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The Importance of Orientation in Evaluating Recovery in Pediatric Traumatic Brain Injury

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Abstract

Objective: Decisions about whether children who have sustained a traumatic brain injury are ready to transition from a medical facility to home and school life requires insight into their cognitive status. This study evaluates whether orientation to time, place, and self (Ox3) serves as sufficient indicator of general cognitive status to support such decisions.

Design: Participants with and without TBI were administered the PTBI in one to three individual testing sessions. Performance on Ox3 items were compared between groups, as well as performance on subtests representing broader cognitive and linguistic skills.

Setting: Pediatric brain injury in patient acute and rehab units.

Participants: Twenty-eight children with TBI (18 male, 10 female) between the ages of 6 and 16 years of age served as participants. Of these, 12 were initially classified as severe, 6 moderate, and 10 mild on the Glasgow Coma Scale.

Interventions: NA

Main Outcome Measures: The Pediatric Test of Brain Injury (PTBI) is a criterion-referenced, standardized test designed to measure neurocognitive, language and literacy abilities in children recovering from brain injury. The entire test, including its Orientation subtest, was administered to participants during the acute phase of recovery (within 3 months of injury).

Results: Despite no differences between the TBI and control group on the Orientation subtests, deficits occurred in other cognitive-linguistic domains that are relevant to functioning outside medical and rehabilitation environments. Furthermore, even neurologically-normal children sometimes failed some Ox3 items.

Conclusion: The findings on Orientation items from the PTBI indicates that caution is warranted in applying the "Ox3" standard for evaluating cognitive status to a pediatric TBI population.

Keywords: Traumatic brain injury; Children; Orientation; Neurocognition

Introduction

Traumatic brain injury (TBI) in children is a widespread and serious health problem. Each year, an estimated 475,000 TBIs occur in children aged 0-14 in the United States [1]. Of these more than 2,600 children die and another 37,000 are hospitalized [2]. Residual neurological disabilities occur in 30-50% of children who have sustained severe head injury [3]. The medical and associated costs of TBI in the United States are estimated to $60 billion per year [3].

When children are admitted into an acute-care hospital following a severe TBI, the initial concern is survival. Once the child is medically stable, interdisciplinary team members become concerned with issues around recovery, outcome, and quality of life. For children and adolescents recovering from TBI, multiple concerns include mobility, cognitive-linguistic communication and learning skills, and psychosocial functioning. Unlike working adults for whom the primary determinant of successful recovery is the ability to return to work, the goal for school-aged children is the successful transition to school. During the acute phase of recovery, children and adolescents may experience rapid changes in their level of consciousness and functioning, both of which are clinically relevant to outcome [4]. Several members of the medical team may monitor consciousness and orientation during the acute phase, looking for signs of recovery.

Recovery to higher states of consciousness occurs along a continuum. Many clinicians rely on behavioral indicators that demonstrate that the child is returning to a state of full orientation. Although most children recover from coma within the first few days after brain injury, variations in rates of recovery occur. Some severely injured individuals permanently lose all brainstem function (brain death); others progress to a state of wakeful unawareness (vegetative state). Still others recover in varying degrees, from a minimally conscious state to a confusional state before partially or fully recovering consciousness [4,5].

Several scales and related tools are used widely to gauge changes associated with stages of recovery from severe brain injury. These include Glasgow Coma Scale (GCS) [6], the Rancho Los Amigos Scale (RLAS), [7] the Children's Orientation and Amnesia Test (COAT) [8] and Galveston Orientation and Amnesia Test (GOAT) [9]. Among the most widely used is the GCS, which is an international rating scale developed to assess individuals with acute brain injury. Also available is a GCS Modified for Children (GCS-MC), which allows for age appropriate scoring [10]. The GSC-MC includes a Verbal Response Score that assesses orientation to self, place, and date [11]. According to Mc Cauley et al. [12], these screening tests are limited in their ability to provide adequate assessment data for making treatment decisions for individuals with TBI. An additional but related question is whether information concerning orientation can be used as an indicator of cognitive readiness for the demands inherent to a return to school.

Orientation is defined as an individual's cognitive sense of his status in time, place, and self. This is often called orientation-times-three ("Ox3"). Orientation to time is most likely to be affected in TBI and the orientation to self is the least likely to be affected [13]. Commonly, a child's responses to the quick Ox3 testing, or in some cases, just knowing one's name, serve as a primary criterion used to make hospital discharge decisions. Many practitioners assume that once this level of orientation is achieved, cognitive functioning in a broader sense has also returned. A problem exists in the potential for over interpretation of Ox3. There is a wide gap between knowing that a child can report information relevant to orientation and establishing that their other cognitive linguistic abilities are sufficient to support return to school. The frequent presence of long-term deficits in children with TBI raises the question of whether Ox3 is indeed a sufficient indicator of potential for successful resumption of pre-trauma activities.

The purpose of this descriptive study was to evaluate whether orientation to time, place, and self (Ox3) serves as a sufficient indicator of general cognitive recovery for children. Orientation items were tested during the acute phase of recovery (within 3 months) as part of the standardization of the Pediatric Test of Brain Injury (PTBI) [14]. The current investigation was designed to evaluate the degree to which children and adolescents with TBI who could meet the criteria for passing the orientation items were functioning similar to age-matched peers in other cognitive areas. We hypothesized that children who could pass an Ox3 screening would nevertheless show areas of deficit that would be likely to interfere with effective cognitive-linguistic performance within the school curriculum.

Method

Participants

Two groups of children were included in this study: 28 right-handed children between the ages of 6 and 16 who had sustained a traumatic brain injury (TBI), and 28 non-clinical right-handed children without TBI. The non-clinical children were matched to the TBI cases by age and gender. Both groups were selected from the PTBI standardization sample.

The TBI participants (18m, 10f) ranged in age from 6 to 16 years (mean age 11 years, 1 month, SD=3 years). Prior to their TBI, five had a diagnosis of attention deficit hyperactivity disorder, one of learning disability, and one was receiving speech-language services in school. The mechanism of injury included motor vehicle crashes (n=11), falls (n=5), pedestrian hit by car (n=3), bicyclist hit by car (n=2), and other causes such as falls (n=7). All were tested during the first 90 days post injury, corresponding to the acute to sub-acute recovery stages. Children who were outside of the age range of the test (6-16 years of age) or were seen more than 90 days post injury were excluded from the study. Likewise, children with other forms of acquired brain damage (e.g., stroke, tumor) were excluded from the study.

Initial GCS6 scores for the TBI group ranged from mild to severe, with 12 participants scoring in the severe range (GCS 3-8; tested an average of 29.5 days post injury [range:15-69 days]), 6 in the moderate range (GCS 9-12; tested an average of 16.83 days post injury [range: 6-30 days]) and 10 in the mild range (GCS 13-15; tested an average of 15.8 days post injury [range: 1-36 days]). As a condition of inclusion in this study, at the time of testing all were able to provide both their first and last name. This assured a minimal level of orientation for all participants.

The control group (18m, 10f) also ranged in age from 6 to 16 years (mean age 11 years, 1 month, SD=3 years,). It is important to note that all children in the control group were selected without regard to their academic standing. Instead, they were selected to represent the general population of neurologically normal children.

Materials

The PTBI [14,15] is a criterion-referenced, standardized test that was designed to measure neurocognitive, language and literacy abilities in children 6-16 years of age recovering from brain injury. The test can be completed in one 30-minute session with children and adolescents who are not experiencing unusual motor, cognitive, or emotional challenges. The PTBI also was designed to investigate a broad assessment of neurocognitive functioning. Similar to orientation measures listed previously, the Orientation subtest of the PTBI assesses orientation to time, place, and self. This subtest also includes eight additional items that assess memory for biographic information. For the purpose of this study, responses to the orientation items (first and last name, day, week and month, place) were extracted from this subtest to reflect Ox3. The orientation items were coded as passed or failed for each child.

The nine additional subtests on the PTBI tap verbal memory, word fluency, the ability to recognize semantic associations, and the ability to extract literal and non-literal information from language input [15]. The individual subtests are described in the Appendix (see below). Scores from these subtests were used to assess broader cognitive-linguistic skills than are represented by solely by Ox3 items. The skills represented by these subtests can be categorized as either constrained or unconstrained, relative to the developmental trajectory [16]. Constrained skills refer to those that are fully acquired early in development and are stable thereafter. Unconstrained skills are those that show a longer period of development over the childhood years, and possibly into adolescence. Figure 1 classifies the PTBI subtests in terms of constrained and unconstrained skills.

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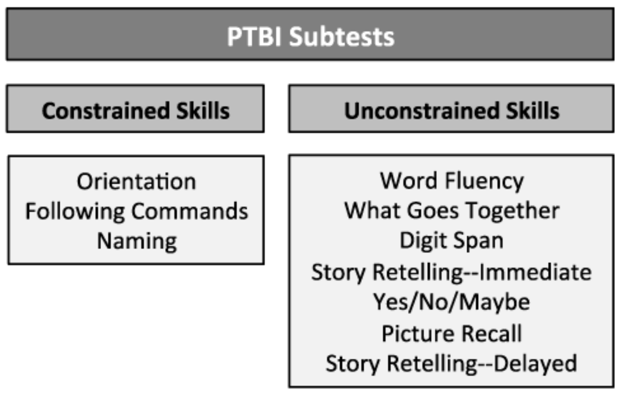

Figure 1: PTBI subtests reflecting constrained and unconstrained skills

The PTBI yields scores that are designed to reflect the relative level of difficulty of the specific items passed for each subtest (i.e., more difficult items earn higher point values). Values associated with items passed are then summed to yield a subtest score. The difficulty value for each item is relative to all other items within the subtest, using values determined using Item Response Theory procedures [14]. The lowest item value for each subtest is 0.5. The highest item difficulty value differs across subtests, depending on the relative difficulty of the items on the subtest as a whole. The maximum point value for a single item on any subtest is with 14.0. This variable scoring method reflects the fact that some subtests (e.g., Following Commands, considered a developmentally constrained task) are inherently less difficult than others (e.g., unconstrained tasks such as Yes/No/Maybe [listening comprehension]). The exception to this scoring convention is the Word Fluency subtest, in which each word generated is assigned a value of 1 and the subtest score is equal to the total number of words generated within a set time limit.

Procedures

The PTBI was administered according to the instructions provided in the test manual. During the test standardization phase, subtests were administered in random to the standardization group, so that order effects and fatigue were not factors in the results. All children were tested individually. The children with TBI were tested while in an acute care facility or rehabilitation hospital setting. The children without TBI in the control group were tested in a single session in quiet rooms in a variety of settings including homes, schools, and community centers. Of the 28 children with TBI, 22 were tested in a single session either at bedside or a clinical exam room, five were tested over 2 sessions, and one was tested over 3 sessions. All were allowed short breaks during testing if needed. Typically, administration of the PTBI to examinees with TBI requires about 30 minutes. The PTBI standardization was approved by multiple site Human Subject Review Boards.

Results

To establish a baseline for performance on test items specific to the issue of Ox3, we first asked how frequently children in the TBI and control groups passed individual items related to orientation to time, place and self. These data are reported in Table 1. As this table indicates, even the youngest typically-developing individuals were able to report where they were at the time of testing. However, information concerning the day, month, and year were not correctly reported by all individuals until somewhat older ages (age 8-9 years). The majority of the TBI group also reported the orientation items correctly, despite being in the acute phase of recovery.

Items	TBI		Control	
	Percent passing	Minimum age at which all children pass	Percent passing	Minimum age at which all children pass
What is your name?	100%	6	100%	6
What is this place?	92.9%	8	100%	6
What day of the week is it today?	71.4%	16	82.1%	9
What month is it?	82.1%	15	89.3%	8
What year is it?	82.1%	10	92.9%	8

Table 1: Performance of children on orientation x 3 items from the PTBI Orientation Subtest. NB: the age range tested was 6 to 16 years of age.

Given that all study participants could report at least their names correctly, we asked whether this was indicative of other areas of functioning. For this, we examined the subtest scores from the entire PTBI. Table 2 provides median score and range for each subtest score for the TBI and control groups. As the results demonstrate, the general trend was for lower scores to be earned by students with TBI.

	Maximum Possible Score	TBI		Control	
		Median	Range	Median	Range
Orientation	38.0	35.25	2.0-38.0	38.0	20.0-38.0
Digit Span	82.5	43.25	0-110.0	62.5	24.0-110.0
Following Commands	15.0	15.0	13.5-15.0	15.0	none
Naming	12.5	12.5	6.5-12.5	12.5	10.5-12.5
Story Retelling-Immediate*	138.5†	34.0	0-106.5	82.75	8.0-116.0
Story Retelling-Delayed*	138.5	29.5	0-58.0	45.25	0-82.0
Picture Recall*	45.5	24.5	3.5-45.5	38.5	21.0-45.5
What Goes Together*	100.5	52.5	0-95.5	77.5	5.0-95.0
Word Fluency*	unlimited	17.5	6.0-46.0	28.5	6-51
Yes/No/Maybe†	39.0	20.0	9.0-38.5	22.25	6.5-39.0

Table 2: PTBI subtest scores for age-matched children with and without TBI who pass orientation x 3 items. *indicates a statistically significant difference (Mann-Whitney U test at $p<.05$, 1 tailed, corrected for multiple comparisons). †for grades 8-11, maximum score for grades 4-7 is 142.5; maximum score for grades 1-6 is 51.5.

As might be expected for a criterion-referenced test, score distributions for both the TBI and control group were non-normal for most subtests of the PTBI. Therefore, nonparametric testing was used to evaluate the results. It also is important to recognize that, because the different subtests have different numbers of items with different difficulty levels, the total possible score varies considerably for different subtests. For this reason, it was not possible to apply an omnibus statistical test to the collection of subtests. Instead, each was analyzed individually, with a Bonferoni alpha correction applied to the results to maintain an experiment-wise .05 probability level.

Group differences were tested using a series of Mann-Whitney U tests. As Table 2 indicates, scores for half of the subtests were significantly different for the TBI and control groups, even with a Bonferroni alpha correction for multiple comparisons (corrected to $p<.05$).These subtests included the Word Fluency subtest ($z=2.62$, $p=.0044$), What Goes Together($z=2.89$, $p=.0005$), Picture Recall ($z=3.61$, $p=.0001$), Story Retelling-Immediate ($z=2.59$, $p=.0048$) and Story Retelling-Delayed ($z=3.12$, $p=.0009$).

To answer the primary research question, we also asked whether group differences would occur for those participants who correctly reported all Ox3 information. For this analysis, we selected only individuals with TBI and their matched controls who passed all five orientation items reported in Table 1. This resulted in 17 individuals in each group (10 male, 7 female, mean age=12 years 11 months, range=8-16 years, 17). No subtest differed by group at the alpha corrected level of $p<.05$. However, both the Orientation subtest (which contains items regarding birth date, age, and school in addition to the five items related to orientation to name, place, and time) and the Story Retelling-Delayed subtests were statistically different at $p<.05$ uncorrected (Orientation: $z= 2.09$, $p=.036$; Story Retelling-Delayed: $z=2.19$ $p=.029$).

Discussion

The data on orientation from the PTBI indicate that caution is warranted concerning application of the Ox3 standards to a pediatric population. Clearly, knowing one's name is not enough. First, our data undermine the assumption that neurologically normal children can routinely report Ox3 information. School-aged children with no history of TBI sometimes missed orientation questions on the PTBI. Our neurologically-normal participants were most likely to miss items related to temporal orientation (day, month, and year). In published studies that have used the GOAT [9] with adults with TBI, personal orientation recovers before spatial orientation. Temporal orientation is considered the most tenuous of the three categories of orientation (person, place, and time) and is the last to recover [17]. When children with TBI fail these types of items, item failure has to be evaluated against age expectations for neurologically unimpaired age-mates. Our data indicate that failure to report information concerning temporal orientation in particular, may not be as informative for pediatric populations as it is for adult populations.

Another key finding is that, even when individuals were oriented to their name, they still showed significantly lower performance in a number of PTBI subtests related to a wider spectrum of neurocognitive-linguistic domains. In particular, they exhibited significant cognitive limitations with respect to memory functioning and executive skills. This indicates that a clinician's ability to predict broader functioning from information concerning orientation is fairly limited. Knowing one's name can be considered a constrained skill, in that once it is learned, no further learning is necessary for full competence. The children in the present study all knew their names, and their performance was also relatively strong on other constrained skills (e.g., naming objects, following simple commands). However, when their performance differed significantly from their age and gender matched peers, the areas of deficit always reflected unconstrained skills, which continue to develop over the course of childhood.

TBI in children affects not only skills in the acute stage, but depending on the age of injury, may have longer-term effects on cognitive-communicative abilities that have not yet matured. Evidence indicates that children who sustain a moderate or severe TBI in infancy or early childhood are particularly vulnerable to longer term consequences than are those who sustain injury later in childhood [17]. Chapman et al. [18] reported that cognitive and language skills that are not developed at the time of the brain injury, or are in a stage of development, may be particularly vulnerable to long term sequel of TBI. Reliance on elements of orientation, even those most reliable for the child's age is inadequate for predicting broader cognitive and linguistic functioning.

Limitations

In this study, only children who could report their name were included. This assured at least some degree of orientation at the time of testing other skills. However, it also restricted the subject sample to children who were arguably less severe overall than if children who showed no evidence of orientation had been included. Although deficits beyond orientation were found for these children compared to their normal peers, this study leaves open the question of whether more skills would show deficits in samples of children who show no evidence of orientation at all. Likewise, although the children studied showed a range of GCS values post injury, we did not have information of factors like loss of consciousness after injury or the presence or absence of post-traumatic amnesia. This could also affect the level of recovery seen. Another possible brain-based variable that could influence recovery is pre-morbid handedness. The present study was limited to right-handed children who were closely matched for gender, age, and handedness to non-injured control subjects. Although the majority of both right and left handed children are left hemisphere dominant for language, [19] it is unknown whether or to what degree the present results would generalize to left-handed children with TBI. Finally, future studies may consider this issue with larger and more diverse samples of children over time. This would serve to extend the present findings to determine whether subtypes of children show different patterns of recovery relative to initial severity of the injury as indexed by measures like the GCS or Orientation x 3.

Conclusion

Careful consideration needs to be taken when evaluating the neurocognitive recovery of children with traumatic brain injury. Our data suggest that being able to report one's own name (the most reliably reported orientation factor for children) is not indicative of other areas of cognitive functioning. Indeed, even full orientation to time, place and self may belie other areas of weakness important to functioning outside of the medical center, especially in academic settings. Future investigations are needed to explore the implication of levels of orientation of children recovering from TBI with regard to phases of recovery, optimal time for discharge from medical facilities,

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and the relationship between Ox3 and functioning in the full range of cognitive skills necessary to personal, social and academic success.

References

1. Langlois JA, Rutland-Brown W, Thomas KE (2005) The incidence of traumatic brain injury among children in the United States: differences by race. J Head Trauma Rehabil 20: 229-238.
2. Mark Faul, Likang Xu, Wald MM, Coronado VG (2006) Traumatic brain injury in the United States: Emergency department visits, hospitalizations and deaths 2002-2006. Centers for Disease Control and Prevention.
3. Stevens JA, Corso PS, Finkelstein EA, Miller TR (2006) The costs of fatal and non-fatal falls among older adults. Inj Prev 12: 290-295.
4. Strauss DJ, Ashwal S, Day SM, Shavelle RM (2000) Life expectancy of children in vegetative and minimally conscious states. Pediatr Neurol 23: 312-319.
5. Laureys S, Owen AM, Schiff ND (2004) Brain function in coma, vegetative state, and related disorders. Lancet Neurol 3: 537-546.
6. Teasdale G, Jennett B (1974) Assessment of coma and impaired consciousness. A practical scale. Lancet 2: 81-84.
7. Hagen C, Malkmus D, Durham P (1972) Levels of cognitive functioning. Downey (CA): Rancho Los Amigos Hospital.
8. Ewing-Cobbs L, Levin HS, Fletcher JM, Miner ME, Eisenberg HM (1990) The Children's Orientation and Amnesia Test: relationship to severity of acute head injury and to recovery of memory. Neurosurgery 27: 683-691.
9. Levin HS, O'Donnell VM, Grossman RG (1979) The Galveston Orientation and Amnesia Test. A practical scale to assess cognition after head injury. J Nerv Ment Dis 167: 675-684.
10. Simpson DA, Reilly PL (1982) Pediatric coma scale (letter). Lancet 450.
11. Reilly PL, Simpson DA, Sprod R, Thomas L (1988) Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. Childs Nerv Syst 4: 30-33.
12. McCauley SR, Wilde EA, Anderson VA, Bedell G, Beers SR, et al. (2012) Recommendations for the use of common outcome measures in pediatric traumatic brain injury research. J Neurotrauma 29: 678-705.
13. Russell WR (1971) The Traumatic Amnesias. Oxford University Press, New York.
14. Hotz G, Helm-Estabrooks N, Nelson NW, Plant E (2010) Pediatric Test of Brain Injury. Paul H. Brookes Publishing Inc., Baltimore, USA.
15. Hotz G, Helm-Estabrooks N, Nelson NW, Plante E (2009) The Pediatric Test of Brain Injury: Development and interpretation. Topics in Language Disorders: 29: 207-223.
16. Paris SG (2005) Reinterpreting the development of reading skills. Reading Research Quarterly 2: 184-202.
17. Anderson V, Catroppa C, Morse S, Haritou F, Rosenfeld J (2005) Functional plasticity or vulnerability after early brain injury? Pediatrics 116: 1374-1382.
18. Gamino JF, Chapman SB, Cook LG (2009) Strategic learning in youth with traumatic brain injury. Evidence for stall in higher order cognition. Topics in Language Disorders 29: 224-235.
19. Szaflarski JP, Rajagopal A, Altaye M, Byars AW, Jacola L, et al. (2012) Left-handedness and language lateralization in children. Brain Res 1433: 85-97.

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