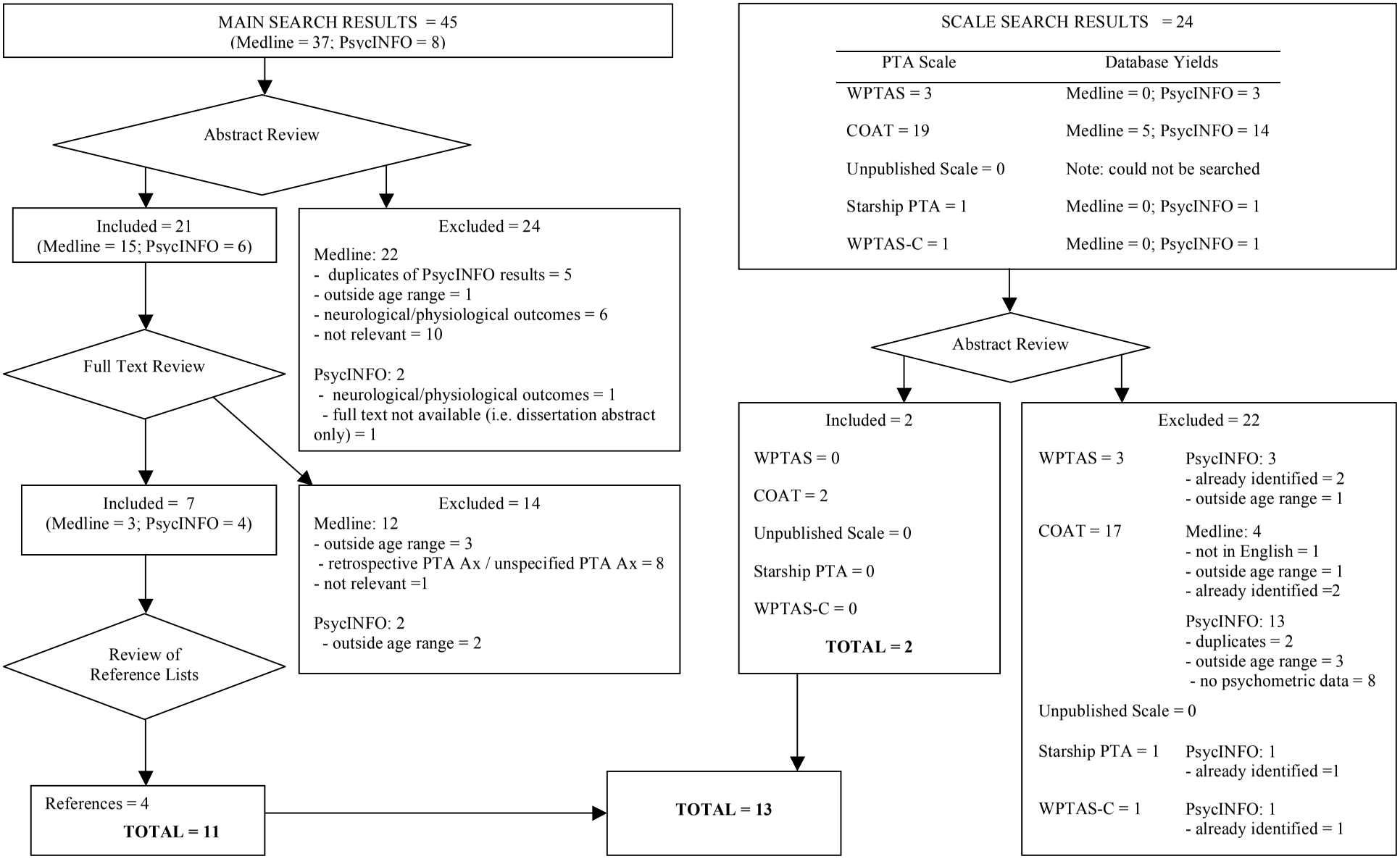

Figure 1.

Literature search and selection process

Description of Studies

Of the 13 studies identified, three pertained to the WPTAS (Marosszeky et al., 1993; Calvert et al., 2008; Paget, Beath, Barnes, & Waugh, 2012), five on the COAT (Ewing-Cobbs et al., 1990; Baryza & Haley, 1994; McDonald et al., 1994; Tremont, Mittenberg, & Miller; 1999; Goldstrohm & Arffa, 2005), two on the Oxford-C (Ruijs et al., 1992; Ruijs, Gabreels & Keyser, 1993), two on the Starship PTA (Fernando et al., 2002; Thickpenny-Davis, Ogden, & Fernando, 2005), and one on the WPTAS-C (Rocca et al., 2008). The specific items that comprise each scale is presented in Table 3; with the exception of the WPTAS which has been detailed in Table 2. Information regarding the validity and reliability of each scale is presented in Table 4. It must be noted that it was not possible to consistently isolate information pertaining to the targeted age range (4-7 years) of the current study. This occurred primarily with studies reporting on the COAT, Oxford-C, and WPTAS. Some of these scales have been used with children and adolescents up to the age of 15-16 years, and therefore results pertaining to these scales were often reported for the wide age range, with no age-specific data for the age groups of interest to the current study. Where possible, the percentage of children in the sample that fell in the targeted age range is indicated in Table 4. A brief summary of each scale and its corresponding psychometric features are presented in the following text.

WPTAS

The WPTAS scale comprises 10 questions: 7 orientation questions (to person, place and time), and 3 items assessing anterograde memory. Recall of three target pictures comprises part of the assessment of anterograde memory, which are renewed each time all three pictures are correctly recalled or recognised. PTA is considered resolved on the achievement of three consecutive perfect scores. PTA duration is the number of days from the day of injury to the first of three consecutive days of obtaining perfect scores. Three studies reported the use of the WPTAS in children aged 7 and under, however only one of these reported data separately for children aged 7 and under (Marosszeky et al., 1993). The remaining two studies involved samples ranging from 6-16 (Calvert et al., 2008) and 3-13 years (interquartile range) (Paget et al., 2012).

Validity

Developmental Validity: One study detailed the responses of typically developing children to each item of the WPTAS, using a hospitalized sample of children aged 6-15

without head injury. Whilst 94% of children aged 8-15 years passed the scale, only 15% of children aged 6-7 passed, deeming the scale inappropriate for children under 8 years of age (Marosszeky et al., 1993). The percentage of 6-7 year old children that correctly responded to each item of the scale is presented in Table 4. The questions correctly responded to by at least 90% of 6-7 year old children were: how old are you?, what time of day is it?, what is the name of this place?, recall of target face, recall of target name, and recall of three pictures.

Content Validity: No available information pertaining to children aged 7 and under.

***Construct Validity*:** No available information pertaining to children aged 7 and under.

***Concurrent Validity*:** No available information pertaining to children aged 7 and under.

***Predictive Validity*:** Two studies reported on the relationship between PTA duration, measured by the WPTAS, and TBI outcome. Neither of these studies reported exclusively on children aged 7 and under. At time of discharge, PTA duration correlated with gross functional outcome, however admission GCS had a stronger correlation with this outcome (correlations presented in Table 4) (Calvert et al., 2008).

With regard to long-term outcome, injury severity determined by GCS and/or PTA duration assessed on the WPTAS, predicted gross functional outcome at a median of 1.3 years following TBI. It must be noted, however, that GCS was primarily relied on as it was most available (PTA duration was only documented for 26/82 children). Children classified with a mild or moderate TBI were significantly more likely to have *good recovery* compared to those with a severe TBI, and only children with a severe TBI had *severe disability* at follow-up (Paget et al., 2012). The percentage of children in each severity classification that fell in these two outcome categories are presented in Table 4.

Reliability

No available information pertaining to children aged 7 and under.

Evaluation

The WPTAS is developmentally appropriate for children aged 8 years and older. There is some data supporting the scale's predictive validity, however the wide age ranges of the samples limit generalisability to very young children. The content, construct, and concurrent validity of the scale, as well as the reliability of the scale, have not been exclusively reported for children aged 7 and under.

COAT

Ewing-Cobbs et al. (1990) modified the adult Galveston Orientation and Amnesia Test (GOAT) for use with children aged 3-15 years, comprising 16 items in total. For children 3-7 years, a subset of 11 items are administered that assess three areas: general orientation (to person and place), temporal orientation, and memory (immediate, remote, and anterograde) (see Table 3 for specific items). For children 8-15 years, an additional five temporal orientation items are administered. The child is considered out of PTA on the first day he/she is able to obtain scores that are within normal range (two standard deviations of the age-appropriate mean) on two consecutive days. The duration of PTA is the number of days from the resolution of coma to the first of two consecutive days of normal COAT scores. Of the five studies reporting on the COAT, only that by Goldstrohm and Arffa (2005) exclusively reported on children aged 7 and under.

Validity

Developmental Validity: Three studies reported on the performance of non-head injured children; altogether presenting the responses of two samples of typically developing pre-school and school children (Ewing-Cobbs et al., 1990; Goldstrohm & Arffa, 2005) and two hospitalized samples without head injury (Baryza & Haley, 1994; Goldstrohm & Arffa, 2005). None of the studies detailed the pattern of responses to each individual item of the COAT. As a result, the age appropriateness of each item cannot be evaluated.

The authors of the scale (Ewing-Cobbs et al., 1990), did however, report that typically developing children under 8 could not reliably answer the temporal orientation items asking for: time (hour), day of week, day of month, month, and year. As a result, current administration guidelines instruct temporal orientation items to be administered only to children 8 years and above. The authors did not specify the accuracy rate to these

items by children under 8. No other information is provided regarding the age appropriateness of the other items.

The COAT was not developed with the criterion that one must be able to correctly respond to each and every item of the scale to be deemed out of PTA. Instead, the above mentioned studies obtained the means and standard deviations of their respective samples (presented in Table 4). Of the pre-school/school samples, one study provided norms for children aged 3-15 years. Presented in Table 4 are the means and standard deviations for each age group of interest (i.e. 4-, 5-, 6-, and 7-years). The second study (Goldstrohm & Arffa, 2005) reported the mean COAT score for children aged 3-6 years as a single group (presented in Table 4), which precludes age-specific analysis against the age-appropriate norms. Nevertheless, the total mean appears to be within normal range, using the norms of Ewing-Cobbs et al. (1990).

Comparison of the COAT scores of hospitalized non-head injured samples with community pre-school and school children revealed comparable scores, indicating that the COAT is not sensitive to the disorientation one may experience due to hospitalization and trauma (other than head trauma). Goldstrohm and Arffa (2005) found no difference between COAT scores of pre-school/school children and hospitalised non-head injured children (means and standard deviations presented in Table 4). Of the 25 children aged 5-15 years in Baryza and Haley's (1994) sample, only three children were within the targeted age range. Bearing in mind the very limited sample, the three children's scores (Table 4) were within normal range when examined against the norms presented by Ewing-Cobbs et al. (1990).

***Content Validity*:** The specificity of the COAT in assessing PTA is questionable. One study found that despite being out of PTA, children with TBI continued to have significantly lower COAT scores than two control groups: hospitalised non-head injured children and pre-school/school children (means are presented in Table 4) (Goldstrohm & Arffa, 2005). The poorer COAT scores of children with TBI may actually be a reflection of residual cognitive deficits following TBI; demonstrating the failure of the COAT to isolate the cardinal symptoms of PTA (disruptions to basic orientation and continuous memory). Furthermore, 6-months later, the TBI group demonstrated significantly more improvement on COAT orientation scores than the two control groups. Again, this may reflect improvement in residual deficits; as PTA was assumed resolved by the first time of testing.

Additionally, one study raised concern about the COAT giving false positive results (i.e. incorrectly classifying a child to be in PTA) particularly in children with mild TBI. Despite being out of PTA, four children in McDonald et al.'s (1994) study would have been classified with persistent PTA according to the COAT protocol. Furthermore, three of the four children were judged to have mild TBI according to other indices of injury severity. The ages of these children were not specified, and may have ranged anywhere between 6-15 years. Nevertheless, these results suggest there are problems evaluating the presence of PTA according to the COAT protocol.

Construct Validity: Only one study investigated the association between the COAT with another PTA measure, however the sample comprised children ranging 3-15 years. COAT scores obtained by children with TBI significantly correlated with scores on the adult version, the GOAT (Baryza & Haley, 1994). Comparison of pass rates on the two scales revealed that 18/23 children passed both scales. Contrary to expectations, of the five remaining children, majority of them (4/5) passed the adult GOAT scale but failed the COAT. The items children failed on the COAT were not specified. This finding suggests that the COAT is more difficult than the GOAT, and raises a possibility that the adult GOAT scale may be more appropriate for children than the COAT. Due to the limited information available, interpretation of these results is not possible.

Concurrent Validity: None of the studies reported exclusively on the concurrent validity of the COAT for children aged 7 and below, and instead included children ranging 4-15 (Ewing-Cobbs et al., 1990) and 6-16 years (Tremont et al., 1999). PTA duration measured by the COAT significantly correlated with other measures of injury severity, namely GCS on hospital admission (Ewing-Cobbs et al., 1990; Tremont et al., 1999), duration of impaired consciousness (Ewing-Cobbs et al., 1990), and length of unconsciousness (Tremont et al., 1999). Correlations are presented in Table 4.

Predictive Validity: None of the studies reported exclusively on the predictive validity of the COAT for children aged 7 and below, and instead included children ranging 4-15 (Ewing-Cobbs et al., 1990) and 6-16 years (Tremont et al., 1999). PTA duration measured by the COAT correlated with early measures of intellectual functioning (full scale, composite scores and factor scores), with stronger correlations than GCS and length of coma (Tremont et al, 1999). PTA duration also correlated more strongly than GCS with verbal and nonverbal memory 6 and 12 months post TBI, though

early measures were more strongly associated with GCS (correlations presented in Table 4) (Ewing-Cobbs et al.,1990).

Reliability

Inter-rater Reliability: None of the studies reported exclusively on the inter-rater reliability of the COAT for children aged 7 and below. Instead, the studies included children ranging 4-15 (Ewing-Cobbs et al., 1990) and 3-15 years (Baryza & Haley, 1994). Nevertheless, these studies demonstrated high inter-rater reliability of the COAT, with 98-100% agreement (Ewing-Cobbs et al., 1990; Baryza & Haley, 1994).

Evaluation

The COAT involves items addressing the core components of PTA, orientation and memory. There is limited information on the developmental validity of the items; the reviewed studies included children whose age ranged from 4 to 15 years, and failed to provide information about the patterns of responses to each individual item by the different ages. This precluded evaluation of the age-appropriateness of each item. Nonetheless, unlike majority of other PTA scales which require perfect scores, children are typically unable to elicit perfect scores on the COAT, thereby necessitating normative data in which normal scores are considered those within two standard deviations of the mean. Potentially, some of the items on the COAT may not be developmentally appropriate, and therefore incorrect responses may not actually be indicative of disrupted orientation or memory. Although the scores of the reviewed non-head injured samples fell within the normal range, this scoring method is critiqued as it allows a very large range of scores to fall within "normal" range (i.e. within 2 standard deviations of the mean), and also allows a child's responses to be variable from day to day which may reflect inadequate return of orientation and anterograde memory. For example, given there is only one single item to assess anterograde memory (i.e. asking for examiner's name), a patient may continually fail to provide a correct response to this item, reflecting disrupted continuous memory (a core feature of PTA), yet the scoring procedure may still consider the child out of PTA. Content validity of the COAT is also questionable, as children with TBI and resolved PTA continued to have significantly lower scores than non-head injured children, raising question about the specificity of the COAT in assessing PTA. In addition, children with resolved PTA following a mild TBI have been incorrectly classified to have persistent PTA. Bearing in mind the uncertain developmental and

content validity of the COAT, the COAT has been shown to have good clinical validity (construct, concurrent and predictive) and high inter-rater reliability.

Oxford-C (Ruijs et al., 1992)

Ruijs et al. (1992) adapted the adult Oxford Scale for use with children aged 3.5 – 10 years. Nevertheless, the protocol and materials are not published, which precludes wider clinical use. The items included in the scale, however, are reported in one of the studies (Ruijs et al., 1992). The Oxford-C scale contains 24 items assessing orientation (to person, time and place), anterograde and retrospective memory. Similar to other PTA scales, recall of pictures is assessed, however the specific administration procedure has not been provided. It is merely stated that "new pictures can be presented daily" (Ruijs et al., 1992, p.889); it is unclear whether a different set of distractors are used each day, or if targets and distractors are re-used. It is important to note that test administration is modified when used with children under 5 years of age. Instead of original items, familiar objects (toys, pets) or persons (relatives, acquaintances, nursing staff), and well-known children's television series and songs are used. The authors do not specify how these familiar items or people are used to replace the original items. PTA is considered to end when the patient answers all questions correctly on three consecutive days. The duration of PTA is the number of days from the day of injury to the first of three consecutive days of perfect scores.

Validity

Developmental Validity: The authors (Ruijs et al., 1992) sampled the scale on 70 healthy children aged 3.5-10 years, but did not describe the pattern of responses by each age group or to each item. The authors merely reported "there were no false-positive responses by any of the children at any point in the tests" (p.889).

***Content Validity*:** No available information.

***Construct Validity*:** No available information.

Concurrent Validity: No available information.

Predictive Validity: Predictive validity of the Oxford-C was examined in two studies with samples aged 2-8 (Ruijs et al., 1992) and 2-15 years (Ruijs et al.,1993). Both studies demonstrated that both PTA (measured by the Oxford-C) and coma duration

significantly correlated with a range of outcomes: gross functional outcome (Ruijs et al., 1992), neurological problems, personality changes and school problems, at various time points up to 2 years following discharge (Ruijs et al.,1993). The indicator that had a stronger correlation with each outcome is indicated in Table 4, however note that the differences were not large, leading to relatively equal predictive validity of the two indices. The only outcome that did not correlate with either of these indicators was the frequency of somatic symptoms (Ruijs et al., 1993).

Reliability

No available information.

Evaluation

The information that is available on the Oxford-C is very limited, making the scale difficult to evaluate. The information that is available, however, suggests variability in content and administration of the scale. Moreover, content, construct and concurrent validity of the scale have not been investigated. Nor has the reliability of the scale been examined. Similar to concerns raised on the adult GOAT scale, concern is raised about the items assessing recall of the accident (e.g. What happened? What were you doing? Were you unconscious?). The failure to recall the accident or trauma, even after PTA has resolved, is not uncommon in patients with TBI (Tate et al., 2000; Tate & Pfaff, 2000). It is therefore likely that children may experience difficulties with these questions, which is likely to inaccurately prolong PTA duration. Interestingly, however, the duration of PTA measured by the Oxford-C PTA scale was found to correlate with various outcomes.

Starship-PTA

The Starship PTA scale was developed for children aged 4-6 years, and comprises 12 items: 7 orientation items (time, place and person) and 5 items assessing anterograde memory. The Starship PTA scale involves recall of pictures as part of the anterograde memory assessment, however in contrast to the procedure of other PTA scales, target pictures and distracters are changed on a daily basis irrespective of whether the child correctly recalls all three targets. Similar to the COAT, perfect scores are not required to be considered out of PTA. In contrast to the COAT, however, scores within *one* standard deviation of the mean are considered normal scores. PTA is defined to end on the first of three consecutive days of normal scoring. Duration of PTA is the number of days from

the day of injury to the first of three consecutive days of normal scoring. Both studies reporting on the COAT involved samples aged 7 years and under (Fernando et al., 2002; Thickpenny-Davis et al., 2005).

Validity

Developmental Validity: The responses of both pre-school and school children, as well as a hospitalised non-head injured sample, were examined on each and every item of the scale. The pilot study found the scale was developmentally inappropriate for 3-year old children due to the great variability in their responses. Additionally, 10% of all 3-6 year old children were unable to answer the question "When is your birthday?", and therefore it was replaced with "What did you last have to eat?" (Fernando et al., 2002).

The responses of typically developing children were analysed for each and every item of the final scale. For every day of testing, the authors indicated the percentage of children in each age group that answered each question correctly (presented in Table 4). Most questions were correctly responded to by 90% of the sample in each age-group, with some exceptions by 4- and 5-year old children. Four-year old children experienced some difficulty with the items: "What did you last have to eat?", "Where are you?", and recall of target name; whilst both 4- and 5-year old children experienced difficulty recalling a different set of pictures on each day of testing. The means and standard deviations obtained from the two control samples are presented in Table 4. There were no significant differences between the scores of the two control samples. Although the authors originally expected that children could obtain perfect scores, children were unable to achieve this and therefore criterion of "normal" scores was re-evaluated to include scores within one standard deviation of the mean.

Content Validity: No empirical data was provided on the content validity of the Starship PTA scale. It was however noted by the authors that development of the orientation items involved consultation with various health professionals experienced in the pediatric field, including speech therapists, occupational therapists and neuropsychologists. The content of the scale was examined by a cultural advisor, who deemed the scale appropriate for children of all cultures provided that their English fluency was equivalent to peers of the same age (Fernando et al., 2002).

Construct Validity: No available information.

Concurrent Validity: No available information.

Predictive Validity: Only one study reported on the predictive validity of PTA duration measured by the Starship PTA scale. The combination of PTA duration and initial GCS predicted memory and learning two months post TBI in 19 children aged 3-7 years; furthermore, PTA duration contributed most to the model (Thickpenny-Davis et al., 2005). Neither PTA duration nor initial GCS predicted any of the other cognitive or psychosocial outcomes measured.

Reliability

No available information.

Evaluation

The Starship PTA scale was the first to focus on younger children. Item analysis was conducted to examine the developmental appropriateness for each item. Although the Starship PTA scale is purported for children aged 4-6 years, the item analysis suggests that some items are not developmentally appropriate for children aged 4-5. Similar to the COAT, the scoring procedure factors in these possible errors and scores are evaluated against age-appropriate norms. Nevertheless, the scale falls short of an ideal method in which all items are developmentally appropriate and therefore children would typically be able to obtain perfect scores. In clinical practice, and particularly with TBI of mild severity, it may be difficult to discern whether errors are due to the developmental inappropriateness of the item/s, or actually due to mild disruptions in orientation or memory. Because of this, the scale may be most applicable in assessing and monitoring PTA in moderate to severe TBI. In comparison to the COAT, however, the Starship PTA scale is suggested to result in less chance of a false negative, as criterion limits normal scores to be within one standard deviation, rather than two as used in the COAT. There is some evidence of predictive validity, though the evidence was limited and involved a small sample size (n=19). The content, construct and concurrent validity of the scale, as well as the reliability of the scale, have not been investigated.

WPTAS-C

The widely used adult WPTAS was modified by Rocca et al. (2008) to develop the WPTAS-C, a version for use with children aged 4 and 5 years. The WPTAS-C comprises 5 items: two orientation questions (to person and place), and three items assessing

continuous memory. In contrast to other PTA scales, the WPTAS-C includes recall of only two target pictures rather than three. The target pictures are renewed each time the child obtains a full score on the scale. The authors state that the child is "presented with two new target pictures from a different set" (p.19); it is presumed from this statement that each new set of targets involve a different set of distracters. PTA is considered resolved once three consecutive perfect scores are obtained. PTA duration is the number of days from the day of injury to the first of three consecutive days of obtaining perfect scores. Only one study reported on the WPTAS-C, which reported on separate samples all aged 7 years and under (Rocca et al., 2008).

Validity

***Developmental Validity*:** The developmental validity of the items were examined in three different samples (Rocca 2001; cited in Rocca et al., 2008). First, the responses to the items of the adult WPTAS were examined (accuracy rates are presented in Table 4). Subsequent samples were only administered the orientation items that were developmentally appropriate (age, place), and a few variations of the picture task, which included provision of cues and reducing the number of target pictures to two. The percentage of children that passed each variant of the scale is reported in Table 4. These results guided the final WPTAS-C scale, which 93% of a subsequent 4-5 year old sample passed, i.e. obtained perfect scores on all four days tested (Rocca et al., 2008).

Content Validity: No available information

Construct Validity: No available information.

Concurrent Validity: No available information.

Predictive Validity: No available information.

Reliability

No available information.

Evaluation

Whilst there is adequate data supporting the developmental validity of the WPTAS-C, it is appropriate for a very limited age range of 4-5 years and validation studies are needed. The content, construct, concurrent and predictive validity of the scale, as well as the reliability of the scale, have not been investigated.

Table 3

Item Description of Post Traumatic Amnesia (PTA) Scales for Children

Scale	Age Range (Years)	Orientation Items	Memory Items	Total Number of Items
Children's Orientation and Amnesia Test (COAT; Ewing-Cobbs et al., 1979)	3-15	What is your name? How old are you? / When is your birthday? Where do you live? What is your father's name? / What is your mother's name? What school do you go to? What grade are you in? Where are you now? Is it daytime or night-time? Temporal Orientation Items (administer if age 8-15) What time is it now? What day of the week is it? What day of the month is it? What is the month? What is the year?	Immediate / Working: Say these numbers after me in the same order. (number presented verbally) How many fingers am I holding up? (3 sets administered: 2, 3, & 10 fingers) Remote: Who is on Sesame Street? Anterograde: What is my name?	16
Oxford Scale for Children (Oxford-C; Ruijs et al., 1992)	3.5-10	What is your name? How old are you? When is your birthday? How many brothers and sisters do you have? Do you go to school? Which grade are you in? Do you know where you are right now? How long have you been here? What have you just done / eaten? What did you do yesterday? Visitors/Tests?	Retrograde: What happened? How/when did it happen? What were you doing? What were you doing before? Were you unconscious? Did you sleep? When did you wake up Where were you then? What happened then? Anterograde: Recall picture 1 Recall picture 2 Recall picture 3 Recall examiner's name	24
Starship PTA (Fernando et al., 2002)	4-6	How old are you? What did you last have to eat? Where do you live? Where are you? Why are you in hospital? What is your mother's / father's name? Is it daytime or night time?	Anterograde: Face recognition (picture of a girl) Recall of girl's name Recall picture 1 Recall picture 2 Recall picture 3	12
Westmead PTA Scale for Children (WPTAS-C; Rocca et al., 2008)	4-5	How old are you? What is the name of this place?	Anterograde: Do you remember me? What is my name? Recall picture 1 Recall picture 2	6

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
WPTAS								
Developmental Validity	Marosszeky et al. (1993)	20 H-nonTBI †	Inclusion: 1) able to converse in English 2) no Hx of CNS dysfunction Exclusion: 1) Hx of psychiatric illness 2) Hx of of significant learning or academic difficulties 3) suspected abuse	6-7	N/A	N/A	Pass rate (Percentage of children that obtained perfect scores on all days of testing)	15% passed
							Accuracy rate to each orientation item obtained on first day of testing (Percentage of children that correctly responded)	Orientation Items / Day 1 Q1 100% Q2 20% Q3 80% Q4 95% Q5 80% Q6 80% Q7 100%
							Percentage of children that responded correctly to each memory item on all days of testing.	Memory items / 3 Days Q8-9 100% Q10-12 90%

CNS= central nervous system, HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, Hx= history, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, Q1= How old are you?, Q2= What is your date of birth?, Q3= What month are we in?, Q4= What time of day is it? (morning, afternoon or night), Q5= What day of the week is it?, Q6= What year are we in?, Q7= What is the name of this place?, Q8-9= recall of examiner's face and name, Q10-12, recall of a new set of 3 target pictures on each day of testing, TBI= traumatic brain injury, WPTAS= Westmead PTA Scale, †subset of larger sample.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
WPTAS								
Content Validity	*Nil available*							
Construct Validity	*Nil available*							
Concurrent Validity	*Nil available*							

N= number of participants, PTA=post traumatic amnesia, TBI= traumatic brain injury, WPTAS= Westmead PTA Scale.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
WPTAS								
Predictive Validity	Calvert et al. (2008)	44 TBI† (subset of 81)	Inclusion: 1) hospital admission with TBI	6-16	Mild to severe.	Discharge	Functional (KOSCHI)	Correlated; GCS > PTA PTA τ = -.32 P< .007 GCS τ = .53 p =<.001
	Paget et al. (2012)	82 TBI† (subset of 97, excluded children 5 and under as no PTA duration was available)	Inclusion: 1) hospital admission with TBI	IQR: 3 – 13 Median: 7.9	Mild to severe. .	Median= 1.3 years IQR: 0.2 - 4.6 years	Functional (KOSCHI)	Predicted; Injury severity based on PTA duration and/or GCS predicted KOSCHI outcome. Higher likelihood of mild-moderate TBI having good recovery, compared to severe TBI, p= .028. TBI severity: Mild — Good recovery: 63% TBI severity: Moderate — Good recovery: 64% TBI severity: Severe — Good recovery: 33% TBI severity: Mild — Severe disability: 0% TBI severity: Moderate — Severe disability: 0% TBI severity: Severe — Severe disability: 8%
Inter-rater Reliability	*Nil available*							

GCS= Glasgow Coma Scale at hospital admission, Hx= history, KOSCHI = King's Outcome Scale for Childhood Head Injury, N= number of participants, PTA=post traumatic amnesia, TBI= traumatic brain injury, WPTAS= Westmead PTA Scale, ">"= stronger correlation, †subset of larger sample, τ= Kendall's Tau b non-parametic correlation coefficient.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
COAT								
Developmental Validity	Ewing-Cobbs et al. (1990)	146 HC	Inclusion: - enrolled in standard preschool or academic programs - no Hx of neurological deficit	3-15	N/A	N/A	Responses to temporal orientation items.	High variability in responses by children under 8 years of age. Temporal orientation items not appropriate for children under 8.
		73 HC†	As above.	4-7	N/A	N/A	COAT means & SDs provided, stratified by age. Normal scores are within 2 SDs of mean.	Age n Mean SD 4 26 59.4 12.6 5 25 61.6 8.5 6 12 64.1 6.3 7 10 68.3 8.5
	Goldstrohm & Arffa (2005)	34 HC & 33 H-nonTBI	HC Inclusion: - Not in first grade at time of initial assessment. H-nonTBI Inclusion: - Hospitalized with mild-moderate injuries to other body regions	3-6	N/A	N/A	Comparison of group COAT means: HC vs. H-nonTBI	HC = H-nonTBI Group Mean SD HC 119.19 11.76 H-nonTBI 115.87 13.13
	Baryza & Haley (1994)	3 H-nonTBI†	Inclusion: - non-neurological traumatic injury that resulted in hospitalization.	5-7	N/A	D/C	Rate of normal scoring	100% achieved normal scores Age n Mean SD 5 1 67 - 7 2 74 9.9

COAT= Children's Orientation and Amnesia Test, D/C= discharge, HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, Hx= history, n= number of participants, N/A= not applicable, PTA=post traumatic amnesia, SD= standard deviation, TBI= traumatic brain injury, vs. = versus/compared to, "="equal mean scores, †subset of larger sample.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
COAT								
Content Validity	Goldstrohm & Arffa (2005)	29 TBI & 34 HC & 33 H-nonTBI	TBI Inclusion: 1) admitted to paediatric trauma unit with mild to moderate TBI TBI Exclusion: 1) pre-existing medical or neurological disorder 2) pre-existing severe psychiatric disorder 3) pre-existing mental retardation or severe neurological/cognitive problems 4) history of abuse HC & H-nonTBI (see above under developmental validity)	3-6	Mild to moderate.	When deemed "medically stable", time not specified. 6 months after initial Ax.	Comparison of group COAT means: TBI vs. H-nonTBI TBI vs. HC Comparison of group improvements on COAT full score, orientation and memory scores since initial Ax.	TBI < HC & H-nonTBI. Group / Mean / SD TBI 94.15 20.27 HC 119.19 11.76 H-nonTBI 115.87 13.13 Improvement in full COAT: TBI > H-nonTBI Improvements in orientation: TBI > HC & H-nonTBI Improvement in memory: TBI = HC = H-nonTBI
	McDonald et al. (1994)	98 TBI	Inclusion:. 1) sustained a closed head injury resulting in LOC 2) identified upon presentation to the emergency department of two regional medical centers. Exclusion: 1) premorbid IQ of 75 or less 2) Hx of major psychiatric disturbance requiring hospitlisation 3) non-English speaking 4) previous TBI requiring hospitalisation 5) suspected physical abuse 7) pre-existing major motor impairment 7) residence outside western Washington	6-15	Mild to severe.	Acute stage	Rate of false positives	4% (4/98) children would have been incorrectly classified with persistent PTA.

COAT= Children's Orientation and Amnesia Test, D/C= discharge, HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, Hx= history, IQ= intelligence quotient, LOC = loss of consciousness, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, SD= standard deviation, TBI= traumatic brain injury, vs. = versus/compared to, "="equal mean scores, "<" = significantly lower mean score, ">" = significantly higher mean score.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
COAT								
Construct Validity	Baryza & Haley (1994)	23 TBI†	TBI Inclusion: not specified	Subset not specified (entire sample: 3-15)	Not indicated	D/C	GOAT scores	Correlated: r = .91, p< .001
							GOAT pass rate	18/23 (78%) passed both COAT and GOAT. 19/23 (83%) passed COAT. 22/23 (96%) passed GOAT.
Concurrent Validity	Ewing-Cobbs et al. (1990)	37 TBI	Inclusion: 1) no previous head injury 2) no other acquired or congenital insults to the CNS 3) adequate school achievement before injury 4) primary language is English.	4-15 Note: 38% (14/37) aged 4-7	Mild to severe	Acute stage	GCS on admission Duration of impaired consciousness	Correlated: r = -.61, p< .001 Correlated: r = .48, p< .001

CNS= central nervous system, COAT= Children's Orientation and Amnesia Test, D/C= discharge, GCS= Glasgow Coma Scale, GOAT= Galveston Orientation and Amnesia Test, N = number of participants, N/A= not applicable, PTA=post traumatic amnesia, r = Pearson product-moment correlation coefficient, TBI= traumatic brain injury, †subset of larger sample.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
COAT								
Predictive Validity	Tremont et al. (1999)	30 TBI	Inclusion: 1) consecutive hospital admissions with TBI	6-16	Mild to severe	Resolution of PTA	Intellectual functioning (WISC-III)	
							Full scale IQ	Correlated; PTA > GCS & LC PTA r= -.61 p< .01 GCS r= .30 p = ns LC r= -.52 p< .01
							Verbal IQ	Correlated; PTA > GCS & LC PTA r= -.55 p< .01 GCS r= .33 p< .05 LC r= -.45 p< .01
							Performance IQ	Correlated; PTA > GCS & LC PTA r= -.54 p< .01 GCS r= .19 p = ns LC r= -.47 p< .01

COAT= Children's Orientation and Amnesia Test, GCS= Glasgow Coma Scale at hospital admission, IQ = intelligence quotient, LC = length of coma, N= number of participants, ns = not significant, PTA=post traumatic amnesia, r = Pearson product-moment correlation coefficient, TBI= traumatic brain injury, WISC-III = Wechsler Intelligence Scale for Children- Third Edition, ">" = stronger correlation.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
COAT								
Predictive Validity	Tremont et al. (1999) (cont.)	30 TBI	Inclusion: 1) consecutive hospital admissions with TBI	6-16	Mild to severe	Resolution of PTA	Intellectual functioning (WISC-III)	
							Perceptual organization	Correlated; PTA > GCS & LC PTA r= -.48 p< .01 GCS r= .28 p = ns LC r= -.45 p< .01
							Verbal comprehension	Correlated; PTA > GCS & LC PTA r= -.52 p< .01 GCS r= .12 p = ns LC r= -.42 p< .01
							Processing speed	Correlated; PTA > GCS & LC PTA r= -.45 p< .01 GCS r= .09 p = ns LC r= -.38 p< .05
							Freedom from distractibility	Correlated; PTA > GCS & LC PTA r= -.52 p< .01 GCS r= .27 p = ns LC r= -.36 p< .05

COAT= Children's Orientation and Amnesia Test, GCS= Glasgow Coma Scale at hospital admission, LC = length of coma, N= number of participants, ns = not significant, PTA=post traumatic amnesia, r= Pearson product-moment correlation coefficient, TBI= traumatic brain injury, WISC-III = Wechsler Intelligence Scale for Children- Third Edition, ">" = stronger correlation.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
COAT								
Predictive Validity	Ewing-Cobbs et al. (1990)	37 TBI	Inclusion: 1) no previous head injury 2) no other acquired or congenital insults to the CNS 3) adequate school achievement before injury 4) primary language is English.	4-15	Mild to severe.	Resolution of PTA	Verbal memory (VSLT)	Correlated; GCS > PTA PTA r= -.37 p= .013 GCS r= .52 p = .001
							Non-verbal memory (NSLT)	Did not correlate; GCS > PTA PTA r= -.10 p= .30 GCS r= .29 p = .07
						6 months after injury	Verbal memory (VSLT)	Correlated; PTA > GCS PTA r= -.45 p= .003 GCS r= .03 p = .43
							Non-verbal memory (NSLT)	Correlated; PTA > GCS PTA r= -.62 p= .001 GCS r= .40 p = .018
						12 months after injury	Verbal memory (VSLT)	Correlated; PTA > GCS PTA r= -.31 p= .031 GCS r= .28 p = .049
							Non-verbal memory (NSLT)	Correlated; PTA > GCS PTA r= -.55 p= .001 GCS r= .35 p = .036

CNS= central nervous system, COAT= Children's Orientation and Amnesia Test, GCS= Glasgow Coma Scale at hospital admission, Hx= history, N= number of participants, NSLT= Nonverbal Selective Reminding Test, PTA=post traumatic amnesia, r = Pearson product-moment correlation coefficient, TBI= traumatic brain injury, VSLT= Verbal Selective Reminding Test, ">" = stronger correlation.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
COAT								
Inter-rater Reliability	Ewing-Cobbs et al. (1990)	11 TBI †	1) no previous head injury 2) no other acquired or congenital insults to the CNS 3) adequate school achievement before injury 4) primary language is English.	Subset not specified (entire sample: 4-15)	Mild to severe	Subacute stage of recovery	COAT scoring by two different raters	$\alpha = 0.98$
	Baryza & Haley (1994)	5 TBI†	TBI Inclusion: not specified	Subset not specified (entire sample: 3-15)	Not indicated	D/C	COAT scoring by two different raters	100% agreement

CNS= central nervous system, COAT= Children's Orientation and Amnesia Test, D/C= discharge, Hx= history, N= number of participants, PTA=post traumatic amnesia, TBI= traumatic brain injury, †subset of larger sample.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
Oxford Scale for Children								
Developmental Validity	Ruijs, Keyser, & Gebreels (1992)	70 HC	Not indicated.	3.5 – 10	N/A	N/A	Rate of false positives	0%
Content Validity	*Nil available*							
Construct Validity	*Nil available*							
Concurrent Validity	*Nil available*							
Predictive Validity	Ruijs, Keyser, & Gebreels (1992)	25 TBI	Inclusion: 1) hospital admission; 2) closed head injury; 3) diagnosis of 'concussion of the brain' Exclusion: 1) local brain-damage (e.g. intracranial haematomas, depressed skull fractures, penetrating wounds; 2) neurosurgical intervention; 3) Hx of neurological or neuropsychological disturbances, or head trauma.	2-8	Mild to severe.	D/C 3months post D/C 12 months post D/C 24 months post D/C	Functional (GOS) Functional (GOS) Functional (GOS) Functional (GOS)	Correlated; PTA > coma duration PTA r= -.80* Coma duration r= -.75* Correlated; Coma duration > PTA PTA r= -.69* Coma duration r= -.72* Correlated; Coma duration > PTA PTA r= -.38* Coma duration r= -.59* Correlated; Coma duration > PTA PTA r= -.52* Coma duration r= -.59*

D/C= discharge, GOS= Glasgow Outcome Scale, HC= Healthy Control/Typically Developing Children, Hx= history, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, , r = correlation coefficient, TBI= traumatic brain injury, ">" = stronger correlation, * significant at p< .05 level.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
Oxford Scale for Children								
Predictive Validity	Ruijs, Gabreels, & Keyser (1993)	54 TBI	Inclusion: 1) hospital admission; 2) closed head injury; 3) diagnosis of 'concussion of the brain' Exclusion: 1) local brain-damage (e.g. intracranial haematomas, depressed skull fractures, penetrating wounds; 2) neurosurgical intervention; 3) Hx of neurological or neuropsychological disturbances, or head trauma.	2-15	Mild to severe	D/C	Neuropsychological/ neurological problems	Correlated; PTA > coma duration PTA r= .81** Coma duration r= .78**
							Personality changes	Correlated; PTA > coma duration PTA r= .75** Coma duration r= .60**
							Somatic symptoms	Did not correlate; PTA = coma duration PTA r= ns Coma duration r= ns
						3 months post DC	Neuropsychological/ neurological problems	Correlated; PTA > coma duration PTA r= .78** Coma duration r= .77**
							Personality changes	Correlated; PTA > coma duration PTA r= .61** Coma duration r= .56**
							School problems	Correlated; PTA > coma duration PTA r= .75** Coma duration r= .61**
							Somatic symptoms	Did not correlate; PTA = coma duration PTA r= ns Coma duration r= ns

D/C= discharge, Hx= history, N= number of participants, ns= non-significant correlation at p> .05, PTA=post traumatic amnesia, r = correlation coefficient, TBI= traumatic brain injury, ">" = stronger correlation, * significant at p< .01 level.

Table 4
Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
Oxford Scale for Children								
Predictive Validity	Ruijs, Gabreels, & Keyser (1993)	54 TBI	Inclusion: 1) hospital admission; 2) closed head injury; 3) diagnosis of 'concussion of the brain' Exclusion: 1) local brain-damage (e.g. intracranial haematomas, depressed skull fractures, penetrating wounds; 2) neurosurgical intervention; 3) Hx of neurological or neuropsychological disturbances, or head trauma.	2-15	Mild to severe	6 months post D/C	Neuropsychological/ neurological problems	Correlated; Coma duration > PTA PTA r= .66** Coma duration r= .69**
							Personality changes	Correlated; PTA > coma duration PTA r= .60** Coma duration r= .48**
							School problems	Correlated; PTA > coma duration PTA r= .68** Coma duration r= .66**
							Somatic symptoms	Did not correlate; PTA = coma duration PTA r= ns Coma duration r= ns
						12 months post D/C	Neuropsychological/ neurological problems	Correlated; PTA = coma duration PTA r= .69** Coma duration r= .69**
							Personality changes	Correlated; PTA > coma duration PTA r= .56** Coma duration r= .50**

D/C= discharge, GCS= Glasgow Coma Scale, Hx= history, N= number of participants, N/A= not applicable, ns= non-significant correlation at p> .05, PTA=post traumatic amnesia, r = correlation coefficient, TBI= traumatic brain injury, ">" = stronger correlation, ** significant at p< .01 level.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
Oxford Scale for Children								
Predictive Validity	Ruijs, Gabreels, & Keyser (1993)	54 TBI	Inclusion: 1) hospital admission; 2) closed head injury; 3) diagnosis of 'concussion of the brain' Exclusion: 1) local brain-damage (e.g. intracranial haematomas, depressed skull fractures, penetrating wounds; 2) neurosurgical intervention; 3) Hx of neurological or neuropsychological disturbances, or head trauma.	2-15	Mild to severe	12 months	School problems	Correlated; Coma duration > PTA PTA r= .75** Coma duration r= .81**
							Somatic symptoms	Did not correlate; PTA = coma duration PTA r= ns Coma duration r= ns
						24 months post D/C	Neuropsychological/ neurological problems	Correlated; Coma duration > PTA PTA r= .70** Coma duration r= .73**
							Personality changes	Correlated; PTA > coma duration PTA r= .50** Coma duration r= .49**
							School problems	Correlated; Coma duration > PTA PTA r= .76** Coma duration r= .80**
							Somatic symptoms	Did not correlate; PTA = coma duration PTA r= ns Coma duration r= ns
Inter-rater reliability	*Nil available*							

D/C= discharge, GCS= Glasgow Coma Scale, Hx= history, N= number of participants, N/A= not applicable, ns= non-significant correlation at p> .05, PTA=post traumatic amnesia, r = correlation coefficient, TBI= traumatic brain injury, ">" = stronger correlation, ** significant at p< .01 level.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
Starship PTA								
Developmental Validity	Fernando, Eaton, Faulkner, Moodley, & Setchell (2002)	20 H-nonTBI (pilot sample)	Inclusion: 1) age-appropriate level in English 2) no psychiatric Hx 3) no significant learning or academic difficulties 4) no documented Hx of CNS dysfunction	3-6	N/A	N/A	Age-appropriateness of items (pilot study)	3-year old children obtained 2-7 correct on the 7 orientation items 10% of all children unable to atate their birthday. Replaced with "What did you last have to eat?"
		129-146 HC (n varied on days due to school absence)	Inclusion: 1) age-appropriate level in English 2) no psychiatric Hx 3) no significant learning or academic difficulties 4) no documented Hx of CNS dysfunction	4-6	N/A	N/A	Range of accuracy rates obtained across 4 days of testing (percentage of children that correctly responded)	Age (years) Item / 4 / 5 / 6 Q1: 96-100 / 98-100 / 100 Q2: 89-100 / 97-100 / 98-100 Q3: 79-96 / 92-97 / 97-100 Q4: 100 / 95-100 / 95-98 Q5: 97-100 / 96-100 / 100 Q6: 92-95 / 96-100 / 100 Q7: 94-97 / 95-100 / 97-100 Q8: 73-88 / 90-97 / 91-97 Q9: 81-96 / 86-100 / 92-100

CNS= central nervous system, HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, Hx= history, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, Q1= How old are you?, Q2= What did you last have to eat?, Q3= Where are you?, Q4= Where do you live?, Q5= What is your mother's/father's name?, Q6= Is it day time or night time?, Q7= recall of target face, Q8= recall of target name, Q9= recall of three pictures, SDs= standard deviations, TBI= traumatic brain injury.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
Starship PTA								
Developmental Validity	Fernando, Eaton, Faulkner, Moodley, & Setchell (2002)	129-146 HC (n varied on days due to school absence)	Inclusion: 1) age-appropriate level in English 2) no psychiatric Hx 3) no significant learning or academic difficulties 4) no documented Hx of CNS dysfunction	4-6	N/A	N/A	Age-appropriate means and SDs. Note: Only 6/7 questions asked. "Why are you in hospital?" was not administered to HC sample.	Day of Testing / 4 years Mean (SD) / 5 years Mean (SD) / 6 years Mean (SD) 1: 5.03 (0.56) / 5.03 (0.45) / 6.00 (0.37) 2: 10.23 (1.17) / 10.70 (0.55) / 10.68 (0.56) 3: 10.41 (1.06) / 10.70 (0.59) / 10.79 (0.52) 4: 10.50 (0.88) / 10.56 (0.74) / 10.72 (0.69)
		11-27 H-nonTBI (n varied on days due to hospital discharge)	Inclusion: 1) age-appropriate level in English 2) no psychiatric Hx 3) no significant learning or academic difficulties 4) no documented Hx of CNS dysfunction	4-6	N/A	N/A	Age-appropriate means and SDs	Day of Testing / 4 years Mean (SD) / 5 years Mean (SD) / 6 years Mean (SD) 1: 6.09 (0.98) / 5.92 (1.26) / 6.67 (0.58) 2: 11.30 (1.06) / 10.15 (0.73) / 12.00 (0.00) 3: 11.57 (1.13) / 10.50 (0.79) / 12.00 (0.00) 4: 10.00 (n/a; n=1) / 11.00 (0.83) / 12.00 (0.00)

CNS= central nervous system, HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, Hx= history, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, SDs= standard deviations, TBI= traumatic brain injury

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
Starship PTA								
Content Validity	*Nil available*							
Construct Validity	*Nil available*							
Concurrent Validity	*Nil available*							
Predictive Validity	Thickpenny-Davis, Ogden, & Fernando (2005)	19 TBI	Inclusion: 1) admitted to hospital between May and October 1999 with a closed TBI 2) GCS of 14-15 and LOC<10mins 3) no previously diagnosed neurological condition or prior TBI that resulted to an alteration of consciousness 4) age-appropriate English 5) no documented developmental disorders causing cognitive impairment 6) No Hx of serious premorbid behavioural or psychosocial problems or psychiatric illness.	3-7	Mild to moderate	2 months	Memory & Learning (NEPSY) Attention/Executive Functioning (NEPSY) Visuospatial processing (NEPSY) Psychosocial (CBCL)	Predicted; Combined PTA and GCS: $R^{2=}$ 42 p= .016 Contribution of PTA > GCS Did not predict Did not predict Did not predict
Inter-rater Reliability	*Nil available*							

CBCL= Child Behavior Checklist, D/C= discharge, GCS= initial Glasgow Coma Scale (at scene of injury or hospital admission), Hx= history, LOC = loss of consciousness, N= number of participants, NEPSY=A Developmmental Neuropsychological Assessment, PTA=post traumatic amnesia, $R^{2=}$ accounted variance, TBI= traumatic brain injury, ">" = better predictor.

Table 4

Characteristics of PTA Scales for Children

Scale & Psychometric Property	Study	N & Sample Type	Inclusion / Exclusion Criteria	Age (Years)	TBI Severity	Time Post TBI	Outcome Measured	Results
WPTAS-C								
Developmental Validity	Rocca (2001; cited in Rocca et al., 2008) Note: Original 2001 source is an unpublished honours thesis.	46 HC	Inclusion: 1) enrolled in kindergarten / pre-school Note: Other details not specified. (Original source is an unpublished honours thesis.)	3y 11m – 6y 2m	N/A	N/A	Response accuracy rate to WPTAS items (Percentage of children that correctly responded)	Temporal orientation items (month, time of day, day, year) 55% Hold old are you? 98% What is the name of this place? 93% Target face (examiner) 100% Target name 98% 3 pictures on all days 0%
		26 HC	As above.	4-5	N/A	N/A	Pass rate to WPTAS-C with trialled variations to picture task (i.e. provision of cue, 3vs. 2 pictures):	Picture task Cue provided to recall 3 pictures < 5% Cue provided to recall 2 pictures >95%
		20 HC	As above.	4-5	N/A	N/A	Pass rate to WPTAS-C with provision of cue and 2 pictures.	Picture task Cue provided to recall 2 pictures 95%

HC= Healthy Control/Typically Developing Children, H-nonTBI= hospitalised children for non-neurological trauma, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, SDs= standard deviations, TBI= traumatic brain injury, WPTAS= Westmead PTA Scale, WPTAS-C= Westmead PTA Scale for Children.

Table 4
Characteristics of PTA Scales for Children

Scale & Psychometric Property	**Study**	**N & Sample Type**	**Inclusion / Exclusion Criteria**	**Age (Years)**	**TBI Severity**	**Time Post TBI**	**Outcome Measured**	**Results**
WPTAS-C								
Developmental Vallidity	Rocca, Wallen, & Batchelor (2008)	55 HC	Inclusion: 1) typically developing 2) adequate English	4-5	N/A	N/A	Pass rate to final WPTAS-C (i.e. without cue for picture task. Recognition procedure layed out 6 cards)	93% (51/55) passed. 7% (4/55) failed. - 3 failed picture recall - 1 failed examiner's name Note: Short of study's initial aim of obtaining a 95% pass rate
Content Validity	*Nil available*							
Construct Validity	*Nil available*							
Concurrent Validity	*Nil available*							
Predictive Validity	*Nil available*							
Inter-rater Reliability	*Nil available*							

HC= Healthy Control/Typically Developing Children, N= number of participants, N/A= not applicable, PTA=post traumatic amnesia, WPTAS-C= Westmead PTA Scale for Children.

Discussion

The aim of the current review was to identify published studies that provide evidence of psychometric features for the PTA scales that have been used with children aged 7 years or below. Psychometric properties of interest were data regarding: 1) measures on developmental, construct, concurrent, and predictive validity; and 2) measures on the reliability of the scales. Review of this literature revealed five scales that have been used with children aged 7 years and below, however only two of these scales were specifically developed for young children aged 7 years and under: Starship PTA scale for children 4-6 years (Fernando et al., 2002) and WPTAS-C for children 4-5 years (Rocca et al., 2008). Our review indicates that these psychometric properties are only partially available for all of the scales.

Common to all scales was the inclusion of orientation and memory items that aimed to assess disruptions to these functions, which are the cardinal features of PTA. Ideally, all the items included in a PTA scale should be answered correctly by healthy children in the first instance. Such a selection of items would eliminate confusion and misclassification of children as being in PTA when they are not, which can occur when developmental norms are used. Due to differences in development, items included in child scales may differ from items of adult scales, even when they measure the same construct. For example, assessment of temporal orientation in adults may involve questions asking the day of week, month or the year. These questions however are not appropriate for preschool aged children who are yet developing their concept of time. Inclusion of developmentally inappropriate items inherently compromise the content validity of the scale; as incorrect responses to these items are unlikely capturing disruptions to presumed normal orientation or memory functions, and may rather be reflective of normal cognitive developmental variations. The COAT and Starship PTA scales are prone to these misinterpretations. Children are typically unable to obtain perfect scores on these two scales, which has necessitated the establishment of age-appropriate norms which scores are compared to. It would be more useful to develop a scale that isolates PTA symptoms, by including items that can be typically answered by the targeted age groups, and therefore errors can be more confidently interpreted as disruptions to orientation and/or memory. To achieve this, it is crucial to determine whether each item included in a scale is developmentally appropriate for the scale's targeted age groups. The WPTAS-C was the only scale that demonstrated all items comprising the scale to be developmentally

appropriate for the purported age group of 4-5 years. That is, 4- and 5-year old children experienced little difficulty, providing correct answers to each and every item of the scale.

No study explicitly investigated the content validity of any scale using statistical procedures, such as factor analysis. The items comprising the Starship PTA scale, however, were selected based on expert judgement of various pediatric health professionals and a cultural adviser. Nevertheless, item analyses raised doubt on the developmental appropriateness of specific questions. Concern was raised about whether the COAT was specific in isolating PTA symptoms, as children with resolved PTA continued to score significantly lower than non-head injured children, and some were misclassified to be in PTA. The COAT was also suspected to lack sensitivity in identifying ongoing disruptions to continuous memory, as there is only one item assessing this dimension of PTA which does not necessitate a correct answer to be deemed out of PTA.

In addition to adequate developmental and content validity, it is paramount that PTA scales also demonstrate that they are sensitive to TBI severity. That is, PTA duration measured by the scale should correlate with other TBI severity indicators (concurrent validity). Only the COAT had been evaluated for concurrent validity, and correlated with other classic indicators of injury severity, admission GCS and duration of impaired consciousness.

Demonstration of construct validity was absent for all scales, with the exception of the COAT which correlated highly with the GOAT (adult version of the scale). It was found, however, that more children failed the COAT than the GOAT, which suggests that adult version of the scale is easier and warrants item analyses to elucidate which items on the COAT may be problematic. Unfortunately, item analyses could not be conducted with respect to these findings as the information was not provided.

Early prediction of outcome aids clinicians to make decisions regarding treatment and rehabilitation needs. Predictive validity was strongest for the COAT, which was demonstrated to be more strongly associated with intellectual functioning than admission GCS and length of coma, and more strongly associated with verbal and nonverbal memory than admission GCS. There was limited support for the Starship PTA scale being a slightly better predictor than initial GCS, though for only one of the four outcome areas measured. All other scales, except for the WPTAS-C, were demonstrated to be no better a

predictor than other TBI severity indices examined. For example, the Oxford-C was found to have relatively equal predictive validity as coma duration, and the WPTAS was relatively equal to admission GCS. The predictive validity of the WPTAS-C had not been examined. Lastly, inter-rater reliability has only been reported for the COAT.

In summary, although most validation studies have been conducted with the COAT with supporting results, strong concerns surround the scale's developmental and content validity. In contrast, the WPTAS-C has appropriate developmental validity, though lacks any other validation studies. Although the WPTAS-C has potential to be the most promising scale, it is limited for use with 4-5 year old children, leaving a gap in the assessment of PTA in children 6-7 years. Clearly, further research and development is needed.

A main limitation of the current study was the failure to consistently isolate information pertaining to the targeted age range, particularly with studies reporting on the COAT, Oxford-C, and WPTAS, which often included children up to the age of 16 years. Although data for children aged 7 years or younger could be extracted in some studies, they often constituted a very small sub-sample and hence the data and generalisability of the results on these particular scales were very limited. This highlights the lack of research in the assessment of PTA in young children.

The collective results of the current review have certain clinical implications. At present, best practice would require different scales being used for different and limited age groups. Of the scales specifically developed for children, only the COAT is available for 7-year old children. Despite concerns about the developmental and content validity of the scale, it remains the currently best scale available for 7-year old children. For 6-year old children, although both the COAT and Starship PTA scale are available, the Starship scale is preferred due to reduced odds of a false negative, i.e. falsely considered out of PTA. Nevertheless, 4-5 year old children experience difficulty on some items of the Starship PTA scale. For these reasons, and in combination with the demonstrated developmental validity of the WPTAS-C, the WPTAS-C is suggested to be the best available PTA scale for 4-5 year old children.

As can be seen, the use of different PTA scales for different age groups complicates the assessment of PTA in children 7 years and under and would cause confusion in clinical settings. This highlights the need for further research and

development for the assessment of PTA in this young age group. It would be ideal to develop a scale for use with children aged 4-7 years; as the WPTAS is suitable for patients 8 years and over, and children 3 years and under are expected to perform differently to children 4 years and above (Fernando et al., 2002). Assessment should be conducted with ease and with standard procedures. It would be ideal to identify basic orientation and memory questions that are typically developmentally appropriate for all children aged 4-7, and would therefore achieve close to perfect responses from typically developing children. This would eradicate the need to evaluate responses with respect to deviations from the age-appropriate means; and rather provide a simpler scoring method whereby the child must attain a perfect score to be considered out of PTA. The scale should be sensitive in isolating and adequately assessing core features of PTA (orientation and continuous memory), rather than other residual cognitive deficits; therefore providing a more accurate and efficient assessment of PTA. The validity and reliability of the scale would need to be demonstrated.

Chapter 3

Study 1: Performance of Typically Developing 4 to 7 Year Old Children on the Sydney Children's Hospital Post Traumatic Amnesia Scale

PTA is defined as the period following a TBI in which the person may be disoriented and unable to establish continuous day-to-day memories. The duration of a patient's PTA is a useful indicator of the severity of injury. In adults, prior to the establishment of PTA scales, clinical judgement was used to determine whether or not a patient is in PTA. The duration of PTA was assessed retrospectively by questioning the patient once confusion and disorientation subsided. The patient would be questioned about events surrounding the injury and first memories, in order to determine the interval between the injury and return of his/her ability to establish continuous memory. However, retrospective assessments are subject to inaccurate and unreliable recall. Subsequently, a number of different standardized scales have been developed, allowing assessment of PTA to commence once the patient has regained consciousness to a level in which they are able to provide verbal or purposeful motor response. Assessment is achieved through daily administration of clinical scales that contain questions relating to assessment of disorientation and amnesia, the cardinal features of PTA. Through daily assessment of orientation and memory, the depth of, and recovery from PTA can be regularly monitored. In Australia, the WPTAS (Shores et al., 1986) is the most commonly used scale for assessment of PTA in adults; and comprises 12 items, seven to assess orientation (person, place, time) and five to assess anterograde memory.

While PTA assessments are routinely conducted not only with adults, but also with children who have sustained TBI, little research has been conducted in the area of child PTA. Studies validating the PTA scales used with children are lacking. For example, although the WPTAS has been routinely used for assessment of PTA in school aged children in Australia, the previous systematic review found lacking psychometric data for the scale's use in very young children, and was found to be developmentally inappropriate for children under 8 years of age ((Marosszeky et al., 1993). Whilst 94% of children aged 8-15 years passed the scale, only 15% of children aged 6-7 passed. Several orientation items were too difficult for younger children.

In clinical practice, however, PTA has been evaluated in children of early primary and preschool age. At Sydney Children's Hospital different procedures were used for assessment of PTA in children of different ages. In children aged 8 years and above, PTA was assessed with the WPTAS (Shores et al., 1986). In children aged 6-7 years, an abbreviated version of the Westmead PTA scale that contained modified orientation probes was used. For children aged 5 years and younger, no particular scale was used. Instead, PTA duration was based on clinical judgment made by the rehabilitation specialist and family members. This variability in approaches highlights the need to develop a PTA scale that would be appropriate for assessment of PTA in children across a wide age-range. While the WPTAS covered a good age range; from 8 years of age to adulthood, PTA assessment of children under 8 years of age was inconsistent and fragmented. Subsequently, the Sydney Children's Hospital Post Traumatic Amnesia Scale (SCH-PTA) scale was developed to meet this clinical need. The SCH-PTA was based on the (i) review of two PTA scales: WPTAS (Shores et al., 1986) and Starship PTA scale (Fernando et al., 2006), and (ii) consultations amongst clinicians within and outside Sydney Children's Hospital. Like adult PTA scales, this SCH-PTA scale also included items that cover areas of orientation and memory (5 items each; see Table 5). The SCH-PTA scale has been in clinical use at SCH since November 2008. The validity of the scale, however, has not been established.

Table 5
SCH-PTA Scale Items

Orientation Items	**Memory Items**
Orientation to Person: 1. How old are you? 2. Where do you live? 3. What is your father's name? / What is your mother's name? Orientation to Time: 4. What time of day is it? Is it morning, afternoon, or night time? Orientation to Place: 5. What is the name of this place?	Anterograde: 1. Target face 2. Target name 3. Target pictures 1 4. Target pictures 2 5. Target pictures 3

SCH-PTA= Sydney Children's Hospital Post Traumatic Amnesia

In this chapter the developmental appropriateness of the items included in the SCH-PTA scale will be (i) evaluated in the context of published literature, and (ii) assessed in a group of typically developing children aged 4 to 7 years.

Orientation

Common across adult PTA scales is the assessment of different areas of orientation, namely to person, time and place. The SCH-PTA scale adhered to the same classic composition.

Orientation to person. Items that have been used to assess orientation to person in other child PTA scales are presented in Table 6.

Table 6
Items to Assess Orientation to Person in Child PTA Scales

COAT	
	What is your name?
	How old are you?
	When is your birthday?
	Where do you live?
	What is your father's/mother's name?
	What school do you go to?
	What grade are you in?
Oxford Scale for Children	
	What is your name?
	How old are you?
	When is your birthday?
	How many brothers and sisters do you have?
	Do you go to school?
	Which grade are you in?
Starship PTA	
	How old are you?
	Where do you live?
	What is your father's/mother's name?
WPTAS-C	
	How old are you?

COAT= Children's Orientation and Amnesia Test, PTA= post traumatic amnesia, WPTAS-C = Westmead PTA Scale for Children

These items inherently require language skills and access to semantic autobiographical memory, as it involves the recollection of personal facts and knowledge of oneself that is (unlike episodic memory) independent of time and place. Although there is evidence that the structure of semantic memory develops early in life, the content of semantic memory continues to increase through life. These improvements coincide with brain maturation and development of cognitive skills such as language skills and higher-order cognitive functions that underpin autobiographical memory development (Willoughby, Desrocher, Levine, & Rovet, 2012).

The SCH-PTA scale assesses orientation to person by asking: "How old are you?", "Where do you live?", and "What is your mother's / father's name?". The first orientation item of the SCH-PTA scale: "How old are you?" was included in all of the child PTA scales identified in the systematic review. Moreover, the reviewed studies consistently reported that 98-100% of children aged 4-7 years were able to accurately state their age on each day of testing (Marosszeky et al., 1993; Fernando et al., 2002; Rocca et al., 2008).

The second orientation item: "What is your mother's / father's name?" was included on the COAT and Starship PTA scales. Only one study provided information about response accuracy to this specific item. Nevertheless, 97-100 % of 4-5 year old children, and 98-100% of 6-year old children answered this question correctly on each of the four days of testing using the Starship PTA scale (Fernando et al., 2008)

The COAT was the only PTA scale that included the item "Where do you live?" Ewing-Cobbs et al. (1990) administered this item to children aged 3-15 years, but failed to provide detailed information about the responses provided by children of different ages.

Overall, items that require a child to answer questions relating to their age and names of their parents seem to be developmentally appropriate for children as young as 4 years. In contrast, it is unclear, whether the item that asks a child to state where they live is developmentally appropriate.

Orientation to place. The SCH-PTA scale assesses orientation to place by asking "What is the name of this place?" which is the common and single question assessing orientation to place in other child PTA scales. Similar to the procedure of other child PTA scales, children are only required to provide a generic (i.e. hospital) rather than a specific (Sydney Children's Hospital) name of the place. Moreover, multiple choice answers (i.e.

school, hospital, or home) are provided if the child does not spontaneously provide an answer.

Although children aged 5-7 years were found to have no difficulty answering this question (Marosszeky et al., 1993; Fernando et al., 2002), variable results are reported for younger children. In a sample of 4 year old children, response accuracy ranged from 79-96% (Fernando et al., 2002). In a combined sample of 4- and 5- year old children response accuracy ranged from 93-100% (Rocca et al., 2008). Closer inspection of Fernando et al.'s findings, however, revealed that low accuracy rate (i.e. 79% correct) was only obtained by 4-year old children on the first day of testing. On subsequent days, the accuracy rate was greater than 90%. It is possible that the accuracy rates increased as a result of children learning the correct answers that were provided to them if they made an error on the first day of testing.

Together, the studies described above suggest that typically developing children aged 5-7 years are likely to provide correct answers to the item assessing orientation to place. Four-year old children may experience some difficulty with this item.

Orientation to time. Orientation to time has been assessed in adults by asking the patient to state the current time, day of week, month, and year. Studies examining the responses of typically developing children reveal consistent evidence that these items are not developmentally appropriate for children under 8 years (Ewing-Cobbs et al., 1990; Marosszeky et al., 1993; Rocca, 2001; cited in Rocca et al., 2008).

This is not surprising, as 4-7 year old children are only starting to learn, or are yet to learn the different abstract units of time, i.e. hours, minutes, days of the week, and months of the year (Schecter, Symonds, & Bernstein, 1955). Learning these time concepts rely on the development of other cognitive skills. For example, learning the time of day is not an isolated skill; it requires and relies on basic numeracy (i.e. knowledge of numbers, ability to count) and literacy skills (i.e. time-related vocabulary), and a sense of chronology (i.e. sense of sequence and order) (Burny, Valcke, & Deosete, 2009). Prior to learning the abstract units of time, young children tend to show age-related differences in how they conceive time. Three- and four-year old children tend to differentiate between day and night according to concrete differences (e.g. day is when there is light, night is when the lights are out), or personal and physiological activities (e.g. morning is when you wake up / have breakfast / wash yourself; afternoon is when mum/dad comes; night is

when I go to sleep). Five- and six-year old children continue to judge the time according to the same personal activities, however, rather than basing orientation on physiological activities (e.g. sleeping/nap time), there is greater reliance on play and interpersonal activities. In contrast, 6-year old children start to demonstrate their newly acquired knowledge of the clock and concept of hours, whilst 7-year old children's skill in applying this knowledge is further developed (Schecter et al., 1955). Therefore, within the targeted age group of 4-7 year old children, there are notable developmental differences; as age increases, the concept of time transitions from focusing on concrete (light vs. dark) to more abstract features of time (interpersonal activities, concept of hours, etc.).

Orientation to time is examined on the SCH-PTA scale by asking a child "What time is it? (morning, afternoon or night?)". This item was also used by the WPTAS, but does not comprise part of any child PTA scale. Ninety-five percent of children aged 6-7 were able to correctly state whether it was morning, afternoon, or night on the WPTAS (Marosszeky et al., 1993). Four- and five-year old children were able to distinguish between day and night on the Starship PTA scale (Fernando et al., 2002), however it is unknown whether they are also able to also discern day as morning or afternoon. It is therefore unclear whether this question is developmentally appropriate for the entire targeted age group.

Continuous Memory / Anterograde Memory

Disruption in the ability to establish new and continuous memory is a cardinal feature of PTA. Serial assessment of memory is conducted to monitor and identify when a patient's ability to establish new memories is recovered. Common procedures in adult PTA scales involve examining a patient's ability to remember a person's face (i.e. the examiner, or a photograph), the person's name, and a set of target pictures. Similarly, the SCH-PTA scale assesses continuous memory with these tasks.

Face and Name Recall. The first two questions on the SCH-PTA scale that examines continuous memory involve selecting a target portrait (amongst distracters) and recalling the photographed person's name. The results of the systematic review revealed that selecting or recognizing a target face is an appropriate item, irrespective of whether the procedure required selecting the target portrait (i.e. Starship PTA scale) or recognition of the examiner's face (i.e. WPTAS, WPTAS-C).

The results regarding name recall, however, varied across the studies. On the Starship PTA scale, 4-year old children experienced the most difficulty recalling the photographed person's name, and responded accurately 73-88% of the time. Five- and six-year old children accurately responded 90-97% and 91-97% of the time, respectively (Fernando et al., 2002). In contrast, when the examiner was used rather than a photograph, 98% of children aged 4-5 years (Rocca et al., 2008) and 100% of children aged 6-7 years (Marosszeky et al., 1993) correctly provided the examiner's name. Variability may therefore be due to differences in the administration procedure of this item. The Starship PTA scale involves using a picture of a face, whilst the WPTAS and WPTAS-C uses the examiner, i.e. the child is to remember the examiner's name and face. These differences suggest that recall of name may be easier when paired to the examiner, rather than to a picture.

As the SCH-PTA scale uses photographs, it is expected that the very young, i.e. 4-year old children, may experience difficulty in name recall, though not face recognition. It is ideal, however to use a photograph system, rather than the examiner. Whilst it may be easier to recall the name of the examiner's face (WPTAS-C), rather than recalling the name of the person in the picture (Starship), concerns have been raised regarding the former method of using the examiner for face and name recall. Concerns pertain specifically to face recall, as the question "do you remember me/my face" tends to elicit an affirmative response and it is difficult to ascertain if the patient in fact recalls the examiner's face (Tate et al., 2000). Additionally, no multiple choice options are provided, due to the logistical difficulties (i.e. the examiner would have to gather staff, etc., for the child to select from). Although this concern has been addressed in the adult PTA literature and was considered in the development of the MOPTAS by Tate et al. (2000), further investigation on the response patterns of children is required. Use of a photograph system would be more effective and efficient, by providing better control and allowing greater ease of administration. It would be worthwhile to obtain further data and gain an experiential insight regarding this procedure.

Picture Recall. The third item on the SCH-PTA scale that examines continuous memory is the recall of three pictured items. Recall of three pictures has been involved in previous child PTA scales, with the exception of the WPTAS-C which reduced the number to two pictures. Similar procedures are used across the scales, such that a different set of pictures are presented each time the child correctly recalls all pictures of

the current set. This procedure inherently involves the function of episodic autobiographical memory, a sense of re-experiencing a past event. One needs to be able to mentally travel back in time, to aid in the recall of which pictures were presented "yesterday". Therefore the concept of "yesterday" also needs to be understood, which is typically achieved between the ages of 5 and 6 years (Schecter et al., 1955). Furthermore, as the days of memory testing succeed, the child needs to be able to monitor and differentiate which different sets of pictures were presented on each of the preceding days of testing. This becomes an increasingly complex task as the child needs to distinguish which set of target pictures are applicable at the current day of testing, and not confuse current targets with previous targets. Consequently, there is an interplay of different cognitive skills required for the picture recall task, which is likely to be developmentally complex for very young children as these skills are still developing.

This item, involving three pictures, was demonstrated to be developmentally appropriate for 6-7 year old children. Accuracy rates ranged from 92-100% for 6-year old children using the Starship protocol, and 90% for 6-7 year old children using the WPTAS protocol (Marosszeky et al., 1993). In contrast, variable results are reported pertaining to younger children. Accuracy rates ranged from 81-96% for 4-year old children and 86-100% for 5-year old children on the Starship protocol (Fernando et al., 2002), whilst none of Rocca's (2001; cited in Rocca et al. 2008) sample of 4-5 year old children were able to correctly recall all three pictures using the WPTAS protocol. The high error rates obtained by 4-5 year old children suggest the three picture protocol is developmentally inappropriate for that age range.

Reducing the target pictures to two, as done with the WPTAS-C scale, led to only 7% of a 4-5 year old sample failing the PTA scale. Of those that failed, all but one child still failed to incorrectly identify the two target pictures on each day of memory testing (Rocca et al., 2008). Nonetheless, the error rate is reduced and more acceptable, demonstrating that two pictures is more developmentally appropriate than using three pictures.

These results suggest that three target pictures are developmentally appropriate for 6-7 year olds, and two would be better appropriate for 4-5 year old children. As the SCH-PTA scale requires recall of three pictures, and follows the procedure of the WPTAS, it is expected that difficulty will be experienced on this item particularly by the younger 4-5 year old children.

Review of the pattern of responses by typically developing children on similar items of other child PTA scales, in combination with the developmental literature, suggests that some items of the SCH-PTA scale may not be developmentally appropriate for the targeted age range of 4-7 years. Without establishing the developmental validity of the SCH-PTA scale, clinicians may risk misinterpreting errors to items of the scale as disruptions to supposed normal orientation and memory. Whilst in fact, errors may be reflective of normal development, as competency in skills required to answer the items are still developing. The current study therefore aimed to determine the developmental validity, diagnostic accuracy and reliability of the SCH-PTA scale in typically developing children aged 4-7 years. In addition, the study aimed to identify developmentally appropriate items, test diagnostic accuracy of the PTA procedure, and establish a procedure that can be used to reliably assess PTA in children aged 4 to 7 years. Based on the review of the literature, the following hypotheses were made:

(i) Of the items assessing orientation to person, asking for age and mother's/father's name were both expected to be answered correctly by children aged 4-7. Due to the lack of data, it was unclear if children would correctly answer their address.

(ii) With orientation to time, it was expected that children aged 6-7 would be able to correctly distinguish between morning, afternoon or night. It was unclear if children aged 4-5 would be able to correctly discern the same.

(iii) Children aged 5-7 were expected to have no difficulty answering "What is the name of this place? (school, hospital or home)". However 4-year old children may experience some difficulty with this item.

(iv) Of the memory items, it was expected that children aged 4-7 would be able to correctly select the target face. However, it was expected that children aged 4 will have difficulty recalling the photographed person's name.

(v) It was expected that difficulties recalling a new set of three pictures on three consecutive days will be demonstrated particularly by 4- and 5-year old children.

(vi) Due to the expected difficulties listed above, it was expected that the scale would not accurately classify the PTA status of typically developing children.

Method

Participants

Fifty-two children were recruited from pre-schools and childcare centres around Sydney, as well as a convenient sample, between February 2012 and May 2013. Pre-schools and childcare centres were selected based on convenience: easy access and proximity to the university. Directors of selected pre-schools and childcares provided informed consent and facilitated recruitment of study participants through their centres. Information and consent forms were distributed to parents of children who met criteria for the study. Some centres advertised the study in the centre's newsletters. A very small proportion of the sample (n=3) were conveniently recruited through direct invitation by the main author (PD), who was acquainted with the parents.

Inclusion criteria were: (i) aged between 4 years, 0 months and 7 years, 11 months; (ii) fluent in English; (iii) free of any major developmental disorder (e.g. intellectual disability, autism, cerebral palsy); and, (iv) free of any neurological illness (e.g. epilepsy, brain tumour). Eligibility was determined through an interview with parents (see Appendix C for screening interview).

Design

The study was a prospective cohort study. Ethics approval was provided by the University of Sydney Human Research Ethics Committee (see Appendix D.1 for approval letter).

Measures

Orientation and Memory

Sydney Children's Hospital Post Traumatic Amnesia (SCH-PTA) Scale. The SCH-PTA scale was developed by a Brain Injury Rehabilitation Team at Sydney Children's Hospital, for the purposes of assessing and monitoring PTA in children aged 4-7 years. The SCH-PTA scale consists of 10 items: 5 items to assess orientation (person, place, and time), and 5 items to assess anterograde memory. The items of the scale were previously presented in Table 5; see Appendix E for test form.

On day one of testing, all orientation and memory items are presented, but only orientation items are scored. Memory items are only scored from the second day of testing, as they require recall of the items presented the day before. On the orientation items, children are first provided an opportunity to freely provide an answer (i.e. free recall). If they fail to spontaneously answer a question, they are provided with multiple-

choice options. Specifically the multiple choice recognition options offered to orientation items are: (i) age: a choice of consecutive ages that includes his/her correct age, (ii) address: surrounding suburbs of the real address, and/or inclusion of the suburb of the pre-school or school, (iii) parent's name: names that sound similar or start with the same letter, (iv) time of the day: morning, afternoon or night, and (v) current place: home, school, or hospital. On testing of memory, children are asked to remember a new person and their name (they are shown a photographed face and informed of the name that goes with that face), and three pictured items that are named on the first day (randomly selected from the set of 9 pictures). On subsequent days, children are asked to pick the target face out of three faces, recall the name that goes with the face, and recall the pictured items that they were asked to remember the day before. If the target name is not recalled, a choice of names that start with the same letter as the target name are provided. Similarly, if the child is unable to spontaneously recall the target pictured items, all nine pictured items are presented and the child is asked to identify the pictured items he/she was shown and asked to remember the day before. The set of target pictures are changed each day the child correctly remembers all three targets. A new set is randomly selected from the six previous distracter pictures, and the previous targets become new foils. Each picture is used as a target for one set only. Each correctly answered item is scored one point. On day one, the maximum score is five (as memory items are not scored); thereafter the maximum score on each day is 10.

Patients that have sustained a TBI may demonstrate fluctuating levels of consciousness as they emerge from PTA. Therefore, obtaining a perfect score on a single day may not reliably indicate that a person has emerged from PTA. In typically developing children, however, fluctuating levels of consciousness should not be a concern and therefore repeated testing is not crucial. Nevertheless, to determine test-retest validity of the scores it was thought appropriate to administer the SCH-PTA scale on a minimum of three consecutive days, which would provide an opportunity for a maximal score to be obtained on two consecutive days (day 2 and 3 of testing). Where possible, however, children were tested for four days, to allow further investigation of the validity of the protocol's procedure, which requires maximal scores to be obtained on three consecutive days.

Intellectual Ability

Wechsler Preschool and Primary Scale of Intelligence - 3rd Edition (WPPSI-III; Wechsler, 2002) Two-Subtest Short Form. In order to obtain an estimate of intellectual functioning, a short form of the WPPSI-III was administered to children aged 4-6 years. Sattler and Dumont (2004) provide reliability and validity coefficients of the various short form combinations. A commonly used two-subtest short form is the Vocabulary and Block Design combination, which has good reliability (r = .91) and validity (r = .86). Tables provided by Sattler and Dumont (2004) were used to convert the Vocabulary and Block Design scores into estimated full scale intelligence quotients (IQ).

Wechsler Intelligence Scale for Children – 4th Edition (WISC-IV; Wechsler, 2005) Two-Subtest Short Form. For participants aged 6-7 years, a short form of the WISC-IV was administered. Review of the reliability and validity measures of the various two-subtest short forms (Sattler & Dumont, 2004) led to the selection of the Vocabulary and Block Design combination. The Vocabulary and Block Design combination has high reliability (r = .916) and validity (r = .874) (Sattler & Dumont, 2004). Tables provided by Sattler and Dumont (2004) were used to convert the Vocabulary and Block Design scores into estimated full scale IQs.

Procedure

Parents that expressed interest in the study were contacted to complete a screening interview that confirmed the child's eligibility for the study. Seven children were excluded as they could not be tested for a minimum three consecutive days. In addition, information needed for the purposes of testing (i.e. address and parents' names) were also obtained from parents of children who were eligible to participate. Only children whose parents provided consent in writing were included in the study.

All testing was conducted on centre grounds by the main author (PD). Children were seen for 3-4 days in the one week, whichever was the maximum number of days the child attended the centre or was available for testing. As much as possible, testing occurred on consecutive days. In clinical practice it is not unusual for a child to miss one day of testing due to drowsiness following surgery, hence if the child could still be tested 3-4 days in the one week, he/she was still recruited. Intellectual ability was assessed as early as possible, typically on the first day of testing, and took approximately 15-25 minutes to complete. Participants completed the subtests of the WPPSI-III or WISC-IV in a quiet room, with one centre staff member discretely present (i.e. out of child's view) as

per pre-school and childcare policies. The orientation and memory items of the SCH-PTA scale were administered immediately afterwards.

On the remaining days of testing, both orientation and memory items of the SCH-PTA scale were administered. Testing on these successive days took approximately 5-minutes each day. When possible, testing was conducted in a separate room from other children; otherwise the child was tested in the main room, with care taken to minimise noise, distractions and interruptions from other children.

Statistical Analyses

Developmental Validity. To determine whether items included in the SCH-PTA are developmentally appropriate, the frequency of pass and fail (score of 1 or 0) responses were examined for each item, at each administration, for every child involved in the study. If the questions were developmentally appropriate, all typically developing children (who were not in PTA) were expected to pass all items on each occasion of testing.

Diagnostic accuracy. In clinical practice a fail is interpreted to indicate that a child is still in PTA. If an item was failed by typically developing children, relying on such a score would provide a false positive classification; it would indicate that the child is in PTA, when he/she is not. The percentage of children that passed and failed was calculated for each day and each item separately. This provided an indication of how many typically developing children would be incorrectly considered to be in PTA (i.e. false positive), according to the SCH-PTA protocol. A false positive rate of 10% was determined acceptable, which was considered acceptable in previous child PTA studies (Fernando et al., 2002; Rocca et al., 2008); this still means that one in every ten patients may be misjudged to be in PTA.

Test-Retest Reliability. In order to assess whether performance on the SCH-PTA scale is reliable over the days of testing, separate repeated measures (Age Group x Days Tested) ANOVAs were conducted on: full PTA scores (days 2-3 where score is out of 10), orientation scores (days 1-3), and memory scores (days 2-3), for all children (n=52). If the SCH-PTA scale is developmentally appropriate for children aged 4-7, the pattern of responses should neither change across days, nor should there be differences between age groups. An additional, separate set of repeated measures ANOVA's was conducted on a sub-group of children (n=41) who were assessed for 4 days.

Mauchly's tests revealed that all analyses met the assumption of circularity, with the exception of one analysis: comparison of memory scores over four days of testing ($\chi^2(2) = 7.89$, p= .019). As a result, the Greenhouse-Geisser corrected results are reported for the four day memory scores, which are adjusted for non-sphericity. All other repeated measures ANOVA results are reported according to sphericity assumed.

Item Analyses. The percentage of correct responses given for each item was calculated, for each day of testing, separately for each age group (i.e. separately for 4-, 5-, 6-, and 7-year olds). Items that were correctly responded to 90% of the time, on each day of testing, were considered developmentally appropriate.

Results

Participants

Fifty two typically developing children aged 4 years and 1 month, to 7 years and 11 months; with a mean age of 5.7 years (*SD*= 1.2) participated. Estimated IQ scores ranged from 85-126, with a mean estimated IQ of 103 (*SD*= 10). The sample comprised 26 boys and 26 girls. The number of children, sex distribution and IQs in each age group, i.e. 4-, 5-, 6-, and 7-year olds, are presented in Table 7. Univariate ANOVA and chi-squared analysis respectively revealed no differences between age groups on estimated IQ measures (F (3, 48)= 1.36, p= .27) or sex distribution, $\chi^2(3, N = 52) = 6.26$, p = .10.

Table 7

Estimated IQ and Sex Distribution of Participants

Age (years)	*n*	Sex boys/girls	Estimated IQ *M* (*SD*)	Estimated IQ *Range*
4	19	6/13	100 (10)	85-118
5	13	7/6	103 (11)	88-118
6	10	8/2	104 (8)	91-115
7	10	5/5	108 (9)	95-126

IQ= intelligence quotient, *M*= mean, *n*= sample size, *SD*= standard deviation

All of the 52 children recruited were assessed a minimum of three days. A sub-group of 41 children were tested for four days. Independent-samples t-tests revealed no difference in the estimated IQs between children tested for three days (*M*= 102, *SD*= 10), compared to children tested for four days (*M*= 104, *SD*= 10); $t(50)$= -0.58, p= .57. Neither was there a difference in mean age between children tested for three days (*M*= 5.3 years,

SD= 1.2), and children tested for four days (*M*= 5.8 years, *SD*= 1.2); *t*(50)= -1.07, *p*= .29. Finally, Chi-squared analysis revealed no differences in the sex distribution between those tested for three (boy:girl ratio 6:5) and those tested for four days (boy:girl ratio 20:21), $\chi^2(1, N = 52) = 0.12, p = .73$.

Developmental Validity of the SCH PTA Scale

Thirty-seven children were tested on consecutive days during the week, whilst the remaining 15 were tested on any 3-4 days in the one week. Preliminary analyses revealed that children tested on non-consecutive days did not have higher odds of failing the PTA scale compared to children tested on consecutive days (see Appendix F for chi-squared results, and pass and fail rates for children tested consecutively and non-consecutively, stratified by age groups and number of days tested). All data was therefore combined for the remaining analyses. When tested for three days, 60% of children did not obtain perfect scores on all three days of testing. When tested for four days, failure rates increased to 85%. The pass and fail rates for each age group is presented in Table 8.

Table 8
Number (Percentage) of Children That Passed or Failed Sydney Children's Hospital Post Traumatic Amnesia (SCH-PTA) Scale Criterion

Age Group & Days Tested	Passed (%)	Failed (%)
4 years		
3 days	3/19 (16)	16/19 (84)
4 days	1/14 (7)	13/14 (93)
5 years		
3 days	3/13 (23)	10/13 (77)
4 days	0/10 (0)	10/10 (100)
6 years		
3 days	7/10 (70)	3/10 (30)
4 days	3/8 (38)	5/8 (63)
7 years		
3 days	8/10 (80)	2/10 (20)
4 days	2/9 (22)	7/9 (78)
TOTAL		
3 days	21/52 (40)	31/52 (60)
4 days	6/41 (15)	35/41 (85)

Of the 11 children that were tested for three days only, two children obtained perfect scores on all three days of testing. It would have been ideal to continue testing these two children to ascertain whether they were able to maintain perfect scores on the fourth day of testing. Nonetheless, the remaining nine children provided an error on at least one of the first three days of testing, and therefore were considered to have already failed the criterion.

Reliability of Responses

Pattern Over Three Days of Testing

Full Score. The means, standard deviations and range of full scores obtained by each age group on each day of testing is presented in Table 9. Repeated measures univariate ANOVA on the scores obtained from day 2 to day 3 (i.e. full scores out of 10) revealed a significant main effect of Age Group (F (3, 48) = 7.27, p< .001), but no main effect of Days Tested (F (1, 48) = 3.14, p= .08) and no interaction (F (3, 48) = 1.21, p= .32). Scheffe post-hoc comparisons revealed that across Days Tested, the full scores of 4-year old children (M= 8.61, SD= 0.19) were significantly lower relative to scores of 6- (M= 9.70, SD= 0.25, p= .012) and 7-year old children (M= 9.90, SD= 0.25, p= .002). There were no significant differences in total scores between the other Age Groups.

Table 9
Means (M), Standard Deviations (SD), and Range of Scores Obtained on the SCH-PTA Scale

Age Group		Day 1	Day 2	Day 3	Day 4
4	*M* (*SD*)	4.21 (0.71)	9.00 (0.96)	8.43 (1.56)	8.00 (1.41)
	Range	3-5	7-10	6-10	6-10
	n	19	19	19	14
5	*M* (*SD*	4.60 (0.52)	9.20 (1.55)	9.10 (0.88)	8.00 (1.05)
	Range	4-5	5-10	8-10	6-9
	n	13	13	13	10
6	*M* (*SD*	4.88 (0.35)	9.75 (0.46)	9.88 (0.35)	9.13 (1.13)
	Range	4-5	9-10	8-10	7-10
	n	10	10	10	8
7	*M* (*SD*	5.00 (0.00)	10.00 (0.00)	9.89 (0.33)	9.00 (0.71)
	Range	5-5	10-10	9-10	8-10
	n	10	10	10	9

n = sample size, SCH-PTA= Sydney Children's Hospital Post Traumatic Amnesia

Orientation. Comparison of scores obtained on orientation items by the four age groups over the first three days of testing (Figure 1) again revealed a main effect of Age Group (F (3,48) = 7.44, p< .001). Scheffe post-hoc comparisons revealed that across Days Tested, orientation scores of 4-year old children were significantly lower (M= 4.23, SD= 0.11) than scores of 6-year old (M= 4.83, SD= 0.15, p= .017) and 7-year old children (M= 5.00, SD= 0.15, p= .001). No other Age Group differences in orientation scores were found. The interaction (F (6, 96) = 0.12, p= .99) and main effect of Days Tested (F (2, 96) = 0.35, p= .71) were not significant.

Memory. In contrast, comparison of scores obtained on memory items by the four age groups on day 2 and 3 of testing revealed a main effect of Days Tested (F (1, 48) = 9.54, p= .003); memory scores reduced significantly at day 3 (M= 4.52, SD= 0.13) compared to day 2 (M= 4.95, SD= 0.04). There was also a main effect of Age Group (F (3,48) = 4.85, p= .005). Similar to the age differences found in orientation scores, Scheffe post-hoc comparisons revealed that scores of 4-year old children were significantly lower (M= 4.40, SD= 0.10) than scores of 6-year old (M= 4.90, SD= 0.13, p= .032) and 7-year old children (M= 4.90, SD= 0.13, p= .032). No other age group differences in memory scores were found. There was no significant interaction between Age Group and Days Tested (F (3, 48) = 1.20, p= .32), suggesting that the pattern of daily memory responses were similar across age groups (Figure 2).

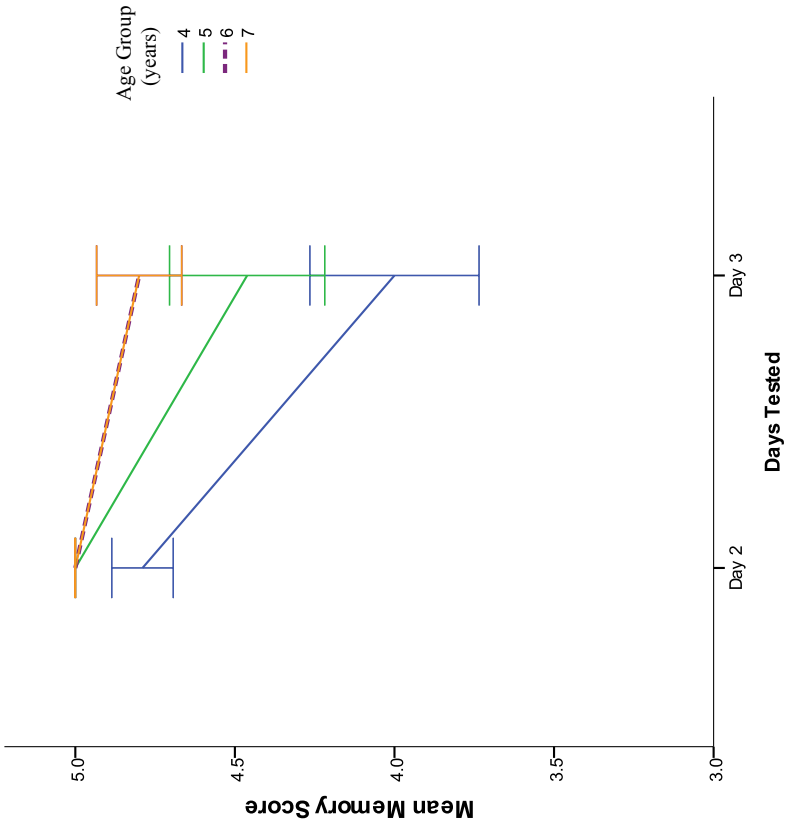

Figure 3. Mean memory score and standard error obtained by each age group on the SCH-PTA scale on day 2 and 3 of testing.

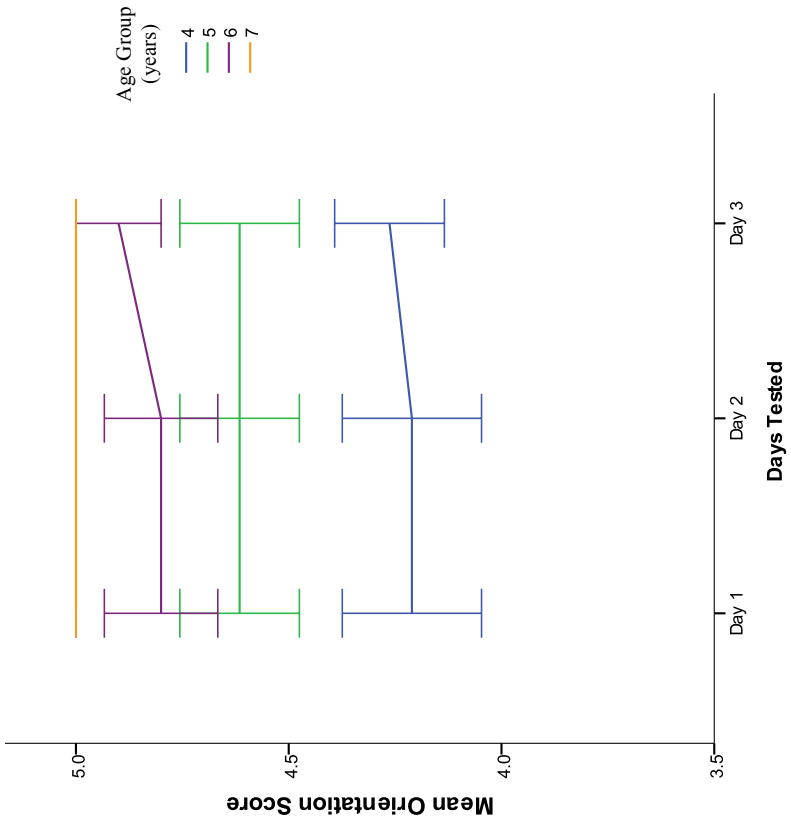

Figure 2. Mean orientation score and standard error obtained by each age group on the SCH-PTA scale on the first three days of testing.

Pattern Over Four Days of Testing

Full Score. Similar to the analysis of the first two full scores (i.e. day 2 and day 3), comparison of the full scores obtained from day 2 to day 4, by the four age groups, revealed a significant main effect of Age Group (F (3, 37) = 6.04, p= .002) and an insignificant interaction (F (6, 74) = 0.51, p= .80). Scheffe post-hoc comparisons revealed that across Days Tested, the full scores of 4-year old children (M= 8.48, SD= 0.21) were significantly lower relative to scores of 6- (M= 9.58, SD= 0.27, p= .024) and 7-year old children (M= 9.63, SD= 0.26, p= .013). The differences in total scores obtained by other Age Groups were not significant. In contrast to the previous analysis, a significant main effect of Days Tested (F (2, 74) = 12.93, p< .001) was also found. Pairwise comparisons that were employed to further examine the effect of Days Tested across Age Groups revealed that higher scores were obtained on (i) day 2 (M= 9.49, SD= 0.16) compared to day 4 (M= 8.53, SD= 0.18, p< .001), and (ii) day 3 (M= 9.32, SD= 0.17) compared to day 4, p= .001.

Orientation. Comparison of scores obtained on orientation items by the four age groups over all four days of testing (Figure 3) revealed the same patterns found in the analysis that included three days of testing: a significant main effect of Age Group (F (3,37) = 6.40, p= .001), with orientation scores of 4-year old children being significantly lower (M= 4.25, SD= 0.12) than scores of 6-year old (M= 4.94, SD= 0.16, p= .017) and 7-year old children (M= 5.00, SD= 0.15, p= .006). No other age group differences in orientation scores were found. The interaction (F (9, 111) = 0.14, p= .998) and main effect of Days Tested (F (3, 111) = .40, p= .76), were not significant.

Memory. Comparison of scores obtained on memory items by the four age groups over the last three days of testing revealed a significant main effect of Days Tested (F (1.67, 61.84) = 23.41, p < .001). All pairwise comparisons were significant. Consistent with previous analysis, the memory scores obtained on day 2 (M= 4.95, SD= 0.04) were significantly higher relative to the memory scores obtained on day 3 (M= 4.62, SD= 0.13), but also on day 4 (M= 3.78, SD= 0.17). Furthermore, memory scores were higher on day 3 compared to day 4 (p< .001). This pattern of results demonstrated that memory scores significantly reduced on each successive day of testing, as can be seen in Figure 4. In contrast to the analysis of scores that considered two days of memory testing (days 2 and 3) , a main effect of Age Group was not significant when the patterns of responses were examined over the three days of memory testing (F (3,37) = 2.50, p= .075). There was no

significant interaction between Age Group and Days Tested (F (5.01, 61.84) = 0.88, p= .50).

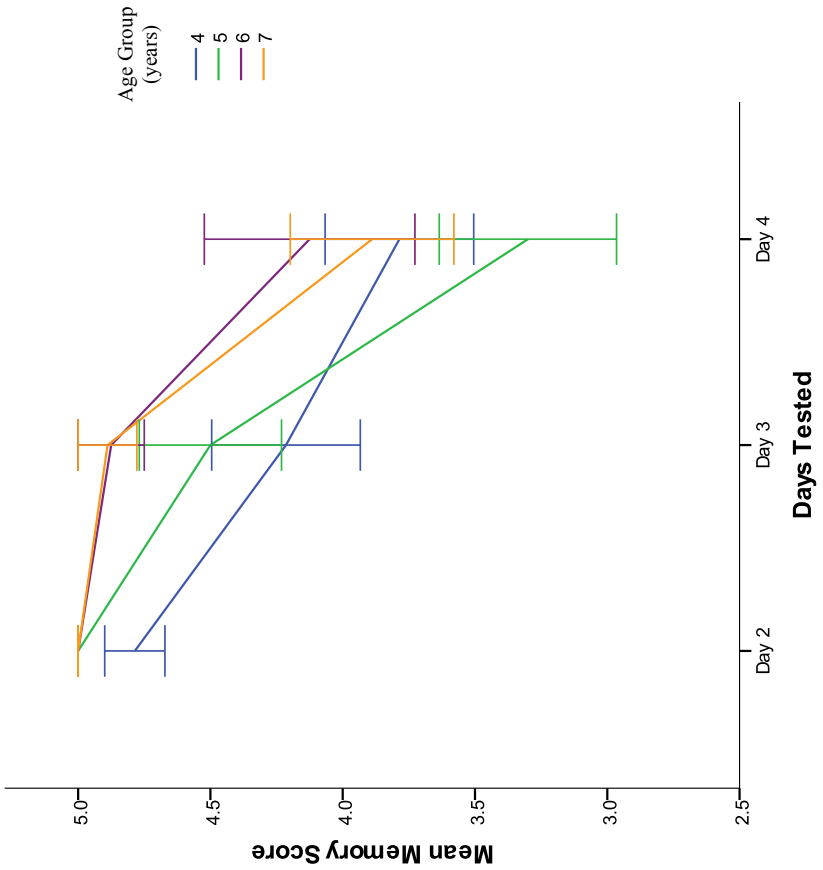

Figure 5. Mean memory score and standard error obtained by each age group on the SCH-PTA scale on last three days of testing.

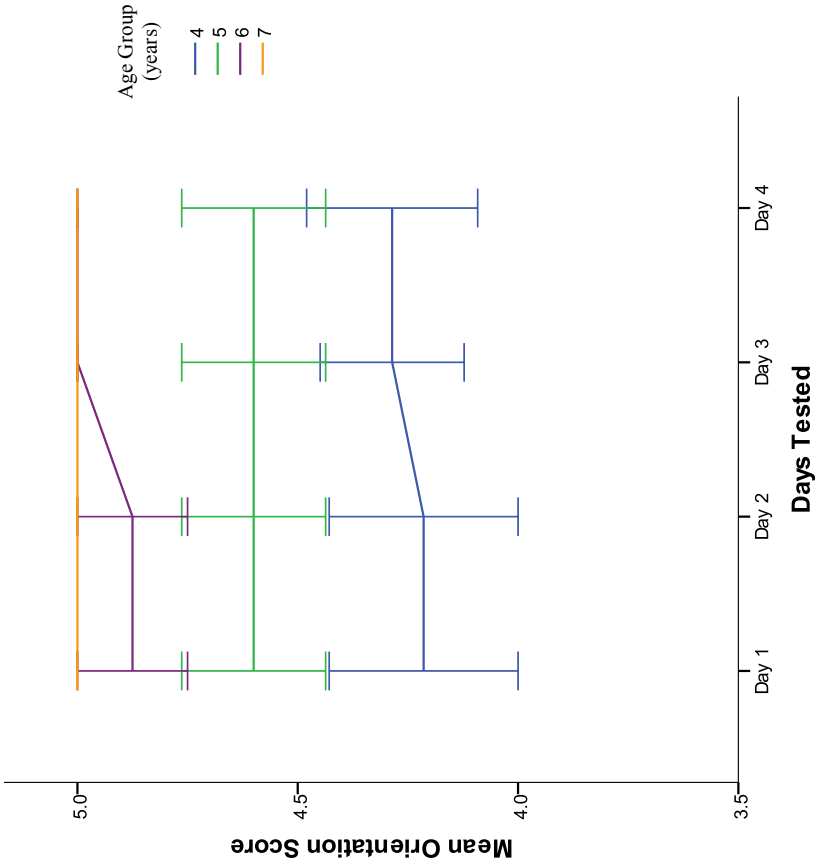

Figure 4. Mean orientation score and standard error obtained by each age group on the SCH-PTA scale on all four days of testing.

Item Analyses

Orientation Items

For each of the five orientation items, the number of children in each age group that correctly responded on each day of testing is presented in Table 10.

Q1. How old are you? All 5-, 6-, and 7-year old participants answered their age correctly on every occasion of testing. There was only one instance of an incorrect response, which was given by a 4-year old participant on the first day of testing. Thereafter all 4-year old children correctly answered their age. Across all days of testing, 4-year old children correctly answered their age 99% of the time.

Q2. Where do you live? All 6- and 7-year old participants provided their address correctly on every occasion of testing. Provision of their suburb or street name was required to be considered a correct response. Four-year old children, however, displayed great difficulty with this item, with only 42-50% of children correctly providing their address on any day of testing. Of the 5-year old children, only one child did not know his address on the three days he was tested. Subsequently, across all days of testing, 5-year old children correctly stated their address 94% of the time.

Q3. What is your mother's/ father's name? All participants answered this question correctly on every occasion of testing.

Q4. What time of day is it? Is it morning, afternoon or night time? All 7-year old participants answered the time of day correctly on every occasion of testing. The remaining age groups experienced difficulty reliably stating the time of day: 4-year old children responded correctly 79-84% of the time, and 5-year old children responded correctly 60-69% of the time. Six- year old children demonstrated more variable results. On two days, 6-year old children obtained accuracy rates of at least 90%. On the other two days, the accuracy rate was 80%.

Q5. What is the name of this place? All participants were able to correctly answer this item on every occasion of testing.

Table 10

Frequency (Percentage) of Correct Responses to Each Orientation Item, Stratified by Age Group and Day of Testing

Question and Age Group	Day 1 C/T (%)	Day 2 C/T (%)	Day 3 C/T (%)	Total (3 Days) C/T (%)	Day 4 C/T (%)	Total (4 Days) C/T (%)
1. *How old are you?*						
4 years	18/19 (95)	19/19 (100)	19/19 (100)	56/57 (98)	14/14 (100)	70/71 (99)
5 years	13/13 (100)	13/13 (100)	13/13 (100)	39/39 (100)	10/10 (100)	49/49 (100)
6 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	8/8 (100)	38/38 (100)
7 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	9/9 (100)	39/39 (100)
Total	51/52 (98)	52/52 (100)	52/52 (100)	155/156 (99)	42/42 (100)	197/198 (99)
2. *Where do you live?*						
4 years	8/19 (42)	8/19 (42)	8/19 (42)	24/57 (42)	7/14 (50)	31/71 (44)
5 years	12/13 (92)	12/13 (92)	12/13 (92)	36/39 (92)	10/10 (100)	46/49 (94)
6 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	8/8 (100)	38/38 (100)
7 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	9/9 (100)	39/39 (100)
Total	40/52 (77)	40/52 (77)	40/52 (77)	120/156 (77)	34/41 (83)	154/197 (78)
3. *What is your mother's/ father's name?*						
4 years	19/19 (100)	19/19 (100)	19/19 (100)	57/57 (100)	14/14 (100)	71/71 (100)
5 years	13/13 (100)	13/13 (100)	13/13 (100)	39/39 (100)	10/10 (100)	49/49 (100)
6 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	8/8 (100)	38/38 (100)
7 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	9/9 (100)	39/39 (100)
Total	52/52 (100)	52/52 (100)	52/52 (100)	156/156 (100)	41/41 (100)	197/197 (100)
4. What time of day is it? Is it morning, afternoon or night time?						
4 years	15/19 (79)	15/19 (79)	16/19 (84)	46/57 (81)	11/14 (79)	57/71 (80)
5 years	9/13 (69)	9/13 (69)	9/13 (69)	27/39 (69)	6/10 (60)	33/49 (67)
6 years	8/10 (80)	8/10 (80)	9/10 (90)	25/30 (83)	8/8 (100)	33/38 (87)
7 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	9/9 (100)	39/39 (100)
Total	42/52 (81)	42/52 (81)	44/52 (85)	128/156 (82)	34/41 (83)	162/197 (82)
5. *What is the name of this place?*						
4 years	19/19 (100)	19/19 (100)	19/19 (100)	57/57 (100)	14/14 (100)	71/71 (100)
5 years	13/13 (100)	13/13 (100)	13/13 (100)	39/39 (100)	10/10 (100)	49/49 (100)
6 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	8/8 (100)	38/38 (100)
7 years	10/10 (100)	10/10 (100)	10/10 (100)	30/30 (100)	9/9 (100)	39/39 (100)
Total	52/52 (100)	52/52 (100)	52/52 (100)	156/156 (100)	41/41 (100)	197/197 (100)

C= correct responses

T= total responses

Memory Items

For each of the memory items, the number of children in each age group that correctly responded on each day of testing is presented below in Table 11.

Table 11

Rate of Correct Responses to Each Memory Item, Stratified by Age Group and Day of Testing

Question and Age Group	Day 1 C/T (%)	Day 2 C/T (%)	Day 3 C/T (%)	Total (3 Days) C/T (%)	Day 4 C/T (%)	Total (4 Days) C/T (%)
6. Target Face: *Which photo did you have to remember?*						
4 years	-	19/19 (100)	19/19 (100)	38/38 (100)	14/14 (100)	52/52 (100)
5 years	-	13/13 (100)	13/13 (100)	26/26 (100)	10/10 (100)	36/36 (100)
6 years	-	10/10 (100)	10/10 (100)	20/20 (100)	8/8 (100)	28/28 (100)
7 years	-	10/10 (100)	10/10 (100)	20/20 (100)	9/9 (100)	29/29 (100)
Total	-	52/52 (100)	52/52 (100)	104/104 (100)	41/41 (100)	145/145 (100)
7. Target Name: *What was her name?*						
4 years	-	18/19 (95)	19/19 (100)	37/38 (97)	14/14 (100)	51/52 (98)
5 years	-	13/13 (100)	13/13 (100)	26/26 (100)	10/10 (100)	36/36 (100)
6 years	-	10/10 (100)	10/10 100)	20/20 (100)	8/8 (100)	28/28 (100)
7 years	-	10/10 (100)	10/10 (100)	20/20 (100)	9/9 (100)	29/29 (100)
Total	-	51/52 (98)	52/52 (100)	103/104 (99)	41/41 (100)	144/145 (99)
4 years	-	16/19 (84)	8/19 (42)	24/38 (63)	4/14 (29)	28/52 (54)
5 years	-	13/13 (100)	9/13 (69)	22/26 (85)	1/10 (10)	23/36 (64)
6 years	-	10/10 (100)	8/10 (80)	18/20 (90)	4/8 (50)	22/28 (79)
7 years	-	10/10 (100)	8/10 (80)	18/20 (90)	2/9 (22)	20/29 (69)
Total	-	49/52 (94)	33/52 (63)	82/104 (79)	11/41 (27)	93/145 (64)

C= correct responses

T= total responses

Q6. Target Face. On every occasion of testing, all participants correctly selected the target face from the set of three portraits presented.

Q7. Target Name. All 5-, 6-, and 7-year old participants provided the name of the target face correctly on every occasion of testing. There was only one instance of an incorrect response, which was given by a 4-year old participant on the first day of memory testing (i.e. day 2). Thereafter all 4-year old children correctly named the target face; which meant that overall, across all days of testing, 4-year old children correctly named the target face 98% of the time.

The frequency of children that required the recognition procedure is presented in Table 12. As days progressed, the requirement of the recognition procedure (i.e. multiple choice) reduced as children's ability to freely recall the target name increased.

Table 12

Number of Participants Requiring Recognition Procedure to Answer Name of Target Face.

Age Group	Day 1 R/T (%)	Day 2 R/T (%)	Day 3 R/T (%)	Total (3 Days) R/T (%)	Day 4 R/T (%)	Total (4 Days) R/T (%)
4 years	-	12/19 (63)	8/19 (44)	20/38 (53)	5/14 (39)	25/52 (48)
5 years	-	5/13 (39)	0/13 (0)	5/26 (19)	0/10 (0)	5/36 (14)
6 years	-	3/10 (30)	2/10 (20)	5/20 (25)	1/8 (17)	6/28 (21)
7 years	-	1/10 (10)	1/10 (11)	2/20 (10)	0/9 (0)	2/29 (7)
TOTAL	-	21/52 (40)	11/52 (21)	32/104 (31)	6/41 (15)	38/145 (26)

R= number of participants requiring recognition procedure
T= total participants

Q8 - Q10. Three Target Pictures. On the first day of memory testing (i.e. day 2), all 5-7 year old participants remembered all three target pictures correctly. In contrast, only 84% of 4-year old children correctly remembered the three target pictures. On the second day of memory testing (i.e. day 3), a reduction in accuracy rates occurred for all four age groups, with accuracy ratings ranging from 42-80%. A further reduction occurred the following day, with accuracy rates falling to a range of 10-50%.

Further inspection of the participants' responses revealed a high occurrence of recalling or recognising pictures that were targets the previous days. As can be seen in Table 13, the rate of selecting previous targets increased as testing days proceeded. On the third day of memory testing memory (following the first change of targets), the frequency of selecting previous targets ranged from 10-37%. In the subgroup of children who were tested for four days, the targets were changed for the second time. Following this change, the frequency of selecting previous targets increased to 50-80%. Based on the subgroup of 41 children tested for four days, McNemar's chi-square test revealed the frequency of selecting previous targets significantly increased on Day 4 (66%) compared to Day 3 (34%), $p < .001$.

Table 13

Q8 - Q10. Three Target Pictures: Frequency of Selecting Previous Target Pictures.

Age Group	Day 1 P/T (%)	Day 2 P/T (%)	Day 3 P/T (%)	Day 4 P/T (%)	TOTAL P/T (%)
4 years	-	-	7/19 (37)	8/14 (57)	15/33 (45)
5 years	-	-	2/13 (15)	8/10 (80)	10/23 (43)
6 years	-	-	1/10 (10)	4/8 (50)	5/18 (28)
7 years	-	-	1/10 (10)	7/9 (78)	8/19 (42)
TOTAL	-	-	11/52 (21)	27/41 (66)	38/93 (41)

P= number of participants that selected previous target pictures
T= total participants

Discussion

The current study aimed to determine whether the newly developed SCH-PTA scale is a developmentally valid and reliable instrument for assessment and memory in typically developing children aged 4-7 years. We also set to determine this scales' diagnostic accuracy: whether it correctly classifies typically developing children as not being in PTA. Finally, we set to utilize this data to establish a procedure that can be used to reliably assess PTA in children aged 4 to 7 years.

Analysis of the responses given by typically developing children to items of the SCH-PTA scale demonstrated that 85% of the 4-7 year old children failed at least one item on one of the days of testing. In clinical practice, if guided by the score obtained on the SCH-PTA scale, 85% of typically developing children would be incorrectly considered to be in PTA. This high false positive rate clearly demonstrates that in its current form, the SCH-PTA scale lacks diagnostic accuracy.

The study also revealed that the SCH-PTA scale has poor reliability. Children's scores on the scale were not stable over time. Instead, a significant drop in scores was noticed on the final (fourth) day of testing. Closer examination revealed that whilst orientation scores remained stable over days of testing, the memory scores showed a gradual decline on each successive day of testing, with a drop being particularly noticeable on the third day of memory testing.

With respect to developmental validity of the scale, 4-year old children consistently had lower scores than 6- and 7-year old children. This youngest age group obtained significantly lower full scale scores, but also orientation and memory scores, regardless of the number of days tested. When more detailed item analysis was conducted, however, five items (3 orientation and 2 memory items) were found to be age appropriate for 4-7 year old children. That is, each age group was able to accurately respond to these five questions (3 orientation and 2 memory) at least 90% of the time, on each day of testing:

Q1. How old are you?
Q3. What is your father's / mother's name?
Q5. What is the name of this place?
Q6. Target face: Which photo did you have to remember?
Q7. Target name: What is her name?

Of the items assessing orientation to person, as expected and consistent with previous studies (Marosszeky et al., 1993, Rocca et al., 2008; Fernando et al., 2002), age and mother's/father's name were developmentally appropriate for all children aged 4-7 years. In contrast, our findings suggest that knowledge of own address (suburb or street name) is unlikely to be reliably established until the age of 5 years. A child may be more likely to learn their age and parents' names in the home and preschool environment. For example, a child may be repeatedly exposed to his/her parent's names, and may state his/her age in everyday life. Home address, on the other hand is not regularly mentioned in communication with a child in day to day life. In addition, learning of address (i.e. name of a suburb) requires an understanding of a more abstract concept. Once a child enters the school setting from the age of 5, conceptual understanding increases, as well as the opportunity to learn and utilize information related to their address in communication with others, both verbally and in writing.

With orientation to time, it was expected that children aged 6-7 would be able to correctly distinguish between morning, afternoon or night. It was unclear if 4-5 year old children would be able to correctly discern the same. The results revealed that stating the time of day (morning, afternoon or night) was difficult for 4-, 5- and 6-year old children, with accuracy rates reducing with younger age. This was somewhat inconsistent with predictions, as both 6- and 7-year old children were expected to correctly distinguish

between morning, afternoon or night based on previous findings (Marosszeky et al., 1993). It must be noted however, that accuracy rates obtained by 6-year old children in the current sample were appropriate (>90%) on two of the four days of testing. The variability observed in the current 6-year old sample, in combination with the inconsistency with previous findings, potentially highlights that these skills are not fully mastered in children aged 6-7 years.

Our findings are in keeping with the developmental literature which suggests that children make significant developmental gains in their understanding of time from 4 to 7 years of age. As the age increases, the concept of time transitions from concrete (light vs. dark) to more abstract (interpersonal activities, concept of hours, etc.) (Schecter et al., 1955). It is at the age of 6, that children start to demonstrate their newly acquired knowledge of the clock and concept of hours. At 7 years of age children's skill in applying this knowledge is further developed (Schecter et al., 1955). Overall, the developmental literature suggests that the time of day question should be revised to only differentiate between morning and afternoon. Instead, a child could be merely asked "Is it day or night?". This question is expected to be developmentally appropriate for children aged 4-6 years.

The question relating to orientation to place ("What is the name of this place?") was correctly answered by all children, irrespective of age, on each and every day of testing. Such a response was expected from children aged 5-7 years, who were previously found to have no difficulties answering this question (Marosszeky et al., 1993; Fernando et al., 2002). In our study, 4-year old children also answered this question correctly, which was encouraging, but not expected, as inconsistent findings had previously been reported in the literature. Rocca (2001, cited in Rocca et al., 2008) found that 93% of 4-5 year old children responded correctly to "What is the name of this place?", whilst Fernando et al. (2002) found 79-96% of 4-year old children responded correctly to "Where are you?". The perfect accuracy rate in the current study may be due to the multiple choice options being readily provided when the child appeared confused about what was being asked. It is unclear whether explicit multiple choice options were provided in the study by Fernando and colleagues (2002) that used the Starship PTA scale.

With regard to the memory items, as expected, all age groups were able to correctly select the target face, which is consistent with findings on the Starship PTA scale which also uses photographs (Fernando et al., 2002). Contrary to expectations based

on findings with use of the Starship PTA scale, however, which lead us to propose that accurate responses to target name would be obtained about 73-88% of the time, children as young as 4 in the current sample experienced very little difficulty stating the target name. Again, this discrepancy in findings may potentially be due to the lack of multiple choice options provided on the Starship PTA scale. In fact, inspection of our findings indicates that multiple choice of the target name was required for 40% of the current sample on the first day of testing. As expected, the most difficult item overall was recalling a different set of three pictures on three consecutive days. Based on previous findings, it was expected that children aged 4- and 5-years (Fernando et al., 2002; Rocca, 2001 as cited in Rocca et al., 2008), but not those aged 6-7 years (Marosszeky et al., 1993) would have difficulties with memory for pictured items. The current study, however, demonstrated that across the ages, children experienced difficulty recalling a new set of pictures on each day of testing. More specifically, 5-7 year old children were able to correctly recall all three target pictures on the first day of memory testing (i.e. day 2), however the rate of accurate recall significantly reduced as the days progressed and target pictures changed. The same trend (decline in memory score on consecutive days of testing) was also documented in 4-year old children. Nevertheless, these children also demonstrated difficulty recalling all three targets on the first day of memory testing. Difficulty in reliably recalling pictured items on consecutive days of testing has contributed the most to the poor validity and reliability of the SCH-PTA scale.

Moreover, we conducted error analysis to determine whether errors were related to recycling previous targets as new distractors. This error analysis revealed that the drop in accuracy over the days of testing was accompanied by increased frequency in selecting previous targets. The children seemed to have difficulties monitoring which set of items had been set as targets for the day. The confusion was particularly marked on day 4, by which point most pictures had been presented as a target at some point. This is not surprising, as by that stage the task requires both episodic autobiographical memory and a developed concept of “yesterday”, which are still developing in this young age group (Schecter et al., 1955; Willoughby et al., 2012). To prompt recall of the appropriate pictures, the child may need to mentally travel to “yesterday” and identify which targets were applicable. Difficulty further increases on the fourth day of testing, when one has to additionally travel back “2 days ago” to help discern the same. The concept of “yesterday” is typically achieved between the ages of 5 and 6 years (Schecter et al., 1955). This may explain why 4-year old children demonstrated significantly lower

memory scores when only three days of testing was analysed, i.e. the task was already difficult for 4-year old children. The extra day of testing, however, made the task more difficult for the remaining age groups, as the task now required discernment of targets not just the day before, but those that applied two days earlier. At this point, i.e. the fourth day, the task was similarly difficult for all age groups. In addition, difficulty in comprehending the task was observed during testing, particularly for the younger children in the sample. Rather than selecting the three targets, some children proceeded to name all the displayed pictures, or selected more than three pictures. To clarify the task, the question was rephrased "Which *three* photos did I show you *yesterday*?". Confusion was still occasionally evident; some children remained unclear about what was required, and many continued to select targets applicable to previous days.

Collectively, these results suggest that the current protocol for the picture task is difficult for 4-7 year old children. Less than 90% of all age groups were able to correctly recall the three appropriate targets on day 3 and day 4 of testing, i.e. once the targets changed. In contrast, 5-7 year old children were able to select the three appropriate targets on the first occasion of testing, which provides strong evidence that the complexity of the task increases as target pictures are changed. It is clear that the protocol for the picture task needs to be amended.

A few options are considered. Firstly, in order to be appropriate for all children aged 4-7, the target pictures may be completely eradicated. A potential concern, however, may be the inadequate assessment of continuous memory if only two memory items are included: target name and face. Eradication of the three target pictures, and the two developmentally inappropriate orientation items (time and address) would provide a 5-item revision of the SCH-PTA scale.

A second option is applicable only to 5-7 year old children. Because difficulty was only experienced on the target pictures after they were changed, a potential consideration would be to assess recall of the three pictures, however revise the criterion to require only *one* perfect score. Only the two orientation items (time and address) would be excluded from this scale, providing an 8-item revision of the SCH-PTA scale.

Alternatively, target pictures could be kept constant for all days of testing, rather than changing and recycling pictures as target-to-distracter and distracter-to-target. This procedure would also be limited to 5-7 year old children as 4-year old children

experienced difficulty with the task even on the first day of testing. Another option that may be applicable to all 4-7 year old children would be the reduction of target pictures to two as per WPTAS-C. Unfortunately these two methods cannot be assessed further in the current study, as the SCH-PTA scale was administered with three target pictures that were changed upon each correct set recall. Future research may further examine these options.

The current arm of the study has shed light on the developmental validity of the items comprising the SCH-PTA scale. As it currently stands, the SCH-PTA scale is developmentally inappropriate and results in a very high (85%) false positive rate, in which typically developing 4-7 year old children are misclassified as being in PTA. Revision of the scale is greatly needed. The study conducted with typically developing children identified a set of items and administrative procedure that are developmentally appropriate and diagnostically accurate in over 90% of cases. A revision of the scale is proposed, and will be further investigated in the next arm of the study with a clinical sample of children with TBI.

Chapter 4

Study 2: Concurrent and Predictive validity of the Post Traumatic Amnesia Scale for Children aged 4 to 7 years: Retrospective Cohort Study

In children and adults that have sustained TBI, assessments of PTA provide information about cognitive recovery, guide inpatient treatment and assist in discharge planning. At the outpatient stage, PTA duration has been found to be an important predictor of outcome in adults. In fact, several studies have found PTA duration to be a better predictor of outcome than other indicators of injury severity such as GCS, length of coma or time to follow commands, or duration of hospitalisation (Brooks et al., 1980; Bishara et al., 1992; Asikainen et al., 1998; van der Naalt et al., 1999; Brown et al., 2005; Avesani et al., 2005; De Guise et al., 2005; Kosch et al., 2010; Zafonte et al., 1997; Tate et al., 2005; Hessen et al., 2007). In school aged children, the predictive validity of PTA duration has not been as extensively studied. Nevertheless, the available information supports the predictive validity of PTA duration. Some studies found PTA duration to be a stronger predictor of TBI outcome than GCS (Tremont et al.,1999; Ewing-Cobbs et al.,1990; Thickpenny-Davis et al., 2005). Whilst other studies found PTA duration to be equally predictive as GCS (Calvert et al., 2008; Paget et al., 2012) and coma duration (Ruijs et al., 1992; Ruijs et al., 1993).

In our first study we have identified developmentally appropriate items to be included in a PTA scale for typically developing children aged 4 to 7 years. In addition to being developmentally appropriate and diagnostically accurate, a PTA scale also needs to provide a valid measure of injury severity and contribute to prediction of outcomes. Only then (upon validation), could the scores obtained on a PTA scale be used to guide inpatient rehabilitation, discharge planning and prediction of outcome. In clinical practice, the most widely used indicator of TBI severity is the GCS (Teasdale & Jennett, 1974). The GCS, which provides information about the level of consciousness and is important for early medical management, is widely used in clinical settings. A patient's GCS is repeatedly assessed at varying time points throughout the day in order to monitor their depth of coma and regaining of consciousness. Assessment of PTA typically commences once the patient has regained consciousness to a level in which they are able to provide verbal or purposeful motor response. Generally, both GCS and PTA scores are used in combination to determine a patient's severity of TBI (Bishara et al., 1992; Katz & Alexander, 1994; Sherer, Struchen, & Yablon, 2008). In adults, initial (on scene or

admission) GCS has been found to correlate with PTA duration (Bishara et al., 1992; Katz & Alexander, 1994; Sherer et al., 2008). Although less widely examined, PTA duration (determined with use of a pediatric PTA scale) has also been found to correlate with admission GCS in young children. This has only been established when PTA duration was assessed with the COAT (Ewing-Cobbs et al., 1990, Tremont et al., 1990). Concurrent validity of other pediatric PTA scales with initial measures of GCS has not been established.

Both PTA duration and initial GCS have been demonstrated to predict TBI outcome in children, though less so with PTA duration. In children and adolescents, initial GCS (i.e. on scene, admission) and/or lowest post-resuscitation GCS scores have been demonstrated to predict a range of outcomes, including gross outcome (Simpson et al., 1991; Levin et al., 1992; Kan et al., 2009; Prasad et al., 2002; Hawley et al., 2004), neurobehavioural and functional outcome (McDonald et al., 1994; Anderson et al., 2005), intellectual functioning (Anderson et al., 2000; Anderson et al., 2004; Anderson et al., 2005; Babikian & Asarnow, 2009), cognitive functioning (Prasad et al., 2002; Anderson et al., 2004; Anderson et al., 2005; Babikian & Asarnow, 2009), academic difficulties (Hawley et al., 2004), motor outcome (Prasad et al., 2002), level of family burden (Anderson et al., 2001; Anderson et al., 2005), personality changes, and need for follow-up services and special education services (Hawley et al., 2004). With regard to PTA duration, there are only limited studies using a pediatric PTA scale. In children and adolescents, PTA duration, measured by the COAT was found to predict cognitive outcomes including intellectual functioning (Tremont et al.,1999) and memory (Ewing-Cobbs et al.,1990; Thickpenny-Davis et al., 2005), as well as gross functional outcome (Calvert et al., 2008; Paget et al., 2012; Ruijs et al., 1992) neurological problems, personality changes and school problems (Ruijs et al., 1993).

It must be noted however, that many of these studies did not only include pre-school and early-school aged children, the current study's targeted age range, but also included adolescents up to 15-16 years of age, and isolating data for the targeted age range was rarely possible. Regarding PTA, the previous described systematic review identified only two studies that included only young children, and compared PTA duration with other indices of injury severity. PTA duration assessed with the Oxford-C was equally predictive as coma duration of gross functional outcome in children aged 2-8 years (Ruijs et al., 1992). The combination of PTA duration, assessed with the Starship PTA scale, and initial GCS was predictive of memory and learning two months post TBI

in children aged 3-7 years (Thickpenny-Davis et al., 2005). Nevertheless, PTA duration contributed most to the predictive model. This highlights the dearth of literature examining the concurrent and predictive validity of PTA duration in young children aged 4-7 years. Given that PTA duration is one of the stronger predictors of TBI outcome in adults, further research is warranted to establish a valid PTA scale for use in young children.

In the present study we set to determine the concurrent and predictive validity of a PTA scale purported for 4 to 7 year old children. At the onset, the study aimed to validate a PTA scale developed by the brain injury team at Sydney Children's Hospital (SCH-PTA). However, during the scale's trial at SCH, difficulties became apparent with its use. Children were typically unable to meet the scale's criteria to be determined out of PTA, despite being judged out of PTA according to other clinical indicators and presentation. Rather, clinicians were led to estimate PTA durations accordingly. The difficulties experienced on the scale is no surprise given the findings of our first study, in which 85% of typically developing children failed to pass criteria and would therefore be incorrectly considered to be in PTA. This high false positive rate clearly demonstrated that in its current form, the SCH-PTA scale lacked diagnostic accuracy. A refined 5-item PTA scale was subsequently developed, comprising the items found developmentally appropriate for 4-7 year old children from the first study. The current arm of the study aimed to investigate the: 1) concurrent validity of the 5-item scale by examining the association between PTA duration assessed by the 5-item PTA scale and initial GCS; and 2) predictive validity of the 5-item scale by examining whether PTA duration assessed by the 5-item scale is predictive of gross functional outcome, and whether it is a stronger predictor than clinical estimates of PTA duration and initial GCS.

Method

Participants

Children considered for the study were consecutively admitted to SCH (i) with TBI, (ii) aged between 4 years, 0 months to 7 years, 11 months, (iii) referred to the Brain Injury Rehabilitation Program and assessed for PTA using the SCH-PTA scale by one of the investigators (JB) within the period of February 2008 – October 2012. Exclusion criteria were: non-fluency in English, pre-existing developmental disorder (e.g. intellectual disability, autism, cerebral palsy), or other pre-existing neurological illness or injury (e.g. epilepsy, brain tumour). Thirty-five children were considered and included in

the study (i.e. none met exclusion criteria). The catchment area of the Brain Injury Rehabilitation Program of SCH is NSW state-wide.

Design

The study was a retrospective cohort study. Ethics approval was provided by the Human Research Ethics Committees of South Eastern Sydney Local Health Network-Northern Sector and the University of Sydney (Appendix D.1 and D.2).

Measures

Early Indicators of Injury Severity

PTA duration according to 5-item PTA scale (Revised PTA duration). The original SCH-PTA scale comprised 10 items to measure orientation and memory. A copy of the SCH-PTA scale is provided in Appendix E and the scale was more specifically described in the first study. During the four years of trialing the SCH-PTA scale at SCH, difficulties with its clinical use became apparent. Clinicians reported that most children experienced difficulty with certain items, and consultation with the child's parents occurred to help ascertain whether an inability to answer a question was due to lack of previous knowledge (e.g. not knowing address) or due to brain injury. Therefore adherence to the protocol of the scale was difficult to maintain. Although clinicians continued to use the SCH-PTA scale, it was mainly to aid *estimations* of PTA duration, rather than systematically assess PTA duration according to the SCH-PTA protocol.

The first arm of the study confirmed the SCH-PTA scale in its current form was not developmentally appropriate for children aged 4-7. Typically developing children aged 4-6 experienced difficulty stating whether it was morning, afternoon or night; and knowledge of address was inappropriate for 4-year old children. Of the memory items, the picture task proved to be developmentally inappropriate for all target age groups ranging 4-7 years. These items were therefore removed, leaving the remaining items to comprise the proposed 5-item PTA scale (presented in Table 14). All five items were found developmentally appropriate for children aged 4-7 as 90% of each age group (i.e. 4-, 5-, 6-, 7-years) responded correctly to each item, on each and every day of testing.

On day one of testing, all orientation and memory items are presented, but only orientation items are scored. Memory items are only scored from the second day of testing, as they require recall of the items presented the day before. On the orientation items, children are first provided an opportunity to freely provide an answer (i.e. free

recall). If they fail to spontaneously answer a question, they are provided with multiple-choice options. For testing of memory, on the first day the child is shown a photo of a face and told their name. The child is asked to try and remember the face and name for when the examiner returns the following day. On subsequent days, the child is asked to pick the target face out of three faces and recall the name that goes with the face. If the target name is not recalled, a choice of names that start with the same letter as the target name are provided. Each correctly answered item is scored one point. On day one, the maximum score is three (as memory items are not scored); thereafter the maximum score on each day is five. A child was required to obtain three perfect scores of 5/5 to be considered out of PTA. PTA duration was calculated from the day of injury to the first of three days of obtaining perfect scores. SCH-PTA charts were reviewed for each patient, and the revised PTA duration was calculated according to this 5-item protocol.

Table 14

5-Item PTA Scale

	5-Item PTA Scale (4-7 years)
Items:	1. How old are you? 2. What is your father's / mother's name? 3. What is the name of this place? 4. Target face: Which photo did you have to remember? 5. Target name: What is their name?
Duration of PTA:	Day of injury to first of three consecutive perfect scores of 5/5

Clinically estimated PTA duration. Medical files were reviewed to record the documented clinical estimate of PTA duration made by the members of the inpatient Brain Injury Rehabilitation Unit on the basis of clinical judgments. Clinical estimates of PTA duration were typically based on various indicators, including GCS, CT scan findings, responsiveness and interaction with staff and the environment, and appropriateness of behaviour.

Glasgow Coma Scale (GCS). The GCS involves identifying and rating the patient's highest response on three basic domains: 1) eye opening response (max. 4

points), 2) verbal response (max. 5 points), and 3) motor response (max. 6 points). The points scored on the three domains are totaled, with a maximum of 15 points. The depth of coma is classified *mild* if total GCS is 13-15 points, *moderate* if 9-12, and *severe* if less than 8. The GCS is assessed and recorded over regular intervals. For the purposes of the study, the initial GCS score was of particular interest, as it is considered to indicate the severity of the head injury, and has been found to relate to outcome. Patient files were reviewed to record initial GCS. Initial GCS was typically assessed at the scene of the injury or upon presentation to the emergency department.

Early Outcome

King's Outcome Scale for Childhood Head Injury (KOSCHI) (Crouchman et al., 2001). The KOSCHI is a child outcome scale that was modeled on the widely used, standardised adult outcome scale: Glasgow Outcome Scale (GOS; Jennett & Bond, 1975). The five main outcome categories of the GOS are also included in the KOSCHI. Nevertheless, in the KOSCHI, three of these categories have two subcategories (Crouchman et al., 2001). The subcategories were included to better capture the variations within the original main descriptors, resulting in an ordinal 8-point scale (see Table 15).

The KOSCHI has been found to have moderate to high inter-rater reliability. Paget et al. (2012) obtained a kappa statistic of 0.71 on KOSHI ratings on 267 children by three raters. Smaller studies have reported moderate inter-rater reliability coefficients. In a study that included 90 children and six raters, Crouchman et al. (2001) reported a kappa statistic of 0.51. Exclusion of one observer, who had a tendency to rate children more severely disabled, resulted in a kappa score of 0.58. Similarly, Calvert et al. (2008) reported a kappa statistic of 0.51 for inter-rater reliability, resulting from the KOSCHI ratings of 61 children by two raters. All studies had a retrospective design; KOSCHI ratings were based on information obtained from clinical notes and documents.

The KOSCHI was also demonstrated to have good external validity. KOSCHI ratings at hospital discharge significantly correlated with indicators of TBI severity, namely PTA duration, GCS on admission, and length of hospital stay (Calvert et al., 2008). More specifically, longer PTA duration was associated with a lower KOSCHI category, i.e. poorer gross outcome (r= -.32, p< .007). Higher level of consciousness at admission, indicated by higher GCS, was associated with better KOSCHI outcome (r=

.53, $p < .001$). Longer stay in hospital was also associated with poorer KOSCHI outcome at discharge ($r = -.60$, $p < .001$).

Table 15

KOSCHI Category Definitions (Crouchman et al., 2001)

Category		Definition
1	Death	
2	Vegetative	The child is breathing spontaneously and may have sleep/wake cycles. He may have non-purposeful or reflex movements of limbs or eyes. There is no evidence of ability to communicate verbally or non-verbally or to respond to commands.
3	Severe Disability	(a) The child is at least intermittently able to move part of the body/eyes to command or make purposeful spontaneous movements; for example, confused child pulling at nasogastric tube, lashing out at carers, rolling over in bed. May be fully conscious and able to communicate but not yet able to carry out any self care activities such as feeding. (b) Implies a continuing high level of dependency, but the child can assist in daily activities; for example, can feed self or walk with assistance or help to place items of clothing. Such a child is fully conscious but may still have a degree of post-traumatic amnesia.
4	Moderate Disability	(a) The child is mostly independent but needs a degree of supervision/actual help for physical or behavioural problems. Such a child has overt problems; for example, 12 year old with moderate hemiplegia and dyspraxia insecure on stairs or needing help with dressing (b) The child is age appropriately independent but has residual problems with learning/behaviour or neurological sequelae affecting function. He probably should have special needs assistance but his special needs may not have been recognised/met. Children with symptoms of post-traumatic stress are likely to fall into this category.
5	Good recovery	(a) This should only be assigned if the head injury has resulted in a new condition which does not interfere with the child's well being and/or functioning; for example: - Minor headaches not interfering with social or school functioning - Abnormalities on brain scan without any detectable new problem - Prophylactic anticonvulsants in the absence of clinical seizures - Unsightly scarring of face/head likely to need cosmetic surgery at some stage - Mild neurological asymmetry but no evidence of affect on function of limb. Includes isolated change in hand dominance in young child. (b) Implies that the information available is that the child has made a complete recovery with no detectable sequelae from the head injury.

KOSCHI= King's Outcome Scale for Childhood Head Injury

Similarly, in a previous study, injury severity determined by GCS scores and PTA duration associated with long-term KOSCHI outcome at a median of 1.3 years following injury (IQR: 0.2 - 4.6 years) in children aged 3-13 years (Paget et al., 2012). PTA duration and GCS on admission were used to categorise injury severity: *mild* was defined as a PTA duration less than one hour and GCS 13-15, *moderate* if PTA duration was between 1-24 hours and/or GCS 9-12, and *severe* if PTA duration was more than one day and/or GCS less than 9. Injury severity, according to these classifications, predicted KOSCHI outcome. Children classified with a mild or moderate TBI were more likely to have *good*

recovery compared to those with a severe TBI. Only children classified with severe TBI had poorest KOSCHI ratings of *severe disability*.

Calvert et al. (2008) found the KOSCHI to have good predictive validity, as KOSCHI ratings at discharge correlated with a range of measures obtained 1-month post TBI: verbal IQ (r= .27, p= .004), performance IQ (r= .21, p= .024), various measures of attention (all *r's* between .25 to .26, all *p's*< .05), quality of life (r= .23, p= .019), and health status (r= -.23, p= .026). At 6-months post TBI, KOSCHI outcomes continued to correlate with verbal IQ (r= .23, p= .048), selective attention (r= .32, p= .015), health status (r= -.23, p= .046), and quality of life (r= .25, p= .026). Lastly, KOSCHI ratings correlated with ratings on the Paediatric Care and Needs Scale which indicated the extent (r= -.57, p< .001) and intensity (r= -.63, p< .001) of support needed (Soo, Tate, Williams, Waddingham, & Waugh, 2008).

Procedure

PTA Testing. The items on the SCH-PTA scare were typically administered by the child's bedside, with care taken to minimise noise, distractions and interruptions. PTA testing was conducted by the Clinical Nurse Consultant (CNC) of the Brain Injury Rehabilitation Program (BIRP) on weekdays, and handed over to an assigned Occupational Therapist or Physiotherapist on weekends. PTA testing was undertaken on a daily basis, until the child obtained three consecutive perfect scores, i.e. criteria required to be considered out of PTA.

File Review. The inpatient and outpatient medical records, as well as SCH-PTA scale protocols, were reviewed by the chief investigator (PD) who extracted all the relevant data, including demographic information (age, gender, fluency in English), any pre-existing developmental disorder (e.g. intellectual disability, autism, cerebral palsy), or other pre-existing neurological illness or injury (e.g. epilepsy, brain tumour). The cause of injury was recorded, as well as indicators of injury severity: clinically estimated PTA duration, revised PTA duration (using 5-item PTA scale), and initial measure of GCS.

Outcome at discharge was documented in patient files, as per standard clinical practice. Clinic reports at discharge reported on common symptoms following TBI (e.g. headache/dizziness, fatigue, physical restrictions/limitations), cognitive functioning (e.g. attention, memory), and behavioural changes. Patients were routinely reviewed as an outpatient by BIRP staff six weeks post discharge; any ongoing or further review occurred

as required. Review was typically undertaken by the Peadiatric Rehabilitation Staff Specialist and any other treating clinicians, e.g. physiotherapist, occupational therapist, speech therapist, social worker. Review notes typically provided an update on symptoms noted at discharge, as well as on academic, behavioural and social functioning. Information obtained from discharge documents, clinical notes and reports were used to rate the patient on the KOSCHI at discharge, first clinic review, and where applicable, second clinic review.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics 20.0.0 (IBM Corp., 2011). Nonparametric tests were used due to the ordinal nature of some of the variables and non-normality of data distributions.

Several preliminary analyses were first conducted to examine the effect of demographic variables on the main variables of interest: revised PTA duration and KOSCHI outcome. If the 5-item PTA scale was developmentally appropriate for children aged 4-7, age was not expected to affect revised PTA duration. To examine this, the correlation (Spearman's rho) between revised PTA duration and chronological age was computed. Spearman correlations were also employed to examine relationships between KOSCHI outcome scores with age, and time since discharge. Mann-Whitney U tests compared KOSCHI scores of boys and girls.

The main analyses followed. First, concurrent validity of the 5-item PTA scale was assessed by examining the correlation (Spearman's rho) between revised PTA duration and initial GCS. Second, to determine the predictive validity of the 5-item PTA scale, the relationship between indicators of injury severity and outcome were assessed. The association between KOSCHI outcome with initial GCS, and the two PTA durations (i.e. estimated, revised) were first examined by computing Spearman correlations. Indicators that significantly correlated with KOSCHI scores, and variables that revealed group differences in KOSCHI scores, were included in the regression analyses. Three separate ordinal linear regressions (complementary log-log function) were conducted to determine which early indicators of injury severity best predicted KOSCHI outcome at each time point: discharge, first clinic review, and second clinic review.

Results

Participants

Sample characteristics are presented in Table 16. The age range was 4.0 – 7.8 years. The boy : girl ratio was 2.9 : 1; significantly more boys than girls, $X^2(1, N= 35) = 8.26$, $p= .004$) sustained a TBI. In order of highest frequency, the causes of injury were falls, bicycle/scooter/skateboard accidents, motor vehicle accidents, and sport injuries. The median duration of hospital treatment was 5 days ($SD= 12.8$).

Table 16
Demographic Information and Injury Details of TBI Sample

	***M* (*SD*)**
Age (years)	5.8 (1.2)
Gender	***n* (%)**
boys	26 (74.3)
girls	9 (25.7)
Cause of Injury	***n* (%)**
Fall	12 (34.3)
Bicycle/Scooter/Skateboard	10 (28.6)
MVA Pedestrian	6 (17.1)
MVA Passenger	5 (14.3)
Sport	2 (5.7)
	Median (*IQR*)
Days in Hospital	5 (3-7)

IQR= interquartile range, *M*= mean, *n*= number of children, *SD*= standard deviation, TBI= traumatic brain injury, **%=** percentage of sample

Indicators of Injury Severity

Estimated PTA Duration. Clinical estimates of PTA duration ranged from less than 24 hours to 32 days, with a median PTA duration of 2 days ($SD= 6.2$; $IQR= < 24$ hours – 4 days).

Revised PTA Duration according to 5-item PTA scale. Revised PTA duration ranged from less than 24 hours to 34 days. The median revised PTA duration was 1 day (*SD*= 6.7; *IQR*= < 24 hours – 4 days).

Initial GCS. Median initial GCS was 14 (*SD*= 3.7, *IQR*= 10-15). According to GCS scores, 71% patients had a *minor* injury (GCS 13-15), 9% had a *moderate* injury (GCS 9-12), and 20% had a *severe* injury (GCS < 9).

Outcome

Refer to Table 17 for the frequency counts of each KOSCHI category, at each time point: discharge, first clinic review, and second clinic review.

Table 17

KOSCHI Outcomes of TBI Sample

	KOSCHI Category	Discharge	1st Review	2nd Review
1	Death (1)	0	0	0
2	Vegetative (2)	0	0	0
3	Severe disability (3a)	0	0	0
4	Severe disability (3b)	3	1	1
5	Moderate disability (4a)	9	4	0
6	Moderate disability (4b)	7	4	3
7	Good recovery (5a)	14	12	14
8	Good recovery (5b)	2	11	11
	TOTAL	**35**	**32**	**29**

KOSCHI= King's Outcome Scale for Childhood Head Injury, TBI= traumatic brain injury

Discharge. Discharge outcome was available for all 35 children. Most frequently, children either achieved *good recovery* (n=16) or presented with *moderate disability* (n=16). Three children had severe disability at discharge. No children died or were in the vegetative state.

First Clinic Review. Twenty-six children attended an initial clinic review at a median time of 6.3 weeks post hospital discharge (*SD*= 3.8, *IQR*= 4.9-8.0). Six children that had achieved the highest gross KOSCHI outcome score (i.e. 5*a* or 5*b*) at the time of

hospital discharge did not require a clinic review, and did not make further contact with BIRP services, which was made available if needed. It was therefore assumed that these children had maintained their good recovery. With this assumption, the discharge outcome scores were carried over as outcome at first and second clinic review. The discharge scores were not carried over for three children as they had not attained good recovery at discharge: one was classified with a severe disability, and two with a moderate disability. Two of these children did not attend their scheduled review, and one child was reviewed by services interstate. Outcome at first review was therefore examined for 32 children in total.

Second Clinic Review. Twelve children attended a second clinic review, at a median time of 19.9 weeks post hospital discharge (*SD*= 9.6, *IQR*= 13.5 – 25.8 weeks). Eleven children had improved and achieved the highest gross KOSCHI outcome score (i.e. 5*a* or 5*b*) at the previous clinic review, and did not require a second review. Hence, their KOSCHI outcome at first review was considered the same at time of second clinic review. A further three children did not have their outcome at first review carried over as outcome at second review, as all three had only attained moderate recovery at first review. Two children did not attend their second review, and one moved outside the SCH catchment area and was therefore referred to the appropriate regional service. Outcome at second review was therefore available for 29 children in total.

Preliminary Analyses: Effect of Demographic Variables

Age did not correlate with revised PTA duration or KOSCHI outcome at any time point: discharge, first clinic review, and second clinic review. Number of weeks since discharge correlated with KOSCHI outcome at second review, but not at first review. Mann-Whitney U tests revealed no gender differences in KOSCHI outcome at any time of assessment. See Table 18 for Spearman's rho correlation coefficients and Mann-Whitney U test results.

Concurrent Validity of 5-Item PTA Scale

Revised PTA duration significantly correlated with initial GCS (Spearman's rho= -.60, $p < .001$).

Predicting Outcome

Correlations between indices of injury severity and KOSCHI outcome. Revised PTA duration correlated with KOSCHI outcome at all time points: discharge, first review,

and second review. Clinically estimated PTA duration correlated with KOSCHI outcome at discharge and first review, but not second review. Initial GCS correlated with outcome at discharge, but not at first or second clinic review (Table 19).

Table 18
Results of Preliminary Analyses:
Correlation Coefficients (Spearman's rho) and Mann-Whitney U Tests

	REVISED PTA DURATION (5-item Scale)	
	r	*p*
Age at Injury	.15	.39

	KOSCHI OUTCOME					
	Discharge		First Review		Second Review	
	r	*p*	*r*	*p*	*r*	*p*
Age at Injury	.09	.60	- .27	.14	- .19	.33
Time Since Discharge	-	-	.16	.44	- .66*	.02
	U	*p*	*U*	*p*	*U*	*p*
Gender	104.50	.62	98.00	.81	71.50	.34

KOSCHI= King's Outcome Scale for Childhood Head Injury, PTA= post traumatic amnesia

r= Spearman's rho coefficient; *p*= significance (2-tailed); *p< .05

U= Mann-Whitney U test statistic; *p*= asymptomatic significance (2-tailed) *p*-value

Table 19
Correlation (Spearman's rho) Matrix Between Predictor and Outcome Variables

	Discharge		First Review		Second Review	
	r	*p*	*r*	*p*	*r*	*p*
Initial GCS	.36*	.04	.34	.06	.27	.16
Estimated PTA Duration	-.43*	.011	-.57**	.001	-.33	.081
Revised PTA Duration	-.47**	.004	-.70**	<.001	-.54**	.002

GCS= Glasgow Coma Scale, PTA= post traumatic amnesia

r= Spearman's rho coefficient; *p*= significance (2-tailed); *p< .05, **p< .01

Indices and factors considered for regression analyses. Subsequently, all three predictors were considered in determining outcome at discharge. For outcome at first review, only estimated PTA duration and revised PTA duration correlated with KOSCHI outcome. Of the two PTA durations, the revised PTA duration had a larger correlation with KOSCHI outcome at first review. At second review, weeks since discharge and revised PTA duration were the only factors that correlated with KOSCHI outcome. However, weeks since discharge is not an *early* indicator of injury severity. Therefore revised PTA duration also remained the best early predictor of outcome at second review.

Multicollinearity was assessed on these three indices (see Table 20 for Spearman's rho correlations). All the variables correlated with each other. The strongest correlation occurred between clinically estimated PTA duration and revised PTA duration. This is not surprising due to their identical constructs. To reduce the overlap of accounted variance, estimated PTA duration and revised PTA duration were analysed in separate regressions.

Table 20

Correlations Between Predictors

	1	2	3
1. Revised PTA Duration	-		
2. Estimated PTA Duration	**.87****	-	
3. Initial GCS	**-.60****	**- .59****	-

GCS= Glasgow Coma Scale, PTA= post traumatic amnesia

****p< .01**

Regression Analyses

KOSCHI outcome at discharge. With estimated PTA duration and initial GCS entered into the ordinal regression, neither of the variables was a significant predictor of KOSCHI outcome at discharge. However, when revised PTA duration replaced estimated PTA duration in the regression, revised PTA duration became the only significant predictor of KOSCHI outcome at discharge. The results of each regression are presented in Table 21.

KOSCHI outcome at first review. As can be seen from the regression results presented in Table 21, the model involving revised PTA duration accounted for greater variance than the model involving clinically estimated PTA duration.

KOSCHI outcome at second review. Inclusion of revised PTA duration in the regression model accounted for 31% of the variance.

Table 21
Regression Results for KOSCHI Outcome

	Predictors				Model	
Predictors	*beta*	*SE*	*Wald's* χ^2	*p*	R^2	*p*
Discharge						
Estimated PTA	-.089	.048	3.490	.062	73.394	<.001
Initial GCS	.130	.071	3.396	.065		
Revised PTA	-.104	.048	4.671	.031	77.48	<.001
Initial GCS	.113	.072	2.442	.118		
1st Review:						
Revised PTA	-.174	.047	13.856	<.001	58.49	<.001
Estimated PTA	-.175	.050	12.442	<.001	48.80	<.001
2nd Review:						
Revised PTA	-.150	.052	8.204	.004	31.22	<.001

GCS= Glasgow Coma Scale, KOSCHI= King's Outcome Scale for Childhood Head Injury, PTA= post traumatic amnesia

Discussion

The current arm of the study aimed to examine the concurrent and predictive validity of a proposed 5-item PTA scale, using a clinical TBI sample aged 4-7 years. The 5-item PTA scale was demonstrated to have good concurrent validity and correlated with initial GCS measures, one of the most widely used clinical indicators of injury severity.

The 5-item PTA scale was also demonstrated to have strong predictive validity, being a stronger predictor of gross functional outcome at all time points: discharge, first and second outpatient review, compared to clinical estimates of PTA duration and initial GCS.

Demonstration of the concurrent validity of previous pediatric PTA scales has rarely been established. The previously described systematic review identified five PTA scales that have been used with young children, though concurrent validity was demonstrated only for the COAT. The COAT was similarly shown to correlate with admission GCS (Ewing-Cobbs et al., 1990, Tremont et al., 1990), however the samples were not exclusive of children within the targeted age range, and included children up to the age of 16 years. The current study therefore demonstrates concurrent validity of the proposed 5-item PTA scale, particularly for children aged 4-7 years.

Only two previous studies were identified to examine the predictive validity of pediatric PTA scales in young children. The Starship PTA scale, in combination with initial GCS, was shown to predict cognitive outcome in children aged 3-7 years (Thickpenny-Davis et al., 2005). Even though PTA duration according to the Starship PTA scale had the strongest contribution in the combined PTA duration and GCS model, the current study found that initial GCS did not significantly contribute to the model when PTA duration according to the 5-item scale was included in the predictive model. This may suggest stronger predictive validity of the 5-item PTA scale over the Starship PTA scale. The second identified study did not compare PTA duration with GCS. Rather, the Oxford-C PTA scale was found to be equally predictive as coma duration of gross outcome in children aged 2-8 years (Ruijs et al., 1992). Nevertheless, the Oxford-C is not published and developmental validity of the scale is unclear. Other studies have demonstrated the predictive validity of the COAT, which was generally a stronger predictor than GCS in predicting cognitive outcome (Ewing-Cobbs et al., 1990; Tremont et al., 1999), however the samples included children up to the age of 16 years, limiting the generalizability to the targeted age groups.

An important strength of the scale is that each included item has been demonstrated to be developmentally valid for each age group of interest, 4-, 5-, 6-, and 7-year old children. Each item was correctly answered by at least 90% of each age group on each day of testing. It is crucial to ensure items are developmentally appropriate if incorrect answers are presumed to be symptoms of disruptions to basic orientation or memory. Previous pediatric PTA scales have generally failed to establish the

developmental validity of the scale, with the exception of the WPTAS-C for use in 4-5 year old children (Rocca et al., 2008). Nevertheless, the WPTAS-C has not been clinically validated, and the current 5-item scale caters for a larger age range of 4-7.

The findings of the current study have potential implications for the clinical field of pediatric TBI. Clinicians at SCH were basing their estimations of PTA duration according to a range of clinical indicators, including their responses to orientation and memory items on the (invalidated) SCH-PTA scale, GCS scores, CT scan findings and behavior. The 5-item PTA scale may now provide a standardized method of assessing PTA duration, and excludes developmentally inappropriate items that may inaccurately prolong one's PTA duration. Furthermore, the stronger predictive validity of the 5-item PTA scale compared to the clinical estimates of PTA duration, indicates that use of the revised protocols may determine PTA durations more accurately than current practice of determining PTA, and subsequently predict gross outcome more accurately than current practice.

A limitation of the proposed 5-item PTA scale is the lack of item to assess orientation to time. To address this, inclusion of the question requiring mere distinction between day and night ("Is it daytime or night time?") can be considered as it was found developmentally appropriate for pre-school and school children as young as 4 years (Fernando et al., 2002). Further distinction between the components of day as morning or afternoon appears appropriate once children reach 7 years and above. It is therefore suggested that questioning "Is it daytime or night time?" is the most developmentally appropriate temporal orientation item for 4-7 year old children.

A potential limitation may also be the inclusion of only two memory items: target face and name, which may be criticized to inadequately assess return of memory. To address this limitation, recall of two pictures may be introduced as utilized in the WPTAS-C. It was clear from the first study that all children aged 4-7 had difficulty recalling a different set of three pictures on three consecutive days. In contrast, 93% of 4-5 year old children passed the WPTAS-C which involves only two target pictures. It is not indicated, however, how many of the 7% that failed were 4-year old children. Due to the uncertainty, it is further suggested that the pair of target pictures are held constant across the days of testing. Holding the pictures constant would likely be more developmentally appropriate as it would eradicate the need to monitor the target pictures as they change, which requires skills that are still developing in this young age group. Concerns with

changing target pictures have been raised even for the adult TBI population. Tate et al. (2006) found that changing pictures according to the procedure of the WPTAS resulted in unnecessary prolonged emergence from PTA in an adult sample of severe TBI. These findings guided the adult MOPTAS scale, which holds the three target pictures constant on all days of testing. Inclusion of a similarly amended picture recall item may therefore provide a more appropriate and adequate assessment of continuous memory than the current 5-item protocol.

Lastly, concern may be raised about the study's procedure of transferring outcome scores. In several cases where the patient failed to attend their next review or no review was needed, their last KOSCHI rating was transferred as the KOSCHI rating at subsequent time points. This, however, only occurred with patients that attained "good recovery" at the prior review, and therefore the highest outcome had already been achieved. Concern may be raised about making assumptions about these outcomes without a formal assessment. However, there is no reason to believe that the outcome may have significantly deteriorated. It is not uncommon for patients to fail attendance at review appointments when they are happy with their progress and have no concerns to address. If deterioration had occurred, it is thought that patients would be more likely to maintain their review appointments.

In conclusion, the current findings clinically validate the proposed 5-item PTA scale. Whilst the first study established the developmental validity of each of the included items; the current study has established clinical utility of the scale in predicting outcome. PTA duration assessed by the 5-item scale was a stronger predictor than GCS, a classic indicator of injury severity. These results support use of the 5-item scale, providing clinicians an objective assessment of PTA that is easily administered with standard procedures. Considering PTA duration alongside other indices of injury severity provides useful information that can strengthen clinical assessments of injury severity.

Chapter 5

Summary and Conclusions

Valid assessment of PTA aids clinicians in determining the severity of a TBI, which subsequently informs prognosis and the prediction of outcome. This information may then aid clinical decisions regarding treatment, rehabilitation, and allocation of resources that help maximise one's recovery. There is no established scale to assess PTA in children aged 4-7 years, a task that has proven difficult to achieve due to the developmental variations of children in these early years. The systematic review revealed five scales that have been used to assess PTA in this young age group, though only two were specifically developed for children within this age range: Starship PTA scale for children aged 4-6 years (Fernando et al., 2002) and WPTAS-C for children aged 4-5 years (Rocca et al., 2008). Nevertheless, none of the scales had been appropriately validated, or was only appropriate for a very limited age range (e.g. WPTAS-C for 4-5 year old children).

The current study evaluated use of the SCH-PTA scale, a scale developed by a team at SCH to assess PTA in children aged 4-7 years, and had been in clinical use at SCH since November 2008. Over the years of using the scale, clinicians had identified difficulties with the scale. Certain items appeared to be problematic, and the developmental appropriateness of the items was questioned. As a result, clinicians typically used the SCH-PTA scale to help guide their clinical estimations of PTA duration, in light of other clinical indicators and the patient's presentation and behavior.

Examination of the responses by typically developing children aged 4-7 years to the SCH-PTA scale found that certain items were indeed developmentally inappropriate. Specifically, children had difficulty stating the time of day (morning, afternoon, or night), their address, and recalling a different set of three pictures on three consecutive days. These questions require the function or interplay of certain cognitive skills, such as orientation to time, episodic autobiographical memory and literacy skills, which are still developing at these young ages.

These difficulties and developmental trends were considered in the proposal of a revision of the SCH-PTA scale: a 5-item protocol. Address and time of day were

eliminated as orientation items, and recall of three target pictures was eliminated from the set of memory items.

The second study investigated the clinical validity of the proposed 5-item PTA scale. PTA durations of a pediatric TBI sample from SCH were revised according to the 5-item protocol. The resulting PTA duration was demonstrated to have good concurrent and predictive validity; correlating with initial GCS measures, and being the strongest predictor of gross functional outcome compared to clinical estimates of PTA duration and initial GCS. Revised PTA duration was the strongest predictor at all time points examined: discharge, first review (approximately 6 weeks post discharge) and second review (approximately 20 weeks post discharge).

Although solid predictive validity of the 5-item protocol was evident in the current study, certain limitations of the scale required addressing. The scale lacked an item assessing orientation to time, and there was concern of the potential inadequate assessment of continuous memory as only two memory items were included: target face and name. Improvements on the scale were therefore suggested based on an integration of the current study's findings and findings of the systematic review. To include an item assessing orientation to time, it was suggested to include "Is it day or night time?" as the systematic review revealed that pre-school and school children as young as 4 are able to identify whether it is day or night. It is distinguishing day as morning or afternoon that is problematic for young children. It must be noted, however, that validation of this item is needed. Although children in the community attending pre-school and school may be able to easily distinguish between day or night, children in a hospital setting may be more susceptible to confusion when they are not in their regular scheduled environments that would prompt one's orientation to time (e.g. day is when I'm at school, night is when I'm at home). It would be ideal to examine responses on this item from typically developing children that are hospitalized without a TBI (e.g. orthopaedic patients).

Additionally, it was suggested that two pictures are used for recall, however these pictures should be held constant across all days of testing rather than changed upon each perfect picture recall. Two pictures were selected as Rocca et al. (2008) had found that 4-5 year old children had little difficulty recalling a different set of pictures on each day of testing when only two were involved. However, due to the uncertainty of the exact accuracy rates achieved separately by 4- and 5-year old children, and in order to consider the still-developing cognitive skills required to

reliably and accurately monitor pictures as they change day to day, it was thought that holding the pictures constant would be a more developmentally appropriate approach.

A final 9-item revision of the SCH-PTA scale is therefore proposed, and addresses the components of PTA: disrupted orientation (person, place, time) and continuous memory (Table 22). The final proposed 9-item scale is a product of the integrated findings of the current study, findings from previous pediatric PTA scales, and review of the developmental literature. Whilst the proposed scale has strong theoretical and empirical underpinnings, future research would need to investigate the validity of the scale. It would be most appropriate to examine responses of children in a hospital setting without TBI (e.g. orthopaedic patients) to control for contextual factors that may affect performance on the scale (e.g. disorientation due to disruption of regular and familiar routine).

Table 22

Final Proposed 9-Item Post Traumatic Amnesia (PTA) Scale for Children 4-7 Years

Domain and Items	
Orientation to Person	
	How old are you?
	What is your father's / mother's name?
Orientation to Place	
	What is the name of this place?
Orientation to Time	
	Is it day or night time?
Anterograde Memory	
	Target face: Which photo did you have to remember?
	Target name: What is her name?
	Which pictures did you have to remember?
	Target picture 1
	Target picture 2
Duration of PTA:	Day of injury to first of three consecutive perfect scores of 9/9

The 9-item PTA scale has likely potential to provide an objective assessment of PTA in children 4-7 years that is easily administered with standard procedures. Previous pediatric scales have been proposed for more limited age ranges, and lack established psychometric properties. Although the proposed 9-item scale is yet to be validated, its 5-item predecessor has been demonstrated to have developmental, concurrent and predictive validity and the additional proposed items are supported by findings of the systematic review. Altogether, the proposed 9-item PTA scale has theoretical and empirical underpinnings that support the developmental validity of the scale for children aged 4-7 years. Examination of responses from a hospitalized non-TBI sample is needed to further validate the contextual validity of the items. Validation with a clinical TBI sample would also clarify its clinical utility in indicating the injury severity and ability to predict outcome. The 9-item scale has the potential to fulfill the clinical gap in the assessment of PTA in young children.

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Tate, R.L., Pfaff, A., Bagueley, I.J., Marosszeky, J.E., Hodgkinson, A.E., King, C., Lane-Brown, A.T., & Hanna, J. (2006). A multicentre, randomised trial examining the effect of test procedures measuring emergence from post-traumatic amnesia. *Journal of Neurology, Neurosurgery and Psychiatry, 77*, 841-849.

Tate, R.L., Pfaff, A., & Jurjevic, L. (2000). Resolution of disorientation and amnesia during post-traumatic amnesia. *Journal of Neurology, Neurosurgery, and Psychiatry, 68*, 178-185.

Taylor, H.G., & Alden, J. (1997). Age-related differences in outcomes following childhood brain insults: An introduction and overview. *Journal of the International Neuropsychological Society, 3* (6), 555-567.

Taylor. G.H., Yeates, K.O., Wade, S.L., Drotar, D., Stancin, T., & Minich, N. (2002). A prospective study of short- and long-term outcomes after traumatic brain injury in children: Behaviour and achievement. *Neuropsychology, 16* (1), 15-27.

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness: A practical scale. *Lancet*, *2*, 81-84.

Thickpenny-Davis, K.L., & Ogden, J.A. (2005). The Starship Post-Traumatic Amnesia Scale: Does it predict outcome after mild to moderate traumatic brain injury in children aged 3 to 7 years? *Brain Impairment, 6* (2), 101-108.

Thompson, H.J., McCormick, W.C., & Kagan, S.H. (2006). Traumatic brain injury in older adults: epidemiology, outcomes, and future implications. *Journal of the American Geriatrics Society, 54* (10), 1590-1595.

Thurman, D.J., Coronado, V., & Selassie, A. (2007). The epidemiology of TBI: Implications for public health. In N.D. Zasler, D.I. Katz, & R.D. Zafonte (Ed.), Brain Injury Medicine: Principles and Practice (1st ed., pp. 45-55). New York, New York: Demos Medical Publishing.

Tremont, G., Mittenberg, W., & Miller, L.J. (1999). Acute intellectual effects of pediatric head trauma. *Child Neuropsychology, 5* (2), 104-114.

van der Naalt, J., Zomeren, A.H., Sluiter, W., & Minderhoud, J.M. (1999). One year outcome in mild to moderate head injury: The predictive value of acute injury

characteristics related to complaints and return to work. *Journal of Neurology, Neurosurgery & Psychiatry, 66* (2), 207-213.

van Velzen, J.M., van Bennekom, C.A.M., Edelaar, M.J.A., Sluiter, J.K., & Frings-Dresen, M.H.W. (2009). How many people return to work after acquired brain injury?: A systematic review. *Brain Injury, 23* (6), 473-488.

Vanderploeg, R.D., Belanger, H.G., & Curtiss, G. (2009). Mild traumatic brain injury and posttraumatic stress disorder and their associations with health symptoms. *Archives of Physical Medicine and Rehabilitation, 90* (7), 1084-1093.

Vangel, S.J. Jr., Rapport, L.J., & Hanks, R.A. (2011). Effects of family caregiver psychosocial functioning on outcomes in persons with traumatic brain injury. *The Journal of Head Trauma Rehabilitation, 26* (1), 20-29.

Varier, S., Kaiser, M., & Forsyth, R. (2011). Establishing, versus maintaining, brain function: A neuro-computational model of cortical reorganization after injury to the immature brain. *Journal of the International Neuropsychological Society, 17*, 1030-1038.

Walz, N.C., Yeates, K.O., Wade, S.L., & Mark, E. (2009). Social information processing skills in adolescents with traumatic brain injury: Relationship with social competence and behavior problems. *Journal of Pediatric Rehabilitation Medicine, 2* (4) 285-295.

Ward, H., Shum, D., Wallace, G., & Boon, J. (2002). Pediatric traumatic brain injury and procedural memory. *Journal of Clinical and Experimental Neuropsychology, 24* (4), 458-470.

Warschausky, S., Cohen, E.H., Parker, J.G., Levendosky, A.A., & Okun, A. (1997). Social problem-skills of children with traumatic brain injury. *Pediatric Rehabilitation, 1* (2), 77-81.

Wechsler, D. (1991). *The Wechsler Intelligence Scale for Children - Third Edition*. San Antonio, TX: Pearson Psychological Corporation.

Wechsler, D. (2002). *Wechsler Preschool and Primary Scale of Intelligence – Third Edition.* San Antonio, TX: Pearson Psychological Corporation.

Wechsler, D. (2005). *Wechsler Intelligence Scale for Children – Fourth Edition.* San Antonio, TX: Pearson Psychological Corporation.

Weir, N., Doig, E.J., Fleming, J.M., Wiemers, A., & Zemljic, C. (2006). Objective and behavioural assessment of the emergence from post-traumatic amnesia (PTA). *Brain Injury, 20* (9), 927-935.

Wilde, E.A., Bigler, E.D., Pedroza, C., & Ryser, D.K. (2006). Post-traumatic amnesia predicts long-term cerebral atrophy in traumatic brain injury. *Brain Injury, 20* (7), 695-699.

Willoughby, K.A., Desrocher, M., Levine, B., & Rovet, J.F. (2012). Episodic and semantic autobiographical memory and everyday memory during late childhood and early adolescence. *Frontiers in Psychology, 3*: 53. doi: 10.3389/fpsyg.2012.00053

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

Yeates, K.O., Taylor, H.G., Wade, S.L., Drotar, D., Stancin, T., & Minich, N. (2002). A prospective study of short- and long-term neuropsychological outcomes after traumatic brain injury in children. *Neuropsychology, 16* (4), 514-523.

Zafonte, R.D., Mann, N.R., Millis, S.R., Black, K.L., Wood, D.L., & Hammond, F. (1997). Posttraumatic amnesia: Its relation to functional outcome. *Archives of Physical Medicine and Rehabilitation, 78*, 1103-1106.

Appendices

Appendix A.1. Systematic Review: List of Studies Excluded Upon Full Text Review (n= 14)

Medline

Outside age range = 3

Hessen, E., Anderson, V., & Nestvold, K. (2008). MMPI-2 profiles after paediatric mild traumatic brain injury. *Brain Injury, 22* (1), 39-50.
NB. Age range at time of injury 14-37 years.

Keskil, I.S., Baykaner, M.K., Ceviker, N., Kaymaz, M. (1995). Assessment of mortality associated with mild head injury in the pediatric age group. *Childs Nervous System, 1*1(8), 467-473.

Königs, M., de Kieviet, J.F., & Oosterlaan, J. (2013). Post-traumatic amnesia predicts intelligence impairment following traumatic brain injury: a meta-analysis. Journal of Neurology, Neurosurgery, & Psychiatry, 83, 1048-1055.
NB. Mean age of total sample is 9-44 years. One relevant study found and isolated (Tremont et al., 1999).

Retrospective PTA assessment or unspecified PTA scale = 8

Asikainen, I., Kaste, M., & Sarna, S. (1998). Predicting late outcome for patients with traumatic brain injury referred to a rehabilitation programme: A study of 508 Finnish patients 5 years or more after injury. *Brain Injury, 12* (2), 95-107.
NB. Estimated PTA duration from reports and interviews.

Brown, G., Chadwick, O., Shaffer, D., Rutter, M., & Traub, M. (1981). A prospective study of children with head injuries: III. Psychiatric sequelae. *Psychological Medicine, 11*(1), 63-78.

Chadwick, O., Rutter, M., Shaffer, D., & Traub, M.U. (1981). A prospective study of children with head injuries: II. Cognitive sequelae. *Psychological Medicine, 11*(1), 49-61.

Hessen, E., Nestvold, K., & Anderson, V. (2007) Neuropsychological function 23 years after mild traumatic brain injury: A comparison of outcome after paediatric and adult head injuries. *Brain Injury, 21* (9), 963-979.

NB. PTA scale also not identified. Cannot extract data for children in target age group. Age range 2-15, mean=8.9, SD=3.4.

Jaffe, K.M., Polissar, N.L., Fay, G.C., & Liao, S. (1995). Recovery trends over three years following pediatric traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 76* (1), 17-26.

NB. Did not use PTA, ony GCS.

Kane, N.M., Curry, S.H., Rowlands, C.A., Manara, A.R., Lewis, T., Moss, T., Cummins, B.H., & Butler, S.R.. Even-related potential – neuropsychological tools for predicting emergence and early outcome from traumatic coma. *Intensive Care Medicine, 22*(1), 39-46.

Lundar, T., & Nestvold, K. (1985). Pediatric head injuries caused by traffic accidents. A prospective study with 5-year follow-up. *Childs Nervous System, 1*(1), 24-28.

Rutter, M., Chadwick, O., Shaffer, D., & Brown, G. (1980). A prospective study of children with head injuries: I. Design and methods. *Psychological Medicine, 10*(4), 633-645.

Not relevant = 1

Massagli, T.L., Jaffe, K.M., Fay, G.C., Polissar, N.L., Liao, S., & Rivara, J.B. (1996). Neurbehavioural sequalae of sever pediatric traumatic brain injury: A cohort study. Archives of Physical Medicine and Rehabilitation, 77 (3), 223-231.

PsycINFO

Outside age range = 2

Avesani, R., Salvi, L., & Gambini, M.G. (2005). Reintegration after severe brain injury: A retrospective study. *Brain Injury, 19* (11), 933-939.

NB. Cannot extract data for children in target age group. Age range 5-77, mean=32, SD=15. PTA scale not specified.

Saneda, D.L., & Corrigan, J.D. (1992). Predicting clearing of post-traumatic amnesia following closed-head injury. *Brain Injury, 6* (2), 167-174.

NB. Age range 12-72; used GOAT.

Appendix A.2.

Systematic Review: List of Studies Excluded During Scale Search

WPTAS

PsycINFO:

Already identified = 2

Rocca, A., Wallen, M., & Batchelor, J. (2008). The Westmead Post-Traumatic Amnesia Scale for Children (WPTAS-C): Aged 4 and 5 years old. *Brain Impairment, 9* (1), 14-21.

Marosszeky, N.E.V., Batchelor, J., Shores, E.A., Marosszeky, J.E., Klein-Boonschate, M., & Fahey, P.P. (1993). The performance of hospitalised, non head-injured children on the Westmead PTA scale. *The Clinical Neuropsychologist, 7* (1), 85-95.

Outside age range = 1

Theadom, A., Barker-Collo, S., Feigin, V.L., Starkey, N.J., Jones, K., Jones, A., Ameratunga, S., & Barber, P.A. (2011). The spectrum captured: A methodological approach to studying incidence and outcomes of traumatic brain injury on a population level. *Neuroepidemiology, 38*, 18-29.
NB. WPTAS available for patients 16 and older.

COAT

Medline:

Not in English = 1

Moreau, J., Laurent-Vannier, A., & De Agostini, M. (2008)[Standardization of the Children's Orientation and Amnesia Test, French version, to evaluate post-traumatic amnesia in children]. *Annales de Readaptation et de Medecine Physique, 51*(1), 24-30.
N.B. French version of the COAT. Authors collected normative data from 137 French children aged 4-, 6-, 8-, and 10-years. According to the abstract, the authors concluded that the French version of the COAT "allows for an accurate evaluation of PTA duration in French children" (p. 25).

Outside age range = 1

Iverson, G.L., Iverson, A.M., & Barton, E.A. (1994). The Children's Orientation and Amnesia Test: Educational status is a moderator variable in tracking recovery from TBI. *Brain Injury, 8*(8), 685-688.

Already Identified = 2

Baryza, M.J., & Haley, S.M. (1994). Use of the Children's Orientation and Amnesia Test at hospital discharge for children with neurological and non-neurological traumatic injuries. *Brain Injury, 8* (2), 167-173.

Ewing-Cobbs, L., Levin, H.S., Fletcher, J.M., Miner, M.E., & Eisenberg, H.M. (1990). The Children's Orientation and Amnesia Test: Relationship to severity of acute head injury and to recovery of memory. *Neurosurgery, 27* (5), 683-691.

PsycINFO:

Duplicates = 2

Baryza, M.J., & Haley, S.M. (1994). Use of the Children's Orientation and Amnesia Test at hospital discharge for children with neurological and non-neurological traumatic injuries. *Brain Injury, 8* (2), 167-173.

Iverson, G.L., Iverson, A.M., & Barton, E.A. (1994). The Children's Orientation and Amnesia Test: Educational status is a moderator variable in tracking recovery from TBI. *Brain Injury, 8*(8), 685-688.

Outside age range = 3

Iverson, G.L., Woodward, T.S., & Iverson, A.M. (2002). Regression-predicted age norms for the Children's Orientation and Amnesia Test. *Archives of Clinical Neuropsychology, 17*(2), 131-142.

Slifer, K.J., Tucker, C.L., Gerson, A.C., Cataldo, M.D., Sevier, R.C., Suter, A.H., & Kane, A.C. (1996). Operant conditioning for behavior management during posttraumatic amnesia in children and adolescents with brain injury. *The Journal of Head Trauma Rehabilitation, 11*(1), 39-50.

Sroufe, N.S., Fuller, D.S., West, B.T., Singal, B.M., Warschausky, S.A., & Maio, R.F. (2010). Postconcussive symptoms and neurocognitive function after mild traumatic brain injury in children. *Pediatrics, 125*(6), 1331-1339.

No empirical data on normative or psychometric (validity or reliability) properties of the scale = 8

Annett, R.D., & Dencoff, J.E. (2011). The pediatric diagnostic interview and neurobehavioral evaluation. In A.S. Davis (Ed.), *Handbook of pediatric neuropsychology* (pp. 435-441). New York, US: Springer Publishing Co.

Bodin, D., & Shay, N. (2012). Cognitive screening and neuropsychological assessment. In M.W. Kirkwood & K.O. Yeates (Eds.), *Mild traumatic brain injury in children and adolescents: From basic science to clinical management* (pp. 264-278). New York, US: Guilford Press.

Chan, D.Y.K., & Fong, K.N.K. (2011). The effects of problem-solving skills training based on metacognitive principles for children with acquired brain injury attending mainstream schools: A controlled clinical trial. *Disability and Rehabilitation: An International, Multidisciplinary Journal, 33*(21-22), 2023-2032.

Malik, O., & Westphal, B. (2013). A role for selective serotonin reuptake inhibitors in the management of residual cognitive dysfunction in pediatric Cushing's disease. Journal of Child and Adolescent Psychopharmacology, 23(1), 65-69.

Richards, P.M., & Kirk, J.W. (2010). Traumatic brain injury across the lifespan: A neuropsychological tutorial for attorneys. *Psychological Injury and Law, 3*(1), 3-24.

Wilde, E.A., McCauley, S.R., Hanten, G., Avci, G., Ibarra, A.P., & Levin, H.S. (2012). History, diagnostic considerations, and controversies. In M.W. Kirkwood & K.O. Yeates (Eds.), *Mild traumatic brain injury in children and adolescents: From basic science to clinical management* (pp. 3-21). New York, US: Guilford Press.

Yeates, K.O. (2012). Independent neuropsychological evaluation of children with moderate to severe traumatic brain injury. In. E.M.S. Sherman & B.L. Brooks (Eds.), *Pediatric forensic neuropsychology* (pp. 229-257). New York, US: Oxford University Press.

Zlotnik, S., Sachs, D., Rosenblum, S., Shpasser, R., & Josman, N. (2009). Use of the dynamic interactional model in self-care and motor intervention after traumatic brain injury: Explanatory case studies. *American Journal of Occupational Therapy, 63*(5), 549-558.

Starship PTA Scale

PsycINFO:

Already identified = 1

Thickpenny-Davis, K.L., Ogden, J.A., & Fernando, K. (2005). The Starship Post-Traumatic Amnesia Scale: Does it predict outcome after mild to moderate traumatic brain injury in children aged 3 to 7 years? *Brain Impairment, 6* (2), 101-108.

WPTAS-C

PsycINFO:

Already identified = 1

Rocca, A., Wallen, M., & Batchelor, J. (2008). The Westmead Post-Traumatic Amnesia Scale for Children (WPTAS-C): Aged 4 and 5 years old. *Brain Impairment, 9* (1), 14-21.

Appendix B.

Systematic Review: List of Included Studies (n=13)

Full Search

Baryza, M.J., & Haley, S.M. (1994). Use of the Children's Orientation and Amnesia Test at hospital discharge for children with neurological and non-neurological traumatic injuries. *Brain Injury, 8* (2), 167-173.

Calvert, S., Miller, H.E., Curran, A., Hameed, B., McCarter, R., Edwards, R.J., Hunt, L., & Sharples, P.M. (2008). The King's Outcome Scale for Childhood Head Injury and injury severity outcome measures in children with traumatic brain injury. *Developmental Medicine and Child Neurology, 50* (6), 426-431.
NB. Age range is 6-16, however cannot extract data for 6-7 year olds; used WPTAS.

Paget, S.P., Beath, A.W.J., Barnes, E.H., & Waugh M-C. (2012). Use of the King's Outcome Scale for Childhood Head Injury in the evaluation of outcome in childhood traumatic brain injury. *Developmental Neurorehabilitation,15*(3), 171-177.

Rocca, A., Wallen, M., & Batchelor, J. (2008). The Westmead Post-Traumatic Amnesia Scale for Children (WPTAS-C): Aged 4 and 5 years old. *Brain Impairment, 9* (1), 14-21.

Ruijs, M.B.M., Gabreels, F.J.M., & Keyser, A. (1993). The relation between neurological trauma parameters and long-term outcome in children with closed head injury. *European Journal of Pediatrics, 152,* 844-847.

Ruijs, M.B.M., Keyser, A., & Gabreels, F.J.M. (1992). Assessment of post-traumatic amnesia in young children. *Developmental Medicine and Child Neurology, 34,* 885-892.

Thickpenny-Davis, K.L., Ogden, J.A., & Fernando, K. (2005). The Starship Post-Traumatic Amnesia Scale: Does it predict outcome after mild to moderate traumatic brain injury in children aged 3 to 7 years? *Brain Impairment, 6* (2), 101-108.

Review of References

Ewing-Cobbs, L., Levin, H.S., Fletcher, J.M., Miner, M.E., & Eisenberg, H.M. (1990). The Children's Orientation and Amnesia Test: Relationship to severity of acute head injury and to recovery of memory. *Neurosurgery, 27* (5), 683-691.

Fernando, K., Eaton, L., Faulkner, M., Moodley, Y., & Setchell, R. (2002). Development and piloting of the Starship Posttraumatic Amnesia Scale for children aged between four and six years. *Brain Impairment, 3* (1), 34-41.

Marosszeky, N.E.V., Batchelor, J., Shores, E.A., Marosszeky, J.E., Klein-Boonschate, M., & Fahey, P.P. (1993). The performance of hospitalised, non head-injured children on the Westmead PTA scale. *The Clinical Neuropsychologist, 7* (1), 85-95.

Tremont, G., Mittenberg, W., & Miller, L.J. (1999). Acute intellectual effects of pediatric head trauma. *Child Neuropsychology, 5* (2), 104-114.

Scale Search

Goldstrohm, S.L., & Arffa, S. (2005). Preschool children with mild to moderate traumatic brain injury: An exploration of immediate and post-acute morbidity. *Archives of Clinical Neuropsychology, 20*(6), 675-695.

McDonald, C.M., Jaffe, K.M., Fay, G.C., Polissar, N.L., Martin, K.M., Liao, S., & Rivara, J.B. (1994). Comparison of indices of traumatic brain injury severity as predictors of neurobehavioural outcome in children. *Archives of Physical Medicine and Rehabilitation, 75* (3), 328-337.

Appendix C.

Screening Interview

Demographic Information

Name : _____ Group (circle): TBI / Control

Date of Birth: _____ Country of Birth: _____ Age:_____ Gender: M / F

Parent/Guardian Interviewed: _____ Relationship to child: _____

Main caregiver (circle): Mother Father Other (specify) _____

Mother's occupation: _____ Father's occupation:_____

Languages spoken at home: _____ Ethnicity: _____

Is you child fluent in English (circle): Yes / No

Medical

Current Medications (drug, frequency, dosage): _____
_____

Has your child ever sustained a head injury that involved a loss of consciousness? If yes, provide details. _____
_____

Has your child been diagnosed with a neurological or developmental condition or disorder such as:

- Epilepsy
- Autism
- Intellectual disability
- Other (specify): _____
- Cerebral Palsy
- Significant hearing impairment
- Significant visual impairment

Has your child ever suffered a serious illness? If yes, provide details:_____
_____

Eligibility (circle): Eligible Not eligible

If not eligible, specify why: _____

Appendix D.1.

Ethics Approval Letter by the University of Sydney Human Research Ethics Committee

THE UNIVERSITY OF SYDNEY

RESEARCH INTEGRITY
Human Research Ethics Committee
Web: http://sydney.edu.au/ethics/
Email: ro.humanethics@sydney.edu.au

Address for all correspondence:
Level 6, Jane Foss Russell Building - G02
The University of Sydney
NSW 2006 AUSTRALIA

22 February 2012

Dr Suncica Sunny Lah
School of Psychology
Brennan MacCallum Building
The University of Sydney
Suncica.lah@sydney.edu.au

Dear Dr Lah,

Thank you for your correspondence received 22 February 2012 addressing comments made to you by the Human Research Ethics Committee (HREC).

I am pleased to inform you that with the matters now addressed your protocol entitled "Assessing the Validity of the Sydney Children's Hospital Post – Traumatic Amnesia scale" has been approved.

Details of the approval are as follows:

Protocol No.: 14540

Approval Date: 22 February 2012

First Annual Report Due: 28 February 2013

Authorised Personnel: Dr Sunica Sunny Lah
Ms Pamela David
Mr Jason Birse
Prof. Robyn Tate
Dr Adrienne Epps
Ms Naomi Brooks

Documents Approved:

Document	Version Number	Date
Invitation Letter/advertisement	1	13/01/2012
Information Sheet	1	29/05/2011
Consent form	1	29/05/2011
Revocation of consent form	1	29/01/2011
Script of recruitment call	1	13/01/2011
Screening interview	1	13/01/2011

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

THE UNIVERSITY OF SYDNEY

Condition/s of Approval

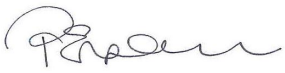
- Continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans.
- Provision of an annual report on this research to the Human Research Ethics Committee from the approval date and at the completion of the study. Failure to submit reports will result in withdrawal of ethics approval for the project.
- All serious and unexpected adverse events should be reported to the HREC within 72 hours.
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the HREC as soon as possible.
- Any changes to the protocol including changes to research personnel must be approved by the HREC by submitting a Modification Form before the research project can proceed.

Chief Investigator / Supervisor's responsibilities:

1. You must retain copies of all signed Consent Forms and provide these to the HREC on request.
2. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely



Patricia Engelmann
Human Ethics Administrator
On behalf of the HREC

cc *Pamela David pdav1945@uni.sydney.edu.au*

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

Appendix D.2.

Ethics Approval Letter by the South Eastern Sydney Local Health Network Human Research Ethics Committee

NSW GOVERNMENT Health
South Eastern Sydney
Local Health Network

HUMAN RESEARCH ETHICS COMMITTEE - NORTHERN SECTOR

Room G71 East Wing
Edmund Blacket Building
Prince of Wales Hospital
RANDWICK NSW 2031
Tel: 02 9382 3587 Fax: 02 9382 2813
www.sesiahs.health.nsw.gov.au/Research_Support/NHN/

6 June 2011

Dr Suncica Lah
School of Psychology
Brennan MacCallum Building A18
University of Sydney
CAMPERDOWN NSW 2006

Attention: Ms Pamela David

Dear Dr Lah

HREC ref no: 11/038
Project title: Assessing the Validity of the Sydney Children's Hospital Post Traumatic Amnesia Scale

Thank you for submitting the above project for ethical and scientific review. The project was first considered by the Human Research Ethics Committee (HREC) at its meeting held on 27 April 2011.

At that meeting the Committee requested that the investigator provide further modification and resubmit amended Participant Information Statement and Consent Forms. The Committee delegated final approval to the Executive Officer.

I am pleased to advise that with your letter dated 29 May 2011 the requested information and revised documents were received incorporating the recommendations of the Committee. Ethical approval has been granted for the above project to be conducted at the Sydney Children's Hospital.

The following documentation has been approved:

- NEAF, submission code AU/1/A0D807
- Study protocol, version 1, dated 23 March 2011
- SCH-PTA Assessment Form: Children Ages 4 – 7 Years Old
- Invitation Letter, version 1, dated 13 January 2011
- Participant Information Statement and Consent Form – Healthy participants, version 1, dated 29 May 2011
- Participant Information Statement and Consent Form – Participants with head injury, version 1, dated 29 May 2011
- Script for Recruitment Call, version 1, dated 13 January 2011
- Screening Interview, version 1, dated 13 January 2011

South Eastern Sydney Local Health Network
Network Executive Unit
Locked Mail Bag 21 TAREN POINT NSW 2229
Tel: (02) 9540 7756 Fax: (02) 9540 8757
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ABN 70 442 041 439

Conditions of approval

1. This approval is valid for 5 years from the date of this letter.
2. Annual reports must be provided on the anniversary of approval.
3. A final report must be provided at the completion of the project.
4. Proposed changes to the research protocol, conduct of the research, or length of approval will be provided to the Committee.
5. The Principal Investigator will immediately report matters which might warrant review of ethical approval, including unforeseen events which might affect the ethical acceptability of the project and any complaints made by study participants.

Optional It is the responsibility of the sponsor or the principal (or co-ordinating) investigator of the project to register this study on a publicly available online registry (eg Australian New Zealand Clinical Trials Registry www.anzctr.org.au).

For NSW Public Health sites only: You are reminded that this letter constitutes ethical approval only. You must not commence this research project until you have submitted your Site Specific Assessment to the Research Governance Officer of the appropriate institution and have received a letter of authorisation from the General Manager or Chief Executive of that institution.

Should you have any queries, please contact the Research Support Office on (02) 9382 3587. The HREC Terms of Reference, Standard Operating Procedures, membership and standard forms are available from the Research Support Office website: http://www.sesiahs.health.nsw.gov.au/Research_Support/NHN/.

Please quote **HREC ref no: 11/038** in all correspondence.

We wish you every success in your research.

Yours sincerely

Deborah Adrian

Deborah Adrian
Executive Officer
Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*, NHMRC and Universities Australia *Australian Code for the Responsible Conduct of Research (2007)* and the *CPMP/ICH Note for Guidance on Good Clinical Practice*.

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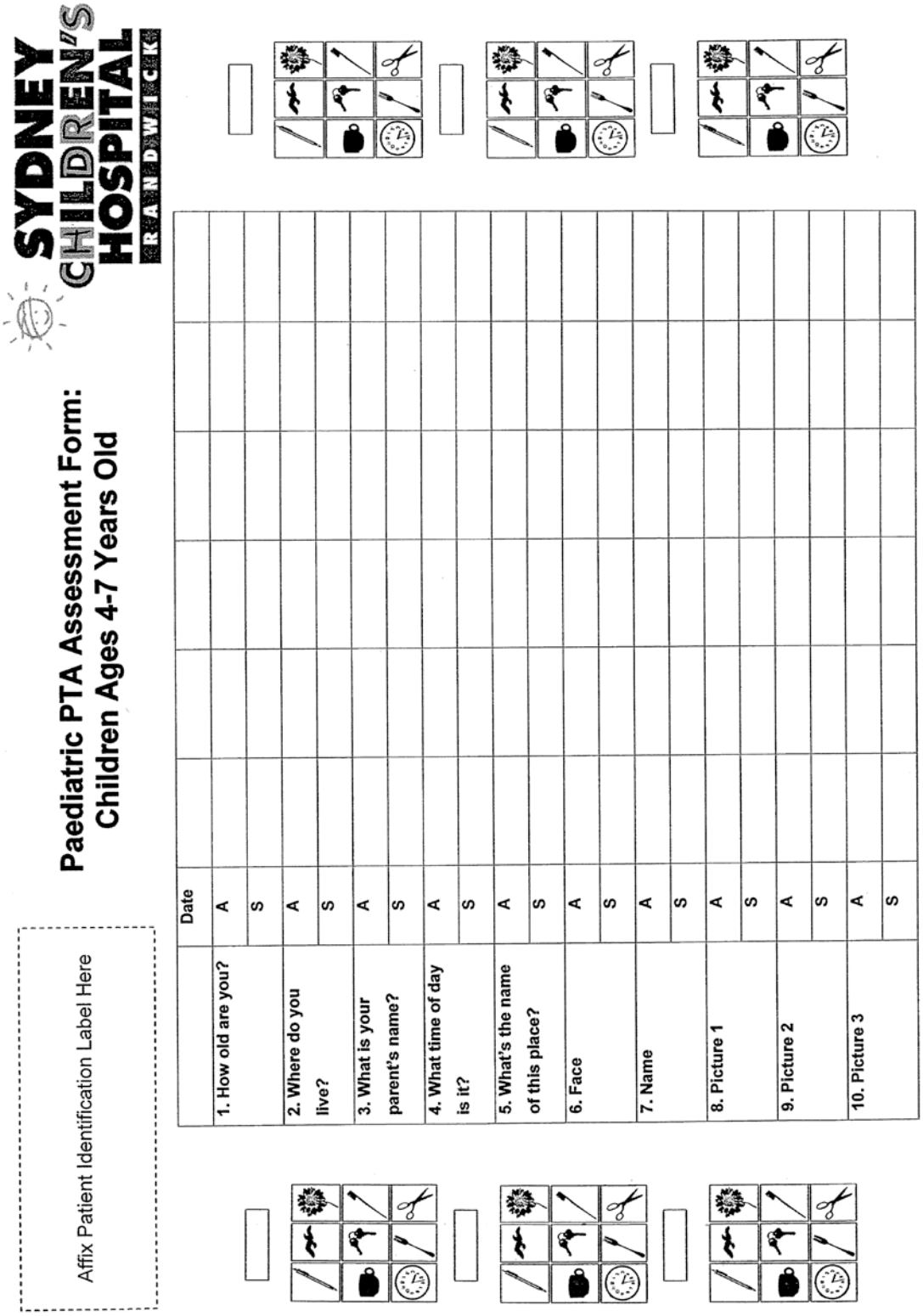
Appendix E.

SCH-PTA Scale: Test Form (Brain Injury Rehabilitation Program, Sydney Children's Hospital, 2009)



Appendix F.

Preliminary Analyses to Examine Effect of Non-Consecutive Daily Testing

Developmental Validity of the SCH-PTA Scale

Of the 52 children recruited, 37 were tested on consecutive days and 15 children had at least a one day break between days of testing. All days of testing were, however, within the one week (e.g. Mon, Tue, Thu, Fri). Chi-squared analyses revealed no differences in the pass or failure rates between children tested consecutively and children not tested consecutively. The chi-squared (Fisher's Exact Test) significance values are presented in Table 23, along with the pass and fail rates for each age group, according to whether or not testing occurred consecutively.

Table 23
Number (Percentage) of Children That Passed or Failed SCH-PTA Scale Criterion

Age Group & Days Tested	Passed (%)	Failed (%)	Fisher's Exact Test (2-sided)
4 years			
3 days Consec	3/13 (23)	10/13 (77)	.52
3 days Non-Consec	0/6 (0)	6/6 (100)	
4 days Consec	1/11 (9)	10/11 (91)	.79
4 days Non-Consec	0/3 (0)	3/3 (100)	
5 years			
3 days Consec	2/10 (20)	8/10 (80)	.58
3 days Non-Consec	1/3 (33)	2/3 (67)	
4 days Consec	0/7 (0)	7/7 (100)	n/a
4 days Non-Consec	0/3 (0)	3/3 (100)	
6 years			
3 days Consec	6/9 (67)	3/9 (33)	.70
3 days Non-Consec	1/1 (100)	0/1 (0)	
4 days Consec	3/7 (43)	4/7 (57)	.63
4 days Non-Consec	0/1 (0)	1/1 (100)	
7 years			
3 days Consec	5/5 (100)	0/5 (0)	.22
3 days Non-Consec	3/5 (60)	2/5 (40)	
4 days Consec	1/5 (20)	4/5 (80)	.72
4 days Non-Consec	1/4 (25)	3/4 (75)	
TOTAL			
3 days Consec	16/37 (43)	21/37 (57)	.37
3 days Non-Consec	5/15 (33)	10/15 (67)	
4 days Consec	5/30 (17)	25/30 (83)	.48
4 days Non-Consec	1/11 (9)	10/11 (91)	

Consec= consecutive, n/a = could not be calculated, SCH-PTA= Sydney Children's Hospital Post Traumatic Amnesia