

EVALUATION OF ASSESSMENTS IN DIRECTING REFERRALS AND INTERVENTION
FOR SPEECH LANGUAGE PATHOLOGY SERVICES FOLLOWING CONCUSSION

by

ANSLEY MESSINA

(Under the Direction of Katy H. O'Brien)

ABSTRACT

Mild traumatic brain injury (mTBI) can result in physical, emotional, and/or cognitive symptoms that negatively impact everyday tasks. To assist rehabilitation referral for mTBI, the primary purpose of this study was to compare utility of a new tool, the Cognitive Symptom Screening Tool (CSST), against commonly used assessments of concussion symptoms in determining referral patterns to speech-language pathology (SLP) and other rehabilitation disciplines. The secondary purpose was to compare the CSST with SLP specific assessment tools in determining dosage/length of SLP services. Results indicated that the CSST and objective testing of cognitive function could predict SLP referral. For those referred for SLP services, the CSST and a self-report measure of metacognition were most closely associated with number of SLP treatment sessions. Overall, the CSST showed promise in both directing referrals and determining plans of care for people with mTBI. Continued study is warranted to examine clinical use of the CSST.

INDEX WORDS: Mild Traumatic Brain Injury (mTBI), CSST, referral, SLP

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ANSLEY MESSINA

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ANSLEY MESSINA

Major Professor: Katy H. O'Brien
Committee: Hannah Krimm
Nina Santus

Electronic Version Approved:

Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
The University of Georgia
May 2023

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CHAPTER 1

Literature Review

The Center for Disease and Prevention Control (CDC) estimates that 2.9 million Americans sustain a traumatic brain injury (TBI) each year. TBI can be caused by a blow, bump, blast, jolt to the head, or a penetrating head injury (CDC, 2021). Most common is mild traumatic brain injury (mTBI), also known as concussion. Globally, it is estimated that 55 million people sustain concussions per year (Dewan et. al., 2018). Concussion is a traumatically induced physiological disruption of brain function (Kay, 1993) resulting in physical, emotional, and/or cognitive symptoms that negatively influence performance during academic, occupational, or social activities (Dawson et al., 2007; McCrory et al., 2017; Ransom et al., 2015; Wasserman et al., 2016). In a study of 2,697 participants with TBI from a level 1 trauma center, persistent symptoms were common of all severities in all TBI cases, and fifty percent of people with TBI reported three or more symptoms one year post injury (Machamer et al., 2022). In mTBI cases, 21% reported a high symptom burden at 3 months after injury. These symptoms may not be specific to mTBI, but their frequency and magnitude create a distinction between patients with mTBI, other orthopedic injury, and healthy controls (Machamer et al., 2022). Therefore, TBIs have significant implications as significantly high populations of individuals present patterns of symptoms after sustaining a TBI.

Some of the persisting symptoms that occur after an mTBI can present as difficulties in learning, memory, attention, processing speed, and executive function (Cornis-Pop et al., 2012). These areas of need all fall within the scope of practice of speech-language pathologists (SLPs). The American Speech and Hearing Association (ASHA) lists SLPs as having a significant role in

the screening, assessment, and treatment of persons with TBI. The professional roles and activities in speech-language pathology include clinical services (assessment, planning, and treatment), prevention, and advocacy, as well as education, administration, and research (ASHA, 2016b). However, problems have been reported for nearly two decades describing a lack of knowledge among healthcare workers and educators in the roles and responsibilities of SLPs serving all populations of mTBI clients (Hardin et al., 2021).

Although the management of treatment with concussion is within a SLPs scope of practice, many physicians are unaware of the role of the SLP in concussion management (Knollman-Porter et al., 2021), and individuals with mTBI are often not referred to SLPs after emergency department visits. Individuals who receive SLP services in the hospital are assumed to be more seriously impaired than those who make emergency department (ED) visits and do not require hospitalization (Leblanc et al., 2020). However, when discharged from the ED, individuals with mTBI typically are not followed for the next few weeks or asked to have a follow-up appointment to manage symptoms. Many individuals return to school or work without formal coordination between the medical team, the family, and the school and/or workplace (Ciccia, 2018; Seabury et al., 2018). This breakdown serves as one of the many barriers SLPs face when assessing and treating individuals with TBI.

Cognitive-Communication Changes in mTBI

Symptoms following concussion typically cluster into six primary phenotypes including: cognitive, ocular-motor, headache/migraine, vestibular, anxiety/mood, and cervical (Collins et al., 2014; Kontos et al., 2019). In addition, secondary phenotypes, such as ocular-motor or headache/migraine may present as well and result in cognitive problems. The cognitive phenotype is described as a decrease in attention, processing speed, reaction time, working

memory, encoding and memory retrieval, and deficits in executive functioning, (Lumba-Brown et al., 2020) and is particularly appropriate for SLP treatment (Collins et al., 2014).

In addition, such cognitive problems can impact communication. Complaints of difficulty with word-finding or keeping up with conversation are common following concussion (Cornis-Pop et al., 2012). A cognitive communication disorder is characterized by difficulty with any aspect of communication that is affected by disruption of cognition (MacDonald, 2017).

Communication complaints are often an important marker of cognitive problems interfering with an individual's daily activities, indicating their need for SLP services. For example, a recent study examined use of the LaTrobe Communication Questionnaire (LCQ) to determine SLP referrals following concussion. The LCQ describes the association between common communication problems experienced by adolescents and adults with brain injury and generates four subscales scores of Initiation/Conversational Flow, Disinhibition/Impulsivity, Conversational Effectiveness, and Partner Sensitivity. LCQ subscales scores of Initiation/Conversational Flow and Partner Sensitivity were better predictors of referral for speech pathology services than standard symptom scales (O'Brien et al., 2022). Thus, examining communication following concussion may provide a referral tool for identifying those in need of SLP services.

The SLP Role in Cognitive-Communication and Interdisciplinary Teams

The SLP addresses the impacts of mTBI by identifying deficits and determining the particular cognitive challenges that impact cognition and communication in functional contexts. The SLP trains and teaches cognitive strategies that can decrease an individual's cognitive communication deficits and maximizes daily function and participation (Brown et al., 2019; Ciccio et al., 2021; Cornis-pop et al., 2012; Krug & Turkstra, 2015; Lundine et al., 2019).

Evidence shows individuals with TBI are at a significantly greater risk of failure in academic settings (Mealings et al., 2016), and that outcomes can be improved through SLP services (O'Brien, Schellinger, & Kennedy, 2018; Wright & Sohlberg, 2021). The SLP's role in the school is to provide support, services, or systems to promote learning by training individuals on self-advocacy and the use of compensatory strategies (Ciccia, 2018). SLPs can also serve as the liaison for advocating academic modifications for a child who has sustained a mTBI, making them important return to learn team members.

Although SLPs play a vital role in the management of cognitive and communication deficits, they are traditionally underrepresented on mTBI treatment teams (Brown & Knollman-Porter, 2020; O'Brien, 2020). Often, physicians and nurse practitioners are unaware of the SLPs role in recovery and symptom management, which contributes to low referrals for treatment (Hardin et.al., 2021). When surveyed, just half of first-line healthcare providers (physicians, physicians assistants, nurse practitioners) expressed they were knowledgeable in an SLP's role in TBI management, while the other half were unaware of the role an SLP might play. In addition, the "unknowledgeable" 50% provided remarks that were inaccurate statements of the role an SLP would play in concussion management. For example, a nurse stated that SLP services, "...would be only for a more severe TBI and is outside my common practice" (Knollman-Porter et al., 2021). This misconception of an SLP's role in mTBI results in an average of 5.6 days for an SLP to receive the first referral in an acute care setting (Leblanc et al., 2020), whereas physical therapy (PT) often receives a referral immediately (Vargo et al., 2016). In some settings (e.g. acute care, inpatient, outpatient), SLP may not receive a referral until weeks later (Knollman-Porter et al., 2021), often when protracted symptoms become apparent (Eagle et al., 2020). Comparing assessment data SLP referrals allow for identification of factors associated

with referral, thereby improving this pipeline of care. It may be that lack of awareness of SLP practice domains and SLPs' role in mTBI management that leaves SLPs often excluded from the multidisciplinary rehabilitation team following mTBI, resulting in individuals with mTBI often not considered for SLP services (MacDonald, 2017). Having tools that identify markers for the need for SLP care that can be easily implemented in clinical settings, would likely improve outcomes for people with mTBI (MacDonald, 2021).

SLP Clinical Practice Challenges

Hardin et al. (2021) described three primary barriers SLPs face in assessment of mTBI, namely: the rapidly changing evidence base, inadequate assessment tools, and the lack of published practice guidelines. In addition to challenges around referral pipelines for SLP care following mTBI, there are also no clinical guidelines for SLP assessment and treatment of mTBI. The lack of field-specific evidence and guidelines often leaves SLPs feeling uncomfortable and confused as to how to provide best practice. These three barriers combine to create particular difficulty for clinicians in selecting reliable and valid assessments that are also sensitive and specific to mTBI. Such problems with assessment compound into variability with the selection of treatments approaches (i.e., frequency and intensity of sessions) and duration of services.

There is a lack of universal valid and reliable assessments capable of evaluating and predicting treatment outcomes within the mTBI population (Kontos, 2019; Frenette et al., 2019; O'Brien et al., 2021; Williams-Butler & Cantu, 2019; Knollman-Porter et al., 2021; Norman, Shah, and Turkstra, 2019). Variability in demographics, previous history of mTBI, and co-occurring health conditions are all factors that create significant difficulty in the diagnosis, assessment, and treatment of mTBI (Knollman-Porter et.al, 2021). There has been significant research and guidelines enacted for military (Cornis-Pop et al., 2012; Picon & MacLennan,

2017) and sports related concussions (McCrorry et al., 2017; Broglio et al., 2014) regarding the initial evaluation received in an mTBI case. However, these clear and structured protocols are less widely available to practitioners who serve individuals with mTBI outside of military or sports contexts. Differing evaluation and diagnostic practices also exist for health care professionals who work solely with pediatric populations (Lumba-Brown et al., 2018), those who work solely with adult populations (Marshall et al., 2018), and those who work across age ranges. These instances create a need for more research to understand care practices associated with mTBI evaluation, diagnosis, and multidisciplinary symptom management (Knollman-Porter et al., 2021).

Due to the need for greater research in the area of mTBI, several studies have examined how assessments may predict recovery or need for rehabilitative services. Eagle et al. (2020) evaluated whether total Post Concussion Symptom Scale (PCSS) and PCSS factors (cognitive/migraine/fatigue, affective, sleep, somatic) and cut off scores can determine recovery duration and possible need for rehabilitation services. They found that PCSS symptom factors accurately differentiated athletes with sports related concussion (SRC) from those who did not have an SRC. The PCSS symptom factors also predicted prolonged recovery, while the total PCSS score results were inconclusive regarding predicted recovery. A secondary finding was that cognitive/migraine/fatigue (CMF) factors and PCSS total score presented significant clinical utility in predicting protracted recovery in patients with SRC who present with early symptoms. Lingering symptoms within the CMF domain past the first week indicated protracted recovery. Although this study does not directly address SLP referral, the CMF subtype has been suggested to be particularly appropriate for SLP intervention (Collins et al., 2013).

LeBlanc et al. (2021) also analyzed how performance on cognitive-communication measures could predict outcomes after mTBI. They evaluated scores on the Boston Diagnostic Aphasia Examination (BDAE-3; Goodglass, Kaplan, and Barresi, 1983), Detroit Test of Learning Aptitude (DLTA-3; Baker and Leland, 1965), Boston Naming Test (BNT; Kaplan et al., 2001), Verbal Fluency using subtests, and Reading Comprehension Subtests of the Canadian Adult Achievement Test (CAAT; Psychological Corporation, 1995). Among these measures, Letter naming on the Verbal Fluency subtests was the only length of stay predictor. Language tests except for reading comprehension were associated with dismissal from acute care. Higher scores on the language tests indicated greater odds of being discharged to home rehab as compared to in-patient or out-patient rehab.

Hardin et al. (2021) also described SLPs challenges in clinical practice when selecting assessment measures. Clinicians reported a high degree of variability when choosing subjective or objective measures for evaluating the cognitive communication skills of people with mTBI. In total, SLPs in the study reported using 19 different objective measures and 22 subjective measures in clinical practices. This inconsistency in measure selection supports SLP reports of unclear practice protocols and challenges in selection of assessments for mTBI cases.

Perhaps as a result of having inadequate tools to describe needs following mTBI, many SLPs use assessments unlikely to yield valid or reliable results. For example, Williams-Butler and Cantu (2019) found that approximately one-fourth (26.19%) of SLPs reported using screening tools as their diagnostic. A further 24.41% reported using language-based assessments (e.g BDAE-3), suggesting that many SLPs may be under-assessing individuals with mTBI or using an assessment that is not aligned with deficits that may present with mTBI. Clinical

implications are that these current practices can lead to under-identification of cognitive-communication disorders or misdiagnoses (e.g., language rather than cognitive needs).

Concussion clinical profiles should be informed by a comprehensive approach to assessment that includes clinical interview and examination, medical history (including risk factors) and injury information, concussion symptoms (somatic, cognitive, affective, sleep), and comprehensive evaluations of impairment (e.g., balance, cognitive, oculomotor, and vestibular systems; Kontos et al., 2019). Impaired communication may also be a particular hallmark for need for SLP care following mTBI (O'Brien et al., 2022). Therefore, there is a need to identify assessments or tools that accurately predict SLP referral and course of SLP rehabilitation (including dosage, i.e., frequency and intensity of sessions).

Aim of the study

As a step toward improving assessment and referral to SLP services following mTBI, the purpose of this study is to examine the utility of standardized objective and subjective assessments as well as a new 7-item assessment of cognitive, communication, and emotional function following mTBI, the Cognitive Symptom Screening Tool (CSST; O'Brien et al., in prep; see Appendix A). Aim 1 will analyze identification of individuals with mTBI referred for SLP services in comparison to other disciplines (i.e. physical therapy, occupational therapy, neuropsychology). In Aim 2, we will analyze scores on standardized assessments of individuals who were referred for SLP care to determine if these predict dosage and length of SLP services.

CHAPTER 2

Method

This study employed a retrospective chart review design to determine referral patterns for all rehabilitation services (i.e., occupational therapy, physical therapy, neuropsychology), with a particular eye toward referral for SLP services. Records were reviewed from patients who received medical care at Shepherd Center's Complex Concussion Clinic (CCC) between August 2019 and March 2020. Data gathered in the chart review included patient demographics, medical history, injury characteristics, and physician testing at first visit (clinic intake). For those referred for SLP services, cognitive-communication testing was also included. In addition, all participants completed the Cognitive Symptom Screening Tool (CSST), a new tool to assess cognitive, emotional, and communication changes following concussion to direct referrals to either SLP or neuropsychological services.

Inclusion/ Exclusion Criteria

Participant records were gathered from the Complex Concussion Clinic (CCC) at the Shepherd Center in Atlanta, GA. All patients who presented with any history of a moderate to severe traumatic brain injury or history of any other acquired brain injury were excluded from the study. Eligibility included having a current concussion, no other neurological disorders, ages 14-65, and proficient in English. Other inclusion criteria included that participants have a completed CSST form from their initial visit to the CCC. Therefore, all participant records used in this chart review were individuals with a documented mTBI in their medical chart.

Data Sources

Data was gathered from measures administered at admission to the CCC in addition to patient demographic and assessment information. Medical chart data was extracted by a team of two trained research assistants at the University of Georgia. For reliability, 20% of the data was coded by both the research assistants. Agreement between the two research assistants was .98, exhibiting excellent reliability. All information extracted from patient records was de-identified.

The following assessments were considered in this chart review:

- Post-Concussion Symptom Scale (PCSS; Lovell & Collins, 1998), a 21-item self-report of concussion symptoms via a 6-point Likert scale;
- Standardized Assessment of Concussion (SAC; Barr & McCrea, 2001), a 30-item assessment of cognitive performance in children and young adults;
- Montréal Cognitive Assessment (MoCA; Nasreddine et al., 2005), a one-page, 30-item screening assessment used to detect cognitive impairment in adults; and
- Cognitive Symptom Screening Tool (CSST; O'Brien et al., in prep; see Appendix A), a 7-question screening assessment including communication and emotion regulation that are rated as worse, same, or better following mTBI.

For participants who received SLP services, scores on the following assessments were also extracted:

- Repeatable Battery for Neurological Assessment (RBANS; Novitski et al., 2012), which generates a total scale score as well as subscale scores in attention, language, visuospatial/constructional abilities, and immediate and delayed memory; and
- Behavioral Rating Inventory of Executive Functioning (BRIEF; Gioia et al., 2000) a questionnaire designed to assess impairment of executive function that includes subscores

of Behavioral Regulation Index (BRI), Metacognition Index (MI), and Global Executive Composite (GEC).

In addition to assessment data, demographics (age, sex, ethnicity, marital status, employment), injury characteristics (mechanism, loss of consciousness, time post injury, imaging), and medical history (concussion, learning disorders, headache, psychopathology, neurologic diseases) were extracted for analyses.

Data Analyses

Aim 1. Examine utility of the CSST in identifying individuals with mTBI referred for SLP services in comparison to other disciplines (i.e., physical therapy, occupational therapy, neuropsychology).

For Aim One, a logistic regression was performed including all independent and dependent variables of interest. The independent variables were the above-mentioned screeners, assessments, and demographic factors. The dependent variables included SLP referrals and referrals to other disciplines. This regression compared the strength of independent variables in predicting SLP referrals and other discipline referrals (i.e., PT, OT, NP). This exploratory analysis allowed us to determine whether certain screeners or assessments are particularly associated with SLP referrals. We hypothesized that the total score or subscales of the CSST would be most strongly related in predicting SLP referrals since it most closely reflects SLP domains, in comparison to the PCSS, SAC, or MoCA. Literature shows the PCSS symptom scales have some utility in predicting referral to SLP services, whereas MoCA and SAC total scores have limited sensitivity (O'Brien et al., 2022).

Aim 2. Examine scores on standardized assessments of individuals who were referred for SLP care to determine if these predict dosage and length of SLP services.

For Aim Two, a linear regression was performed to compare the RBANS and BRIEF in predicting dosage and duration of SLP services. Because both measures were statistically significant predictors of SLP services, a multiple regression was also used to determine which measure was most sensitive in predicting SLP services. The total scores from the BRIEF and RBANS were used first in the linear regression. There was a need to determine a distinction between the two measures, so the subscales from the BRIEF and the RBANS were used for comparison. The independent variables are the RBANS and BRIEF. The dependent variables are the duration and dosage of sessions per week recommended of SLP services. We hypothesized that the RBANS and BRIEF would each predict the dosage and duration of SLP services. Patient self-report of problems on the BRIEF may be a greater indicator of how patients perceive their needs than the RBANS, and therefore could more closely correspond to the number of sessions the patient is willing to attend. This information will benefit SLPs in clinical practice by providing guidance as to how these standardized assessments may play a role in shaping treatment plans.

CHAPTER 3

Results

Demographic and Injury Characteristics

This study included 129 participants with a mean age of 28.02 years ($SD = 15.19$). There were 69 females, and 60 males. The majority of the participants were employed full-time or full-time students. More than 40% of participants had a history of concussion. The most common mechanisms of injury were for motor vehicle crash (MVC; $n = 26$), struck by/against ($n = 26$), and sport ($n = 30$). The majority of participants did not experience a loss of consciousness after the injury. Time post injury varied from 3 to 3,702 days ($M = 57.16$, $SD=55.36$). Of the 129 participants, 117 were referred for additional services (i.e. PT, OT, ST, NP); 57% of the 117 participants were referred for SLP services. Table 1 provides a summary of additional participant characteristics.

Table 1

Participant Characteristics, N = 129.

		n (%)
Ethnicity	White	92 (64%)
	Black	25 (17%)
	Asian	6 (4%)
	American Indian or Alaska Native	1 (.7%)
	Hispanic/Latino	1(.7%)
	Not disclosed	17 (12%)
Employment	Full time Employed	45 (35%)
	Part time Employed	2 (2%)
	Full time Student	78 (60%)
	Part time Student	1 (1%)
Education	Less than high school	15 (10%)
	High School	36(25%)

	Some college	25(17%)
	Bachelors	33 (23%)
	Masters	23(16%)
	Doctoral degree	10(7%)
Mechanism of Injury	MVC	34 (26%)
	Struck by/against	34 (26%)
	Sport	39 (30%)
	Fall	22 (17%)
Loss of Consciousness	Yes	20 (14%)
	No	122 (85%)
Concussion History	No history	75 (58%)
	1 prior concussion	36 (28%)
	2 prior concussions	10 (8%)
	3+ prior concussions	8 (6%)
Learning Disability History	Yes	23 (16%)
	No	119 (83%)
Headache Disorder History	Yes	26 (20%)
	No	116 (80%)
History of Psychopathology	Yes	61 (42%)
	No	81 (57%)
Neurological History	Yes	8 (6%)
	No	134 (94%)
Imaging	None	87 (67%)
	Nonremarkable	39 (30%)
	Remarkable	3 (2%)
Mean Time Post Injury	<i>M</i>	57.16
	<i>SD</i>	55.36
SLP Referral	Yes	81 (62%)
	No	48 (37%)
PT Referral	Yes	106 (76%)
	No	33 (23%)
OT Referral	Yes	53 (40%)
	No	77(59%)
NP Referral	Yes	45 (36%)
	No	80 (64%)

Table 2

Demographic Data for Participants Who Received Speech Therapy Services, n = 81.

Ethnicity	White	56 (69%)
	Black	15 (18%)
	Asian	2 (2%)
	American Indian or Alaska Native	1 (1%)
	Hispanic/Latino	1 (1%)
	Not disclosed	6 (7%)
Employment	Full time Employed	26 (32%)
	Part time Employed	2 (2%)
	Full time Student	50 (62%)
	Part time Student	1 (1%)
	Casual	1 (1%)
Education	Less than high school	4 (5%)
	High School	26 (32%)
	Some college	8 (9%)
	Bachelors	19 (23%)
	Masters	16 (20%)
	Doctoral degree	7 (8%)
Mechanism of Injury	MVC	27 (33%)
	Struck by/against	23 (28%)
	Sport	17 (21%)
	Fall	14 (17%)
Loss of Consciousness	Yes	16 (20%)
	No	65 (80%)
Concussion History	No history	47 (58%)
	1 prior concussion	20 (25%)
	2 prior concussions	7 (8%)
	3+ prior concussions	7 (8%)
Learning Disability History	Yes	16 (20%)
	No	65 (80%)
Headache Disorder History	Yes	25 (31%)
	No	56 (69%)
History of Psychopathology	Yes	45 (55%)
	No	36 (44%)
Neurological History	Yes	5 (6%)
	No	76 (94%)
Mean Time Post Injury	<i>M</i>	81
	<i>SD</i>	74

Note. MVC= Motor Vehicle Crash

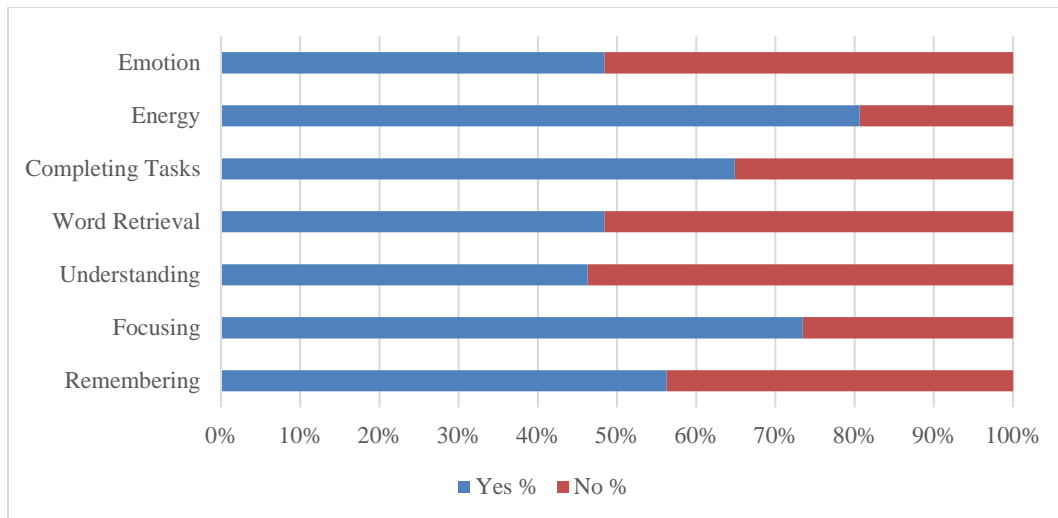


Figure 1

Responses to CSST questions for all participants.

Figure 1 shows the breakdown of participant responses on the CSST. Maintaining energy was most commonly endorsed, followed by focusing, completing tasks, and remembering. The remaining three – emotion, word retrieval, and understanding – were reported by just less than half of participants.

Demographic and Injury Predictors of Rehabilitation Services

Several demographic and injury characteristics predicted referrals for rehabilitation services, although these varied by discipline (see Table 3). People who were female, had a history of headache disorders, were injured in a motor vehicle crash, or received neuroimaging (regardless of presence of radiological findings) were more likely to receive SLP services. In contrast, only having a history of learning disorders and no other demographic or injury characteristics predicted PT referral. OT and NP showed remarkably similar patterns, with age, being injured in a motor vehicle crash, losing consciousness, and receiving imaging all being associated with referral for services. In addition, those injured either in falls or by being struck by or against an object were also more likely to receive a referral to OT.

Table 3

Relationship between demographic and injury factors with referrals to rehabilitation disciplines.

		SLP			PT			OT			NP		
		OR	95%CI	p	OR	95%CI	p	OR	95%CI	p	OR	95%CI	p
Demographics	Age	1.01	[0.99, 1.04]	.196	1.02	[.99, 1.05]	.271	1.04**	[1.02, 1.07]	.001	1.03*	[1.01, 1.05]	.020
	Sex	2.84*	[1.44, 5.69]	.003	1.91	[.86, 4.33]	.271	1.88	[.93, 3.88]	.081	1.74	[.84, 3.70]	.173
Medical History	Prior concussion	.96	[.68, 1.38]	.847	.97	[.65, 1.49]	.875	.99	[.69, 1.42]	.969	.97	[.66, 1.42]	.965
	Learning Disorders	1.44	[.60, 3.67]	.415	.36*	[.14, .93]	.031	.72	[.27, 1.81]	.499	.94	[.35, 2.37]	.937
	Headache Disorders	4.2**	[1.68, 11.92]	.004	2.39	[.84, 8.62]	.132	4.0**	[1.72, 9.85]	.001	2.84*	[1.22, 6.77]	.013
	Mental disorders	1.73	[.89, 3.40]	.108	1.29	[.58, 2.89]	.536	1.53	[.76, 3.12]	.239	1.67	[.80, 3.53]	.209
Injury characteristics	Neurological disorders	.44	[.13, 1.40]	.174	.57	[.17, 2.27]	.388	.69	[.18, 2.33]	.5682	.56	[.12, 2.01]	.224
	Mechanism												
	MVC	2.72*	[1.31, 6.81]	.028	1.55	[.56, 4.92]	.403	7.10***	[2.58, 21.33]	<.001	4.38**	[1.64, 12.41]	.003
	Fall	2.20	[.78, 6.4]	.139	1.49	[.47, 5.32]	.514	2.21***	[.69, 7.25]	<.001	1.20	[.35, 3.89]	.763
	Strike	2.16	[.89, 5.4]	.092	1.71	[.60, 5.19]	.321	3.06*	[1.12, 8.92]	.033	1.36	[.48, 3.88]	.703
	Loss of consciousness	1.93	[.77, 5.34]	.177	1.98	[.61, 8.87]	.301	3.20*	[1.21, 9.15]	.022	6.77***	[2.37, 22.46]	<.001
	Received Imaging	2.63**	[1.29, 5.57]	.009	2.25	[.93, 6.07]	.085	3.63***	[1.73, 7.79]	<.001	4.82***	[2.22, 10.80]	<.001
Time post onset	1.00	[0.99, 1.00]	.332	1.00	[.99, 1.00]	.965	1.00	[1.00, 1.00]	.143	1.00	[.99, 1.00]	.216	

Note. *p ≤ .05. **p < .01. ***p < .001, OR= Odds Ratio, CI= Confidence Interval

CSST Utility Across Disciplines

Aim 1. Examine utility of the CSST in identifying individuals with mTBI referred for SLP services in comparison to other disciplines (i.e., physical therapy, occupational therapy, neuropsychology).

A linear regression was performed to compare the utility of the CSST in identifying individuals with mTBI for SLP referrals in comparison to PT, OT, and NP referrals. The CSST total score correlated with SLP, $t(72) = 3.522$, $p < .001$, PT, $t(98) = 5.009$, $p < .001$, OT, $t(47) = 3.33$, $p = .002$, and NP, $t(42) = 1.89$, $p < .001$. The odds ratios were greatest for SLP referrals, followed by PT, NP, and OT referrals (see Table 4 below).

Figure 2 presents the odds ratio comparisons amongst disciplines for each question asked on the CSST. The CSST total score showed the lowest correlation in directing referrals to each discipline (See table 4). Thinking of words (i.e., word finding) had a strong association with referral for PT services (OR=7.32, 95% CI: 2.82-22.92, $p < .001$). Remembering had a strong association with referrals for SLP services (OR=6.41, CI: 3.12-13.63, $p < .001$). When interpreting the p values, thinking of words, ($p < .001$), correlated with referrals to PT (OR=7.32, 95% CI: 2.82-22.92, $p < .001$) and NP (OR= 4.83, CI: 2.23-10.98, $p < .001$). Completing tasks, ($p < .001$), correlated with referrals to SLP (OR = 4.93, CI: 2.39-10.57, $p < .001$) and PT (OR= 3.11, CI: 1.39-7.13, $p < .001$). Maintaining energy exclusively correlated referrals to PT, (OR= 5.56, CI: 2.26-14.03, $p < .001$). Emotion only correlated with NP referrals (OR = 4.10, CI: 1.90-9.26, $p < .001$). Understanding Information only correlated with SLP services (OR= 3.74, CI: 1.87-7.72, $p < .001$). The CSST total score p-values had a significant correlation, ($p < .001$), for all disciplines (SLP (OR= 1.57, CI: 1.32-1.91, $p < .001$), PT (OR= 1.55, CI: 1.27-1.93, $p < .001$),

OT (OR= 1.39, CI: 1.17, 1.67, $p < .001$), and NP (OR= 1.45, CI: 1.20-1.78, $p < .001$) and odds ratio fell within a narrow range (see table 4).

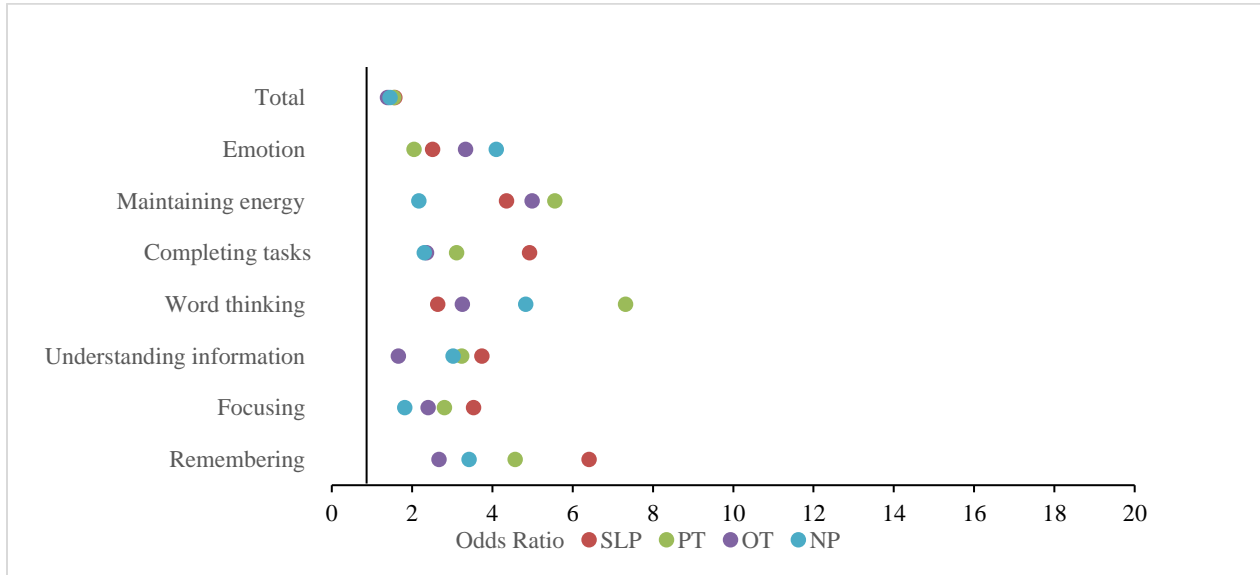


Figure 2

CSST Referral Patterns for All Disciplines

Note: The vertical axis is placed at an odds ratio of one, which indicates no relationship. The further to the right the circles are located, the greater the relationship and likelihood that the CSST question would result in referral for a particular discipline.

When interpreting the PCSS scores across disciplines, the PCSS cognition ($p < .001$) correlated with all disciplines. The PCSS Physical, Emotion, and Total scores ($p < .001$) correlated with SLP, OT, and NP referrals (see table 5). The PCSS Sleep correlated with SLP (OR= 1.15, CI: 1.07, 1.23, $p < .001$) and NP (OR= 1.11, CI: 1.03, 1.09, $p < .001$). The MoCA and SAC assessments had low correlation in referring to OT (OR= .80, CI: .63-.97, $p = .045$) and NP (OR= .78, CI: .61, .94, $p = .030$) and no correlation with SLP referral (OR= .83, CI: .64-1.02, $p = .114$) or PT (OR = .89, CI: .67-1.10, $p = .322$) referrals. The SAC exhibited a weak

correlation to exclusively SLP services (OR = .84, CI: .69-.99, p = .046). Of note, higher scores on the PCSS indicate more symptoms, whereas lower scores on the SAC indicate more difficulty completing cognitive activities. This means that odds ratios greater than 1 for the PCSS should be interpreted as higher scores aligning with increased odds of referral. In contrast, lower scores (poorer performance) on the SAC or MoCA would align with greater likelihood of referral.

Table 4

Relationship between the referral to SLP services in comparison to other disciplines.

	SLP			PT			OT			NP		
	OR	95%CI	p	OR	95%CI	p	OR	95%CI	p	OR	95%CI	p
Remembering	6.41***	[3.12, 13.63]	<.001	4.57***	[1.98, 11.37]	<.001	2.67**	[1.28, 5.76]	.010	3.42**	[1.56, 7.94]	.003
Focusing	3.53***	[1.64, 7.90]	.001	2.81*	[1.21, 6.51]	.015	2.40*	[1.04, 5.93]	.046	1.82	[.78, 4.53]	.200
Understanding information	3.74***	[1.87, 7.72]	<.001	3.24**	[1.38, 8.29]	.009	1.66	[.82, 3.39]	.159	3.02**	[1.42, 6.57]	.006
Thinking of Words	2.64**	[1.35, 5.30]	.005	7.32***	[2.82, 22.92]	<.001	3.25**	[1.58, 6.86]	.001	4.83***	[2.23, 10.98]	<.001
Completing tasks	4.93***	[2.39, 10.57]	0	3.11***	[1.39, 7.13]	<.001	2.36*	[1.11, 5.24]	.029	2.30*	[1.09, 5.59]	.041
Maintaining energy	4.35**	[1.82, 11.29]	.001	5.56***	[2.26, 14.03]	<.001	4.99*	[1.76, 17.96]	.005	2.17	[.94, 6.36]	.142
Emotion	2.51**	[1.28, 5.03]	.008	2.05	[.92, 4.83]	.085	3.33**	[1.62, 7.07]	.001	4.10***	[1.90, 9.26]	<.001
Total	1.57***	[1.32, 1.91]	<.001	1.55***	[1.27, 1.93]	<.001	1.39***	[1.17, 1.67]	<.001	1.45***	[1.20, 1.78]	<.001

Note. *p ≤ .05. **p < .01. ***p < .001, CI = Confidence Interval, OR = Odds Ratio

Table 5

Relationship between assessments with referrals to rehabilitation disciplines.

	SLP			PT			OT			NP		
	<i>OR</i>	<i>95%CI</i>	<i>p</i>	<i>OR</i>	<i>95%CI</i>	<i>p</i>	<i>OR</i>	<i>95%CI</i>	<i>p</i>	<i>OR</i>	<i>95%CI</i>	<i>p</i>
PCSS cognition	1.17***	[1.11, 1.25]	< .001	1.14***	[1.06, 1.23]	< .001	1.12***	[1.06, 1.18]	< .001	1.12***	[1.06, 1.19]	< .001
PCSS physical	1.10***	[1.06, 1.14]	< .001	1.07*	[1.03, 1.12]	.002	1.07***	[1.04, 1.11]	< .001	1.07***	[1.03, 1.10]	< .001
PCSS sleep	1.15***	[1.07, 1.23]	< .001	1.11*	[1.02,1.22]	.016	1.09*	[1.02, 1.17]	.008	1.11***	[1.03, 1.19]	. < .001
PCSS emotion	1.11***	[1.06, 1.18]	< .001	1.07*	[1.01,1.15]	.026	1.10***	[1.05, 1.16]	< .001	1.10***	[1.05, 1.17]	< .001
PCSS total	1.04***	[1.02, 1.06]	< .001	1.03**	[1.01, 1.05]	.001	1.03***	[1.02, 1.04]	< .001	1.03***	[1.02, 1.05]	< .001
MoCA	.83	[.64, 1.02]	.114	.89	[.67, 1.10]	.322	.80*	[.63, .97]	.045	.78*	[.61, .94]	.030
SAC	.84*	[.69, .99]	.046	.88	[.70, 1.07]	.213	.90	[.74, 1.09]	.270	.92	[.75, 1.14]	.447

Note. * $p \leq .05$. ** $p < .01$. *** $p < .001$

Role of Assessments in Determining SLP Dosage

Aim 2. Examine scores on standardized assessments of individuals who were referred for SLP care to determine if these predict dosage and length of SLP services.

A total of 81 participants were referred for SLP services. When contrasting the number of treatment sessions recommended to number of sessions received, SLPs were fairly well-calibrated, although participants were more likely to miss sessions rather than attend all recommended sessions. The majority of recommended number of sessions ranged from 6-11. This aligns with the typical 8-12 session recommendation SLPs typically give to their patients (Hardin et al., 2021). However, when looking at the actual number of sessions attended, most participants (38) attended 0-3 sessions with the next highest number of attending from patients (23) ranging from 3-6 sessions. Figure 3 represents the distribution of discrepancy between recommended and actual number of sessions attended. SLPs under recommended by one session 17% of the time. It is also important to note that consistently SLPs over recommended by 1-3 sessions 33% of the time (see Figure 3).

A linear regression was used to determine whether there was a relationship between CSST, RBANS, and BRIEF scores and the recommended dosage of SLP services ($M = 7.10$ sessions, $SD = 3.85$). The CSST proved to have a significant association with recommended dosage of sessions for SLP services, $t(72) = 3.52$, $p < .001$. The RBANS Total, $t(57) = -2.84$, $p = .0061$, RBANS Immediate Memory, $t(57) = -2.045$, $p = .0454$, and RBANS Visuospatial, $t(57) = -3.428$, $p < .001$, were also associated with recommended dosage of sessions for SLP services. Similarly, the BRIEF Behavioral Regulation, $t(67) = 2.415$, $p = .0185$, and Meta-cognition, $t(67) = 3.384$, $p < .001$, subscales were associated with recommended dosage of SLP sessions, but the Global Executive Function subscale was not (see Table 6 for summary of results). The greatest

amount of variance in recommended dosage was explained by the RBANS Visuospatial subscore (15.6%) followed by the CSST total (13.5%).

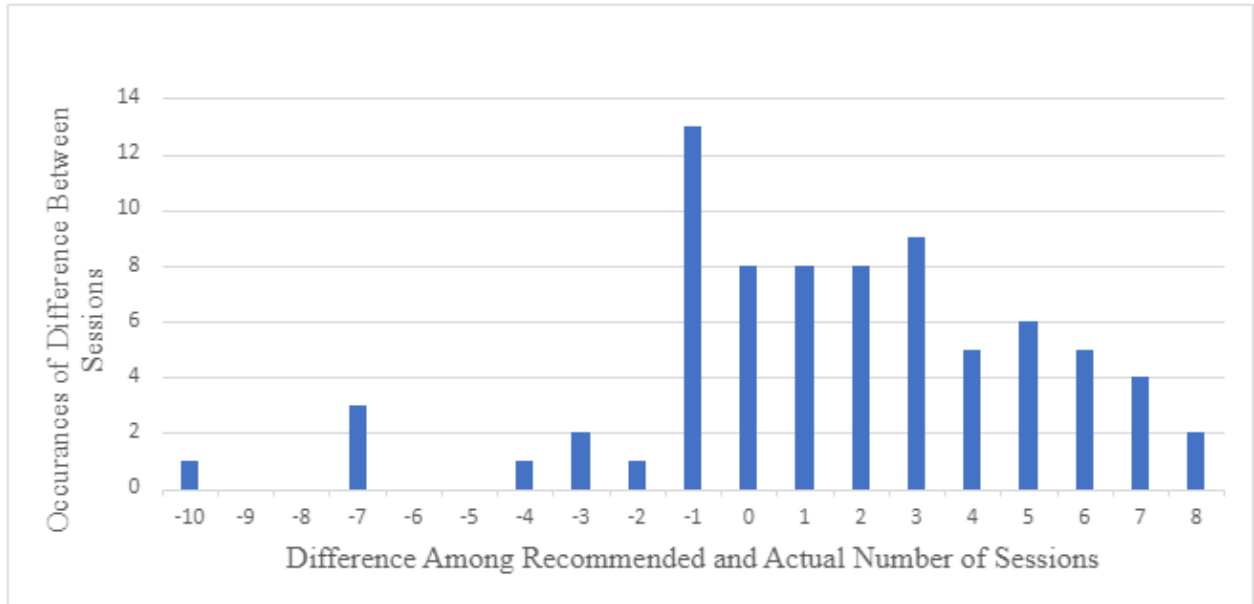


Figure 3.

Histogram of Distribution of Difference Between Recommended and Actual Number of Sessions

Note: The x-axis depicts the difference between the recommended number of SLP sessions and the actual number of sessions attended. The y-axis represents the difference between sessions recommended and sessions completed, calculated as the recommended number of sessions minus the actual number of sessions. Positive values represent that the participant attended fewer sessions (missed more sessions) than were recommended. The negative values indicate that the person attended more sessions than the recommended dosage.

Table 6.

Results of Linear Regression Analysis for Recommended Number of SLP Sessions in Comparison to Actual Number of Sessions Attended

	Recommended Dosage			Actual Sessions Attended		
	<i>t</i>	<i>p</i>	<i>R</i> ²	<i>t</i>	<i>p</i>	<i>R</i> ²
CSST Total	3.522	<.001***	.135	4.982	<.001***	.234
RBANS Total	-2.840	.006**	.109	-.608	.54	-.011
RBANS Attention Index	-1.965	.054	.047	-1.531	.131	.022
RBANS Delayed Memory	-1.691	.096	.031	.399	.691	-.012
RBANS Immediate Memory	-2.045	.045*	.052	-.287	.775	-.015
RBANS Language	-1.488	.142	.021	-.021	.983	-.019
RBANS Visuospatial	-3.428	<.001***	.156	-1.115	.269	.004
BRIEF Behavioral Regulation	2.415	.018*	.066	1.746	.0853	.0284
BRIEF Meta-Cognition	3.384	<.001***	.133	3.123	.003**	.111
BRIEF Global Executive Function	1.817	.074	.033	1.894	.062	.036

Note. **p* ≤ .05. ***p* < .01. ****p* < .001

Number of SLP Sessions Attended by Participants

In terms of actual number of SLP sessions attended, the CSST again was associated with the actual number of SLP sessions attended ($M = 4.95$ sessions, $SD = 3.62$), $t(77) = 4.982$, $p < .001$. In contrast to recommended dosage, the variance in actual sessions attended explained by the CSST almost doubled to 23.4%. The BRIEF Meta-cognition index, $t(69) = 3.123$, $p < .001$, was also associated with the number of SLP sessions attended by participants, explaining 11.1% of the variance. No other test or subtest was associated with the number of actual sessions attended by participants.

CHAPTER 4

Discussion

The purpose of this study was to examine the utility of standardized objective and subjective assessments (PCSS, MoCA, and SAC) as well as a new 7-item assessment of cognitive, communication, and emotional function following mTBI, the Cognitive Symptom Screening Tool (CSST; O'Brien et al., in prep; see Appendix A) in predicting rehabilitation needs of people with mTBI. We examined the predictive value of these assessments in identifying individuals with mTBI referred for SLP services against other disciplines (i.e. physical therapy, occupational therapy, and neuropsychology), finding that the CSST identified the need for SLP services, but also correlated with the need for PT and OT services. This study also looked at patient information (time post injury, mechanism of injury, age, gender, etc.), finding that several injury characteristics were associated with increased likelihood for rehabilitation. In addition, we analyzed scores from the RBANS and BRIEF of individuals who were referred for SLP care to compare the dosage and length of SLP services recommended to the number of sessions attended by the participants. The RBANS Total Score, RBANS Immediate Memory, and RBANS Visuospatial scores exclusively correlated with SLP services. Among the RBANS subtests the Visuospatial subtest had the strongest relationship to SLP services, followed by the CSST. The CSST and BRIEF Metacognition also had strong relationships to the number of actual sessions, with the CSST predicting 23.4% of the variance in number of SLP sessions attended. These results suggest that the CSST may be useful both in

predicting who may benefit from SLP services following mTBI, as well as informing their overall course of care, particularly in regard to dosage.

Aim 1

For Aim 1 we examined the utility of the CSST in predicting referrals for SLP services when compared to other disciplines. The CSST Total Score was associated with referral for SLP services. However, the CSST was also related to the need for other disciplines outside of speech therapy (i.e., PT and OT). The CSST assesses for cognitive-communication and emotional regulation problems after mTBI (CSST; O'Brien et al., in prep; see Appendix A). However, there may be other factors or phenotypes that contribute to the participant's concerns and influence their answers as they complete the CSST. As mentioned previously, participants could have co-occurring phenotypes characterized by cognitive, ocular-motor, vestibular, or cervical (Collins et al., 2014; Kontos et al., 2019) symptoms that would result in referral to PT and/or OT. For example, participants may have been experiencing cognitive symptoms comorbid with ocular-motor symptoms preventing them from task and assignment completion. This would suggest the need for SLP and OT referral. Because concussion symptoms rarely occur in isolation, the occurrence of multiple phenotypes in an individual is common (Kontos et al., 2019).

The "Staying Focused," "Remembering Things," "Understanding Information," and "Completing Tasks and Assignments" items on the CSST had the highest association in directing referrals for SLP services. Therefore, if a patient answered yes to difficulties with any of these items, then there was a strong chance that the patient would be referred for SLP services. Each question item on the CSST measures elements of cognitive reasoning that are associated with the

executive abilities of attention, memory, and executive function (i.e. inhibition, planning, organization, etc.; Jurado & Rosselli., 2007).

In regard to attention, attention may be quantified by intensity or selectivity. This can be explained as a person consciously making an effort to initiate one task, and how the individual can selectively stay focused on the task or withdraw from the task. (Chan, 2001). Patients with mTBI often struggle to maintain or appropriately allocate their attentional resources while performing one or more tasks (Haltermann et al., 2006). The “Staying Focused” question on the CSST specifically targets this difficulty experienced with attention. Sustained attention is the ability to focus on a stimulus over a long period of time. Sustained attention represents a basic attentional function that recruits the efficacy of the “higher” aspects of attention (i.e., selective and divided attention; Chan, 2001). In addition, attending to a task requires the capacity to select which stimuli to attend to and which stimuli is irrelevant and should not be attended to (inhibition) (Rosenberg et al., 2016). Attention also allows for more complex cognitive activities, such as decision making, troubleshooting, sequencing, and managing unfamiliar tasks (Howell et al., 2013). SLPs can provide strategies to help with the allocation of limited attentional resources (Kurland, 2011). The strategies can help individuals modify situations that may result in a heavy cognitive load and minimize distractions to remain focused to complete a task (Cornis-Pop et al., 2012; Rees et al., 2007).

On the CSST, if a patient answered yes to difficulties with “Remembering,” then there was the strongest chance that the patient would be referred for SLP services. Studies show that information processing speed may be the most prominent function to be affected after mTBI (Johansson et al., 2009), and that information processing speed has an important influence on higher order cognitive functions such as working memory and episodic memory (Deluca &

Kalhmar, 2007). The accurate processing and recall of information requires appropriate encoding and retrieval of stimuli (Gallagher & Azuma, 2018) that plays a role in remembering, understanding information, and completing tasks. These processes are associated with the prefrontal cortex, an area commonly affected by mTBI (Stuss, 2011). To successfully encode information, cognitive reasoning is associated with the executive abilities of attentional control, planning, cognitive flexibility, and verbal initiative to ignore unimportant details and plan, initiate, execute, and complete the task (Jurado & Rosselli., 2007). The same cognitive processes are functioning when processing and encoding communicative information. These information processing, encoding, and retrieval impairments may have important implications for functional memory performance. Given that accurate encoding and retrieval of information is a critical skill in both professional and social settings, any memory retrieval impairment could have wide-ranging consequences (Gallagher & Azuma, 2018). Training from SLPs on internal (e.g. mnemonics, repetition, visual imagery) (O’Neil-Pirozzi, Kennedy & Sohlberg, 2016) and external (Rees et al., 2007) (e.g. calendars, notebooks, apps) memory aids can decrease the demand on the impaired memory processes to improve an individual’s functional memory skills (Cornis-Pop et al., 2012; Hardin & Kelly, 2019).

For the item, “Understanding Information,” the central executive also plays an essential role in understanding information in occupational and social settings. After mTBI, individuals may require more cognitive resources when comprehending information auditorily or visually (Wasserman et al., 2016). Deficits in this domain can present as difficulty understanding material (Norman, Shah & Turkstra., 2016) and/or difficulty understanding social communication (Honan et al., 2015). Auditory working memory, information processing, and reasoning is required to comprehend information. When stimuli are presented auditorily the brain will store the sounds

and begin to code the individual parts of the information (Arnott et al., 2005). Cognitive reasoning analyzes and perceives abstract information, arranging the information into a logical order (Krawczyk et al., 2010). When there is a breakdown in information processing, treatment should focus on coping strategies to reduce stresses from environmental factors (Collins et al., 2014), as well as target the underlying cognitive functions that impact processing speed (e.g., attention) (Cornis-Pop et al., 2012; Cicerone, 1996).

The item “Completing Tasks” reflects the most clearly executive skill on the CSST. One executive ability used for task completion is task shifting. Task shifting (i.e. attention shifting), involves flexibly switching attention and cognitive control back and forth between multiple relevant tasks (Miyake et al., 2000; Monsell, 2003). The individual organizes the task into multiple parts and an individual’s inhibition ignores extraneous information to help the individual complete the task efficiently (McAlister & Schmitter-Edgecombe, 2016). Lastly, the individual must monitor incoming information for task-relevance and evaluate their own performance to know when they have successfully completed the task (Miyake et al., 2000). When individual’s have difficulty with their executive functioning, intervention will typically target metacognition and problem solving. This will include strategies and explicit instruction with a gradual shift to internalization of self-regulation strategies through self-instruction and self-monitoring (Cornis-Pop et al., 2012). This is due to impaired self-regulation and executive functions manifesting in individuals as difficulty initiating, inhibiting, shifting, and adjusting, as well as overconfidence or under confidence in beliefs of their skills (Kennedy & Coelho, 2005). Therefore, in these cases, patients will benefit from skilled SLP services to strengthen and provide strategies for cognitive functioning to improve outcomes in functional contexts (Hardin & Kelly, 2019; Sohlberg & Mateer, 1989).

In contrast, and unexpectedly, the word retrieval item on the CSST had the highest association with referral for PT services, meaning, when a patient answered “yes” to experiencing difficulties with word retrieval, they had an increased chance of receiving a referral to PT services. Word retrieval is the process of finding the correct terminology for an object, picture, orthographic representation, or cognitive representation, in which a person converts the initial concept to a lexical version. (King et al., 2006). Word retrieval is a basic process in communication; a deficit in this area may significantly impact an individual's overall communicative ability. Therefore, typically, the assessment and treatment of word retrieval deficits is under SLP's scope of practice. From the data available, it is unclear why there would be such a strong association between word finding and PT referral, but it may be that this was a common symptom related to other, PT domains of practice. For example, there is also a relationship between information processing and fatigue (Johansson et al., 2009), and maintaining energy throughout the day was the most frequently endorsed item on the CSST. Fatigue following concussion may be managed by PT, so that there may be an indirect relationship between PT referral and difficulty with word retrieval that is mediated by fatigue (Marcora et al., 2009; Abd-Elfattah et al., 2015). In general, fatigue may underlie a broader spectrum of primary or secondary symptoms (i.e. cognitive/fatigue, vestibular, ocular, posttraumatic migraine, anxiety/mood, cervical) (Kontos et al., 2019), which was perhaps reflected in the fact that across all disciplines and the entire sample, PT was the most often recommended service for people with mTBI (see Figure 4).

It should also be noted that many people reporting problems with thinking of words were also referred for SLP services. Across the entire sample, 48% (n = 68) of all participants responded “yes” to having word retrieval difficulties. Of that 48% that expressed word retrieval

difficulties, 91% (n = 62) were referred to PT and/or SLP services. Of that subgroup, 76% (n= 47) were referred to both PT and SLP services. Additionally, 23% (n = 14) were referred for only PT services, and .78% for SLP services only (n = 1; see figure 5). Overall, though, future work will have to determine the interactive impacts of concussion symptomatology on communication, and how such communication problems may, in fact, indicate need for interdisciplinary care.

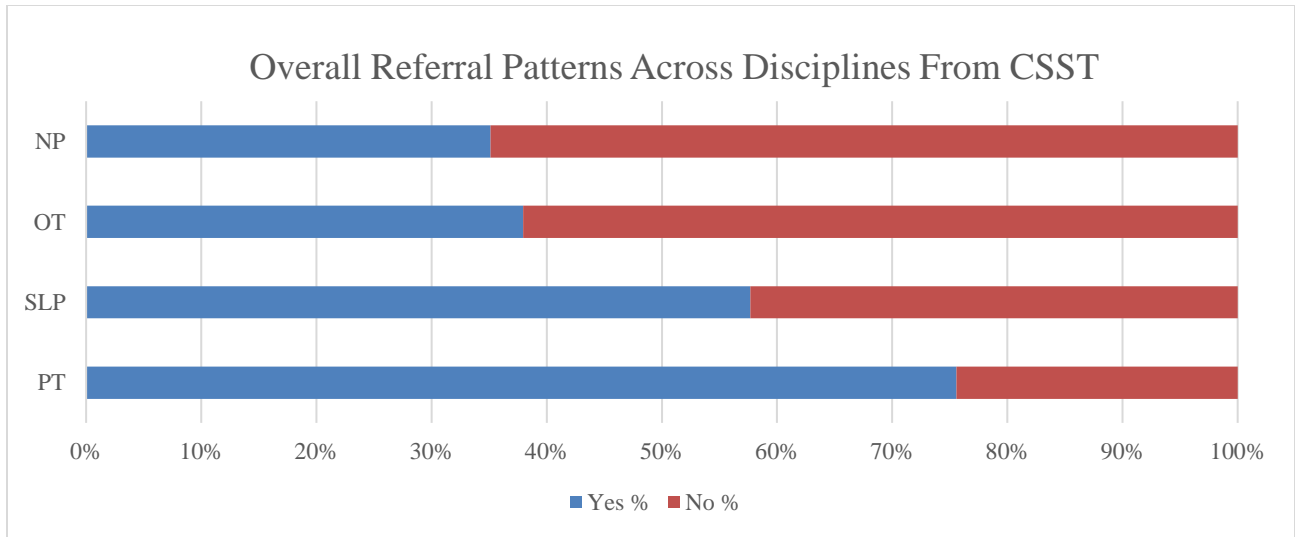


Figure 4.

Overall Referral Patterns Across Disciplines From CSST. This figure compares the overall referral patterns for NP, OT, SLP, and PT after participants completed the CSST.

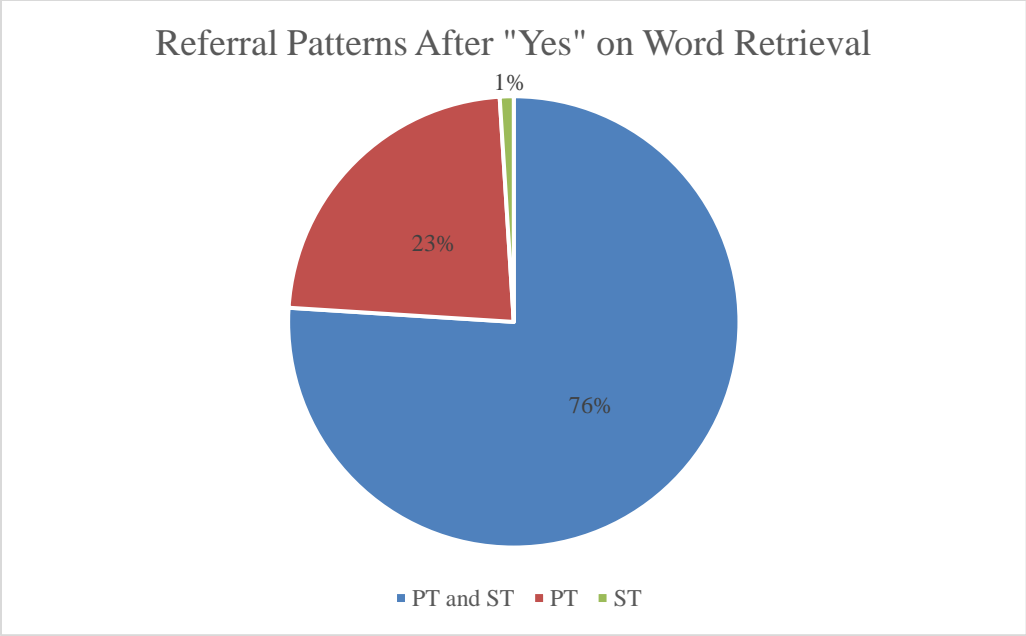


Figure 5.

Referral Patterns After “Yes” on Word Retrieval.

The PCSS and SAC were both associated with referral for SLP services, whereas the MoCA was not. PCSS scores were close to 1, meaning little adjustment in likelihood of referrals as symptoms increased. On the PCSS, a high score indicates greater symptomatology. In contrast, higher scores on the SAC are indicative of more preserved function. Thus, the SAC had odds ratios of less than 1, meaning that as scores decreased, likelihood of referral to SLP increased. However, similarly significant associations between these tools and referrals for rehabilitation services were demonstrated across all disciplines, with remarkably similar odds ratios. Therefore, these tools may have limited utility in directing referrals. Overall though, across measures, remembering things, difficulty completing tasks, understanding information, and staying focused from the CSST along with lower SAC scores may provide the most sensitive information when used in combination to provide direction to SLP referrals.

Aim 2

All participants who were referred for SLP services (n = 81) received the RBANS and BRIEF assessments. For Aim Two we examined the RBANS, BRIEF, and CSST in predicting the recommended as compared to actual dosage of SLP services. Overall, SLPs were reasonably well-calibrated to their client's needs, although they were more likely to over-recommend by a few sessions than under-recommend the number of sessions required to meet goals and move towards discharge. In terms of recommended dosage, the RBANS Visuospatial subscale explained the most variance followed by the CSST total score and the BRIEF Meta-cognition subscale score. The RBANS Visuospatial subtest requires participants to copy a multipart geometric figure, while the figure remains on display. This task involves visual alternating attention which is the ability to shift between the geometric figure on the test booklet and the copied geometric figure, while also using scanning to record all the details of the image in an organized and thorough manner (Raymond et al., 1996). The second part of the subtest requires participants for ten trials to identify and match two lines to a separate image of 13 equally distributed lines organized in a semicircle fan shaped pattern. This task requires individuals to use their sustained attention and short-term memory to recall the lines that were shown in the original geometric figure. This task also requires visual memory (the ability to visually process stimuli, store them in memory and retrieve that information) and pattern recognition (the ability to identify salient features of an object) (Raymond et al., 1996). The RBANS Visuospatial task requires multiple cognitive processes, and therefore, the findings may suggest that the RBANS task more closely relates to memory and attention rather than visual processing alone.

When these cognitive processes are intact they will facilitate information processing with cognitive functions such as spatial reasoning, visual memory, and perceptual constancy

(Raymond et al., 1996). However, the RBANS Visuospatial task can show common symptoms reported in individuals with mTBI. These symptoms can consist of the inability to attend to critical features, difficulty in sustaining gaze on specific objects or features, inability to organize unstructured information, and poor attention (Raymond et al., 1996). Sohlberg and Mateer (1989) proposed a model of visual processing incorporating the functions of the brain that are primarily important to SLPs. In Sohlberg and Mateer's model the temporal lobe is responsible for object and facial recognition based on experience and memory; the frontal lobe is responsible for the high-level planning of movements in relation to spatial positions of objects and some aspects of visual memory (Raymond et al., 1996). Elements of the visual processing model are reflected in Baddeley and Hitch's (1994) working memory model. Together, these models comprise the basis of the RBANS visuospatial task.

Baddeley and Hitch's working memory model comprises of systems specialized for the temporary retention of verbal and visuospatial material on short-term memory tasks. The model incorporates the central executive, a limited-capacity and flexible system with responsibility for attentional control, high-level processing activities, and the coordination of activities within working memory (Archibald & Gathercole, 2006). The attentional control limits the information that is allowed into the working memory (Adams et al., 2018). An individual's attention must be directed towards a stimulus that is distinctive from the background in the environment. This focus of attention can also be directed by the central executive, allowing it to pick up more abstract, semantic information voluntarily that can integrate representations within all subsystems of working memory to create a memory (Adams et al., 2018). Within the working memory model, the storage demands of complex memory span depend on appropriate

subsystems, with processing supported principally by the central executive (Baddeley & Logie, 1999; Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002).

Along with the RBANS Visuo-spatial task, the BRIEF Meta-cognition subtest also proved to have a strong relationship in determining the recommended dosage of SLP sessions. The BRIEF questionnaire requires participants to complete a self-report on their perception of their emotional control, self-monitoring abilities, working memory, and executive function. In particular, the BRIEF Metacognition Index reflects an individual's ability to initiate, plan, organize, self-monitor, and sustain working memory. In contrast, the BRIEF Behavioral Regulation Index was also related to recommended dosage, but explained just under 3% of the variance, suggesting limited value despite the statistically significant association. The BRIEF Behavioral Regulation index rate an individual's ability to shift cognitive set and modulate emotions and behavior via appropriate inhibitory control. The index is composed of the inhibit, shift, and emotional control scales. Intact behavioral regulation is typically a precursor to appropriate metacognitive problem solving and appropriate self-regulation (Isquith et al., 2008). However, it may be that needs following concussion that require SLP services are more likely to be reflected in the more complex metacognitive tasks captured by the subscale. It seems that characteristics of concussion that SLPs view as being associated with more or fewer SLP sessions are represented in the RBANS Visuospatial subscale, the BRIEF Meta-cognition subscale, and the CSST.

In contrast, the CSST had the strongest relationship with actual dosage of SLP services, explaining 23% of the variance in number of sessions attended before discharge from care. This provides value to SLPs when determining care, since SLPs tend to overestimate the number of sessions an individual will need. The CSST question items all target varying cognitive processes,

allowing for repetitive opportunities throughout the questionnaire for a patient to suggest a problem. This variability shows that when looking at all factors that contribute to a patient attending sessions, the CSST provides useful information in estimating the dosage of services an individual will need. The BRIEF Metacognition subscale continued to be related to actual number of sessions as well, explaining 11% of the variance in number of treatment sessions. The CSST total score alone is best to explain the variance in actual number of ST sessions attended. However, if used in combination with the BRIEF Metacognition subscale, these assessments could provide an optimal model for the recommendation of sessions for SLPs.

Limitations and Future Directions

The sample for this study was recruited from a single specialty clinic. Therefore, the population resided in similar geographic locations with access to potentially similar resources to attend the specialty clinic. This could serve as a limitation, because most participants were more educated and were currently employed or in school. When looking at the sample, almost half of the participants had history of previous concussion. This could have contributed to the participants willingness to attend the complex concussion clinic. Since the participants willingly sought out the clinic, they may have been predisposed to having a more complicated recovery. This may not be representative of mTBI generally, and why there was no positive correlation between history of concussion and referral for services. However, this may provide useful information on the predisposition of those who may require rehabilitation services.

Regarding testing, this study may be limited due to the SLP specific assessments only given if a person was originally referred to an SLP after seeing the physician. The test the physicians administered, and the physicians' own biases could have played a role in a participant

being referred for any of the services. Other, more qualitative responses could have influenced referral patterns; for example, a patient may have described difficulty in school, problems with writing papers, organizing ideas, or keeping up with work that triggered referral to the SLP irrespective of assessment results. Without being in the room with the physician and patient during the appointment, the data may not fully account for what directed the physicians' referral choices. As described in our results, much of the testing had low specificity to SLP services, so physicians may have relied on their clinical judgment in combination with the patient interview to determine referral decisions. Future research should consider other sources of variability (e.g. among questions, physician bias, clinical interview, etc.) in referral patterns to each discipline.

Along with this limitation, there may have also been limitations in the measures used for comparison. The BRIEF self-report was used during testing. For individual's with mTBI there may be heightened levels of self-awareness, in comparison to individuals with moderate to severe TBI. This could cause discrepancy between what the individual views as having changed about themselves and what others perceive as changed. Donders & Strong (2016) found that on average, individuals with mild TBI self-rated about a half standard deviation higher reflecting worse perceived functioning than when compared to other reports. Although an individual's biases could play a role in their self-report, this suggests that an individual with mTBI may be more aware of their executive function changes post injury, even as others perceive little change from baseline. The BRIEF was normed with individuals with ADHD, multiple sclerosis, and TBI. Although there is research supporting the use of BRIEF with mTBI (Donders & Strong, 2016), it is unclear the severities of TBI included in the BRIEF normative testing when determining validity.

Conclusion

Identifying appropriate rehabilitation needs after mTBI is imperative for successful treatment and recovery following mTBI. This evidence suggests that in comparison to other measures (i.e. PCSS, MoCA, SAC) the CSST may be useful in both directing referrals for SLP services as well as determining dosage. Using suitable assessment measures will have direct implications on the level of care patients receive. In addition, the assessment measures used by SLPs (i.e., RBANS and BRIEF) also appear to provide useful information in determining treatment plans. Future research may continue to determine the validity of the CSST in accurately identifying referral patterns. In particular, such research may examine why certain communication items were highly associated with services other than speech therapy (e.g., word retrieval and PT) and determine if patterns of responses are more specifically associated with each discipline. SLPs play a key role in the identification and treatment of cognitive communication deficits after mTBI that affect individual's performance in academic, occupational, and social settings. Therefore, there is a need for continued study on the use of tools in directing SLP care and services following mTBI to positively impact the management of impairment and patient successes.

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Appendix A. Cognitive Symptom Screening Tool.

Initial Appointment Questionnaire

Date: _____

For the following questions, please check what best represents your **CURRENT** level of functioning compared to before your injury. Be sure to consider your functioning at home, school, work, or in the community.

	Worse	Same	Better
1. Remembering things	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Staying focused	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Understanding information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Coming up with the right words	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Completing tasks or assignments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Maintaining mental energy throughout your day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Managing emotions throughout your day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>