THESIS

FACTOR ANALYSIS OF THE BRAIN CHECK SURVEY

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ABSTRACT

FACTOR ANALYSIS OF THE BRAIN CHECK SURVEY

Children who have a traumatic brain injury (TBI) are under-identified and lack appropriate educational supports to help them achieve their academic goals. Because TBI can greatly impact a child's ability to succeed at school, there is a need for a convenient and effective way to screen for TBI in students who are struggling in school so they can obtain appropriate school-based services. The purpose of this study was to work toward establishing construct validity for the Brain Check Survey (BCS), which is a parent-report questionnaire intended to help school personnel screen for possible TBI in students. The BCS can act as a starting point in the process of qualifying students for Special Education, a 504 Plan, or Response to Intervention assistance. In five different school districts in Colorado, parents completed the BCS for their child who was recruited from one of three groups: has identified TBI, is currently receiving special education services for diagnosed specific learning disabilities, or is considered typically developing. Construct validity was tested using multiple factor analyses: 1) all participants combined (typically developing, traumatic brain injury, and specific learning disability), 2) elementary, middle, and high school level categories of all participants, and 3) all ages from the typically developing group only. These factor analyses confirmed the two-factor construct of the BCS that measures student *Symptoms* and *Behaviors*. The analysis also gave insight into two distinct aspects of behaviors that the instrument is measuring: *Cognitive Processing* and *Behavior Control*. The positive findings from this factor analysis study suggest that the BCS has strong construct validity and can be effective in screening students for possible TBI.

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Literature Review

Traumatic brain injury (TBI) is a widespread problem in the United States. The Centers for Disease Control and Prevention have estimated that 1.7 million people experience a traumatic brain injury every year. Children ages 0 to 4 and 15 to 19 have some of the highest risks of sustaining a TBI with almost 500,000 emergency department visits for TBI made annually for children 0-14. It is estimated that around 5.3 million men, women, and children in the United States today are living with permanent disability that is related to TBI (Centers for Disease Control and Prevention, 2013). For children who experience a TBI, life after the injury can be very different. There are many symptoms that children experience that can affect their daily lives, such as headache, fatigue, dizziness, blackouts, lack of concentration, vision problems, problems with attention and memory, low frustration tolerance, and emergence of new learning and/or behavioral problems (Hooper et al., 2004; Petersen, Scherwath, Fink, & Koch, 2008). Depending on the severity of the injury, these symptoms may be temporary or they may remain for the rest of the child's life.

As children return to school after a TBI, they may experience symptoms that continue to affect their performance in school. Preschool children who experience a mild to moderate TBI are likely to have long-term adverse effects that influence their development and may lead to increased symptoms of attention deficit/hyperactivity disorder and oppositional defiant/conduct disorder (McKinlay, Grace, Horwood, Fergusson, & MacFarlane, 2009). In a study that asked teachers to report on academic performance and educational needs of school-age children with TBI, 79% of the children with severe TBI and 50% with mild to moderate TBI were described as having trouble with schoolwork. Also, 40% of those students with TBI were performing below the average level for the class (Hawley, 2004). Other problems for children who have severe TBI

may include physical impairments, lowered cognition, behavior issues, difficulty socializing appropriately, and lowered adaptive functioning, as well as new behavior impairments that were not present before the injury (Gfroerer, Wade, & Wu, 2008; Chapman et al., 2010). One study found that about 10% of participants with TBI were reported to be experiencing a new learning and/or behavioral problem after returning to school following the injury, even at a 10-month follow-up (Hooper et al., 2004).

Students with TBI may at first appear to be doing fine in school but then experience more problems later in the recovery process (Hooper et al., 2004). This is especially the case when the injury occurs very early in the child's life. A combination of lowered IQ and impaired learning efficiency may interfere with the normal development of the child's academic skills (Ewing-Cobbs et al., 2006). Children with severe TBI frequently have impaired executive functioning, which becomes increasingly problematic as children become older and face demands for higher cognitive functioning (Chapman et al., 2010). For example, school age children are expected to monitor their behavior and emotional response more than preschool children. In a case study of a student with moderate TBI, the student dealt with an increased number of lessons and a larger variety of teachers in his second year of the study compared to the first year. This resulted in deteriorated behavior, more difficulty dividing attention, and lower ability to start a task compared to the previous year (Hawley, 2005).

A lack of transition services between hospital(s), home, and school results in children with TBI returning to school without proper assessment, modifications, and staff education. Communication between many hospitals and/or rehabilitation centers and the schools is lacking (Glang et al., 2008; Hooper et al., 2004). Teachers may not even be aware that the child has a TBI and therefore will not associate behavioral problems and poor performance with the injury.

This can lead to an undue amount of discipline or inappropriate treatment of the child due to the school's ignorance regarding the TBI and how long-lasting negative outcomes are directly caused by the injury (Hawley, 2004). Increasing teachers' awareness and understanding of TBI and facilitating coordination between medical personnel and teachers can help to provide the necessary support and adapted education to students with TBI.

In order to bridge the gap between hospitals and schools and to deal with the struggles that students with TBI often experience, there has been a long-term need for screening tools that can be used in schools to help screen for and/or identify children who have experienced a traumatic brain injury and are struggling to succeed. The recognition of TBI through the use of effective identification tools allows educational teams to facilitate this unique group of students in getting the services they need (Glang et al., 2008; Petersen et al., 2008; Schutz, Rivers, McNamara, Schutz, & Lobato, 2010). Screening for TBI is an important initiative because the injury is often overlooked or misdiagnosed, and screening is the first step in coordinating appropriate resources and services (U.S. Department of Health and Human Services, 2006). A systematic approach to screening children in schools for lowered levels of executive functioning and other cognitive problems can help educators recognize the TBI-related learning problems affecting the child, and allow the child and family to access appropriate educational and health services (Sesma, Slomine, Ding, McCarthy, & Children's Health After Trauma Study Group, 2008).

Many students with TBI need to receive proper, focused services that suit their unique needs in order for them to be successful in school. Unfortunately, students with TBI may actually be misdiagnosed or "labeled" as having a learning disability or other disorder that results in an Individualized Educational Program (IEP) that may lead to the development and delivery of

inappropriate school-based supports for the child. In fact, after reviewing public information and epidemiological studies, Schutz et. al. (2010) found that when considering prevalence rates of TBI and the number of students classified under the TBI special education label, 98%-99% of students with TBI are either misclassified and receiving possibly inappropriate services or unclassified and receiving no services. This means that many struggling students with TBI may be failing to meet their educational goals because they are not being supported appropriately. Traditional special education services that address specific deficit areas in school subjects like math and reading are not appropriate for students with TBI who have underlying cognitive impairments that need to be addressed as a whole (Hibbard, Gordon, Martin, Raskin, & Brown, 2001; Ylvisaker, Hartwick, & Stevens, 1991). However, when given specialized services, students who are properly identified as having a TBI can receive appropriate school-based interventions to help them learn to respond to their school environment with self-control, increase their pro-social behavior, and work on cognitive strategies to self-monitor behavior (Dykeman, 2003). Since students who sustained fairly severe brain injuries early in life may have limited recovery in cognitive abilities over time (Ewing-Cobbs et al., 2006), they need special education and related services that can help schools work with them and their families in order to make accommodation plans for their new learning issues. Environmental factors at school can significantly influence the behaviors of students with TBI (Hawley, 2005); therefore, services focused on modifying or accommodating the environment can optimize the student's appropriate behavior.

There are few tools available that are intended to screen for TBI in children and adolescents, particularly related to the school-centered portions of their lives. Researchers at the Research and Training Center on Community Integration of Individuals with Traumatic Brain

Injury at Mount Sinai School of Medicine developed the Brain Injury Screening Questionnaire (BISQ) in 1997. This tool was created for the screening of adult or child populations for possible TBI. The BISQ includes questions about events that may have resulted in brain injury, functional difficulties and symptoms of brain injury, and events or conditions that may have resulted in symptoms similar to brain injury (Cantor et al., 2004). Though the BISQ is a thorough instrument, it requires specialized training of education personnel, must be purchased, and the completed forms must be sent to Mount Sinai School of Medicine for scoring. This process makes it difficult, inconvenient, and possibly expensive for school personnel to use. The Columbus Public Schools Brain Injury Screen (U.S. Department of Health and Human Services, 2006) is another available tool, but to the author's knowledge no research specifically confirms its reliability and validity. Additionally, there is the Brain Injury Alert, which screens for cognitive, emotional, and social problems after pediatric TBI (Rasquin et al., 2011). The Brain Injury Alert is intended for use by professionals to provide a qualitative picture of the problems that a child is experiencing after a known TBI. To this point it has shown reasonable internal consistency ($\alpha = 0.68$ for parents and 0.82 for teachers), inter-rater reliability ($r > 0.66$), and test-retest reliability ($r > 0.46$). The article describing the development and validity of the tool explicitly does not define the sensitivity and specificity of the tool, but the authors predict that it would be sensitive for problems reported after pediatric TBI, and possibly may possess low specificity to identify a child with a TBI versus another similar condition. Therefore, it would not be a good tool to use to differentiate students who are struggling in school due to a TBI versus students who are struggling due to some other cause.

None of these tools is a perfect match for screening students for possible TBI in the schools to facilitate the process of receiving appropriate services. Researchers in the

Occupational Therapy Department at Colorado State University developed the Brain Check Survey to help school personnel screen for possible traumatic brain injury in students who are struggling in school. The tool is a parent-report questionnaire intended for use by schools as a starting point in the process of qualifying students for Special Education, a 504 Plan, or Response to Intervention assistance. This current study examines one aspect of the construct validity of the Brain Check Survey screening tool.

Methods

Participants

Parent participants for this study of the BCS were recruited from five Colorado school districts that included a variety of urban sizes (i.e. – rural, urban, suburban). Three groups of children were targeted: (1) children with identified traumatic brain injury (TBI group); (2) children currently receiving special education services for diagnosed specific learning disabilities (SLD group); and (3) children who are considered typically developing and not identified as having an IEP or 504 Plan (TYP group). The number of students selected for the project was based on the size of the district so that there would be a proportionately larger number of participants recruited from the larger districts and a proportionately smaller number of potential participants recruited from the smaller districts. Stratified-random sampling was used for the typical group from each district to recruit equal numbers of males and females, as well as an equal number of students from each school level (elementary, middle, and high). Whole group convenience sampling was used for the participants with TBI, due to the low incidence of students in schools who have been diagnosed with TBI. The SLD group was recruited using the same stratified random sampling strategy used to recruit the TYP group of students, only adjusting the sample size to match that of the whole group of students with TBI. Once the student names were selected from each school district, the parent(s)/guardian(s) of those students became the actual sampling frame, since the BCS is a parent-report questionnaire. All participant contact in the actual recruitment process was made by mail with the parents/guardians only; no students were contacted for the duration of the study.

Instrument

The Brain Check Survey is a parent-report screening tool that assesses students' history of any injuries or illnesses related to brain injury, behaviors that the child is currently showing that may affect learning, and symptoms that the child currently displays. Table 1 summarizes the items contained in the behaviors section and symptoms section of the questionnaire, and the entire Brain Check Survey can be viewed in the Appendix. The BCS also requests information on demographics, educational services the child is currently receiving, and difficulties and strengths the child has in school. An earlier version of the instrument was found to have high content validity through the work of an expert panel (Dettmer, Daunhauer, Detmar-Hanna, & Sample, 2007). The instrument has since been thoroughly revised and the researchers obtained a research grant in 2009 to conduct a larger study of the reliability and validity of the BCS. Psychometric property analysis of the BCS using this most recent data set has shown that it has good specificity in differentiating between the TYP group, TBI group, and SLD group. The total behavior and symptoms scores for each of these groups have shown to be significantly different from each other except for the symptoms score between SLD and TYP (Sample, Daunhauer, & Dettmer, 2011). The data collected from the larger study of reliability and validity of the BCS research project was used for this factor analysis study, as we sought to further establish the construct validity of the Brain Check Survey.

Table 1. Symptom and behavior items of the Brain Check Survey.

Behaviors that can affect learning	Symptoms
- Focusing and maintaining attention - Getting started on activities, tasks, chores, homework and the like on his or her own - Being understood (speech is easy to understand, speaks clearly)* - Understanding others* - Coping with change or transition - Maintaining family and friend relationships - Letting go of one activity to attend to another - Reaction to simple problems - Monitoring own progress on homework, assignment, chores, and the like - Solving everyday problems - Waiting for his or her turn in a game - Learns from past mistakes or behavior - Thinks before speaking or acting - Listens without interrupting others often - Handles a change in plans - Demonstrates good judgment - Learns new things easily - Remembers lists - Remembers day-to-day events	- Headaches and/or migraines - Loss of muscle coordination - Blackouts/fainting - Confusion - Blank staring/day dreaming - Dizziness - Change in vision - Fatigue - Seizures - Slurred speech - Has trouble finding the "right" word when talking - Noise sensitivity - Light sensitivity - Sleepiness - Mood swings* * item removed from tool based on factor analysis
For each item above, circle a number or check N/A No problem 1 2 3 4 5 6 Extreme Problem	

Procedures

The Brain Check Survey reliability and validity testing study, from which the data for this research project were collected, was funded by the Colorado Traumatic Brain Injury Trust Fund and approved by Colorado State University's Institutional Review Board. The ethics committees of the five school districts that participated in the study also gave approval.

After being selected using the sampling strategies described above, parent participants received the Brain Check Survey study packets through the mail. Two weeks after the original packet with the survey was mailed, participants were sent a reminder packet containing the same items. The district-appointed "TBI specialist" in each of the five school districts contacted the selected parents of students with known TBI to encourage them to participate in the study by completing and returning the BCS questionnaire in the enclosed envelopes. A total of 546 participants returned the survey (51 for TBI group, 34 for SLD, and 461 for the TYP group). The overall return rate was 28.79% (43.86% for the TBI group, 22.67% for the SLD group, and 28.13% for the TYP group).

Data Analyses

An exploratory approach using factor analysis was used in this study to test the construct validity of the Brain Check Survey. Data analysis was completed using SPSS version 21. As a preliminary step, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity were performed to ensure that the data were appropriate for factor analysis. The value of the KMO test is always between 0 and 1 and it is considered acceptable to proceed with a factor analysis when the value is above 0.6 (UCLA: Statistical Consulting Group, 2013). The Bartlett's Test of Sphericity tests the strength of the relationships between variables and should reach a significant level ($p \leq 0.05$). With the results of these preliminary tests (KMO: 0.956; Bartlett's: $p \leq 0.000$) it was deemed appropriate to proceed with the factor analysis. Principal component analysis was performed to determine if the items of the tool clustered into factors corresponding to the BCS's intended constructs. Varimax rotation was used in order to minimize the number of variables that have high loadings on each factor, thereby presenting a clearer factor structure. A value of 0.40 or greater was considered to be a significant loading

onto a factor (Portney & Watkins, 2009). Only factors displaying an eigenvalue greater than 1.00 were used in the interpretation because they accounted for a significant amount of variance, with the total variance of usable factors accounting for roughly 70% of the overall variability.

Multiple factor analyses were run on the original symptom and behavior items for the following participant sets: 1) all participants combined (typically developing [TYP], traumatic brain injury [TBI], and specific learning disability [SLD]), 2) elementary, middle, and high school level age categories of all participants, and 3) all ages from the typically developing group only. The first participant set was intended to determine the general construct of the instrument for all participants. The second participant set was used to determine if grade level impacted the factor loadings. The third participant set was used as a normalization group and to help determine if the TBI and SLD groups had a significant influence on the factor analysis outcome. It was not possible to factor analyze the results of the BCS for the TBI and SLD groups individually, though this would have been useful. The low numbers of participants in these groups prohibited factor analysis on the individual groups because they did not satisfy the accepted guidelines of 300 participants total or 50 participants per factor (VanVoohris & Morgan, 2007).

Results

Factor Analysis of All Participants

The factor analysis of all participants combined resulted in a two-factor construct that aligned with the behaviors section and symptoms section of the BCS. All behavior items clearly loaded onto factor 1 (loadings ranged from 0.709-0.865), which was given the label *Behaviors*. All symptom items clearly loaded onto factor 2 (loadings ranged from 0.624-0.805), which was given the label *Symptoms* (see Table 2 for the total variance explained by the two factors). Results from this factor analysis of all age categories and participant groups showed three variables ("Mood swings," "Being understood," and "Understanding others") that had similar high loadings in multiple factors. Considering the constructs emerging per factor and the failure of these three items to clearly load on one factor or another, the items were dropped from the analysis, and will be removed from the actual BCS tool.

Table 2: Factor analysis of all participants

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Behaviors	14.288	46.089	46.089	11.293	36.428	36.428
Symptoms	5.250	16.937	63.026	8.245	26.598	63.026

Factor Analysis of Individual Age Categories

The factor analyses for elementary school, middle school, and high school age categories initially exhibited a four-factor construct for each. For the elementary school and high school categories, all BCS items had low loadings on the fourth factor and demonstrated a high loading on one of the other factors. Therefore, the fourth factor was disregarded for elementary and high school factor analyses. The fourth factor for the middle school age category contained two items that loaded highest on the fourth factor but also had significant loadings on one of the other

factors. Because this fourth factor for the middle school category did not contain enough information to label it as a unique factor and there were only two items with high loadings (which also loaded onto other factors), it was reasoned that the fourth factor could be disregarded because these items were represented by an existing factor.

The elementary school category demonstrated high loadings onto the *Behaviors* factor (loadings ranged from 0.699-0.869) and the *Symptoms* factor (loadings ranged from 0.505-0.881) with the exception of the "Noise sensitivity" item, which was the only item to load highest on a third factor. Therefore, this third factor was disregarded (see Table 3 for the total variance explained for each factor in the elementary school category).

The middle and high school categories each demonstrated a clear *Symptoms* factor (middle school loadings: 0.571-0.813; high school loadings: 0.651-0.841). Out of the behavior items for these categories, two new factors emerged that represented more specific groupings of the *Behaviors* factor. These groupings were called subfactors, and were labeled *Cognitive Processing* and *Behavior Control* (Figure 1). Some behavior items loaded highest on *Behavior Control* (middle school loadings: 0.544-0.825; high school loadings: 0.558-0.750) and other items that were more cognitive in nature loaded highest on *Cognitive Processing* (middle school loadings: 0.606-0.761; high school loadings: 0.578-0.819). The remaining behavior items loaded higher on one or the other of the two subfactors, depending on the age category. See Tables 4 and 5 for the total variance explained by each factor for middle school

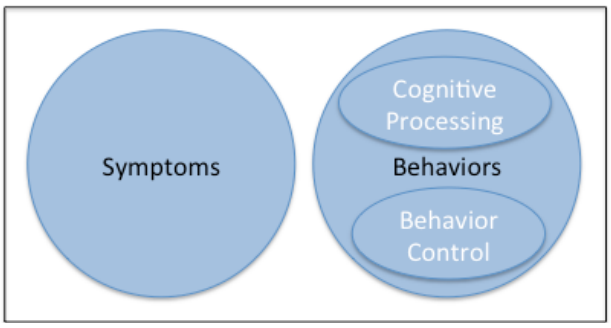

Figure 1: Graphic representation of factors

and high school, respectively. For an example of the BCS items that loaded onto the factors for the high school category, see Table 6.

Table 3: Factor analysis of Elementary School age category

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Behaviors	14.497	46.763	46.763	12.099	39.030	39.030
Symptoms	5.559	17.932	64.696	7.617	24.571	63.601
Factor 3*	1.184	3.820	68.516	1.428	4.606	68.208
Factor 4**	1.099	3.545	72.060	1.194	3.853	72.060

* BCS item "Noise Sensitivity" was the only item to load highest on this factor
** no items loaded highest on this factor

Table 4: Factor analysis of Middle School age category

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Symptoms	15.063	48.591	48.591	8.025	25.887	25.887
Behavior Control	4.532	14.619	63.210	7.071	22.811	48.698
Cognitive processing	1.058	3.414	66.624	4.032	13.008	61.706
Factor 4*	1.014	3.270	69.894	2.538	8.189	69.894

* BCS item "Coping with change or transition" and "Learns new things easily" were the only items to load highest on this factor. These items also loaded significantly on other factors.

Table 5: Factor analysis of High School age category

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Symptoms	13.905	44.854	44.854	8.460	27.291	27.291
Cognitive Processing	5.262	16.975	61.829	6.778	21.865	49.156
Behavior Control	1.371	4.421	66.251	5.024	16.207	65.363
Factor 4*	1.136	3.665	69.916	1.411	4.552	69.916

* no items loaded highest on this factor

Table 6: Items loading on factors for factor analysis of High School category

Factors		
Symptoms	**Cognitive Processing**	**Behavior Control**
Headaches and/or migraines	Focusing and maintaining attention	Coping with change or transition
Loss of muscle coordination	Getting started on activities, tasks, chores, homework and the like on his or her own	Maintaining family and friend relationships
Blackouts/fainting	Monitoring own progress on homework, assignment, chores, and the like	Letting go of one activity to attend to another
Confusion	Solving everyday problems	Reaction to simple problems
Blank staring/day dreaming	Learns from past mistakes or behavior	Waiting for his or her turn in a game
Dizziness	Learns new things easily	Thinks before speaking or acting
Change in vision	Remembers lists	Listens without interrupting others often
Fatigue	Remembers day-to-day events	Handles a change in plans
Seizures	Demonstrates good judgment	
Slurred speech		
Has trouble finding the "right" word when talking		
Noise sensitivity		
Light sensitivity		
Sleepiness		

Factor Analysis of TYP Group

The factor analysis of all ages from the typical group resulted in three factors. The *Symptoms* factor emerged again with clear loadings (loadings ranged from 0.615-0.892). Nearly all of the behavior items loaded heavily on the *Behavior Control* factor (loadings ranged from 0.530-0.841) and about half of the behavior items loaded moderately to heavily on the *Cognitive Processing* factor as well (loadings ranged from 0.606-0.771). See Table 7 for the total variance explained by each factor.

Table 7: Factor analysis of Typical group

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Symptoms	12.019	38.771	38.771	8.782	28.328	28.328
Behavior Control	6.766	21.825	60.596	7.082	22.844	51.172
Cognitive Processing	1.156	3.730	64.327	4.078	13.155	64.327

Discussion

The purpose of this study was to conduct a factor analysis, which is one critical component of establishing construct validity for the Brain Check Survey (BCS), thereby assisting in validating the use of the BCS as a screening tool for students in school who may have a TBI. It is important to establish construct validity to ensure that the instrument is measuring what was intended, thereby operationalizing the concept the tool claims to measure: potential TBI in children.

The factor analysis of the BCS using the data from all participants revealed that the items in the tool do, in fact, cluster together in the anticipated constructs of *Symptoms* and *Behaviors*. Because three test items did not cluster into these factors, the current study informed the possible revision of the instrument by removing those items so that the scales have a purer construct. The items being removed include: "Mood swings," "Being understood (speech is easy to understand, speaks clearly)," and "Understanding others." "Mood swings" seemed to be a typical concern of all adolescents, so the item may not have been specific enough to differentiate normal mood swings from severe, sudden, and uncontrolled changes of mood that can be a symptom of TBI. "Being understood" and "Understanding others" are complex behaviors that incorporate a variety of different skills and may have been confounded by the fact that these behaviors measure multiple factors that may not be directly related to the effects of TBI, such as the effect of social environment and communication.

The factor analysis of each age category revealed that age did influence the way items in the BCS correlated to each other. The elementary school age category aligned with the simple two-factor construct of *Symptoms* and *Behaviors*, but as the participants got into middle and high school the factor loadings became more complex. As with all of the factor analyses, the

Symptoms factor was clear for both of the older age categories. The *Behaviors* factor, however, revealed that the instrument is measuring two specific and independent aspects of behavior: *Cognitive Processing* and *Behavior Control*. The *Cognitive Processing* factor included the items that measured skills such as attention, initiation, monitoring self, problem solving, learning, and remembering. The *Behavior Control* factor included items that focused more on impulse control skills such as waiting for one's turn, not interrupting, thinking before speaking, and handling changes in plans. Compared to high school aged students, students in the middle school tend to experience more changes in early adolescence, so it is not surprising that they exhibited some differences in behavior, as noted by their parent(s) on the completed BCS forms.

The TYP group acted as a normative sample and the findings of its factor analysis were consistent will all other factor analyses in the current study in demonstrating a clear *Symptoms* factor. The TYP group also revealed that the *Behaviors* factor measures two distinct aspects, but the differentiation was less clear than the analysis of the separate age categories of all participants. The *Cognitive Processing* factor contained fewer items loading highest on it, and the *Behavioral Control* factor seemed to be more prominent.

The difference between the factor analysis of all participants (TYP, TBI, and SLD combined) and the factor analysis of the TYP group only is the obvious two-factor construct (*Symptoms*, *Behaviors*) in the former, and the emerging behavior subfactors (*Symptoms*, [*Behavior Control*, *Cognitive Processing*]) in the latter. We were unable to attribute the emerging behavior subfactors as a feature of the TYP group only, because the emerging factors were evident in the age category (elementary, middle school, high school) analysis, which included the combined TBI, SLD, and TYP groups. This difference in results does not have a clear and evident explanation. The differences could have been a result of the differing numbers

of participants included in each analysis, potentially a lack of homogeneity of the TYP group (some participants in the group reported having a history of head injury), or some other influence. Unfortunately, there is not enough information to make a conclusion about the differences between the factor analyses. More research needs to be conducted on larger sets of completed surveys for samples of students with TBI and SLD so that each group can be compared directly.

The factors that emerged from this study are consistent with the intended design of the BCS that included the two original scales: "Symptoms" and "Behaviors that can affect learning." This study's results revealed that the "Behaviors that can affect learning" section is measuring two distinct types of behaviors – *Cognitive Processing* and *Behavior Control* – for middle school students, high school students, and those is the typical group. These subcategories of behavior are consistent with the two indexes from the Behavior Rating Inventory of Executive Function (BRIEF) which is a parent, caregiver, and teacher questionnaire developed by neuropsychologists that measures executive functioning of children at home and in the community (Donders, DenBraber, & Vos, 2010; Gioia, Isquith, Guy, & Kenworthy, 2000). The BRIEF contains a Behavioral Regulation Index and Metacognition Index that include similar measures as the BCS's behavior factors of *Behavior Control* and *Cognitive Processing*. The similarities between the behavior portions of these two tools help verify that the BCS is measuring relevant components of behavior related to executive dysfunction seen in TBI.

The limitations of this study include a low response rate to the questionnaires, especially from the TBI and SLD groups. Traumatic brain injury, historically, has a lower incidence rate than the other IEP eligibility groups, and therefore it was difficult for the researchers to obtain large numbers of representative questionnaires from that group. The return rate of BCS forms

representing students with known TBI, however, was larger than for the SLD and TYP groups. The SLD group had potential for a larger sample size, but few participants in this group returned the questionnaire. Due to the low numbers of participants in these two groups, individual group factor analyses and group comparison analyses were not appropriate.

Conclusion

The Brain Check Survey's construct validity is confirmed by the results of this study and it is therefore a valuable tool that can be confidently used in the school system to screen for students who may have a TBI. The ultimate goal for the parent-completed BCS is to provide a starting point for educators and parents to discuss a course of action that can optimize a child's potential by better understanding what may be leading to the child's difficulty participating in school. The Brain Check Survey was designed to be user-friendly for parents to complete; to be conveniently interpreted by a variety of professionals in the schools; and to be used exclusively to examine children's problems with being successful learners in school. The positive findings from this factor analysis study demonstrate the strong construct validity of this tool and its effectiveness in screening students for possible TBI.

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Appendix

Brain Check Survey

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Brain Check Survey

Parent/Guardian Version

Student Information

Today's Date: ___/___/___ Child's Age: _____

Child's Date of Birth: ___/___/___ Child's Gender: ☐ Male ☐ Female

Child's race: (circle one or more)	1: American Indian/Alaska Native 2: Asian 3: Native Hawaiian or Other Pacific Islander	4: Black or African American 5: White 6: More than one race Please describe:_____
Child's ethnicity: (circle one)	1: Hispanic or Latino 2: Not Hispanic or Latino	3: Unknown or Not Reported

Injuries or Illnesses

Injury or Illness	Age	Outcomes
Please check all that apply		
☐ **Blow to Head** (from sports, playing, biking, falling, getting hit by an object, etc.)	At what age?___	Check all that apply: ☐ Concussion ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Whiplash**	At what age?___	Check all that apply: ☐ Concussion ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem

Injury or Illness	Age	Outcomes
☐ **Car accident** (resulting in any degree of injury or lack of injury)	At what age?____	Check all that apply: ☐ Concussion ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
Please check all that apply ☐ **Assault/Violence (child abuse, fights, firearm injury)**	At what age?____	Check all that apply: ☐ Concussion ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Sustained High Fever**	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Brain Tumor**	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Anoxia** (definition: lack of oxygen; caused by such events as a near-drowning experience or suffocating experience)	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem

Injury or Illness	Age	Outcomes
☐ **Meningitis**	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Encephalitis**	At what age?____	Check all that apply: ☐Loss of consciousness, *for how long?_____ ☐Coma, *for how long? _____ ☐Confusion or altered mental state ☐Missed school ☐ Resulted in no problem
☐ **Seizures** (example: epilepsy)	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
Please check all that apply ☐ **Overdose of** drugs or alcohol, or inappropriate use of prescription drugs or over- the-counter medication?	At what age?____	Check all that apply: ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem
☐ **Other:** _____ _____	At what age?____	Check all that apply: ☐ Concussion, *for how long? _____ ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem

Injury or Illness	Age	Outcomes
☐ **Other:** _____ _____	At what age?____	Check all that apply: ☐ Concussion, *for how long? _____ ☐ Loss of consciousness, *for how long?_____ ☐ Coma, *for how long? _____ ☐ Confusion or altered mental state ☐ Missed school ☐ Resulted in no problem

Has your child ever been to the emergency department? ☐ *Yes* ☐ *No*
If YES, at what age?_____ Please explain:

_____
_____
_____
_____

Behaviors that can affect learning

Please tell us about your child's learning styles and behaviors

Learning Style or Behavior	Not Applicable? (check)	Circle the number on the scale which best describes your child: No Problem ⟺ Extreme Problem					
	€ N/A	**1**	**2**	**3**	**4**	**5**	**6**
Focusing and maintaining attention	€ N/A	1	2	3	4	5	6
Getting started on activities, tasks, chores, homework and the like, on his or her own	€ N/A	1	2	3	4	5	6
Being understood (speech is easy to understand, speaks clearly)	€ N/A	1	2	3	4	5	6
Understanding others	€ N/A	1	2	3	4	5	6
Coping with change or transitions	€ N/A	1	2	3	4	5	6
Maintaining family and friend relationships	€ N/A	1	2	3	4	5	6
Letting go of one activity to attend to another	€ N/A	1	2	3	4	5	6
Reaction to simple problems	€ N/A	1	2	3	4	5	6
Monitoring own progress on homework, assignments, chores, and the like	€ N/A	1	2	3	4	5	6
Solving everyday problems (example:	€ N/A	1	2	3	4	5	6

Learning Style or Behavior	Not Applicable? (check)	Circle the number on the scale which best describes your child: No Problem ⟺ Extreme Problem
thinking of different options when something is not working for him/her.)		
Waiting for his or her turn in a game	€ N/A	1 2 3 4 5 6
Learns from past mistakes or behavior	€ N/A	1 2 3 4 5 6
Thinks before speaking or acting	€ N/A	1 2 3 4 5 6
Listens without interrupting others often	€ N/A	1 2 3 4 5 6
Handles a change in plans	€ N/A	1 2 3 4 5 6
Demonstrates good judgment	€ N/A	1 2 3 4 5 6
Learns new things easily	€ N/A	1 2 3 4 5 6
Remembers lists	€ N/A	1 2 3 4 5 6
Remembers day-to-day events	€ N/A	1 2 3 4 5 6

Symptoms

If your child has experienced any of the following symptoms, rank the severity of those symptoms.
Please check all that apply:

Symptom	Not Applicable? (check)	Circle the number on the scale which best describes your child: No Problem ⟺ Extreme Problem
	€ N/A	**1 2 3 4 5 6**
Headaches and/or Migraines (sudden, not responsive to medications, can last for more than a day)	€ N/A	1 2 3 4 5 6
Loss of muscle coordination (can look like awkward movements, problems with balance, slowed reactions, uncoordinated running and catching)	€ N/A	1 2 3 4 5 6
Blackouts/ Fainting	€ N/A	1 2 3 4 5 6
Confusion	€ N/A	1 2 3 4 5 6
Blank staring/Day dreaming	€ N/A	1 2 3 4 5 6
Dizziness	€ N/A	1 2 3 4 5 6
Change in vision (blurred vision, double	€ N/A	1 2 3 4 5 6

Symptom	Not Applicable? (check)	Circle the number on the scale which best describes your child: No Problem ⟺ Extreme Problem					
vision, depth perception)							
Fatigue (tires easily, is often tired)	€ N/A	1	2	3	4	5	6
Seizures	€ N/A	1	2	3	4	5	6
Slurred speech	€ N/A	1	2	3	4	5	6
Has trouble finding the "right" word when talking	€ N/A	1	2	3	4	5	6
Noise sensitivity (can be easily upset by loud noises or specific sounds like a ticking clock.)	€ N/A	1	2	3	4	5	6
Light sensitivity (can be easily upset by bright or strobe lights)	€ N/A	1	2	3	4	5	6
Sleepiness (has trouble staying awake during the day)	€ N/A	1	2	3	4	5	6
Mood swings (unusual and/or quick changes between sadness, happiness, depression, anxiety, anger and the like; irritability)	€ N/A	1	2	3	4	5	6

Educational Services

*Is your child having difficulties with school performance? Please describe:*_____

_____

_____

*What does your child do best at in school? Please describe:*_____

_____

_____

Is your child currently receiving any of the following services?
Check all that apply (If "yes", please check if they are provided through school and/or being provided privately).

Service	*Child's Status (please check)*	
Occupational therapy	**€ No**	**€ Yes** If Yes, please check whether these services are delivered by: ☐ *school-supported specialists* (the school pays for the specialist); and/or ☐ *by private specialists* (you and/or your insurance pays)
Physical therapy	**€ No**	**€ Yes** If Yes, please check whether these services are delivered by:

		☐ *school-supported specialists* (the school pays for the specialist); and/or ☐ *by private specialists* (you and/or your insurance pays)
Speech-Language therapy	**€ No**	**€ Yes** If Yes, please check whether these services are delivered by: ☐ *school-supported specialists* (the school pays for the specialist); and/or ☐ *by private specialists* (you and/or your insurance pays)
Other: _____	**€ No**	**€ Yes** If Yes, please check whether these services are delivered by: ☐ *school-supported specialists* (the school pays for the specialist); and/or ☐ *by private specialists* (you and/or your insurance pays)

Has your child ever been evaluated for special education services? € YES € NO

If Yes, at what age was your child first evaluated? _____

Does your child have a 504 plan? € YES € NO

If Yes, are the accommodations helping your child's school performance? € YES € NO

Does your child have an IEP, Individualized Education Plan?

€ No

€ Yes → if YES, please answer 1 & 2 immediately below:

1. Is the IEP helping your child's school performance? € YES € NO
2. Please check all categories listed on the IEP:
   - € Autism
   - € Hearing Disability
   - € Multiple Disabilities
   - € Physical Disability - Conditions such as, but not limited to, attention deficit disorder, attention deficit hyperactivity disorder, and cerebral palsy may qualify as a physical disability
   - € Pre-School Child with a Disability
   - € Significant Identifiable Emotional Disability (SIED)
   - € Specific Learning Disability (SLD)
   - € Speech-Language Impairment
   - € Significant Limited Intellectual Capacity (SLIC)
   - € Traumatic Brain Injury (TBI)
   - € Vision Disability
   - € Other_____

Family Information

*Please answer the following questions about **YOURSELF***

Are you the student's (circle all that apply):

€ Mother € Father € Foster Parent € Other (ex: stepmother) please describe:_____

Your Age: _____ **Date of Birth**: ___/___/___

Your race: (circle one or more)	1: American Indian/Alaska Native 2: Asian 3: Native Hawaiian or Other Pacific Islander	4: Black or African American 5: White 6: More than one race Please describe:_____
Your ethnicity: (circle one)	1: Hispanic or Latino 2: Not Hispanic or Latino	3: Unknown or Choose not to Report

What is your highest level of education? (Check one.) This question is optional.

€ Some high school
€ High school graduate
€ Some college
€ College graduate (Associate's Degree)
€ College graduate (Bachelor's Degree)
€ Some graduate training
€ Master's Degree
€ Doctorate or professional degree (lawyer, PhD., M.D., etc.)

Family Gross Income (Before taxes-- check one.) This question is optional.
Note: If parents are divorced and child lives in both families, then record the income of both households separately.

1. less than $5,000
2. $5,000 to $10,000
3. $10,001 to $15,000
4. $15,001 to $20,000
5. $20,001 to $25,000
6. $25,001 to $30,000
7. $30,001 to $35,000
8. $35,001 to $40,000
9. $40,001 to $45,000
10. $45,001 to $50,000
11. $50,001 to $60,000
12. $60,001 to $70,000
13. $70,001 to $80,000
14. $80,001 to $90,000
15. $90,001 to $100,000
16. $100,001 to $150,000
17. $150,001 to $200,000
18. $200,001 to $250,000
19. $250,001 to $300,000
20. more than $300,000

Thank you very much for your time!