THE IMPACT OF mTBI ON WORD-FINDING ABILITY IN YOUNG ADULTS

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Communication Sciences and Disorders to the Office of Graduate and Extended Studies of East Stroudsburg University of Pennsylvania

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ABSTRACT

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Communication Sciences and Disorders to the Office of Graduate and Extended Studies of East Stroudsburg University of Pennsylvania.

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Cognitive and linguistic deficits have been found to be present in individuals in the subacute phase of mild traumatic brain injury (mTBI). The present study compared word-finding performance between young adults without a history of mTBI and those with a history of mTBI in the post-subacute phase of injury and examined the relationship between the number of incidents of mTBI and word-finding performance. The Test of Adolescent/Adult Word Finding-Second Edition, Brief Test (TAWF-2, BT) was administered to 33 age and gender matched participants (N=17 mTBI; N=16 controls) to assess word-finding based on timing and accuracy. Participants were divided into four groups based on the number of mTBIs they had experienced in their lifetime from 0 to 3+. There was no significant difference in TAWF-2, BT performance for participants with or without a history of mTBI, regardless of the number of mTBI experienced, in the post-subacute phase of injury.

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER I:

INTRODUCTION

Mild Traumatic Brain Injury (mTBI)

Traumatic brain injury (TBI) is a serious, acquired injury that results in damage to the brain's normal function. TBI may occur if the head experiences a sudden, intense collision with an object or if an object penetrates the skull and brain tissue. Causes of TBI include falls, motor vehicle accidents, and sport- or recreational-related accidents (Centers for Disease Control and Prevention, 2019). There are approximately 2.8 million new cases of TBI in the United States each year. It is estimated that 5.3 million individuals live with a TBI-related disability in the United States (Centers for Disease Control and Prevention, 2015). TBI can be characterized as mild, moderate, or severe, depending on the degree of the symptoms. Nearly 75% of TBIs that occur each year are mild (Centers for Disease Control and Prevention, 2003). An individual that has suffered from a mild TBI (mTBI), commonly referred to as a concussion, may remain conscious or experience a brief loss of consciousness for several seconds or minutes. Symptoms of mTBI include headache, confusion, nausea, dizziness, blurred vision, sensitivity to light

and/or noise, fatigue or drowsiness, changes in sleep patterns, changes in mood or behavior, and difficulty with memory, concentration, or thinking (Centers for Disease Control and Prevention, 2019). Recovery phases of mTBI symptoms are hyperacute, occurring within one hour of injury (Ganti et al., 2014), acute, manifesting hours to days following injury, and subacute, occurring weeks post-injury (Mayer et al., 2017).

Cognitive Impacts of mTBI

Many individuals with a history of a single mTBI will continue to demonstrate significant impairment in various cognitive areas including executive function, memory, attention, and processing speed long after the initial injury (McInnes et al., 2017). Episodic memory and executive processes associated with encoding, storage, and retrieval, together with strategy formulation, have been found to be the main altered cognitive functions in individuals with a history of a single mild to moderate TBI more than one-year post-injury (Miotto et al., 2010). On the other hand, multiple mTBIs can result in cumulative damage to an individual's brain. This can be identified through electrophysiological measures, such as event-related potentials, of brain function (Gaetz et al., 2000). Multiple mTBIs are associated with more severe symptoms than single incident mTBIs and slower recovery of neurological function after subsequent incidents (Centers for Disease Control and Prevention, 1997; Covassin et al., 2013; Guskiewicz et al., 2003; Institute of Medicine and National Research Council, 2014; Slobounov et al., 2007). Individuals with a history of multiple mTBIs demonstrate worse performance on neuropsychological tests, in the areas of attention, visual memory, and working memory, than those with a history of a single mTBI. Individuals in the acute phase of recovery with a history of three or more mTBIs take longer to recover verbal memory and have

slower reaction times than those with a history of one or no previous mTBI (Covassin et al., 2013). Enduring effects of mTBI, such as mild reductions in attention and mental processing speed and persistent symptoms similar to individuals in the acute phase of mTBI recovery, have been documented in young adults with multiple incidences of mTBIs who are no longer in the acute phase of recovery (Moser & Schatz, 2001).

Language Impacts of mTBI

The frontal and temporal lobes of the brain are involved in encoding, storage, retrieval of information, and information processing speed. Right and left frontal-temporal and left parietal-occipital lesions due to history of a single mild-to-moderate TBI may result in impaired word-finding, nominal verbal fluency, and reduced information processing speed (Miotto et al., 2010). Language deficits may reveal an interaction with reduced cognitive abilities (Stockbridge & Newman, 2019). Individuals that have suffered from one or more mTBIs demonstrate reduced mental processing speed, which likely plays a role in cognitive-linguistic performance (Stockbridge & Newman, 2019; Norman et al., 2019). Adequate mental processing speed is critical for daily language tasks, such as word-finding, which contributes to conversational success (Norman et al., 2019).

Word-Finding Deficits

Impaired word-finding is a frequently reported language deficit resulting from mTBI (King et al., 2006; 2006). Word-finding is defined as the "process of finding the correct terminology for an object, picture, orthographic representation, or conversation in which a person converts the initial conception to a lexical version" (Walker et al., 2006). Word-finding difficulties may be described by a variety of terms, such as problems getting

words out, using jumbled words, complaints of a reduced vocabulary, frequently experiencing *tip-of-the-tongue* phenomenon, or overlapping difficulties with word-finding and message-planning in conversations, all of which could indicate a general deficit in accessing stored lexical representations (Popescu et al., 2017). Individuals that have suffered from a single moderate or severe TBI demonstrate reduced efficiency in the ability to access feature information in the subacute phase of recovery, despite the presence of intact semantic knowledge, but this is not specific to mild forms (McWilliams & Schmitter-Edgecombe, 2008). The inability to access and integrate features may interfere with activation of a semantic memory and its associated word representation due to multiple incidents of mTBI (Fratantoni et al., 2017). Previous research has revealed that individuals in the subacute phase of single and multiple incidents of mTBI exhibit lower accuracy rates during completion of word-finding tasks (Norman et al., 2019).

Efficient word-finding is necessary for performance of activities of daily living, and even mild deficits can impair communication in the work environment, academic setting, and during social interactions (Fratantoni et al., 2017). According to data from the Colorado TBI registry, which includes all individuals hospitalized with TBI in that state, approximately 50% of those who suffered from a severe TBI failed to return to work at one-year post injury, and 20% of those who suffered from mTBI were unemployed (Whiteneck et al., 2001). Therefore, many individuals with a history of mTBI who may struggle with word-finding, an important skill for most high-level tasks in the workplace, may experience the negative effects of this deficit in their daily lives.

CHAPTER II:

LITERATURE REVIEW

The purpose of this literature review is to provide an overview of the existing body of literature regarding the impact of mTBI on word-finding ability in young adults in the post-subacute stage of recovery. A search was conducted of the following EBSCOhost databases: Academic Search Ultimate, Google Scholar, Journal of the American Medical Association (JAMA), MEDLINE Complete, PubMed, and Psychology and Behavioral Sciences Collection. Inclusion criteria required that studies be empirical and peer-reviewed, utilize individuals 18-24 years of age with a history of single or multiple mTBIs, and evaluate word-finding ability in the subacute or post-subacute phase of recovery. Five journal articles met these criteria, and 27 did not meet these criteria. The following search terms were used: mTBI, brain injury, concussion, word-finding, word retrieval, naming.

Barrow et al. (2006) investigated confrontation-naming latency and accuracy using pictures. Participants included 24 adults 18-53 years of age with mTBI examined within one-week post-injury and 24 age matched controls. Participants were presented

with 72-line drawings that were divided into three sets of 24 pictures to correspond to a picture vocabulary age of 3 years or below, 4-7 years of age, and 18 years or older. The picture stimuli were presented on a computer with prompts given to the participant to attend to the stimulus. Participants were asked to speak the name of the pictures as quickly as possible. The task examined latency and accuracy for word-finding ability under speeded conditions. A three-factor mixed analysis of variance (ANOVA), with one between and two within subject variables, was conducted to determine the effects of vocabulary level, category, and group on naming latency. The analysis revealed that the mTBI group demonstrated significantly slower response latencies than the control group ($F(1, 46) = 11.90$, $p < 0.001$), and both groups demonstrated slower response latencies as vocabulary level increased ($F(2, 92) = 103.50$, $p < 0.001$). A three-factor mixed ANOVA, with one between subject and two within-subject variables, was conducted to investigate the effect of vocabulary level, category and mTBI on picture naming accuracy. The analysis revealed statistically significant main effects of group ($F(1, 46) = 11.10$, $p = 0.002$), vocabulary level ($F(2, 92) = 20.65$, $p < 0.001$) and category ($F(1, 46) = 6.99$, $p = 0.011$). A significant two-way interaction of vocabulary level by group ($F(2, 92) = 3.27$, $p = 0.043$) was found. The mTBI group exhibited significantly more difficulty with naming and had even greater difficulty than the control group as vocabulary level increased.

Norman, Shah, and Turkstra (2019) studied reaction times and error rates on a category-naming task. Twenty adults with mTBI ages 18-55 were compared to age- and education-matched adults with orthopedic injury (OI). Participants were tested in the sub-acute phase of recovery, 3–12 weeks post-injury. Participants viewed 120 pictures and named one other item belonging to the same category as the picture in view. Pictures

were presented in speeded and unspeeded conditions. The picture stimuli were manipulated by presentation time, stimulus category, and vocabulary difficulty. It was hypothesized that participants in the mTBI group would demonstrate longer response times and a greater number of errors than those in the OI group when given a category-naming task. Repeated measures ANOVA with main effects of group and condition on response time and overall accuracy were performed. Results revealed a significant effect of condition on response time for both groups ($F(1,39) = 58.05$, $p = .00$, $\eta^2 = .04$), where speeded conditions had faster response times and more errors than the unspeeded conditions. Regarding accuracy, participants in the mTBI group had significantly more errors than participants in the OI group ($F(1,39) = 1.75$, $p = .09$, $\eta^2 = .04$). Participants with mTBI demonstrated more errors than the OI group in both speeded and unspeeded conditions, but this difference was not statistically significant. In both groups, most errors occurred in the unspeeded condition.

Stockbridge and Newman (2019) examined narrative performance and discrete cognitive-linguistic skills in isolation in those who had experienced one or more mTBIs. The study included a total of 81 participants ages 12-40 years old, including 58 individuals with a history of at least one mTBI (most recent was nearly 5 years previous) and 23 individuals without a history of mTBI. Those with a history of mTBI reported an average of 3 mTBIs in their lifetime. Participants completed language and cognitive tasks and surveys online. They were asked to produce two written narrative samples: a retelling of Cinderella (supplemented by pictures of key events) and a retelling of a short video titled “Pigeon: Impossible” immediately after watching it. The narrative samples were analyzed for general all-purpose (GAP) verbs that could have indicated underlying

language deficits. It was hypothesized that individuals with a history of mTBI would show deficits in complex writing. Participants with a history of mTBI had difficulty providing key content when presented with a novel video and asked to provide a summary. Individuals with a history of mTBI used a greater proportion of GAP verbs than individuals without a history of mTBI, which approached significance based on an independent-samples *t*-test, $t(77) = 1.85$, $p = .07$ (two-tailed). This finding indicates that these individuals may have been experiencing word-finding difficulties, since GAP verbs are non-specific high-frequency words. During a confrontation naming task, participants read a series of 20 definitions and provided the word that best fit the definition as quickly as possible. Results indicated that individuals with a history of mTBI performed similarly to individuals with no mTBI on tasks that targeted this single skill. These findings suggest that individuals with a history of multiple mTBIs may continue to experience deficits in cognitive and linguistic skills required for written narratives long after injury. However, no significant difference was found in naming abilities between the two groups.

King et al. (2006) examined the differences in standard scores and error types during word-finding in naming and discourse tasks. Ten participants with mTBI and 10 age, gender, and education matched controls (Age mean = 28.813, SD = 8.138) were included in the study. Participants with mTBI were tested in the acute phase of recovery, ranging from 2 to 14 days post-injury. All participants were administered the Test of Word Finding in Discourse (TWFD; German, 1991) and a computerized version of the Test of Adolescent/Adult Word-Finding (TAWF; German, 1990). The TAWF assesses word-finding skills in various contexts, and the TWFD consists of three pictures that are

presented in order to obtain a narrative discourse sample. Data was analyzed between both groups on the TAWF and TWFD using a repeated measures ANOVA. Additionally, an independent samples *t*-test was performed to measure the significance of latency as an error type in word-finding. Results indicated that three participants for each task demonstrated psychometrically-based word-finding deficits with standard scores of less than 85. A significant difference was found between the two groups in the mean standard scores for the TAWF ($F(1, 18) = 13.252$; $p = 0.002$) indicating that the mTBI group performed significantly worse than the control group regarding accuracy. Results of an independent-samples *t*-test revealed a significant group difference on the TAWF regarding the occurrence of latency errors based on total words produced ($t = 2.337$, $p = 0.03$), indicating that the MTBI group demonstrated overall slower responses than the control group. There were no significant differences between groups for the measures from the TWFD. Greater word-finding errors occurred for the TAWF than the TWFD, revealing latency as the most common error.

King et al. (2006) investigated differences in accuracy and response time for noun and verb naming in individuals with a history of mTBI using the TAWF as the experimental task. Ten participants with a history of mTBI and 10 non-brain damaged (NBD) participants between the ages of 18 and 45 years old were age, gender, and education matched. Inclusion criteria included normal vision and hearing and no history of developmental disabilities, previous head injury, or substance abuse. Time post-injury ranged from 4 to 37 days (mean = 15.6). Visual and auditory stimuli from the subtests of the TAWF were presented via laptop computer in order to ensure that all participants received the same conditions. A one-tailed independent sample *t*-test was performed to

determine if there was a difference in accuracy between noun and verb naming. Results revealed a significant difference between the mTBI group and the NBD group in noun naming ($t = 2.593$, $p = .018$), indicating that the mTBI group was less accurate than the NBD group. There was no significant difference between the groups in accuracy for naming verbs. One-tailed independent sample *t*-tests were performed to determine response time differences for each of the TAWF subtests between groups. Results indicated significant group differences for all subtests (Noun1 $t = 2.571$, $p = .009$; Noun2 $t = 1.976$, $p = .032$; Noun3 $t = 1.935$, $p = .034$; Noun4 $t = 2.812$, $p = .006$; and Verb $t = 3.680$, $p = .001$), with the NBD group exhibiting faster response times on all subtests. In addition, there was a significant group difference when all noun subtests were combined ($t = 2.708$, $p = .007$), indicating that response times for the NBD group on the noun naming tasks was significantly faster than the mTBI group.

This literature review reveals that four studies provide evidence that word-finding deficits are experienced by individuals with a history of mTBI when compared to individuals without a history of mTBI. Of these studies, two looked at the subacute phase of recovery and two looked at the acute phase of recovery. A single study conducted during the post-subacute phase of recovery indicated that differences in word-finding performance were not observed. All studies took place less than 12 weeks post-injury. Most studies reviewed included a small number of subjects and a wide range of ages in the subject population. A single study clustered 40-year-old adults with children as young as 12-years-old in their subject population.

Overall, the studies reviewed were conducted with a small number of subjects and included a broad range of ages as well as varied in the phase of recovery when subjects

were assessed. Inconsistencies in findings, a lack of studies examining the impact of multiple mTBIs, and a lack of studies focusing on the presence of word-finding deficits in young adults in the post-subacute phase (6 months or greater post-injury) of recovery support the need for additional research in this area. Long term deficits in word-finding can result in extreme social distress due to the inability to maintain previous levels of performance at work and participation in life (King et al., 2006).

Current Study

The goal of this study is to look more closely at word-finding performance in young adults with a history of mTBI in the post-subacute phase (6 months or greater post-injury) of recovery, to determine the presence or absence of word-finding deficits, and to determine the impact of single vs multiple mTBIs.

The current study aims to answer the following questions:

a. Do subjects with a history of mTBI demonstrate significantly lower word-finding performance on the TAWF-2, BT than controls?
b. Does word-finding performance correlate with reported number of mTBI?

CHAPTER III:

METHOD

Participants

Participants included college students enrolled at the local university and individuals from the surrounding areas. Participants were recruited via university public relations dissemination of flyers through university listserv, Facebook, Instagram, and Twitter, or referred by word of mouth. All participants met the following inclusion criteria: 18-24 years of age, with or without a history of mTBI, in the post-subacute phase of recovery (6 months or greater post-injury), without hearing or vision loss, and without a history of learning disability, language impairment, or speech or language therapy services per self-report.

Word-Finding Assessment

The Test of Adolescent/Adult Word Finding-Second Edition Brief Test (TAWF-2, BT) (German, 2016) was administered to all participants to assess word finding ability based on timing and accuracy. The TAWF-2, BT is a norm-referenced, single-word expressive language test specifically designed to assess the word-finding ability of adolescents and adults. It is used by speech-language pathologists to identify individuals

who have word-finding problems, plan word finding intervention, and measure word finding ability in research studies. The TAWF-2, BT consists of 28 items chosen from the Complete Test organized into four naming sections: (1) Picture Naming: Nouns, which assesses efficiency in naming target words (2) Sentence Completion Naming, which assesses efficiency in naming words to complete sentences read aloud by the examiner (3) Picture Naming: Verbs, which assesses efficiency in naming present and past-tense regular and irregular verbs and (4) Picture Naming: Word Groups, which assesses efficiency in naming nouns in semantic and phonemic word groups. The normative sample included 1,710 individuals 12:0–80:11 years of age from 28 states. The characteristics considered and represented in the normative sample include gender, chronological age, geographic region (USA), educational level, race, Hispanic status, exceptionality status, and household income.

Reliability of TAWF-2, BT

Reliability of the TAWF-2, BT is reported in three forms: internal consistency, test-retest, and interscorer. The test authors note that in order for a test to be considered minimally reliable, its reliability coefficient must approach or exceed .80 in magnitude. However, coefficients of .90 or greater are deemed most desirable. High levels of internal consistency reliability signify that all test items measure the same construct. The internal consistency reliability coefficient for the TAWF-2, BT across all age groups is .76. Evidence of internal consistency reliability for specific subgroups indicates that the coefficients all round to or exceed .80, which suggests that the TAWF-2, BT is reliable for the seven gender, racial, and ethnic subgroups included in the normative sample. Test-retest reliability is a measure of how consistent a test taker's scores are over time. The

test-retest coefficient for the Word Finding Index is .94 for the TAWF-2, BT, which demonstrates strong test-retest reliability. Interscorer reliability refers to the consistency of scores across various examiners. The interscorer reliability coefficient for the TAWF-2, BT is .99, indicating near complete agreement between examiners. These findings indicate that the TAWF-2, BT exhibits high levels of reliability, thus, test users should feel confident in its results (German, 2016).

Validity of TAWF-2, BT

Validity of the TAWF-2 is reported in three forms: criterion-prediction, construct-identification, and content-description. Criterion-prediction validity is described as the test's success in predicting an individual's performance on specific tasks, which was measured by comparing the TAWF-2 to well-known spoken language tests. The average correlation of the Word Finding Index with those of other common expressive language tests is large in magnitude. Diagnostic accuracy studies suggest that the TAWF-2, BT can accurately identify students with word-finding difficulties, demonstrating criterion-prediction validity (i.e., sensitivity = .98, specificity = .84, receiver operating characteristic (ROC)/area under the curve (AUC) = .96, cut score = 90). Construct-identification validity relates to the degree to which the skill of word-finding can be identified and that one dominant factor underlies the four naming subtests. Exploratory factor analysis (EFA) of the TAWF-2's subtest raw totals indicated that the word-finding factor produced an eigenvalue of 2.79. All four naming subtests had substantial loadings on the word-finding factor (i.e., Picture Naming: Nouns = .72, Sentence Completing Naming = .65, Picture Naming: Verbs = .66, Picture Naming: Categories = .76), indicating strong construct-identification validity. Content-description validity is

demonstrated through the rationale for the TAWF-2 content, formats, and target word selection, as well as the analyses used to choose appropriate items statistically. When choosing the TAWF-2, BT target words, the author considered semantic-taxonomic and thematic relations, syntactic features, word comprehensibility, word frequency, neighborhood density, neighborhood frequency, phonotactic probability, and word length. Additional justification for the TAWF-2 content-description validity is provided in the examiner's manual (German, 2016).

Procedure

This study was conducted in compliance with requirements of the East Stroudsburg University Institutional Review Board (Appendix A). All participants received and signed an informed consent prior to participation (Appendix B). Participants were provided with randomly selected code numbers to protect each participant's identity and all identifying information was stored separately. Participants were asked to complete a brief case history form developed by the primary co-investigator and report on the number of mTBIs experienced, causes of mTBIs, date of most recent mTBI, and self-interpretation of word-finding ability by answering three yes/no questions regarding presence of periodic word-finding problems (Appendix C). Participants were divided into four groups based on the number of mTBIs they had experienced in their lifetime [0 mTBI (no history of mTBI), 1 mTBI (history of single incident mTBI), 2 mTBIs (history of two incidents of mTBI), and 3+ mTBIs (history of three or more incidents mTBI)]. Following the case history form, all participants completed the Concussion Symptom Inventory (CSI) (Randolph et al., 2009) and were asked to rank their current symptoms based on how they were feeling on the day of testing. Any participant with a history of

mTBI that noted any of the following were excluded due to symptoms indicative of the acute phase of mTBI: nausea, balance problems/dizziness, feeling like “in a fog”, difficulty concentrating, sensitivity to light, sensitivity to noise, blurred vision, or feeling slowed down (Appendix D). After completion of paperwork, a bilateral pure-tone hearing screening following the American Speech-Language-Hearing Association (ASHA) Adult protocol was conducted on each participant (ASHA, 2020). The TAWF-2, BT was administered by the primary co-investigator and trained graduate students of the Department of Communication Sciences and Disorders in therapy rooms. Participants were informed of their right to discontinue testing at any time if they began to experience psychological distress. Raw scores, Word Finding Index scores, and percentile scores on the TAWF-2, BT were collected and analyzed using the standardized administration guidelines in the examiner’s manual between subject groups (0 mTBI, 1 mTBI, 2 mTBIs, 3+ mTBIs). Examiners were blinded to which group the participant was in when administering the TAWF-2, BT. All examiners attended training on the specific test administration, scoring, and fidelity check procedures associated with this study. A specific fidelity check system was used to ensure the accuracy of data collected and the reliability and validity of the assessments (Appendix E).

CHAPTER IV

RESULTS

Participant Description

Seventeen participants with a history of mTBI (11 females, 6 males) and 16 participants without a history of mTBI (8 females, 8 males) were included in this study. Ages of participants ranged from 19-24 years old. The causes of injuries reported by participants with a history of mTBI included sport-related accidents, falls, and injuries where the head was hit with an object. Prevalence of mTBI in the experimental group is provided in Table 1. Time post-injury for the mTBI group was a maximum of 18 years and a minimum of 10 months prior to testing. All participants passed bilateral pure-tone hearing screenings following the ASHA Adult protocol (ASHA, 2020).

Table 1

Prevalence of mTBI

Number of mTBI	*n*	%
1	5	29.4
2	5	29.4
3 or greater	7	41.2
Total	17	100.0

Note. mTBI = mild traumatic brain injury.

Research Question 1: TAWF-2, BT Performance mTBI vs Control

An independent-samples *t*-test was conducted to compare TAWF-2, BT raw scores between participants with and without a history of mTBI. There was no significant difference ($t(31) = 0.443$, $p = 0.661$) in the TAWF-2, BT raw scores for participants with a history of mTBI (M = 21.65, SD = 4.20) and participants without a history of mTBI (M = 21.00, SD = 4.20). An independent-samples *t*-test was conducted to compare TAWF-2, BT Word Finding Index between participants with and without a history of mTBI. There was no significant difference ($t(31) = 0.39$, $p = 0.697$) in the TAWF-2, BT Word Finding Index for participants with a history of mTBI (M = 84.65, SD = 18.01) and participants without a history of mTBI (M = 82.65, SD = 16.96). Frequency of descriptive ratings for participants with a history of mTBI (M = 3.18, SD = 0.287) and participants without a history of mTBI (M = 2.81, SD = 0.319) is provided in Table 2. These results indicate that history of mTBI does not have an effect on TAWF-2, BT raw scores and Word Finding Index. Specifically, these results suggest that history of mTBI does not affect word-finding ability in this subset of young adult college population.

Table 2

Frequency of Descriptive Ratings

Word Finding Descriptive Rating (Index Score Range)	Hx of mTBI (N = 17)	No Hx of mTBI (N = 16)
Average (90-109)	10	7
Below Average (80-89)	3	3
Weak (70-79)	1	2
Very Weak (<70)	3	4

Note. Hx = history; mTBI = mild traumatic brain injury.

Research Question 2: TAWF-2, BT Performance Frequency of Incident

A one-way between subjects analysis of variance (ANOVA) was conducted to compare raw scores on TAWF-2, BT in individuals with 0 mTBI, 1 mTBI, 2 mTBIs, and 3 or more mTBIs. There was no significant difference at the $p<0.05$ level for the four groups [$F(3, 29) = 0.434$, $p = 0.730$]. These results suggest that the number of mTBI experienced does not affect TAWF-2, BT performance. Specifically, these results suggest that an increased number of mTBI may not affect word-finding ability in the post-subacute phase of mTBI.

CHAPTER V

DISCUSSION

Implications

The purpose of the present study was to determine if individuals with a history of mTBI demonstrate reduced word-finding performance compared to individuals without a history of mTBI. No significant difference was found between TAWF-2, BT raw scores and Word Finding Index of participants with a history of mTBI and the control group. This finding did not confirm the hypothesis that individuals with a history of mTBI would perform worse than those without a history of mTBI, as previous research has indicated that individuals with a history of mTBI demonstrate slower response times and commit more errors compared to individuals without a history of mTBI when performing word-finding tasks (Barrow et al., 2006; King et al., 2006; 2006; & Norman, Shah, & Turkstra, 2019). This contrast may be explained by the fact that the subject pool in previous studies included older adults, whereas the current study focused on young adults for the purpose of attempting to eliminate the effects of aging on word-finding ability. Additionally, mTBIs typically results in diffuse damage, which may explain the diverse findings in previous research. Participants with a history of mTBI are a highly

heterogeneous group, and young adults may have experienced different patterns of spontaneous recovery than older adults. Variability in outcomes is typically seen with a small subject group as well.

King et al. (2006) and King et al. (2006) used the same mode of assessment in their studies, which was the TAWF, an earlier publication of the TAWF-2, BT. Participants with a history of mTBI demonstrated impaired word-finding ability in their studies, but the time of testing post-injury ranged from the acute to subacute phase (i.e., 4-37 days; 2-14 days). Participants in the current study were tested in the post-subacute phase of injury, which ranged from 18 years to 10 months. This broad recovery window used to indicate the post-subacute phase in the current study may have affected the participants' word-finding performance, perhaps improving word-finding performance as additional time post-injury led to recovery of cognitive and linguistic skills.

The relationship between the reported number of mTBI and word-finding performance was examined, hypothesizing that those with an increased number of mTBI would perform worse on the TAWF-2, BT. No significant difference was found between the TAWF-2, BT raw scores of those with 0 mTBI, 1 mTBI, 2 mTBIs, or 3 or more mTBIs. This result is in line with what Stockbridge and Newman (2019) found in their study when targeting cognitive and linguistic skills in isolation, as significant differences were not observed between individuals with and without a history of mTBI when performing a confrontation naming task. However, Stockbridge and Newman (2019) additionally analyzed narrative writing tasks between individuals with and without a history of mTBI and noted a significant increased use of GAP verbs among those with a history of mTBI, which potentially signifies word-finding deficits. This finding contrasts

with those of the present study, though word-finding was targeted in isolation and not through narrative writing. This might be due to the amount of brain involvement required for narrative writing, which requires more engagement among areas of the brain than are required for confrontation naming tasks. Confrontation naming tasks are more similar to day to day word-finding challenges and do not require the same level of linguistic complexity as written narratives, such as use of appropriate syntax.

It was of interest to examine the relationship between performance on the TAWF-2, BT and the participants' perceptions of the presence or absence of word-finding issues in day to day life. Participants answered three yes/no questions related to word-finding ability on the case history form prior to completing the TAWF-2, BT in order to determine if their scores correlated with their perceived ability. If the participants circled "yes" to all three questions, they were believed to perceive a word-finding deficit. A review of the data that was gathered revealed that only 2 participants indicated on the case history form that they had perceived the presence of word-finding issues in day to day life, and both of these participants scored below the standard score of 85 on the TAWF-2, BT. However, a total of thirteen participants scored below the standard score of 85 on the TAWF-2, BT; 6 from the mTBI group and 7 from the control group. This suggests that individuals who believe they demonstrate word-finding issues in day to day life may not exhibit word-finding issues on standardized assessments, and vice versa. In addition, participants may not be good reporters of their deficits. Since the researchers were unaware of the participants' word-finding ability prior to their mTBIs, the participants' perceptions could not be confirmed. Word-finding deficits may impact individuals differently due to how often this skill may be necessary for their occupations,

social activities, or education classes. Thus, some individuals may not perceive a noticeable difference in their abilities after the injury.

Limitations

There are several limitations to the current study that should be considered when interpreting the results. First, it is important to note that mTBI history data were self-reported by the subjects and were not verified with medical records. It was presumed that the subjects provided the correct number of mTBIs sustained, however, there could have been variation in the reported data, as some subjects may have interpreted the term "concussion" differently since there was no formal definition or criteria given by the researcher. Thus, participants who did not report ever experiencing a concussion could have had one at one point in their life. In addition, those who claimed that their health histories did not include learning disability, language impairment, or speech or language therapy services (exclusion criteria utilized in the study) on the case history form could have had such disorders and services, whether formally diagnosed or not. This study was limited by its small sample size and was not representative of the culturally diverse university population.

While limitations were present, the current study had several positive attributes as well. First, the subject group consisted of young adults, which should have eliminated any possible influence of the natural impact of aging on word-finding ability. An additional strength is that all examiners were trained following the same procedures regarding test administration, scoring, and fidelity check system. Examiners were blinded to which group the participant belonged to when administering the word-finding assessment. The primary co-investigator administered the TAWF-2, BT to a limited

number of participants and was blinded to which group the participant belonged to until after the assessment was completed.

Future Directions

Future studies investigating the effects of mTBI on word-finding ability should aim to overcome these limitations by including an increased number of participants. Variability in time post-injury should be reduced by focusing on smaller recovery windows to better understand how specific time periods post-injury affect cognitive and linguistic performance. Participants should be presented with a clear definition of mTBI, and medical verification should be sought in order to confirm the medically diagnosed number of mTBIs experienced by each participant and date of injury. The case history form should include more questions that ask whether the participant experienced a loss of consciousness or was hospitalized due to the injury. Research should be conducted on individuals' perceptions of word-finding deficits in day to day life after experiencing mTBI, perhaps by comparing scores from a standardized assessment to a quality of life questionnaire to measure of self-awareness of word-finding problems or a Likert scale to determine the severity of the possible deficit. Additional research is needed on other severities of TBI (i.e., moderate, severe), as well as word-finding during more complex linguistic tasks, such as discourse, which require integration of skills with word-finding. Future studies should consider the possibility of other diagnoses that may impact word-finding ability.

Conclusion

In summary, the present study explored the impact of mTBI on word-finding ability. Results of the study suggest that young adults with a history of mTBI may not

experience word-finding difficulties in the post-subacute phase of mTBI, despite the number of incidences of mTBI. Due to the cognitive and linguistic deficits that often occur following mTBI, it was expected that individuals with a history of mTBI would demonstrate impaired word-finding ability when compared to individuals without a history of mTBI. Cognitive and linguistic functioning falls within the scope of practice of speech-language pathologists. Continuous monitoring, frequent follow-ups, and providing education to those who have experienced single or multiple incidences of mTBI is important for the early identification and intervention of possible cognitive and linguistic deficits due to the injury. Additional research is necessary to determine if further assessment and treatment of word-finding deficits is necessary for this population.

REFERENCES

Adult Hearing Screening. (2020). American Speech-Language-Hearing Association. Retrieved from https://www.asha.org/PRPSpecificTopic.aspx?folderid=8589942721&section=Key_Issues

Barrow, I. M., Hough, M., Rastatter, M. P., Walker, M., Holbert, D., & Rotondo, M. F. (2006). The effects of mild traumatic brain injury on confrontation naming in adults. *Brain Injury*, *20*(8), 845–855. https://doi.org/10.1080/02699050600832445

Centers for Disease Control and Prevention. (1997). Sports-related recurrent brain injuries. *Morbidity and Mortality Weekly Report*, *46*(10), 224–227. https://www.cdc.gov/mmwr/preview/mmwrhtml/00046702.htm

Centers for Disease Control and Prevention (2003). *Report to Congress on mild traumatic brain injury in the United States: Steps to prevent a serious public health problem.* National Center for Injury Prevention and Control. Atlanta, GA. https://www.cdc.gov/traumaticbraininjury/outcomes.html

Centers for Disease Control and Prevention. (2015). *Report to Congress on traumatic brain injury in the United States: Epidemiology and rehabilitation.* National Center for Injury Prevention and Control; Division of Unintentional Injury Prevention. Atlanta, GA. https://www.cdc.gov/traumaticbraininjury/pdf/TBI_Report_to_Congress_Epi_and_Rehab-a.pdf

Centers for Disease Control and Prevention. (2019, March 4). *Traumatic brain injury and concussion.* https://www.cdc.gov/traumaticbraininjury/index.html

Covassin, T., Moran, R., & Wilhelm, K. (2013). Concussion symptoms and neurocognitive performance of high school and college athletes who incur multiple concussions. *American Journal of Sports Medicine, 41*(12), 2885–2889. https://doi.org/10.1177/0363546513499230

Fratantoni, J. M., Delarosa, B. L., Didehbani, N., Hart, J., & Kraut, M. A. (2017). Electrophysiological correlates of word retrieval in traumatic brain injury. *Journal of Neurotrauma, 34*(5), 1017–1021. https://doi.org/10.1089/neu.2016.4651

Gaetz, M., Goodman, D., & Weinberg, H. (2000). Electrophysiological evidence for the cumulative effects of concussion. *Brain Injury, 14*(12), 1077–1088. doi:10.1080/02699050050203577

Ganti, L., Khalid, H., Patel, P. S., Daneshvar, Y., Bodhit, A. N., & Peters, K. R. (2014). Who gets post-concussion syndrome? An emergency department-based prospective analysis. *International Journal of Emergency Medicine, 7*(31). https://doi.org/10.1186/s12245-014-0031-6

German, D. J. (1990). *Test of Adolescent and Adult Word Finding*. Austin, TX: Pro-Ed.

German, D. J. (1991). *Test of Word Finding in Discourse*. Austin, TX: Pro-Ed.

German, D. J. (2016). *Test of Adolescent/Adult Word Finding* (2nd ed.). Austin, TX: Pro-Ed.

Guskiewicz, K. M., McCrea, M., Marshall, S.W., Cantu, R. C., Randolph, C., Barr, W., Onate, J. A., & Kelly, J. P. (2003). Cumulative effects associated with recurrent concussion in collegiate football players: The NCAA Concussion Study. *Journal of the American Medical Association, 290*(19), 2549-2555. doi:10.1001/jama.290.19.2549

Institute of Medicine and National Research Council. (2014). *Sports-related concussions in youth: Improving the science, changing the culture*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18377

King, K. A., Hough, M. S., Walker, M. M., Rastatter, M., & Holbert, D. (2006). Mild traumatic brain injury: Effects on naming in word retrieval and discourse. *Brain Injury, 20*(7), 725–732. https://doi.org/10.1080/02699050600743824

King, K. A., Hough, M. S., Vos, P., Walker, M. M., & Givens, G. (2006). Word retrieval following mild TBI: Implications for categorical deficits. *Aphasiology, 20*(2-4), 233–245. doi:10.1080/02687030500473155

Mayer, A. R., Quinn, D. K., & Master, C. L. (2017). The spectrum of mild traumatic brain injury: A review. *Neurology, 89*(6), 623–632. https://doi.org/10.1212/WNL.0000000000004214

McInnes, K., Friesen, C. L., MacKenzie, D. E., Westwood, D. A., & Boe, S. G. (2017). Mild traumatic brain injury (mTBI) and chronic cognitive impairment: A scoping review. *PLoS ONE*, *12*(4), 1–19. https://doi-org.navigator-esu.passhe.edu/10.1371/journal.pone.0174847

McWilliams, J., & Schmitter-Edgecombe, M. (2008). Semantic memory organization during the early stage of recovery from traumatic brain injury. *Brain Injury*, *22*(3), 243–253. https://doi.org/10.1080/02699050801935252

Miotto, E.C., Cinalli, F.Z., Serrao, V.T., Benute, G.G., Lucia, M.C., & Scaff, M. (2010). Cognitive deficits in patients with mild to moderate traumatic brain injury. *Arquivos de Neuro-Psiquiatria*, *68*(6), 862-868. https://dx.doi.org/10.1590/S0004-282X2010000600006

Moser, R. S. & Schatz, P. (2002). Enduring effects of concussion in youth athletes. *Archives of Clinical Neuropsychology, 17*(1), 91–100. https://doi.org/10.1093/arclin/17.1.91

Norman, R. S., Shah, M. N., & Turkstra, L. S. (2019). Reaction time and cognitive-linguistic performance in adults with mild traumatic brain injury. *Brain Injury, 33*(9), 1173-1183. doi:10.1080/02699052.2019.1632487

Popescu, M., Hughes, J. D., Popescu, E., Mikola, J., Merrifield, W., DeGraba, M., Riedy, G., & DeGraba, T. J. (2017). Activation of dominant hemisphere association cortex during naming as a function of cognitive performance in mild traumatic brain injury: Insights into mechanisms of lexical access. *NeuroImage: Clinical, 15*, 741-752. https://doi.org/10.1016/j.nicl.2017.06.029.

Randolph, C., Millis, S., Barr, W.B., McCrea, M., Guskiewicz, K.M., Hammeke, T.A., Kelly, J.P. (2009). Concussion Symptom Inventory: An empirically-derived scale for monitoring resolution of symptoms following sports-related concussion. *Archives of Clinical Neuropsychology, 24*(3), 219–229.

Slobounov, S., Slobounov, E., Sebastianelli, W., Cao, C., & Newell, K. (2007). Differential rate of recovery in athletes after first and second concussion episodes. *Neurosurgery, 61*(2), 338–44. doi:10.1227/01.NEU.0000280001.03578.FF

Stockbridge, M. D. & Newman, R. (2019). Enduring cognitive and linguistic deficits in individuals with a history of concussion. *American Journal of Speech-Language Pathology, 28*(4), 1554–1570. https://doi.org/10.1044/2019_AJSLP-18-0196

Walker, M. M., Rastatter, M., & Holbert, D. (2006). Mild traumatic brain injury: Effects

on naming in word retrieval and discourse. *Brain Injury*, *20*(7), 725–732. https://doi.org/10.1080/02699050600743824

Whiteneck, G., Mellick, D., Brooks, C., Harrison-Felix, C., Noble, K., & Sendroy Terrill, M. (2001). Colorado traumatic brain injury and follow up system data book. Englewood, CO: Craig Hospital.

Appendix A: Institutional Review Board Approval

200 Prospect Street
East Stroudsburg, PA
18301-2999

East Stroudsburg University Institutional Review Board
Human Research Review
Protocol # **ESU-IRB-008-1920**

Date: **October 21, 2019**
To: **LuAnn Batson-Magnuson**
From: **Shala E. Davis, Ph.D., IRB Chair**
Proposal Title: **"Impact of Concussion on FAWF-2 Brief Test Scores"**

Review Requested:	Exempted	Expedited **X**	Full Review
Review Approved:	Exempted	Expedited **X**	Full Review

FULL RESEARCH

____ Your full review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your full review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your full review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit.

EXEMPTED RESEARCH

____ Your exempted review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your exempted review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your exempted review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

EXPEDITED RESEARCH

__**X**__ Your expedited review research proposal has been approved by the University IRB (12months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your expedited review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your expedited review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

Please revise or submit the following:

Appendix B: Consent Form

INFORMED CONSENT
For a Research Study entitled
"The Impact of mTBI on Word-Finding Ability in Young Adults**"**

You are invited to participate in a research study that will examine if there a significant difference in language test scores between young college students with a history of concussion compared to those without a history of concussion. The study is being conducted by Lori DeFazio, B.S. under the direction of LuAnn Batson-Magnuson, Ph.D., CCC-SLP in the East Stroudsburg University Department of Communication Sciences and Disorders. You were selected as a possible participant because you are between the ages of 18 and 24 years old and you may or may not have experienced one or more concussions.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to complete a survey regarding your personal history of concussion, receive a hearing screening, and participate in a brief language test that will assess your word finding ability. Your total time commitment will be approximately 45 minutes.

Are there any risks or discomforts? No risks or discomforts beyond what would be expected in everyday clinical interactions would be expected. The standardized evaluation is a standard component in a clinical setting. Evaluation protocol are standardized and those with evidence-base to support their use. Psychological distress may occur during testing due to feelings of frustration or embarrassment with test items. Subjects may discontinue testing at any time.

Are there any benefits to yourself or others? If you participate in this study, the expected benefit will be to increase knowledge within the field of communication sciences and disorders.

Will you receive compensation for participating? You will receive no financial compensation for participating in the study.

Are there any costs? If you decide to participate, there will be no cost. I have no financial interest to disclose regarding this study.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with East Stroudsburg University or the Department of Communication Sciences and Disorders.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be published in a professional journal or presented at a professional meeting.

Participant's Initials _____ **Page 1 of 2**

If you have questions about this study, please ask them now or contact Lori DeFazio by phone at (570)-905-7617 or e-mail at ldefazio@live.esu.edu or LuAnn Batson-Magnuson at batsonmagn@esu.edu. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the East Stroudsburg University Institutional Review Board by phone (570)-422-3336 or e-mail at sdavis@po-box.esu.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

_____	_____
Participant Signature Date	Investigator obtaining consent Date
_____	_____
Printed Name	Printed Name
	_____
	Co-Investigator Date
	_____
	Printed Name

Appendix C: Case History Form

Case History Form

Have you ever suffered from a concussion or head injury? YES NO

If yes, how many? _____

What was the cause of the concussion(s)?

_____

_____

Were you diagnosed with a concussion by a doctor? YES NO

When was your most recent concussion? _____

Are you currently experiencing any symptoms resulting from the head injury? YES NO

If yes, please describe:

_____

_____

Did you ever receive speech or language therapy? YES NO

Do you have a history of any learning disabilities? YES NO

Do you struggle to think of the names of people, places, or objects? YES NO

In response to questions from other people? YES NO

During conversations? YES NO

Appendix D: Concussion Symptom Inventory (CSI)

Concussion Symptom Inventory (CSI)

Date of Birth: _____ Sex: _____

	absent 0	*mild* 1	2	*moderate* 3	4	*severe* 5	6	Score
Headache								
Nausea								
Balance problems/Dizziness								
Fatigue								
Drowsiness								
Feeling like “in a fog”								
Difficulty concentrating								
Difficulty remembering								
Sensitivity to light								
Sensitivity to noise								
Blurred vision								
Feeling slowed down								
	TOTAL:							
Other symptoms evident since injury?								

Randolph, Millis, Barr, McCrea, Guskiewicz, Hammeke, & Kelly (2008)

Appendix E: Fidelity Procedures

Following test administration:

1. Examiner 1 verified accuracy of administration (correct number of items administered, complete test administered, etc.)
2. Examiner 1 scored test.
3. Examiner 2 reviewed test score sheets and administration procedures.
4. If there was disagreement, examiners met to resolve any discrepancies, referring to testing manuals or the co-investigators as needed.
5. A designated data entry person rechecked all tests for accurate scoring and entered data into the master project spreadsheet.

   Note: Throughout the duration of the study, co-investigators and selected assessors completed fidelity observations of assessors while tests were being administered to ensure all language, prompting, and testing procedures were accurate and effective across examiners. If examiners exhibited difficulty with test administration or scoring errors, additional training was provided.