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Brain Injury in Children: Assessment and School-based Interventions

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BRAIN INJURY IN CHILDREN:

ASSESSMENT AND SCHOOL-BASED INTERVENTIONS

by

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Abstract

A traumatic brain injury is an acquired injury to the brain caused by an external physical force, resulting in total or partial functional disability or psychosocial impairment that adversely affects a child's educational performance. It is considered the leading cause of mortality and disability among children with estimates of over one million occurrences each year. The 1990 revision of the Individuals with Disabilities Education Act included Traumatic Brain Injury as a special education diagnostic category. Although this allowed students greater access to appropriate services, it pointed out the need for additional knowledge and training for educators working with this population. Therefore, a review of published studies on assessment and school-based interventions for students with TBI was conducted. Assessment included both formal, standardized measures and informal methods. Despite the apparent need, few empirical studies have examined rehabilitation for children and adolescents who have sustained a head injury. Treatment approaches were divided into three categories: cognitive remediation, social/behavioral interventions, and the impact of the family on child outcome. Evidence was found supporting all three areas, but more studies are needed to confirm the findings as well as study the duration of effects over time. Finally, recommendations for components of a school-based intervention program are outlined.

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Brain Injury in Children: Assessment and School-Based Interventions

Background

Traumatic brain injury (TBI) in children is a common acquired condition with estimates of over one million occurrences each year (Clark & Orme, 1999; Walker, Boling, & Cobb, 1999). The Individuals with Disabilities Education Act (IDEA) of 1990, PL 101-476, defines TBI as:

> Traumatic Brain Injury means an acquired injury to the brain caused by an external physical force, resulting in total or partial functional disability or psychosocial impairment, or both, that adversely affects a child's educational performance. The term applies to open or closed head injuries resulting in impairments in one or more areas, such as cognition; language; memory; attention; reasoning; abstract thinking; judgement; problem solving; sensory, perceptual and motor abilities; psychosocial behavior; physical functions; information processing; and speech. The term does not apply to brain injuries that are congenital or degenerative or brain injuries induced by birth (IDEA, Reg. Sec. 300.7b{12}).

TBI is considered the leading cause of mortality and disability among children and adolescents (Farmer & Peterson, 1995; Garcia, Krankowski, & Jones, 1998), accounting for one-half of all childhood fatalities (DiScala, Osberg, Gans, Chin, & Grant, 1991). Although the majority of TBIs are mild, approximately 200,000 are severe enough to require hospitalization (DiScala et al., 1991). One survey indicated 3% of all responding high school students had experienced some degree of traumatic brain injury (Franzen, Roberts, Schmits, Verduyn, & Manshadi, 1996). Many incidents of mild injuries are unreported to medical personnel in spite of the potential for long-range difficulties. The apparent mildness of the injury may cause the victim to underestimate the severity of the impairment and neglect seeking medical attention or may cause medical personnel to fail to fully inform survivors of the possibility of future consequences (Hux & Hacksley, 1996).

In those cases where the injury is considered significant, (as determined by an alteration in level of consciousness or a Glasgow coma scale rating of less than 13), an estimated 20%

to 40% of children experience moderate to severe impairments that impact learning and development. This rate increases to 90% with a severe injury (DiScala et al., 1991; Clark et al., 1999). Regardless of the severity of the injury, most children are discharged from hospital care directly to the home still having rehabilitation needs (Clark, 1996). Because recovery can take months or even years, children often return to school while still in the recovery period. Therefore, schools are frequently expected to extend the rehabilitation process begun in the hospital.

Historically, the needs of children with TBI often went unrecognized. During the 1960s and 1970s, the National Head Injury Foundation (Farmer, et al., 1995) referred to traumatic brain injury as the "silent epidemic". Many children who suffered a TBI often displayed no outward deficiencies and few people appreciated the extent and potential severity of the injury. Only those close to the children with TBI would note the significant changes in their behavior and ability to learn. Often these children were sent home, with the belief that they were fully recovered, only to later discover they had learning and behavioral disorders.

In part, the historical lack of recognition of children's impairments from TBI could be attributed to the low survival rates. Prior to the development of modern medical treatments and trauma centers, the majority of patients with moderate to severe traumatic brain injury died. Not only was there no need for long-term therapy or follow-up, but the opportunity to study the relationship between brain injury and behavior was lost. Even for those who survived the methods for investigation of their injuries was limited. The only procedure to visualize the brain was through neurosurgery. With improved survival owing to advances in medical care, the study of brain injury has also been aided by technological advances. We now have several methods of brain imaging, such as computerized tomography (CT), magnetic resonance (MRI), and positron emission tomography (PET) where both structure and metabolic changes can be examined. With these new measures, we are in a better position than ever before to serve the needs of the brain-injured population.

With increased numbers of children who have sustained head injuries reentering the schools, the educational setting becomes the primary vehicle for further recovery. One of the most positive changes for these children has been the passage of the Individuals with Disabilities Education Act (IDEA; P.L. 106-476) which included Traumatic Brain Injury as a special education diagnostic category. This law has increased educators' awareness of the problems of children with TBI and allowed students greater access to appropriate services. Prior to this time, placement was a large deterrent to successful school reentry following a brain injury. Most children required a modified program, yet there were few suitable alternatives to regular education that were available to them. Many of the children did not meet the eligibility requirements for special education, such as mentally retarded, seriously emotionally disturbed, or having a specific learning disability (SLD). Few exhibited the required severe discrepancy between intellectual ability and achievement (Telzrow, 1987), as frequently children with TBI showed a higher achievement score than intellectual ability. Additionally, when children were placed in a special education program usually tailored for SLD, it was often inappropriate for their needs. For example, SLD programs are typically directed toward remediation of specific academic skills, such as reading or math. They are not designed to provide intensive cognitive rehabilitation of the sort needed by many children with brain injuries. Specifically, children with TBI may require specially designed instruction and services including, speech-language therapy, physical and occupational therapy, adapted physical education, psychological services and counseling, school health services, and parent counseling and training to address the variety of cognitive, memory, language, motor, and/or behavioral disturbances that can occur following a TBI.

Although this law has facilitated the access to services these children need, it has introduced more challenges. Many educators do not feel prepared to deal with the problems of this population. They do not understand the needs these children have and some are not even aware of what it means to have a TBI. Educators have a responsibility to become more prepared in serving the needs of those students who qualify for service under the federal law.

School psychologists are in an excellent position to provide services to children with brain injuries. With the appropriate training they can function in the role of case manager/consultant, evaluator, and counselor. Because of their training in current educational and psychology practices, they have the basic skills to integrate educational services with a neuropsychological perspective (Walker, et al., 1999). The purpose of this paper is to examine traumatic brain injuries in children, outline various assessment measures, and identify from current research, effective interventions that are appropriate for school application. First, TBI injuries will be defined; next, typical sequelae will be discussed, followed by an examination of outcome factors. Various methods of assessment including brain imaging and neuropsychological assessment will be reviewed, and lastly school-based interventions for students with head injuries will be explored.

Traumatic Brain Injury

An acquired brain injury is characterized by a sudden accelerating or decelerating injury to the head and underlying brain matter, with subsequent alteration of consciousness (Donders, 1994). The brain is protected by the skull and has the capability of withstanding minor trauma, such as the mild, ordinary bumps common in childhood. Traumatic injury occurs when an external force is sufficient enough to cause damage in the brain's regulatory processes, resulting in either temporary or permanent changes in a person's physical, cognitive, emotional, and/or behavioral functioning. According to Hux and Hacksley (1996) the definition of TBI has been expanded to include the term concussion. One does not have to lose consciousness to sustain a brain injury. Repeated, mild concussions can have a cumulative effect. Additionally, a TBI can occur without a direct blow to the head, as seen in whiplash injuries or forms of child abuse such as "Shaken Baby Syndrome."

There are two general types of head injuries, focal and diffuse. Focal injury results from impact and is usually seen in falls from bicycles. The impact of the head against a stationary structure causes the injury. There is damage at the place of impact, called the "coup," as well as in the area involved in the rebound from the impact, referred to as the "contrecoup," when the brain slams back against the opposite region from the origin of impact. Diffuse injury is the result of the shearing of white matter and gray matter due to either the acceleration or deceleration of the brain. Damage to the areas most commonly affected by diffuse injury influence behavior, emotion, memory, and attention. Diffuse injury is commonly seen in car accidents and Shaken Baby Syndrome (Semrud-Clikeman, 2001).

Considerable improvements in imaging technologies have increased the understanding of how brain trauma alters structure and affects behavior. Past research focused on shear/strain effects at the level of the axon that often occurs in diffuse trauma. Any structure can withstand only so much tensile strength when stretched lengthwise. During trauma there may be tissue compression and stretching that exceeds the limits of normal tissue extension capability. This leads to a tear or rupture of the axon. Once damaged, the axon may degenerate and eventually lead to cell death. If there is enough damage, the neuron next in line may also be affected and degenerate (Bigler, 1997). Additionally, rotational effects, which also may occur with diffuse injury, may be exerted on the axons. This twisting motion may literally tear the axon, resulting in the same degenerative consequences as mentioned above. Shearing most often occurs at the boundaries between white and gray matter. Consequently, on MRI scanning, the effects of shearing are generally seen at gray matter/white matter junctures.

Current research has focused on other mechanisms, which either alone or in combination are responsible for cellular injury. A breakdown of the blood-brain barrier (a chemical barrier in the central nervous system that protects the brain from foreign substances) has been noted at the site of impact. This breakdown may lead to neurotoxic damaging effects. The hippocampus, the most important structure for memory function, is especially vulnerable to this type of damage regardless of the point of impact. This finding is interesting since one of the most common symptoms following a TBI is memory loss. Magnetic resonance imaging (MRI) will often show the hippocampus as smaller in size than normal (Bigler, 1997).

Another cause of brain cell damage as a consequence of TBI is the excessive release of excitatory neurotransmitters. Prolonged over-excitation will impair metabolic cell function and may lead to cell death (Salazar, 1992). Sometimes a cell is not dead, but has its membrane deformed through trauma. This may slow or alter the neural transmissions and disrupt normal neurologic function (Murphy & Horrocks, 1993). Secondary effects such as edema (swelling), hemorrhaging, infection, and respiratory complications compound the damaging effects.

Epidemiology

Head injuries occur most often in the age range of 15 to 24 year-olds, with the average annual incidence rate at approximately 550 cases per 100,000. It is almost as frequent in children under the ages of 15 with an annual incidence of 220/100,000 (Mira & Tyler, 1991; Goldstein & Levin, 1987). The head injury mortality rate is 10/100,000, more than five times the rate of the next leading cause of death in childhood, leukemia (Farmer, et al., 1995; Goldstein, et al., 1987). Males are twice as likely as females to suffer a TBI, and to have more severe injuries, with a mortality ratio of 4:1 (Moyes, 1980). Young children most frequently receive their head injuries in falls. One reason hypothesized for the increased risk of head versus trunk/extremity injuries is due to children's relatively large head size and a high center of gravity. Middle-aged children in the 5-14 year-old range most often suffer both sports and recreational-related injuries, and motor vehicle-bicycle-pedestrian accidents. Older children are more likely to sustain injuries in motor vehicle accidents (Bigler, 1987; Goldstein, et al., 1987).

Risk Factors

Attempts have been made to identify antecedent risk factors. Children with head injuries may not represent a random sample of the general population (Craft, Shaw, Cartlidge, 1972). Craft et al., (1972) found a higher rate of occurrence of teacher-reported, pre-injury behavioral problems (e.g. antisocial behavior, hyperactivity) in brain injured children than in classmates serving as controls. These findings suggest characteristics such as impulsivity and overactivity may lead to risk-taking behaviors, which in turn may cause head injury. Additionally, the post-injury sequelae could be an outcome of the premorbid characteristics rather than a direct result of the brain trauma (Rutter, 1981).

Goldstein et al., (1987) reports conflicting evidence that children with head injuries live in congested areas, have a lower SES background, and that their parents are more often unemployed or have emotional difficulties. Further studies are needed to establish the relationship between pediatric head injuries and environmental risk factors.

An additional risk factor for TBI is having sustained a previous TBI. Evidence shows (Annegers, 1983) an increased risk for future head trauma following a brain injury. The incidence rate doubled after a head injury for children under age 14, tripled through ages 15-24, and increased to five times the expected rate after age 25. Two possible explanations for this are that (1) individuals develop behavioral patterns that predispose them to injury, or (2) neuropsychological sequelae, such as a slowed reaction time, poorer psychomotor coordination, or poor planning abilities, contribute to further traumas.

Common Sequelae of Head Injuries in Children

Cognitive

Most children with severe head trauma experience some degree of cognitive impairment when compared to premorbid functioning. The degree of deficit is related to the amount of damage to the brain (Chadwick, et al., 1981). At least two-thirds of individuals with severe injuries continue to show long-term impairment (Boyer & Edwards, 1991). There is less agreement as to the level of deficits following a mild head trauma (Rutter, 1981). A common problem is that many children appear physically "normal" following a head injury, when in fact many of their cognitive processing abilities are impaired. When administered the Wechsler Intelligence Scale for Children-III (WISC-III), it is typical to see significant discrepancies between Performance IQ and Verbal IQ (with Verbal IQ scores being higher) in moderately to severely injured children. This could be attributed to the fact that Verbal

IQ measures well learned and previously acquired skills, which are less affected by brain injury (Chadwick, Rutter, Brown, Shaffer, & Traub, 1981). In contrast, Performance IQ measures a child's processing speed and the ability to learn new material and solve problems. These latter skills may be more sensitive to neurological damage (Chadwick, Rutter, Brown, Shaffer, & Traub, 1981).

Often a child's long-term memory, or the information that has been previously acquired, remains intact while the ability to store and act on new information is disrupted (Glang, Singer, & Todis, 1997). Thus, a child with TBI may recall his or her former abilities, social status, and goals, but demonstrate poor understanding and awareness of the present and future. This can lead to memory gaps, confusion, frustration, and behavioral disturbances. Cognitive skills, such as problem solving, abstract reasoning, and planning and organizing are frequently impacted.

Children with TBI often have decelerated motor and cognitive processing speed (Donders, 1994). Alternatively, a child may achieve a normal IQ when assessed despite having deficiencies in other cognitive domains. Skills that influence their ability to function in the classroom such as memory and attention as well as comprehension are impacted. Formal measures of intelligence may not reflect a child's actual abilities to perform now and in the future. Although vocabulary and general information may give the impression of normal intelligence, a child may be incapable of reasoning and problem solving at a similar level. Furthermore, standardized tests, administered one-on-one with an examiner in a quiet setting, often overestimate the child's ability to perform in the classroom, where demands and distractions are greater (Telzrow, 1987).

Academic Skills

A number of studies have reported poor academic achievement and an increased need for special education for children with TBI (Donders, 1994; Chadwick et al., 1981). More than 25% of brain-injured students reported they had failed a grade or been retained (Clark, 1996). This could be due to achievement test scores overestimating children's abilities, since these measures assess skills that were overlearned before the injury. Achievement tests basically assess retention and recall of previously learned material. Many children with a TBI evidence stronger achievement scores when compared to intelligence estimates immediately after injury (Farmer et al., 1995) because achievement measures gauge preinjury skills rather than postinjury potential. Also IQ scores, especially performance tests, may be depressed as a result of the TBI. Only after the passage of time may some deficits in academic skills emerge. Because the injury interferes with further academic learning, the student lags behind his or her peers. For example, Fay (1994) found that some children with serious injuries did not show evidence of academic problems in reading and mathematics until one to two years after the injury. When these problems are detected they are not always attributed to the brain trauma. The longer the interval from the time of injury to the detection of the achievement problems, the less likely an attribution will be made to the prior injury (Clark, 1996).

Perceptual/Visual-motor functioning

Commonly occurring visual deficits include hemianopsia (blindness to one side of the visual field), diplopia (double vision), blurred vision, and loss of the ability to interpret visual information. Visual perceptual deficiencies are seen in children with TBI, such as impairments in visual discrimination, visual attention, and visual spatial relations (Farmer, Clippard, Luehr-Wiemann, Wright, & Owings, 1997). Evidence of this may be seen when a child is asked to copy a figure from the Developmental Test of Visual-Motor Integration (VMI; Beery, 1990). One of the figures to be copied is a horizontal line bisected by an X. Children may be able to draw the lines in isolation, but often have trouble integrating them.

Other perceptual problems are frequently demonstrated. Children often have trouble distinguishing right from left, they have diminished body awareness, decreased depth perception, and difficulty knowing where one's body is in space. Hearing loss occurs in about 35% of children. Auditory perceptual skills, such as the ability to separate target stimuli from background noise and to attend to auditory stimulation may be impaired. Sensitivity to tactile stimulation is frequently diminished with the child being unable to differentiate hot from cold, or dull from sharp. Even if the child were able to input the various sensory data, they may lack the ability to integrate the stimuli into meaningful information that can be used functionally.

Although motor problems often resolve early, new deficits in the areas of refined and complex psychomotor movements may appear. These notably emerge when speed is involved. Implications in the classroom include an inability to copy, organize material, and produce significant amounts of work (Miya, 1991).

Attention

Attentional problems are an often-seen sequelae after TBI. These include problems of attentional capacity, the amount of information that can be processed at one time, and attentional control, the ability to focus or shift attention according to situational demands (Farmer et al., 1995). This may appear as off-task behavior in the classroom, difficulty identifying the main points in reading comprehension, disorganization, difficulty transitioning, and day-to-day variable performance on similar tasks. Such difficulties are often unnoticed in a highly structured testing environment, but appear in the more demanding circumstances found in the classroom that has various distractors, several transitions, minimal cuing and the necessity for skill integration.

Language deficits

Language problems immediately following injury may include an inability to speak, restricted expressive output, and breath control problems (Mira et al., 1991). Although these deficits may subside rapidly, more subtle and residual language-related difficulties become apparent. These include dysnomia, which is difficulty in retrieving a particular name of an item or individual, especially in demanding situations; dysarthria, slow, poorly articulated speech; impaired organization of sequenced utterances; and comprehension breakdown with increasing instructional complexity (Mira, 1981; Telzrow, 1987).

Memory

Memory deficits are among the most lasting and universal sequelae of head injuries (Telzrow, 1987). There is a direct effect on education since learning is adversely affected. Memory for new information is worse than remote or old memories. Injuries in the left hemisphere of the brain yield verbal memory task difficulty, while right hemisphere injury yields visual-spatial problems. Occasionally, with a severe injury, children not only forget certain facts, such as state capitals, and skills, such as long division, but do not remember ever learning how to do those things. When a child has difficulty retaining new information he/she often present a slow but steady decline in academic performance over time as peers advance in knowledge and he/she does not. Noninstructional aspects of school are affected, as well. Students often may not remember their class schedules or be able to locate different rooms when changing classes. Sometimes even basic skills, including moving through a cafeteria line or organizing a notebook, are lost.

Physical functioning

A number of physical problems are present following a brain trauma. Five per cent of children have seizures following a TBI, with the number increasing to 40% with a severe injury (Miya, 1991). Because the onset of seizures can be delayed for as long as one year, children are often routinely placed on anticonvulsant medication for the first year as a prophylactic measure.

Frequent headaches are noted in 20% of children following a brain injury (Miya, 1991). Reduced stamina and fatigue can hinder effective interactions with the environment and performance in school. Another characteristic with education implications is frequent yawning. This is often interpreted by teachers as boredom or insolence, but is a further manifestation of the injury (Miya, 1991).

Deficits in motor functioning, such as decreased motor steadiness and coordination, partial or total paralysis of limbs, and motor slowing, are among the most common problems with brain trauma (Clark et al., 1999; Farmer et al., 1995). This decreased speed is frustrating for children, parents, and teachers. Slowed speed and incoordination may cause difficulty with fine motor tasks, such as handwriting, or gross motor tasks, such as moving efficiently between classes. Motor disabilities can adversely impact the quality of life in children and adolescents. Young people's sense of self is often a direct result of their body image and athletic ability. Lasting motor impairments carry a particularly negative consequence (Telzrow, 1987).

Behavioral and Personality

Although there is a great deal of variability in children's functioning following a head trauma, researchers agree the most disturbing, long-lasting, and dramatic changes can be those related to behavior and personality (Clark et al., 1999; Farmer et al., 1995; Telzrow, 1987). These changes reinforce the truth of the National Head Injury Foundation's slogan, "Life after head injury is never the same" (NHIF, 1985). The incidence of behavior problems and psychiatric disorders are increased for those suffering both mild and severe injuries (Farmer et al., 1995; Telzrow, 1987). The range of behavioral concerns include hyperactivity, impulsivity, aggressiveness and poor anger control, noncompliance, disinhibition, apathy, poor social skills, impaired judgement, low self-esteem, substance abuse, and depression (Clark et al., 1999; Farmer et al., 1995; Mira et al., 1991, Telzrow, 1987). Often these symptoms are present even when intellectual, perceptual-motor, and language disabilities are not.

These striking changes frequently produce feelings of anxiety and confusion in both the patient and their families. Telzrow (1987) tells of a 12-year-old girl who was transformed after her head injury from a friendly, agreeable honor student to a loud, complaining youth who made racist statements towards classmates and teachers. Another 17-year-old girl, whose neuropsychological assessments were all within normal ranges, was reported by her mother to have regressed to the level of an 11-year-old, insisting on carrying a stuffed animal with her at all times. She also displayed poor social judgment and self-monitoring, describing her sexual experiences to the examiner during the first few moments of the interview.

Behavioral changes may reflect executive functioning deficits associated with frontal lobe injury. These difficulties involve problems with planning and organizing, as well as diminished insight into the child's own behavior. Children often demonstrate a decreased capacity to self-monitor and self-regulate in their daily activities and interactions (Farmer & Peterson, 1995).

There is some question as to the etiology of postinjury problem behaviors. They could be a result of abnormal brain activity, the demands of therapy, psychological reactions to the injury, or environmental stressors. For example, the agitation and aggressiveness a child displays in the early stages following an injury, may reflect the child's struggle to return to normalcy, as much as the injury itself. As the rehabilitation period advances and children do not make the progress they and their parents expected, depression and hopelessness often replace the anger. Emotional concerns such as these increase a child's risk for suicidal behavior (Clark et al., 1999).

Another variable is the issue of preinjury behavior. Some studies have found that children with premorbid behavioral problems are twice as likely to develop psychosocial problems following injury as those with normal preaccident behavior (Rutter, 1981). This suggests TBI could exacerbate pre-existing behavior problems. Thus, an abnormal behavior observed after TBI may be a behavioral precursor that lead to the injury, a direct result of the injury, or an emotional response to recent disabilities.

Social problems.

Just as disabling for a child as the deficits listed above, are the loss of friends, decreased social involvement, and absence of social supports that frequently accompany brain injury (Glang et al., 1997). In many ways they experience the same difficulties as children who are socially ignored and rejected (Farmer et al., 1995). The child with TBI may have deficits that impact social interactions he or she may have, difficulty understanding social situations and social cues, tangential speech, and low self-esteem and self-consciousness. Many times the impulsivity and poor anger control leads to peer rejection and isolation. Parents of these children report poor problem-solving skills in social situations, especially in handling teasing and being left out, solving arguments and problems, accepting "no" for an answer, and exerting self-control (Clark et al., 1999). One study by Willer (1990) found the most significant problem following TBI for adolescent males ages 14-20 was difficulty in gaining and maintaining friendships. Fatigue may restrict their access to social activities, especially those of a physical nature. Maladaptive behavior, including disinhibition, decreased motivation, and insensitivity to others, further alienates them. Peers may become confused by these changes in the student's behavior. All these factors when also combined with cognitive deficits contribute to the isolation of the TBI youth.

Sustaining a traumatic head injury is not only devastating to children, but to their families as well. Although the physical stress of caring for a child with TBI decreases after the first year, the psychological stress tends to get worse. Families studied 10 years following the injury were found to still experience psychological stress (Clark et al., 1999). For many parents these tensions lead to unemployment, substance abuse, depression and social isolation, which may further negatively impact the child.

Factors Contributing to Outcome

The outcome following an injury to the brain of a child is a result of a multitude of complex interactions between the child and his/her environment. Most salient is the nature of the injury itself. Pre-injury characteristics, as well as family, school, and community factors contribute to long-term outcome as well. The course of recovery is typically more rapid in the first 6-12 months following injury, although many children continue to show slow but ongoing improvement in abilities for 18-36 months and in some cases even longer (Chadwick, Rutter, Brown et al., 1981). Twenty per cent of injured students will require special education services due to residual problems (Semrud-Clikeman, 2001). Some children will be discharged from the hospital to a residential placement, while others with severe injuries may need homebound instruction.

Those students requiring special education classes will vary from needing self-contained settings to complete inclusion. A study by Rosen and Gerring (1986) found that 10% of children with TBI required home instruction, 11% a reduced or modified school program, 20% special education programs, 10% residential placement, and 14% were unable to return to school because of an ongoing comatose state. In addition, they found that 18% did not require any special education services. The moderating factors of outcome are discussed in greater detail in the following sections.

Severity of injury

One of the best predictors of outcome in a TBI is the severity of the injury. Severity has been associated with greater deficits in areas such as: attention, memory, Performance IQ, language, motor skill, and adaptive behavior (Clark et al., 1999). Severity also predicts which children will need special education services (Donders, 1994). The greater the severity, the more likely it is that there will be long lasting changes in physical, behavioral, and cognitive abilities (Farmer et al., 1995).

Brain injuries are diagnosed as mild, moderate, or severe. This classification is based on three factors. First is the level of consciousness, which is measured with the Glasgow Coma

Scale (GCS; Teasdale & Jennett, 1974). The GSC assesses three domains: (a) eye opening, (b) best motor response, and (c) best verbal response. See Table 1 for scoring criteria. Mild injuries are classified for scores between 13-15, moderate injuries range from 9-12, and severe injuries are designated by a GCS of 8 or less. For example, a coma, or severe level, is diagnosed when there is no eye opening, an inability to follow commands, and no utterance of recognizable words.

Table 1
Glasgow Coma Scale

Activity	Score	Description
Best motor response		
obeys commands	6	follows simple verbal directions
localized pain	5	moves limbs to attempt to escape painful stimuli
withdrawal from pain	4	normal flexor response (abduction)
abnormal flexion	3	"decorticate"—abnormal adduction of shoulder
extensor posturing	2	"decerebrate"—internal rotation of shoulder and pronation of forearm
no response	1	flaccid, without evidence of spinal transection
Best verbal response		
oriented	5	aware of self, environment, time and situation
confused	4	attention is adequate and patient is responsive, but responses suggest disorientation and confusion
inappropriate	3	understandable articulation, but speech is used in a nonconversational (exclamatory or swearing manner); conversation is not sustained
incomprehensible	2	verbal responses (moaning) but without recognizable words
no response	1	
Eye opening		
spontaneous	4	eyes are open; scored without reference to

		awareness
to speech	3	eyes are open to speech or shout without implying a response to a direct command
to pain	2	eyes are open with painful stimulus to limbs or chest
none	1	no eye opening, not attributable to swelling

G. Teasdale & B. Jennett (1974)

A second indicator of head injury severity is the degree of posttraumatic amnesia (PTA) or the period of time for which a child has difficulty retaining new information (Farmer et al., 1995). A third method to judge severity is by examining neurological findings (e.g. cerebral blood flow, computerized tomography, and paralysis), where abnormal responses signify greater severity of injury. Hence, an injury is considered medically significant when any of the following three conditions have been met: (1) there is an alteration in consciousness, (2) the patient has a PTA of longer than 5 minutes, and (3) there is physical evidence of injury based on neurodiagnostic measures (Bigler, 1997). Furthermore, an injury is rated as severe if a coma continues for longer than 24 hours or if PTA is longer than 1 week.

Several advances in computer-assisted methods of analyzing brain-imaging data have been made in the last 10 years. The focus now is on quantifying pathological changes via neuroimaging techniques and presenting the data three-dimensionally. Often a beginning step is to examine the ventricular system, assessing symmetry and an increase in size. An expansion of the ventricular space indicates brain tissue wasting away as a result of cellular death.

Psychometric principles for behavioral assessment involve the use of comparing a subject's score on a measure with a normative sample. This principle is being applied to

MR imaging. A quantitative comparison can be created when a patient's MRI scan is compared with age and gender matched controls. This allows a structure by structure comparison using statistical analysis to determine which structures or areas of the brain are the most damaged (Bigler, 1997).

There are other techniques being used to assess postinjury pathology. Computer-assisted quantitative electroencephalography provides a physiological indicator of brain pathology. Neuroimaging techniques based on regional cerebral blood flow and metabolic measures are now employed to a greater extent. One example of this is single photo emission computed tomography (SPECT) scanning. The benefit of SPECT scanning is that it reveals pathologic areas of metabolic functioning or cerebral blood flow that typically extend beyond the actual anatomic boundaries (Bigler, 1997). This technology allows one to confirm physiological changes short of actual structural damage (i.e. not visible on neuroimagery).

Age and development.

Some researchers believe age is a better predictor of long-term outcome, while severity a better predictor of the rate of recovery (Clark et al., 1999). Generally, the older individuals are at the age at time of injury, the greater the probability of increased morbidity and mortality. It was believed that young children's brains had more resiliency to injury and that as yet undeveloped portions of the brain would compensate for the damaged areas. However, it has been found that children younger than 7 years of age at the time of impairment show more persistent deficits in cognitive skills than children who receive their injuries after the age of 7 (Clark et al., 1999). It seems that impairment that occurs during the critical learning period of early childhood causes more severe disruptions than those occurring in later years. Pre-school children seem to be particularly at risk. Early injury may interfere with rapid brain growth and differentiation. Rather than hindering a specific ability, an injury during a child's early years may result in global changes in his or her capacity to learn (Farmer et al., 1995).

Furthermore, damage to immature areas of the brain that are necessary for later learning and skill acquisition may cause those areas to fail to develop properly. The effects of the damage may not become apparent until later in the child's life following maturation of those developmental skills. An example of this late-onset effect of injury might be in the area of reasoning. If a child is injured during his/her first few years, problems in the area of complex reasoning may not be evidenced until adolescence when that skill is expected to develop. This is a unique problem to childhood brain injury that clouds the recovery process, as well as the issues of assessment. Because developmental tasks vary with age and create more challenges for children with brain injuries and the assessment of their capabilities, determining whether a behavioral response is a normal variation in performance, an atypical behavior, or a pathological response, requires an in-depth understanding of normal and abnormal development in children (Vanderploeg, 2000). Consequently, although the passage of time brings improvement and recovery of abilities, it can also present further obstacles.

Pre-injury functioning.

Besides severity and age, the pre-injury functioning of the child and family influences the child's eventual outcome. Children who have had cognitive, behavioral, and social/emotional problems before the injury have been found to have poorer outcomes than children who had good pre-injury functioning (Clark et al., 1999). The level of pre-injury family functioning also affects outcome. Rivara et al. (1992) found the poorest outcomes one year after the injury were for those children whose families lived in poverty, had little family cohesion, and limited access to social resources in the community. Access to medical care may also be confounded with these variables.

Several family factors may impact a child's recovery from TBI. Brown, Chadwick, and Shaffer (1981) identified not living with his or her natural parents as leading to a greater probability that a child with head injuries will display more negative behaviors. Barry and Clark (1992) investigated data from forty-one children with head injuries, aged 8-18 years, to ascertain the effect of family intactness on injury rehabilitation. The children were divided into two groups according to the family's intactness. An intact family was defined as one with both of the child's biological parents living in the home. Forty one percent of the sample was considered an intact family. The children from intact families were found to be significantly older at time of injury, with an average age of 15.24 years, compared to 13.21 years for children from non-intact families. Boys and girls were more evenly represented in the intact sample, with 59% boys, compared to 71% males from non-intact families. Severity of injury showed no significant difference between the two groups. An unexpected difference was evidenced in the length of stay. Children from intact families stayed a significantly shorter time in the rehabilitation facility, 149 days versus 227 days for the non-intact group. The authors hypothesize that there is a more stable discharge environment for children of intact families. They also note that the age difference is significant, in that children from non-intact families are about 2 years younger and more likely to be males. These findings suggest the benefits of targeting prevention programs at a higher risk group, namely male children in a single-parent home.

Kinsella, Ong, Murtagh, Prior, and Sawyer (1999) studied the relationship between the family environment and behavioral functioning in children up to two years following a traumatic brain injury. Fifty-one children between the ages of 5 and 15 were classified into three severity of injury groups: mild, moderate, and severe. Parents were asked to complete the Child Behavior Checklist according to the child's preinjury behavior immediately following the injury. Behavior was reassessed at 3 months, 1 year, and 2 years postinjury. In addition, at each point of time parents completed questionnaires regarding family functioning and emotional status. The Teacher's Report Forms were completed by teachers at each of the postinjury assessment stages.

The relationship between injury severity and child behavior was assessed using a 2 (Group) x 4 (Time) ANOVA. Children with severe injuries were significantly more likely than children with mild or moderate injuries to exhibit behavior problems above the clinical cutoff. Severely injured children's problems also worsened over time.

Regression analyses provided evidence that at 3 months postinjury a single-parent family and higher emotional distress of the parent predicted more child behavior problems. By 1-year follow-up, the family's preinjury resources and family environment continued to predict behavioral impairment, although injury severity started to emerge as a factor. By 2-year follow-up, only the severity of the injury predicted change in child behavioral outcome. It can be suggested that the parent's ability to cope may impact the child's development of behavioral problems. Implications are that identifying and offering treatment and counseling support to families with less coping resources may promote more favorable child outcomes.

School environment.

Several variables within the school setting can produce positive or negative outcomes for the child with TBI. One is teacher characteristics. When teachers are well educated about brain injury, their sense of efficacy is bolstered, which has been shown to positively relate to student achievement and self-concept. This in turn predicts better outcome (Farmer & Peterson, 1995). Peer interactions are another moderating factor. Many studies report the healing effect of social relationships (Moore & Stambrook, 1995; Glang, Todis, Cooley, Wells, & Voss, 1997). Having a social support system increases children's overall outlook on themselves and their environment. TBI can interfere with a child's social skills. Not only should the patient receive skill training, but their peers can receive training in what to expect from and how to respond to the injured child. The third school environmental variable is the instructional setting. Structured schedules and classrooms, reduced noise and activity levels, and the use of assistive devices, such as calculators and tape recorders, have been shown to improve a student's academic success (Farmer et al., 1995).

In conclusion, a traumatic brain injury occurs when an external force causes an impairment in the brain's ability to regulate physical, cognitive, emotional, or behavioral functioning. The extent of the damage depends on the mechanisms of injury, the specific sites concerned, and the severity of the injury. Furthermore, the child's age, developmental level, preinjury academic achievement, and behavioral functioning interact with the injury to determine the child's prognosis.

Assessment

Assessment begins immediately following the injury. One of the initial tasks of rehabilitation specialists is to identify the impact of the injury on the child. The primary focus at this time is on recovery and stability of the medical condition. In the early stages subsequent to the injury, cognition is assessed only at a gross level. Following relative medical stability, higher cognitive functions will be assessed.

As described earlier, the Glasgow Coma Scale assesses the level of consciousness. After a child is medically stable, early cognitive recovery during the rehabilitation period is measured using the Rancho Los Amigos Levels of Cognitive Functioning Scale (Hagen, Malkmus, & Durham, 1981), which outlines eight stages of cognitive and behavioral recovery (see Table 2). Improvement following a brain injury tends to occur in a predictable pattern of stages from coma to more purposeful behavior.

Table 2
Rancho Los Amigos Scale of Cognitive Functioning

Level	Description
I	No response to pain, touch, or sight. Appears asleep.
II	Generalized response to external stimuli. Nonpurposeful, inconsistent, and limited responses.
III	Localized response. Blinks to strong light, orients to sound, responds to physical discomfort. May respond inconsistently to simple response commands.
IV	Confused-Agitated. Alert, motorically active, inconsistent and nonpurposeful behaviors that can be aggressive or bizarre, extremely short attention span, and no short-term recall.
V	Confused-Nonagitated. General attention to environment, follows simple commands consistently, but requires frequent redirection due to high distractibility: new information is not retained. May cngagc in social conversation but with inappropriate verbalizations.
VI	Confused-Appropriate. Inconsistent orientation to time and place, new learning impaired, begins to recall remote memories, follows simple directions, goal-directed behavior with environmental supports and assistance.

VII	Automatic-Appropriate. Performs daily routine in familiar settings in a non-confused but automatic, robot-like manner. Skills decrease in unfamiliar environment. Judgment impaired.
VIII	Purposeful-Appropriate. Responsive to the environment, but cognitive abilities (e.g., memory, reasoning) may be decreased relative to preinjury levels.

Hagen, Malkmus, & Durham (1981).

Neuropsychological Approach

Once the patient's behavior becomes more purposeful and appropriate to the environment as suggested in Rancho level 7 or higher, neuropsychological testing would be appropriate. Neuropsychological assessment is beneficial because it provides a comprehensive record of strengths and weaknesses, detects cognitive functioning disturbances that may be missed in a neurological examination, and provides a baseline to evaluate recovery of function and treatment efficacy. A neuropsychological evaluation involves assessment of functioning in a number of domains, including cognitive, academic, visual-spatial, motor, memory, and attention. There are traditional batteries used for neuropsychological assessments, the most popular being the Halstead-Reitan Batteries (Reitan and Wolfson, 1985a) and the Luria-Nebraska Neuropsychological Battery for Children—Revised (Golden, Purish, & Hammeke, 1980).

The ultimate goal of assessment is to predict and guide the recovery of cognitive functioning. Because each child's presentation is unique, there is no standard approach to assessment, however the following objectives should be met.

- Determine child's baseline pattern of cognitive and behavioral strengths and needs
- Document improvements in functioning
- Develop a specific plan for interventions

- Describe environmental factors that will affect performance
- Determine needed educational services and develop the child's Individualized Education Program.

To facilitate school reintegration, a multidisciplinary team approach to assessment is helpful in coordinating the various services, such as physicians, physical therapist, speech pathologist, neuropsychologist, social worker, occupational therapist, recreational therapist and other personnel. The rehabilitation team should include family members and educators. The family can provide valuable information regarding the child's preinjury adjustment and coping style, while educators can furnish objective records of premorbid academic functioning.

The advantages of formal, standardized measures (such as the WISC-III or Halstead-Reitan) include norm-referenced testing where a child's performance is compared against a peer group, also a uniformity of procedure, ease in communicating with other professionals, and in most cases, high reliability and validity. It also provides a baseline measure against which the extent of recovery can be compared. The disadvantages are that isolated pieces of behavior are sampled, the testing situation is not representative of the child's functioning in the classroom, it can be time-consuming, and in the case of the Halstead-Reitan Battery, requires extensive training. In addition, caution must be taken when using standardized tests with children with TBI, in that children may be experiencing temporary deficits that would prevent them from being able to participate adequately in the assessment. The temporary presence of pain may prevent the child from performing at his or her optimal level. However, assessment may reflect their functioning, given the present circumstances. Also test scores may overestimate classroom performance and perhaps create false optimism.

Since TBI is now a specific special education category under the IDEA, the need for standardized testing to determine eligibility for services is no longer necessary.

Informal Assessment

Alternative, informal assessment is essential for obtaining a complete picture of a child's capabilities following head injury. It first requires forming a careful hypothesis based on expected competency at the appropriate developmental level, followed by testing to measure if the child meets the expectations. The evaluator can systematically examine the child's various cognitive processes through learning logs (a collection of learned information self-recorded in a journal), think-aloud strategies (assessing a child's thought processes by having him/her explain the steps in how to solve a problem), self-assessment (children rate their own progress), and permanent products (samples of student's work). The evaluator is able to manipulate the learning environment to determine the impact on performance. Criterion and curriculum based measurements yield valuable information without being susceptible to practice effects. Since assessment is continuous, ongoing documentation of progress and treatment effectiveness can be calculated. It is vital, as well, since many deficits are not discovered through formal measures.

Difficulties also exist with this procedure. The examiner must be skilled and possess an accurate knowledge of appropriate child development. The subjective nature of this type of assessment might produce biased responses. The use of multiple raters can minimize the likelihood of error.

Ideally, assessment will include both formal and informal measures in order to obtain a complete picture of a child's strengths and needs, as well as involve family members and professionals. Assessment of the various domains will be examined from both the viewpoint of using standardized measures, which are important to neuropsychologists, and also appropriate, informal assessment techniques.

Cognitive

Cognition is defined as "all mental processes and systems involved in acquiring and using knowledge (Ylvisaker et al., 1998). This includes basic psychological processes, such as attention and reasoning, and component systems, as working memory and executive functions. In the early stages of recovery, the Children's Orientation and Amnesia Test (COAT) (Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990) (see Appendix for references of all assessment measures) can be used to measure orientation to person, place, or time, as well as attention/concentration and posttraumatic amnesia. This test is intended for children aged 3-15. For adolescents over the age of 15, the Galveston Orientation and Amnesia Test (GOAT) (Levin, Benton, & Grossman, 1982) is equivalent.

During rapid improvement, informal probes are often used. To assess attention, length of time on task can be gauged during a variety of conditions, ranging from one-on-one assistance in a quiet room to multiple distractors in a mock classroom setting. A pretend-play task, as a tea party, can be designed to assess numerous competencies, including memory for names and faces, word-finding skills, visual discrimination, and problem-solving abilities.

Standardized intelligence measures, such as the Wechsler Intelligence Scale for Children Third Edition (WISC-III) (Wechsler, 1991) are used to determine a baseline for the child's global cognitive functioning following TBI. However, these measures should not be used in isolation, as an average score does not rule out the existence of impairments in functional skills and is not predictive of academic success. Other measures exist that are more sensitive to the effects of brain injury. For example, the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990) measures various aspects of a child's memory; the California Verbal Learning Test Children's Version (Delis, Kramer, Kaplan, & Ober, 1989) assesses memory and new learning; the Wisconsin Card Sorting Test (Heaton, 1981) gauges concept formation and problem-solving; Tower of London (Levin, et al., 1994) measures planning ability; Controlled Oral Word Association Test (Benton, 1968) and the Inventions of Designs Test (Jones-Gotman & Milner, 1977) for cognitive productivity.

A flexible battery approach is used to integrate these tests with other formal and informal evaluations of a child's cognitive strengths and weaknesses to develop recommendations for the child's rehabilitation. Although a fixed battery test, such as the Halstead-Reitan Neuropsychological Test Battery for Older Children (Reitan & Wolfson, 1992) is not recommended since its primary purpose is diagnosing brain damage rather than suggesting practical interventions, selected subtests, such as the Trail Making Test or the Tactual Performance Test can provide information as to specific cognitive abilities (Fay et al., 1994).

Speech and language assessment.

Typical language deficits in children with TBI include impaired language comprehension; problems with abstraction and making inferences; difficulty with acquisition of receptive skills; impaired ability to express complex information, state main ideas, or organize information; and problems in word fluency and word retrieval. Some useful standardized measures are the Clinical Evaluation of Language Fundamentals-Revised (CELF-R) which assess phonology, semantics, morphology, syntax, word retrieval, and verbal memory. The Word Test evaluates ability to understand and use increasingly complex and abstract language, such as semantic absurdities, inferences and figurative language.

Informal measures aid in gaining an understanding of language skills within a natural context. Merely asking children questions after they have listened to a lecture will provide a measure of auditory comprehension. By manipulating variables, such as length of information, visual prompts, and novelty, a reliable evaluation of receptive language can be established. Expressive language can be examined during the course of a conversation. Again variables, such as time constraints, can be manipulated to provide more information. The Pragmatic Protocol (Prutting & Kirchner, 1987) assesses higher order abilities, including initiation, maintenance, and appropriate shifting of topic in conversations.

Assessment of academic achievement.

Standard assessments to measure academic achievement may be given to students after a head injury, but should be interpreted with caution. The Kaufman Test of Educational Achievement (K-TEA) and the Woodcock-Johnson PsychoEducational Battery-Third Edition (Tests of Achievement) (WJ-III) are two that are reliable and highly correlated with educational achievement of nondisabled students. These types of measures may be beneficial in determining the child's relative standing as compared with peers and in yielding a baseline by which to measure improvement. However, achievement tests, such as the K-TEA and WJ-III, are likely to overestimate an injured student's performance in real settings since standardized testing sessions do not reflect conditions found in the average classroom. They are administered individually with no time limits, they require no synthesis of information, and they usually assess previously learned material rather than the more relevant issue of new learning.

Performance-based assessment of academic skills is more likely to target areas of concern for intervention. Having a student read a passage from a text, noting errors, and then having the student retell the story with and without cues, yields information regarding reading skills, comprehension, memory, and the cognitive processes involved. Length of the passage and how the student manages unknown words reveal how the student deals with frustration. In some cases the child might omit whole lines or paragraphs, giving clues as to his/her attention level.

Many classrooms focus on the product of writing. For children with TBI, the focus of assessment should be on the process of writing. Initially, it is important to notc how physical limitations affect their motivation and ability to write. Writing probes can detect a student's inability to generate ideas, organizational skills, and mechanics (spelling, capitalization, punctuation) of writing. If a portfolio of such skills is begun in the hospital, the child's progress in this area can be documented (Farmer, Clippard, Luehr-Wiemann, Wright, & Owings, 1997).

When assessing the mathematics area, it is important to use a think-aloud technique. With this method the child is asked to speak aloud everything he thinks or does. Often children lack awareness of their own performance and this strategy helps them to become more conscious of it. This technique will help pinpoint efficient and inefficient thinking strategies. Using math skills in a natural context, for example purchasing an item from a gift shop, requires a variety of skills, such as decision making, math reasoning and social appropriateness.

Besides assessing the child's ability to learn, many studies support the necessity of assessing the learning environment (McKee & Witt, 1990; Farmer et al., 1997). By creating a mock classroom, situational variables such as distractions, optimal length of instructional periods, effective materials and test formats, expectations for quality of work production, and the need for classroom aids can be determined.

Sensorimotor domain.

Standardized measurements are available to assess a child's level of physical functioning. For visual-perceptual and visual-motor skills, tests such as the Motor Free Visual Perception Test (Colarusso & Hammill, 1972) and the Developmental Test of Visual Motor Integration (Beery & Buktenica, 1982) are useful. They are brief and easy to administer. To assess gross and fine motor skills, the Bruininks-Oseretsky Test of Motor Proficiency is recommended (Bruininks, 1978). The Miller Assessment for Preschoolers (Miller, 1982) and the Peabody Developmental Scales (Folio & Fewell, 1983) are measures of sensory and motor abilities in younger children. Several tests from the Halstead-Reitan Test Battery are beneficial for assessing sensory input. These include the Tactual Performance Test , Finger-Tapping Test (motor speed), Tactile Form Recognition, and Sensory-Perceptual Exam. This examination incorporates several techniques for assessing unilateral and bilateral stimulation of tactile, visual and auditory sensations. The tasks are simple enough that nondisabled subjects would score almost without error, thus lending support to the discriminatory validity of the measure.

Observations made during multisensory play activities will provide additional assessments of the child's strength and endurance, postural stability, and sensory integration. This will provide clues as to the level of adaptive devices the child will need when returning to school. Educators will want to provide those that will yield the highest level of functional independence for the student. For example, does the child need a wheelchair, or will extra time to move from class to class suffice?

Behavioral functioning

The Vineland Adaptive Behavior Scales (VABS) (Sparrow, Balla, & Cicchetti, 1984) is useful in examining behavior competence in children. Besides measuring levels of performance in the domain of communication, self-care, mobility, and socialization, the VABS can indicate the extent of caregiver assistance necessary to complete daily living tasks. Because it has been normed on children from birth to 19 years, it is useful for documenting progress over the course of development.

Of all the adaptive behaviors, social problems with peers tend to be among the most persistent deficits in children with brain injuries. Social problems are only weakly associated with measures of cognitive functioning, such as IQ, memory, or other neuropsychological tests (Farmer, 1997) and so must be assessed separately from cognitive recovery. Formal measures, such as the Social Skills Rating Scales, yield standardized information about a child's social behavior and provides the advantage of gathering comparable data from parents, teachers, and children themselves. Informal observations of the child's interactions with peers, and parent and educator social validation ratings (adult ratings of the child's social interactions) are among the informal assessments that may be used.

Some children have developed disruptive behaviors or adjustment problems following a head trauma. However, few of the standardized behavioral assessment measures fully capture this behavior change. For example, the Child Behavior Checklist (CBCL) (Achenbach, 1991) does not typically reflect clinically significant problems on the

Internalizing or Externalizing scales following TBI (Fletcher, Ewing-Cobbs, Miner, Levin, & Eisenberg, 1990). Other options include nonstandardized checklists to assess specific behavior problems.

The wide variability of behavioral adaptation following TBI has been found to depend on preinjury child and family functioning as much as injury severity (Rivara, 1992). This suggests that the family stress level and coping ability must be examined as well. Possible measures include The Parenting Stress Index (Abidin, 1983), the Family Environment Scale, and the Family Crisis Oriented Personal Evaluation Scales (F-COPES) (McCubbin, Larsen, & Olson, 1985).

Standardized measures should only be used as a supplement to clinical interviews and direct behavioral observations. These contacts allow for more in-depth assessment and are more sensitive to developing problems.

Summary

In conclusion TBI is one of the leading causes of disability in children. The resulting disability is more complex than may be revealed by observation, neurological examinations and conventional educational assessments. Many forms of motor, behavior, and cognitive dysfunctions may become apparent. Not all appear in the initial stages of trauma but may reveal themselves in later years. The primary challenge facing educators who work with children with brain trauma is to accurately assess the nature and the extent of brain injury and guide recovery of cognitive functioning through the use of appropriate educational strategies.

Interventions

Although one of the purposes of this paper was to review the literature on the efficacy of interventions with brain-injured children and adolescents, there are few studies that focus on children's intervention efficacy and even fewer that examine school-based interventions. Much of the literature describing educational programs and interventions for this population is anecdotal in nature. That is, logical and accepted approaches to treatment are described, but empirical validation is not provided. It may be fair to characterize the current published literature for this topic as primarily exploratory.

Inclusion and Exclusion Critera for Studies Reviewed

The remainder of this paper will focus on the current research of efficacy of school-based interventions for traumatic brain injured children. In order to locate empirical studies and current findings of interventions for children who have sustained a TBI that would be applicable in the schools, a computer search of ERIC (CIJE), PsychLit, PubMed and CINAHL was conducted. Additional articles were found in the references of the initial primary source articles. To be included in the study, each article had to discuss interventions for TBI in children or adolescents and had to include outcome data for participants who had sustained a head injury. Seventeen articles were located that fit the criteria of studies focusing on interventions for children and adolescents with traumatic brain injuries. Eleven dealt with cognitive remediation, four with social/behavioral interventions, and two examined the impact of the family on child outcome.

In examining the studies, critical issues that can affect the outcome and validity of the study were noted. These include the severity of injury, time since injury, age at injury, pre-injury characteristics, experimental design and controls, follow-up of duration of effects over time, and generalizability. In addition, the major findings and limitations of the studies will be discussed, as well as directions for future research.

<u>Cognitive Remediation</u>

Successful reentry into school following a TBI often requires remediation of cognitive skills, such as problem solving, attention, and memory. In a comparative study by Light, Neumann, Lewis, Morecki-Oberg, Asarnow, and Satz (1987), a cognitive reeducation program for children was examined. The Neuro-Cognitive Education Project (NEP) is a cognitive rehabilitation program designed to facilitate the integration of children with head injuries into the school environment and to assist them in coping with the learning problems that are frequently a result of head injury. It focuses on attention, memory, self-control, and problem solving. Fifteen children who met eight inclusion criteria, including ages between 4 and 11, PTA of at least one hour, and absence of pre-existing brain dysfunction, were in the intervention group while a comparison group was made of six children who also met criteria but could not participate due to distance from the hospital, time of referral, conflict with co-interventions, or lack of parental consent. All subjects were at least one-year post injury. In addition, a group of 21 normal control subjects, matched for age, sex, race, and socioeconomic status, was administered the Peabody Picture Vocabulary Test to provide comparison data of intellectual functioning.

Four types of measures were used: neuropsychological, intelligence, educational, and adaptive. A variety of neuropsychological assessments were administered to assess the areas of cerebral dysfunction, visual-motor integration, receptive and expressive language, verbal fluency, attention, and memory. A standardized, normative cognitive assessment was used to obtain intellectual functioning. Two measures to assess academic skills were used, with the final area of assessment being adaptive and behavioral. Children were evaluated with these measures pre- and post-intervention. Total hours of tutoring ranged from 19 to 68 hours with a mean of 39.7 hours (SD14.2). The authors explain the large range of tutoring hours was due to scheduling difficulties and problems with school or parent accessibility. Duration of the intervention was from 3 to 7 months with a mean of 21 weeks.

The NEP program provides one-on-one tutoring for each child, with instruction at home and in the school setting in order to increase generalization, along with a component to assist families in understanding their child's limitations. The curriculum was based on each child's individual strengths and weaknesses and targeted educational and neuropsychological goals. The children were taught to recognize their strengths and weaknesses and to use cognitive strategies. The tutors taught cognitive strategies using the following principles:

1) Begin at or below a child's level of competence.
2) Be concrete, clear, and consistent in approach and expectation.
3) Provide limits and structure on expected behavior.
4) Use multiple repetitions and variations of a task.
5) Offer frequent feedback on performance.
6) Use a multimodal approach (including visual, auditory, tactile, and motor).
7) Present lessons in a motivating and relevant manner.

On the neuropsychological and intelligence measures, the children with head injuries in the comparison group performed better than the children in the intervention group at pre-test. Both groups tended to show improved scores relative to their own performance at initial testing, however these differences were only significant on two measures (K-ABC simultaneous processing and Expressive One-Word Picture Vocabulary Test). On educational measures, no significant differences were found between the two groups at pre- and post-test, with both groups' performance staying about the same. There were significant differences between the children in the intervention group and the comparison group on initial and follow-up testing on the adaptive behavior scales, with the comparison group performing better at both testings. Children in the intervention group demonstrated greater improvement than those in the comparison group, although this difference only reached statistical significance on two measures (adaptive behavior composite and communication functioning). On two other measures of adaptive performance (daily living and socialization) there was a trend for children in the intervention group to display greater improvement, but the difference did not reach statistical significance.

In general, both groups improved from pre- to post-testing. Significant increases occurred in the area of adaptive functioning even though that was not a target area of the program. This fact may suggest that adaptive functioning is enhanced by cognitive rehabilitation. The authors do not address the possibility that the counseling to parents may have improved adaptive behavioral performance, but note that the improvement in adaptive behavior supports similar findings from the literature on adults.

However, this study had several methodological problems. First, the small sample size hampered analysis and generalization. Lack of randomization of subjects led to significant baseline differences between the groups. It could be that higher functioning individuals tend to make greater improvements after intervention. In addition, there were differences in the level and duration of the intervention. Further studies are needed to investigate the potential of cognitive rehabilitation programs, examining both cognitive and adaptive behavior outcomes.

A compensatory approach to teach individuals with brain injuries the use of techniques or strategies to compensate for cognitive impairments was brought directly into the school environment. Brett and Laatsch (1998) examined the effect of cognitive rehabilitation therapy within a high school setting. The intervention was administered by teachers who had been trained by psychologists. Cognitive rehabilitation therapy (CRT) can be defined as "structured activities that improve a brain-injured patient's higher cerebral functioning or help the individual to better understand the nature of those difficulties while teaching him or her methods of compensation" (Brett and Laatsch, 1998). It is a program that uses strategies to assist brain-injured individuals in developing ways to compensate for cognitive deficits. It teaches students to think about their thinking. An example would be remembering a pair of words by linking them semantically or a rehearsal of facts.

The subjects were 10 high school students with traumatic brain injury, all at least one year post-injury. No information regarding severity of injury was provided. Selection criteria were high school attendance and intelligence in the borderline or above range. All received CRT twice a week for 20 weeks. Each student had individualized goals in the three levels of the developmental model of cognitive rehabilitation: (1) attention, (2) perception and memory, and (3) executive processes, such as problem solving. Examples of tasks within each level are listed below.

Level 1: Attention—Reaction time to a visual stimulus.
Following 1- and 2-step commands
Level 2: Perception and Memory—Recalling a list of words
Recalling location of objects on a floor plan
Level 3: Problem solving—Locating towns and roads on a map
Figuring out the next number in a numerical sequence.

Sessions were 40 minutes each and typically used computerized tasks, flash cards, and games such as GeoSafari (National Geographic Society, Washington, D.C.). Students were assessed pre- and post-treatment for general intellectual ability, self-esteem, and cognitive functioning using nine measures, such as Wechsler Inteligence Scale for Children—Third

Edition (WISC-III), Culture-Free Self-Esteem Inventories, 2nd Edition, Stroop Color and Word Test, Wide Range Assessment of Memory and Learning (WRAML), and the Wisconsin Card Sorting Test.

Post-assessment yielded only slight improvements. A significant increase was found on only one of the measures, verbal memory skills. The authors believe this was due to the emphasis placed on repetition, clustering, and semantic skills. Overall intellectual functioning and performance on other measures evidenced a modest improvement but were not statistically significant.

Although this study suggested that cognitive rehabilitation within a school setting may enhance the verbal memory learning of children with TBI, there are several problems. Increased performance was significant on only one of the nine measures. There was no measurement of how these skills generalized to the classroom. The individualized attention that each subject received may have effected the change in performance rather than the CRT. The use of a control group that receives individual attention, but not CRT, would be appropriate for examining this issue.

Other factors could also explain the modest findings. The authors reported irregular student attendance with some students only receiving 18 of the sessions. Only two of the subjects reached the Level 3 (problem solving) training. Severity of injury, which may reflect a subject's ability to learn, was not furnished. Many of the students were several years post-injury and thus, several years behind in school. Many had developed negative attitudes and behaviors toward the school environment. Furthermore, the researchers found that there was a lack of parental support for academic achievement. It is possible that this intervention would be more successful with younger children or when training is presented closer temporally to the acute injury. Taking these factors into account, it is premature to dismiss this treatment as ineffective, and, in fact, providing cognitive rehabilitation services within a naturalistic environment is an admirable goal.

In a case study by Suzman, Morris, Morris, and Milan (1997), cognitive and behavioral training to enhance problem-solving skills for five children with brain injuries was delivered in a special education setting. All of the students had sustained a moderate to severe brain injury 3-9 months before treatment began. The multi-component cognitive-behavioral treatment program consisted of four elements: self-instruction and self-regulation training, metacognition training, attribution training, and reinforcement.

Self-instruction training (SIT) involved teaching the students self-directed statements that provided them a thinking strategy as they solved problems. The SIT strategy comprises 4 steps: recognizing that there is a problem, initiating a strategy, taking action on a chosen plan, and evaluating the performance. Self-regulation training (SRT) consists of establishing a goal, monitoring whether one has met the goal, and rewarding oneself upon achievement of the goal. Metacognition training involved teaching students techniques to help them identify when they were facing a problem and what they should do to solve the problem. Attribution training helped the child to identify the connection between effort and successful performance and involved statements such as "I tried hard and used my strategies" (Suzman et al., 1997). Reinforcement was given as points for successful use of the strategies. Students could trade points for tangible reinforcers.

Errors made on a computerized problem-solving task functioned as the outcome measure and was conducted each session throughout baseline and treatment. In addition, four standardized problem-solving instruments were used to evaluate the participants pre- and post-treatment. The battery included the Rey-Osterrieth Complex Figure Test, The Porteus Maze Test, The Wisconsin Card Sorting Test, and the Word Fluency Test. The parents, teachers, and participants completed satisfaction rating scales as well.

Results showed a decrease in the number of errors made on the computerized tasks for all students. Statistically significant improvements on the standardized problem solving measures were seen on two of the instruments, the Rey Osterrieth Complex Figure Task and the Word Fluency Test. Parents, teachers, and participants rated the program as very satisfactory. The results suggest that this package of cognitive-behavioral strategies may be effective in increasing problem-solving ability in children with TBI. Further evidence is needed to assess the generalization and maintenance of the intervention, and whether or not the children would have shown the same recovery without treatment. This is an issue as the subjects in this study were 3-9 months post injury when much of the recovery from brain injury occurs. Thus, much of the effects of the intervention could reflect spontaneous recovery. The inclusion of a placebo or no treatment control group in future studies would clarify this issue. Also, it is not clear if all four of the components are necessary for treatment efficacy. The authors suggested that the decrease in errors was mainly seen immediately after implementing the SIT and SRT strategies, suggesting these aspects may be the most potent elements of the treatment package.

Another study involving twelve adolescents looked at attention, memory, and problem solving training with the additional component of language and word retrieval. Thomas-Stonell, Johnson, Schuller, and Jutai (1994) evaluated a computer-based program (TEACHware) for remediating cognitive-communication skills in individuals with traumatic brain injury. The TEACHware program consists of two modules: a screening module (pretest/posttest measure) and six related remediation modules. The screening module is composed of 25 tasks, 5 from each of the skill areas: attention, memory, comprehension of abstract language, organization, and reasoning/problem solving skills.

A randomized controlled experimental design was employed using two groups of six subjects with TBI, a remediation group and a control group. The subjects were from 3 months to 4 years post injury. Both groups were approximately equal in terms of time since injury and severity of injury. None of the adolescents had a preinjury history of learning disabilities. While the remediation group received therapy for an eight-week period, the control group continued with their traditional rehabilitation and community school programs. The TEACHware screening module and several standardized tests were administered to both groups at baseline, 4 weeks, and at the end of the 8 week remediation period. Results indicated that the remediation group made significantly more gains than the control group on both the screening module and the standardized tests. Furthermore, the classroom teachers of the students from the remediation groups provided unsolicited reports of improved class performance, concentration, and memory skills. No such reports were made by the teachers of the students in the control group. The authors suggest that skill improvement from the remediation program generalized to classroom activities. However, teachers were not blind to student participation in the study, which may account for the improved reports. Results suggest that computer-based programs such as TEACHware may enhance traditional rehabilitation after brain injury. Replication of this research with increased number of subjects is needed in order to substantiate the results, and to examine long term effects.

The inability to learn and remember new verbal information is one of the most common cognitive sequelae of TBI (Oberg and Turkstra, 1998). Two case studies by Oberg and Turkstra outline an encoding procedure to facilitate verbal learning. Encoding is defined as a process that transforms information being held in short-term memory in ways that facilitate storage in long-term memory (Oberg and Turkstra, 1998). It uses strategies such as the association of to-be-learned items with other semantically, acoustically, or visually related information. Two adolescents with severe memory impairments participated in the study. The learning of word definitions was chosen as the dependent variable for three reasons: (1) It was considered to be more relevant for school demands; (2) generalization would be facilitated since it used materials used by the subjects in school contexts; and (3) it would be a preliminary step in addressing teachers' concerns about how TBI students respond to traditional educational approaches. One hundred age appropriate words were chosen for which the subjects were asked to provide definitions. A baseline score was obtained. Intervention efficacy was assessed immediately after treatment and one month later. Treatment consisted of 10 sessions of 30 minutes each over a 5-week period. Intervention strategies included

- Review of words and definitions
- Matching words to synonyms
- Matching words to definitions
- Fill in the blanks of sentences with target words
- Subject generation of definitions with help from the dictionary
- Subject generation of synonyms with help from the dictionary
- Subject uses each word in self-generated sentence
- Subject gives self-generated definitions to a classmate for feedback

Results indicated that both subjects improved from the intervention and that treatment gains were maintained at one-month post treatment. This study provides evidence that adolescents with TBI can increase their verbal learning through the process of elaborative encoding. However, it must be kept in mind that the results of single-subject experimental studies are limited in their generalizability and that more studies with larger sample sizes are needed. It is also important to assess whether the results are maintained over time.

Rehearsal and encoding strategies seem to be promising in addressing deficits in academic functioning. Further support of this strategy for improving memory was found in a study by Franzen, Roberts, Schmits, Verduyn, and Manshadi (1996). Robinson's (1970) elaborative encoding technique (PQRST) was employed by Franzen et al., (1996) to treat two fourth-grade boys with verbal memory deficits following traumatic brain injury. PQRST is an organized rehearsal strategy used with reading passage comprehension. The students were given an index card with the initials written down the side. They were instructed in each component of the technique: *P*review the passage; *Q*uestion, *R*ead the passage; *S*tate answers to questions of who, what, where, and when; and *T*est self on the answers to questions of who, what, where, and when. In addition, a metacognitive technique, asking the subjects to record what they were thinking as they read each sentence or paragraph, was taught for comparison information.

Three male, 10-year old students were the subjects. None of the participants had a premorbid history of learning or behavior problems. Two of the boys suffered either a mild or moderate TBI. The third participant served as a normal comparison subject. One of the head-injured boys was 3 months post-injury, while the other had sustained his injury 16 months before participating in the study. Each of the head-injured children received 15 thirty-minute sessions of training. One subject received the PQRST first and then the metacognitive training; the other child received the training in reverse order. The control subject received practice sessions only, reading the same passages, but without the intervention. Reading passages were taken from fourth-grade reading programs. After reading the passage, the students were asked to recall as many ideas as possible from the story to yield a free recall percentage. Sentence completion and multiple-choice questions were given as well. Long-term recall was assessed at the beginning of each following session.

Free recall performance increased for both head-injured participants, but only during the PQRST phase. Baseline rates were between 30-50%, while PQRST rates increased to 60-80%. For both boys, free recall returned to baseline levels during the metacognitive phase. The control subject's performance remained stable across all conditions at about 70-80%.

Performance on the Sentence Completion and Multiple Choice questions showed higher performance during PQRST when compared to the metacognitive stage. The children demonstrated better long-term recall performance during the PQRST phase, as well. These results suggest that the PQRST intervention strategy may be effective in treating reading comprehension deficits. There are practical implications for the classroom in that this study showed promise in improving both short and long-term recall of information. Further research is needed though, to assess performance on lengthier passages and retention of information over longer periods of time.

Difficulties with memory and attention may interfere with the ability to learn new information (Telzrow, 1987). The efficacy of computer-assisted attention and memory retraining for head-injured patients was the focus of another study by Ruff, Mahaffey, Engel, Farrow, Cox and Karzmark (1994). THINKable is a computer-based multi-media program developed by IBM. In this study, selected exercises for attention and memory training were administered to15 head-injured subjects in a multiple baseline procedure, using pre- and post-group comparisons. All participants had received a severe injury and were at least 6 months post-injury. The 15 subjects were randomly assigned to one of two treatment conditions. Group A received the attention training first, followed by the memory training, while Group B received the same training but in reverse order. Treatment was terminated after either 20 hours or when scores of 90% were achieved on the most advanced program. A variety of assessment measures were used, including computer-based assessments; neuropsychological tests (processing speed, freedom from distractibility, verbal learning, attention, and memory); behavioral assessments, consisting of observer and self-rating scales of eight behaviors in the areas of attention and memory; and the Beck Depression Scale.

On the computerized measures, small but consistent gains were noted for both groups. The standardized testing results were mixed, with gains seen in psychomotor speed and on the Wechsler Mental Control subtest. Group A generally demonstrated greater improvements than Group B on these measures. The behavioral ratings of both groups indicated that the subjects noted improvement in themselves, but it was the observers' behavioral pre- and post-ratings which reached statistical significance. No average changes were demonstrated on the depression scale. In summary, while some restricted benefits of the attention retraining program are manifested, two limitations were noted in this study. Groups A and B performed differently, but their data were combined because sample sizes were considered too small to be analyzed separately. When the data from the two groups were averaged, any treatment effects were lost. A second limitation is that both groups started out near the ceiling on measures of attention. Gains due to the intervention would have been difficult to see.

There has been little empirical research on the effectiveness of a specific instructional strategy for children with TBI. In a single subject design, Direct Instruction was the focus of a study conducted by Glang, Singer, Cooley, and Tish (1992). Three children who had sustained head injuries, ages 6, 8, and 10, manifested significant learning problems. Each of the subjects experienced severe head injuries. Each was in a coma ranging from 3 weeks to several months. All students were at least one year postinjury, well beyond the most rapid period of spontaneous recovery. They participated in a six-week tutoring program and received 12 hours of instruction. The theory of Direct Instruction states that all students can learn if educational instructions are presented logically, unambiguously, and clearly (Glang et al., 1992). Direct Instruction emphasizes the following features:

- All component skills are pretaught.
- Students are taught general case problem-solving strategies. Instruction on new skills is built upon skills previously learned.
- Instructional wording is consistent and clear.
- Immediate feedback is given, as well as immediate practice on difficult items.
- Sufficient practice is given to ensure mastery on each level.
- Cumulative review of all skills ensures integration with previously learned material.

Students were tutored in targeted areas of reading, math, language, and keyboarding. Portions of instructional programs such as Corrective Mathematics (Engelmann, 1982) and Distar Language I (Engelmann, 1976) were used as the instructional foundation. An example of Direct Instruction with reasoning skills was provided by the authors:

1. **Listen to this rule. *All* birds have feathers. Say that.**
   All birds have feathers.
2. **What do *all* birds have?**
   Feathers.
3. **Say the rule again.**
   All birds have feathers.
4. **Listen. Robins are birds. Say that.**
   Robins are birds.
5. **Listen. *All* birds have feathers. Robins are birds. So, robins...**

... have feathers.

As the lessons progress, the teacher support is lessened. After students have mastered the concept of *all*, they proceed to *no* and *some.*

Subjects 1 and 2 experienced substantial academic progress, in one case improving from 7% correct at baseline to 80% correct at post-intervention. Subject 3 was unusual in that instruction focused on positive behavior rather than on academic skills. A Direct Instruction approach was utilized, in that a generalizeable strategy was taught using rapid pacing, a wide variety of examples, immediate corrections, and positive feedback. Decreasing the subject's aggressive behavior was the target goal of the tutoring program. However, academic subjects were the context for teaching the behavioral strategy. It was noted during the baseline assessment that the student became frustrated and aggressive when the task became difficult and he required corrective feedback. He was taught a self-management strategy for handling his frustration. Whenever he made an error, he was to (1) stop, (2) look at the problem, (3) listen to the answer, and (4) try it again. He practiced this during one session only. In order to assess generalization, data were taken during two other types of instructional sessions as well. The use of the self-management system decreased the student's aggressive behavior and generalized to the other learning sessions. Furthermore, the student displayed continued use of the strategy during a follow-up probe 3 months later. This study provides evidence that Direct Instruction can be an effective tool in correcting academic and behavioral problems of students with brain injuries. In addition, there is indication that the effects of this approach were maintained after the intervention ended and that it generalized to other situations. No documentation of generalization of effects to classroom performance was provided, however. This would be an area for further investigation.

Various approaches have been used to remediate attention in children . Environmental modifications, including preferential seating or wearing earplugs, are simple techniques to implement. Cognitive-behavioral methods, such as response cost programs, are outlined in the literature (Mateer, Kerns, and Eso, 1997). Increasing evidence is emerging to support the effectiveness of direct retraining of attention. Sohlberg and Mateer (1986) developed an Attention Process Training program that has been effective with adults. It is based on the theory that attention is divided hierarchically into five domains: focused attention, sustained attention, selective attention, alternating attention, and divided attention.

Attention training for children was the focus of an article by Semrud-Clikeman, Nielsen, Clinton, Sylvester, Parle, and Connor (1999). Although this study used children with attentional deficit disorder, the authors state that attentional training evolved from research on cognitive rehabilitation after head injury, and thus it is reviewed here. The program is based on Luria's (1980) idea that attention training can result in a reorganization of function. Sohlberg and Mateer (1986) developed a program, Attention Process Training (APT), that emphasizes repeating sustained attention tasks until mastery is achieved. The use of these strategies has been successful with brain-injured adults (Niemann, 1989; Sohlberg and Mateer, 1987; Sohlberg, Mateer, and Stuss, 1993) and was hypothesized to work with children with attention deficits.

Thirty-three children who met the criteria for ADHD and twenty-one control children without attention deficits symptoms served as the subjects. The ADHD children were divided into an intervention group and a control group. All participants were in grades 2 through 6. Tests of visual and auditory attention were administered pre- and post-treatment to all three groups. Training was for 60 minutes twice a week for 18 weeks and consisted of both a visual and an auditory attention task. The visual task required the child to find a target among an array of distractors. Tasks increased from simple to complex. The auditory task required the child to count targets that were presented on a cassette tape. For example, a child would be asked to count words beginning with a specific sound.

A 3 (Group) x 2 (Pre- and posttest) ANOVA was run on the visual and auditory tasks. A significant interaction was found between group and measure, with both ADHD groups performing significantly more poorly than the control group on the pretest. Only the ADHD control group performed significantly more poorly on the posttest. Results showed that the ADHD intervention group performed at about the same level as the control group at post-test. Similar findings were obtained for the auditory attention tasks. Only the ADHD intervention group achieved a significant increase in performance from pre- to posttest. For this sample, children with attention and task persistence deficits improved performance on visual and auditory attention tasks following training in sustained attention and problem-solving skills.

The Attention Process Training (APT) program was examined by Thomson (1994) with 6 children who had sustained traumatic brain injury. The subjects, aged 14-17, had suffered either moderate or severe head trauma at least 12 months before the study. They received treatment for approximately 6 weeks within their school setting. Utilizing a single case study design, increased performance was seen on several psychometric measures of attention, including: The Children's Paced Auditory Serial Addition Test (Johnson, Roethig-Johnston, and Middleton, 1988), the Trail Making Test-Part B, and the Arithmetic subtest of the WISC-R, as well as tasks of academic efficiency (timed mathematics worksheets). Most of the gains were made in the first three weeks of training, with improvements leveling off after that time. Improvements were not seen however, in classroom attentive behavior, as measured by the Attention Deficit Disorders Evaluation Scale-School Version (McCarney, 1989).

The author noted some problems with APT for children. Most of the training before this study had been conducted with adults, where it had been assumed that they possess the necessary cognitive abilities to perform the required tasks. Many of the tasks are contingent on manipulation of overlearned abilities, such as number sequencing, simple mathematical operations, alphabetizing, and ordering operations. With young children, many of these skills have not yet been learned or are not well established. Researchers in this area have noted the efficacy of the training and have begun to modify the tasks to make them more applicable for children. Although more data are needed, the literature suggests that direct attention training can improve children's attentional behavior on some academic tasks.

A single subject experiment with a male adolescent explored the effectiveness of training caregivers to implement interventions to those with brain injuries. Sohlberg, Glang, and Todis (1997) found that having caregivers measure performance functioned as a type of intervention. A current trend in cognitive rehabilitation is collaborative research that includes subjects and support persons in designing the goals, and the independent and dependent variables. Furthermore, research in special education has shown positive effects from assessing student performance without modifying instruction (Fuchs & Deno, 1994). The authors' purpose in this study was to encourage the caregiver in the brain-injured client's environment to implement cognitive supports that had been collaboratively identified with little direction from professionals. Although this study examined three different individuals, only one fit the criteria of this paper, which are children and adolescents with head injuries. In the three cases described, the desired outcomes were achieved before other interventions were begun.

A 16-year-old high school sophomore had sustained a brain injury at the age of 13. He evidenced significant deficits in memory, attention, and concentration. He received very poor grades his first year of high school and had to repeat the year. His parents referred him to the study because of school difficulties and related self-esteem issues. The client, his parents, the special education teacher, and the researchers chose the goal of the intervention as well as the methods to measure it. Completion of homework assignments was the target behavior. The team decided that data would be collected in three different classes: design, math and English.

Homework completion was broken down into the following steps which yielded a compilation score: (1) record the assignment, (2) locate correct assignment at home, (3) initiate work, (4) persist in completing the homework, (5) put assignment away, and (6) turn in assignment. A percentage of homework behaviors performed was recorded daily, with parents, teachers, and a research assistant providing the data. Homework performance was tracked for a two-week baseline period. During this period of time, homework performance behavior was from 80-100%. This suggests that the subject did not have problems completing homework. When the youth and his special education teacher were interviewed they agreed that the teachers' behavior had changed. Teachers assigned the work differently in that they were more careful to explain it to him, and they now checked with him to make sure he understood the assignment. It appears from this case study that the act of measuring performance changed the behaviors of the support person. Perhaps the act of data collection could be a first-line procedure in interventions with brain-injured children.

In summary, there is evidence that cognitive and attention retraining may provide some benefit for children who have sustained a head injury. Additional gains, such as the improvement in adaptive behavior, may be seen as well. The use of self-management strategies may be particularly appealing to this population, who frequently are unaware of the extent of their deficits. However, most of the studies used small sample sizes and looked at effects over short periods of time, both of which fail to yield generalization and maintenance information. Future research could focus on replication with better experimental designs, such as increased numbers of subjects and the use of control groups.

Social-Behavioral Interventions

Some of the most long-lasting effects of brain injury, including mild injury, are the loss of friends and social alienation (Glang, Todis, Cooley, Wells, and Voss, 1997). This alienation may result from physical disabilities that limit patients' social activities, as well as the development of maladaptive behaviors, such as disinhibition and poor anger control, that alienate or confuse their peers. This isolation can also lead to difficulties with depression and anxiety (Clark et al., 1999). A study by Glang et al. (1997) evaluated the effects of a school-based intervention intended to increase the social networks of students with traumatic brain injury. The Building Friendships process (Sowers, Glang, Voss, and Cooley, 1996) uses a collaborative, student-centered approach. The student, his or her family, school staff, and existing friends combine to identify goals and strategies that will increase the student's social opportunities.

In this case study, three boys, ages 8, 11, and 13, paired with special educators who acted as their Friendship Facilitators, providing instructional assistance. There are four phases of the Building Friendships Process:

Phase 1. Gather information through interviews. Identify opportunities to increase social contacts.
Phase 2. Recruit family members, school staff, and peers to be team members.
Phase 3. Conduct an initial team meeting to develop goals and strategies with which to meet those goals.
Phase 4. Hold regular review meetings every 2-3 weeks to review progress.

A multiple baseline, across subjects design was used to evaluate the efficacy of the program. There were two experimental conditions: baseline and post-intervention. Intervention was different for each subject. The team, including the student, planned individualized activities. One team organized a weekly lunch meeting and activity with a large group of peers. Another initiated a friendship group that hosted lunch meetings and a school dance. The final team designed problem-solving activities to help the subject's close friend better understand his disability, as well as involving both boys in community activities. Outcome measures were frequency of students' social contacts with nondisabled peers, parent and educator social validation ratings, and participant observation.

The results show that the number of weekly social contacts increased from a mean of 2.14 during baseline to 9.9 after the intervention. The students spent more time playing with peers at recess, eating lunch with companions, and attending a school dance with a friend. Both facilitators' and parents' satisfaction with the students' social inclusion increased pre- to post-treatment. Qualitative data were obtained from the observations. Facilitators and parents reported improved behavior as well as improved social skills. Students were noted to be happier, more cooperative, and able to engage in longer interactions with peers. For one subject, improvement in homework completion was noted. Only one measure did not increase: facilitators rated their students' satisfaction with their social inclusion as decreasing over the course of the project. A possible explanation for this finding could be that before the intervention, students were unaware of the degree to which they lacked social interactions. The intervention drew their attention to this deficiency and the focus on what was missing in their lives contributed to the decrease in satisfaction. Anecdotal follow-up data indicated that the increased social contacts were not maintained once the facilitators' involvement ended and the student advanced to the next grade. This raises questions as to the level of follow-up support that is needed for such interventions and if it is possible to gradually diminish team support and leave the process self-sustaining. Equally questionable is whether these were "real" initial effects or forced outcomes. More research in this area is needed to answer these questions.

Adolescents with head injuries often feel isolated from their peer group because time away from peers interferes with the development of social skills, intimacy, and relationships. The area of communication competency and pragmatics (the ability to perceive and respond to contextual clues within a conversation) is frequently impacted. Wiseman-Hakes, Steward, Wasserman, and Schuller (1998) evaluated a method of peer group training to six head-injured students with cognitive communication disorders. The study focused on the social context of communication and on pragmatic skills, such as eye contact, appropriate initiation and closure of conversations, the ability to maintain and change the topic of a conversation, as well as the ability to organize and adequately express one's thoughts.

Six adolescents with TBI, ages 14-17, participated in the study. All of the participants suffered a severe brain injury with initial GCS scores of between 3-5. Time postinjury varied from 3 months to 9 years. Subjects met the following inclusion criteria:

- Cognitive recovery level of VII or higher on the Rancho Levels of Cognitive Functioning
- Ability to respond to verbal commands
- Ability to attend for at least a 1-hour period of time

Communication ability was measured by the Rehabilitation Institute of Chicago Rating Scale of Pragmatic Communication Skills (RICE-RSPCS), the Communication Performance Scale, and the Vineland Adaptive Behavior Scales. Intervention was provided through the program, "Improving Pragmatic Skills in Persons with Head Injury", a program designed for individual therapy but modified for a group setting. The modifications included teaching peers to give positive feedback to each other, rating their own and other's communication, observing both positive and negative pragmatic examples and role-playing them, using a tracking sheet to identify and quantify behaviors, and cuing one another to promote self-monitoring. Training lasted for six weeks, 4 days a week, for an hour each day.

Statistically significant changes were noted in the pre- and post-administrations of the RICE-RCPCS subscales, with mean scores improving 44%. A six-month follow-up administration of all 3 measures indicated subjects were performing within 5% of their post-treatment achievement. Functional information was obtained from the Vineland interviews. One mother reported that her son now made relevant comments in a conversation, was able to initiate interaction, and that for the first time he was accepted by his peers. The authors noted that the subjects' awareness of pragmatics increased to the point that the teens were able to joke with the staff and each other about their conversational behaviors. There was a decrease in egocentric speech and a carryover into unstructured environments. Thus, there is some evidence that this may be an effective intervention for teaching communication skills to brain-injured students. Further evidence is needed to explore if an increase in communication skills translates to an increase in social skills and social status.

Behavioral deficits frequently observed following a TBI include disorganized and impulsive behavior, shallow moral thinking, impaired social judgement, and aggressive behavior (Feeney and Ylvisaker, 1995). Oppositional and aggressive behaviors tend to be the most problematic for educators and vocational trainers to deal with. A behavioral study by Feeney and Ylvisaker (1995) explored an antecedent intervention to reduce aggressive behavior in three adolescent males with severe brain injury. Their behavior had deteriorated during the three to five year period of time following their injuries. All three exhibited physical aggression usually associated with increasing academic demands. The intervention was based on four hypotheses:

1. The students needed concrete advance organizers to compensate for cognitive impairments.
2. The behavioral approach needed antecedent control to compensate for limited self-regulation.
3. The subjects needed to be involved in the decision making because of their oppositional behavior.
4. They needed a high level of success to counteract their history of failure.

Behavior was measured by frequency of challenging behaviors, the Aberrant Behavior Checklist, and percentage of assigned work completed. An A-B-C-A changing treatment design was utilized. The A condition was the baseline period and included observations of the students' performance under normal conditions. Condition B lasted 2 to 3 weeks and involved tasks of the same difficulty. Changes were added to the students' daily schedule. (1)The student and staff would decide on a minimal amount of work to accomplish and the sequencing of the student's routine. (2) The subjects were given photograph cues that showed the subject performing that task (e.g. student sitting at his desk with his math books). (3) A rehearsal and review of every element of the routine was practiced verbally with the student ("What do you need to do next?" "How did it go?"). The C condition was very similar to the B phase except that written cues were substituted for the photograph cues. A return to baseline (A) followed this. After completion of the study, the adolescents returned to the C condition and were observed occasionally by the authors.

Frequency of aggressive behaviors decreased for all 3 adolescents. Subject 1 went from 5-8 episodes a day at baseline to near zero during the B and C phases. The behavioral episodes increased to five or more when the baseline conditions were returned. Subject 2's behaviors decreased from 27-33 at baseline to near zero. At baseline, Subject 3 evidenced 18-23 aggressive behaviors a day. Following treatment, this dropped to 1-2 per day. The intensity of the aggressive episodes decreased during phases B and C for all subjects, but rose to baseline levels with removal of the intervention. Likewise, the percentage of work completed increased during the intervention phases and dropped during the return to baseline. In some cases this was a dramatic improvement.

These results suggest that the intervention was successful in reducing both the frequency and intensity of aggressive behaviors in brain-injured youth. Initial reduction in the level of support (moving from B condition to C condition) resulted in a slight increase in behaviors but quickly returned to acceptable levels. When the intervention was removed, the aggressive behaviors returned to baseline levels indicating a need for some degree of cognitive and behavioral support for an as yet unknown extended time period. Even though the sample size was too small to allow results to generalize to the larger population, the data are promising. The anecdotal follow-up reports indicated all three individuals graduated from high school and are either working independently or with some assistance. Employers reported that they are happy with the young men's work.

The last study in this area examined operant conditioning for behavior management during posttraumatic amnesia (Slifer, Tucker, Gerson, Cataldo, Sevir, Suter, and Kane, 1996). Research in the area of assessment and treatment of behavioral sequelae following brain injury is just beginning. The effects of behavior management strategies on orientation and memory during early posttraumatic injury have not been investigated. Posttraumatic amnesia (PTA) refers to the period of recovery during which motor and speech functions return before orientation, memory, judgment, and self-regulation. The disorientation during this period of time frequently results in anxiousness, agitation, noncompliance, and combative behavior. It has been assumed that children cannot learn during this period of time, which influences decisions about when to begin certain types of therapy. During PTA children may be less responsive to verbally mediated methods of learning and may benefit more from direct behavioral training involving repetition, concrete prompts, and environmentally mediated reinforcement contingencies.

Six children, between the ages of 8 and 16 years, in a neurorehabilitation unit had all experienced a recent, severe brain injury, had at least one behavior problem that interfered with their participation in therapy, and were experiencing significant posttraumatic amnesia. There were a variety of problem behaviors including inattention, aggression towards others and the environment, elopement (physically leaving the treatment area without permission), crying, and noncompliance with medical procedures. The outcome measure was a frequency count of problem behavior. The level of amnesia was periodically examined using either the Children's Orientation and Amnesia Test (COAT) or the Galveston Orientation and Amnesia

Test (GOAT). A multiple baseline design was used. No behavioral modifications were made during the baseline phase. A differential reinforcement of appropriate behavior (DRA) was applied during the treatment phase. The contingencies for earning rewards were reviewed with the child at the beginning of the session and whenever target behavior occurred. Cooperative and socially acceptable behavior was rewarded immediately with verbal praise and contingent access to a preferred activity or tangible reward at the 15-minute midpoint and at the end of the 30-minute session. Inappropriate or disruptive behavior resulted in planned ignoring or in the form of withholding all social interaction. Aggression or noncompliance after one warning resulted in a response cost by the loss of the next scheduled activity or reward.

The DRA procedure resulted in a decrease of target behavior in every case, with a baseline average of 44% and a post-treatment average across the six subjects of 10%. This suggests that operant conditioning can be effective in reducing problem behaviors during early stages of recovery from brain trauma. The purpose of this study was to understand more about what forms of learning are most likely to occur at different stages of recovery. It also focused on reducing problem behaviors that interfered with interventions. Operant techniques may be useful for teaching the acquisition of functional skills and not only for curbing behavioral excesses.

To summarize, there is data to support the use of specific interventions to help increase positive behaviors in youth with brain injuries. Some important components are to involve the students in planning their interventions, realizing that continuing support may be necessary, and that antecedent interventions may bring more positive results than consequential interventions. Future research may want to focus on the maintenance of results over longer periods of time.

Impact of the Family

A relationship between higher family functioning and better outcomes for children with brain injuries has been demonstrated in the literature (Taylor, Drotar, and Wade, 1994; Rutter, 1981). The cognitive and behavior changes in the child disrupt family life and adversely affect the family's pattern of interactions. This poorer family adaptation may negatively impact the child's subsequent psychological adjustment despite cognitive recovery (Wade, Drotar, Taylor, and Stancin, 1995). Rutter (1981) found that negative family circumstances increased the likelihood of psychiatric problems in children with brain injury. Thus, support services to the family may be an important intervention for the child.

Wade, Taylor, Drotar, and Stancin (1996) examined the impact of TBI on families during the first month following injury. They gathered information from 44 families of children with severe TBI, 52 families of children with moderate TBI, and 69 families of children with orthopedic injuries who served as a control group. Parents were interviewed regarding the perceived burden of the injury and asked to complete questionnaires regarding their children's premorbid functioning as well as the family's preinjury functioning. The children's teachers were also asked to rate preinjury behavior and school performance. Impact of injury and family coping were assessed by a variety of measures including, the Family Burden of Injury Interview; the Impact on Family Scale, Version G; the Brief Symptom Inventory; and the COPE (Carver, Scheier, & Weintraub, 1989). The COPE is a 52-item, self-report inventory measuring coping behavior.

Results indicate that the families of children with severe TBI experienced significantly more overall stress than the families of the other two groups. The highest endorsed areas of stress were for the injured child's recovery and adjustment, and the reactions of family and friends to the injury. Furthermore, they found that families of severely injured children were more likely to express a need for help in the form of concrete services such as childcare, housekeeping, and financial assistance. However, only 15% of families whose child had sustained severe TBI desired counseling or emotional support. The rate for families of moderately injured children and orthopedic injured children was less, only 6%. This seems to indicate that among parents experiencing high levels of stress, few will seek counseling services. Consequently, professionals working with families of injured youth cannot merely ask what type of help is needed but should provide anticipatory guidance regarding the stress within the family. It was also found that families who were already living stressful lives perceived the burden arising from the injury as more severe than higher functioning premorbid families, pointing out that at-risk families are particularly vulnerable and deserve close attention. Since this study occurred 1 month following injury, family priorities may change as families are faced with long-term care and rehabilitation. A longitudinal study would more effectively examine a family's later priorities and need for support.

The question of the effect of support to families of children with TBI has not been studied enough to yield strong conclusions. No randomized controlled trials have been conducted that examine the effect of support versus no support; however, one study compared two forms of support with each other. There is some evidence that shows a relationship between higher family functioning and better outcomes for the child and that emotional support may be particularly helpful for families at greater risk for depression (e.g.

single parent, severity of injury). This suggests that family support may act as one intervention for children with brain injuries.

Since many parents of children with traumatic brain injury suffer emotional distress, a need for parent counseling has been observed. It would be helpful to understand what kind of support is more likely to be of benefit for parents. An exploratory study by Singer, Glang, Nixon, Cooley, Kerns, Williams, and Powers (1994) compared two kinds of support groups for parents of children with brain trauma. One group received instruction in psychoeducational stress management that emphasized coping skills, while the other group was an informational support group. Fifteen parents of nine children with brain injury participated in the study. Parents were randomly assigned to either the information group or the stress management group. Both interventions consisted of nine 2-hour meetings held weekly. The Beck Depression Inventory (BDI) and the State Scale of the State-Trait Anxiety Inventory (STAI) were used as the outcome measures. The stress management class combined psychoeducational instruction of coping skills with parent-to-parent self-help and social support. The program included regular relaxation training, homework assignments, practice exercises, and follow-up discussions of the use of the skills. The information group focused on helping the parents understand the issues surrounding TBI and provided an emotional support group for them. The main difference between the groups was that the information group emphasized the parents' understanding of the children's needs, while the other focused on the needs of the parents.

Using a two-group, pretest-posttest comparison, it was found that the stress management group experienced statistically significant pre- to post-test reductions in depressive symptoms and anxiety when compared to the information-only group. In fact, the information group mean scores rose slightly on both the Beck Depression Inventory and the State Scale of the STAI.

The parents in this study had an initial group mean score of 10.2 on the BDI , indicating a mild level of depression. Studies suggest that parents suffering from depressive symptoms have been found to have less successful parent-child interactions (Singer et al., 1994). Mothers suffering depression when compared to mothers without symptoms have been found to interact less with their children, are less positive, use more explosive discipline, and are less contingently responsive (Downey & Coyne, 1990). Children with head injuries require a consistent and structured environment. Because parents of children with TBI are at risk for depression, they may be less able to provide the necessary structure and consistent environment. It is clear that the provision of efficacious interventions to parents is important to increase outcome successes in the children. The stress management program outlined in this study may be an effective means of providing parents with help for depressive symptoms and state anxiety.

In summary, these studies give some indication that providing counseling and support services to parents may increase child outcomes. Those families with high premorbid stress levels, less coping resources, single-parents, and children sustaining severe levels of injury are most in need of support services and may be less likely to ask for help. Support that focuses on the parents' needs may be more beneficial than interventions that target the child's needs. Again, future research should focus on long-term effects.

Summary and Recommendations

In conclusion, many of the research studies of interventions for children with brain injuries seem promising. Although most of them used small sample sizes that may or may not generalize to larger populations, many of their techniques suggested that they were effective in remediating cognitive and behavioral problems. However, treatment effects were not examined over time; many studies lacked the use of a control group; and some interventions were conducted with youth 3 months to several years post-injury, thus confounding treatment effect with spontaneous recovery of skills. In addition, several interventions required the use of computer programs or commercial programs that are not readily available to average school personnel. What is needed are proven interventions that are easily accessible to educators. During the literature search, several ideas were suggested that may be effective but have not been examined in an experimental design. Some of those will be mentioned now.

Glang, Singer, and Todis (1997) recommend the use of a full-time instructional aide. The aide may read assignments aloud to the student, take notes on lectures, provide prompts during class, help the student organize his or her thoughts, write out answers dictated by the student, manage materials, and type or edit final drafts of a student's papers. The eventual goal would be to help the TBI student become independent and gradually diminish the assistance. Other accommodations would be to give shorter assignments, longer preparation time, simplified materials, graphic organizers, shorter work periods, preferred seating, textbook organizers, study guides, and a peer tutor.

Bigler, Clark, and Farmer (1997) recommend modifying the classroom, which may include changing seating, selective amplification, the use of study carrels or study rooms, or allowing a student to wear earphones. Changes in teaching methods, such as keeping presentation of material short and concise, providing repetitions, and frequent breaks may also be appropriate. Additional tips are to make sure the child is focusing on the teacher, allow the child to work in small groups, cue the child to pay attention, and provide frequent, distributed skills practice. The use of visual or verbal mnemonic strategies may remediate memory deficits, as well as using memory notebook training and electronic organizers. The authors endorse the use of two specialized instructional strategies: errorless learning and direct instruction.

When confronted with behavioral problems Kehle, Clark, and Jenson (1996) have several suggestions that have been empirically supported with other populations, although not with students who have sustained a TBI. They suggest antecedent classroom-based strategies such as publicly posted rules, flexible scheduling, seating students near teachers, and teacher movement around the room. They provide consequential classroom-based interventions as well. Reprimands should be used sparingly and presented correctly. Correct presentation involves providing time for the student to comply, discusses the distance away from the student when issuing the command, and the tone of voice. Teachers can increase compliance by requesting something from a compliant student seated near the target child before asking the behavioral-problem student for compliance. Behavior momentum increases compliance rates as well. This technique builds a momentum of compliance by having the student respond to positive and preferred requests immediately prior to an aversive request. Other suggestions are the use of precision requests and the "Sure I Will" program. Precision requests involve using the key word, "need," as well as following the request with a reinforcer if it is followed and a pre-planned negative consequence if it is not. The student is also taught to answer a teacher request with, "Sure I will," and is reinforced for compliance. The effective use of praise, as well as providing modeling and self-modeling experiences often cause positive changes in behavior. Reductive procedures, such as time-out, withdrawal of student's work materials, and response cost have been effective. Over-correction is the last behavioral strategy that is mentioned. This is the enforced practice of behaviors that are incompatible with the inappropriate behavior. Interventions like these are familiar to educators and easy to implement. Future research should focus on these readily available techniques when investigating effective interventions for brain-injured students.

After reviewing the literature, several recommendations become evident that could be incorporated into school-based interventions for children with TBI:

1. A multi-dimensional approach, emphasizing individualization is necessary to address cognitive deficits, social-emotional/behavioral issues, and family issues.
2. Implement the program early in the course of recovery before maladaptive behaviors become entrenched.
3. Frontal lobe injury is often associated with delayed consequences. Injury when a child is young may not manifest problems until that area of development is expected to mature. Monitoring and support may be necessary for years following the injury. This is also good practice to ensure maintenance of appropriate behavior.
4. Intervention will be most effective when it is delivered in the natural setting and incorporates materials relevant to everyday routines.
5. Antecedent interventions may be more effective than consequential management plans.
6. Intense retraining has been shown to improve students' problem-solving ability, attention, social skills, and appropriate behavior.
7. Involve peers to address social issues.
8. Include the student in intervention planning.

9. Providing emotional support to parents may increase the student's outcome.
10. It is advantageous to designate someone as a TBI reentry specialist. They will give direct service to the schools, as well as mediating between the hospital, school, and family. School psychologists are in an excellent position to provide this service.

To implement such a program in the schools, a reentry specialist would be assigned by the school administrator. Soon after the occurrence of the injury, the specialist would contact the parents and hospital staff to obtain information regarding the child's status and disseminate the information to the school. Prior to the student's discharge, an IEP team, including the parents, would convene to discuss needed accommodations and develop a tentative plan. After arrival at school, the team will reassess the child's needs and make further modifications when needed. Assessment information will suggest appropriate interventions. Educational planning will need to be reviewed frequently (perhaps monthly) and adjustments made often. Finally, communication between parents and teachers must be on-going.

Even the most flexible of educational programs will not ensure a smooth return to school life. For this reason, school professionals should be aware of the complex nature of head injury and have some knowledge of how to help students overcome these challenges. They must prepare for the ongoing education of students who have sustained brain trauma. Because children will have substantial changes in functioning that may be difficult to measure, a coordinated team approach, including various school personnel and family members, will be required. Treatment strategies should address the specific needs of each child, as well as considering premorbid factors, injury severity, time since injury, ongoing medical issues (such as seizures), and family resources. Frequent evaluations will ensure relevant and realistic goals to meet the student's changing needs over time.

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Appendix
Assessment Measures

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