Microlinguistic and Fluency Characteristics of Narrative and Expository Discourse in Adolescents with Traumatic Brain Injury

Thesis

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By

Heath Daniel Barron, B.M.E.

Graduate Program in Speech Language Pathology

The Ohio State University

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Thesis Committee:

Jennifer Lundine, Advisor

Rebecca McCauley

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Abstract

Adolescents with traumatic brain injury (TBI) may exhibit subtle cognitive-communication deficits that are not consistently identified by the formal assessments commonly used to qualify children for special education services. Expository discourse production is rarely used as an assessment tool with students who have TBI, despite its relevance to the curriculum. Research is needed to explore the cognitive-linguistic processes and linguistic features that are required for students to successfully produce exposition. The current study conducted microlinguistic and fluency analyses of verbal summaries produced by five adolescents with traumatic brain injury and five matched peers with typical development (TD). Each participant verbally summarized one narrative and two expository (compare-contrast, cause-effect) discourse lectures that were then transcribed and analyzed for microlinguistic measures, mazing behaviors, and pausing patterns. The group with TBI was significantly less productive than the group with TD during cause-effect and compare-contrast productions. No other microlinguistic differences were identified between groups. The group with TBI produced significantly fewer filled pauses per utterance during cause-effect production. The group with TBI also produced significantly more within-clause pauses per utterance during compare-contrast production. No significant differences were found between groups on any variable analyzed during narrative productions. On average, the group with TD produced more mazes, and the group with TBI produced more pauses of longer lengths. These findings support other studies that suggest that different types of exposition have different production requirements, and that they are distinct from narrative productions. The different patterns of mazing and pausing found between groups help to characterize discourse production by adolescents with TBI and are discussed in terms of decreased language processing abilities. Differences in discourse production may be relevant to classroom performance and useful in future research exploring more sensitive ways to identify cognitive-communication deficits.

Vita

August 2009 to May 2013…………………. B.M.E., The Ohio State University

August 2013 to June 2016…………………. Vocal Music Teacher, Columbus School for Girls

January 2017 to present……………………. Graduate Research Associate, Department of Speech and Hearing Science, The Ohio State University

Fields of Study

Major Field: Speech Language Pathology

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Introduction

Children with Traumatic Brain injury

It is estimated that nearly 700,000 children under the age of 19 experience a traumatic brain injury (TBI) annually in the United States (Faul et al., 2010). Following a TBI, children may exhibit lasting deficits in physical, behavioral, social, linguistic, and cognitive functioning that impede academic success (Catroppa et al., 2008; Ewing-Cobbs & Barnes, 2002; Sullivan & Riccio, 2010; Yeates et al., 2004; Yeates et al., 2005). Yet, TBI is often referred to as a "silent epidemic," because these deficits may be difficult to perceive and knowledge about TBI is lacking in the general public (Faul et al., 2010). Though children with TBI may initially appear to recover language abilities consistent with their pre-injury levels, the acquisition of more advanced and later developing linguistic skills may be inhibited (Moran & Gillon, 2004). Unfortunately, current neuropsychological assessment batteries are often not sensitive enough to identify these cognitive-communication deficits, especially in milder cases, leaving many children in this population without the documentation necessary to qualify for support services at school (Coelho, 2007; Cook, DePompei, & Chapman, 2011).

Discourse Genre and Structure

The analysis of expository discourse production and comprehension offers promise as a more sensitive method of identifying the subtle cognitive-communication deficits often present in children with TBI (Hay & Moran, 2005; Lundine et al., 2018). Discourse refers to the supra-sentential organization of language and can be divided into at least four genres based on communicative intent: conversation, narration, exposition, and persuasion (Nippold, 2014; Scott & Windsor, 2000). Narratives and conversation have traditionally been the most prevalent discourse genres encountered by students in the classroom and, as such, have generated the most comprehensive research base regarding their development in both students who are typically developing and those with language impairments. However, expository discourse has been gaining attention in the academic and research settings due to its incorporation into the Common Core State Standards (Common Core State Standards Initiative, 2015). Referred to as the "language of the curriculum" (Ward-Lonergan, 2010), students are expected to comprehend and produce expository discourse as early as kindergarten (Common Core State Standards Initiative, 2015).

In an attempt to add to the sparse literature exploring expository discourse, the current paper will focus on expository and narrative discourse production. Narrative and expository discourse genres differ in terms of how they are structured. Narrative discourse is used to tell stories and is organized around an agent, their actions, motivations, and a sequence of events (Berman & Nir-Sagiv, 2007). In contrast, expository discourse is used to convey information (e.g., textbook entries, directions, lectures) to another person and is organized around a topic, with the presentation of facts advancing based on logical relationships between them (Berman & Nir-Sagiv, 2007). Expository discourse can be further divided into different types, the most common of which include description, procedure, enumeration, cause-effect, compare-contrast, and problem-solution (Lundine & McCauley, 2016). Each of these different expository types have distinct organizational structures.

Discourse Genre and Cognitive-Linguistic Processes

In addition to differences in structure, burgeoning evidence suggests that differing linguistic and cognitive underpinnings may be responsible for the comprehension and production of discourse genres and types (Hay & Moran, 2005; Lundine et al., 2018 Wolfe & Mienko, 2007; Wolfe & Woodwyk, 2010). A child’s ability to produce and understand narrative discourse relies heavily on their familiarity with story grammar (Mandler & Johnson, 1977): the typical organizational structure found in narrative discourse. On the other hand, in a study comparing the summary quality of one narrative and two expository discourse samples (i.e., compare-contrast, cause-effect) of adolescents with typical development, Lundine et al. (in press) found a measure of expressive syntax to be predictive of narrative summary quality and a composite cognitive measure to be predictive of exposition summary quality. These findings suggest that linguistic processes may be more heavily involved in narrative processing, whereas expository processing might be more dependent upon cognitive processes. This suggestion is supported by past research that has linked expository comprehension and production to cognitive processes such as (a) working memory (Berninger et al., 2010; Wolfe & Woodwyk, 2010), (b) access to and incorporation of prior knowledge (Nippold & Scott, 2010; Wolfe & Mienko, 2007), (c) inferencing (Eason et al., 2012; Nippold & Scott, 2010), and (d) executive functions (e.g., planning and organizing information, self-monitoring, attention; Berninger et al., 2010; Eason et al., 2012; Nippold & Scott, 2010; St. Clair-Thompson & Gathercole, 2006). Children with TBI often exhibit impairments in the very cognitive processes that appear to facilitate expository discourse production and comprehension (e.g., attention, speed of thinking, working memory, and executive function). These deficits may not be apparent until later points in development and can persist into adulthood (Turkstra, Politis, & Forsyth, 2015; Moran & Gillon, 2010; Walz et al., 2012). For this reason, the analysis of expository production and comprehension could be a valuable tool to identify the subtle cognitive-communication deficits exhibited after TBI.

Discourse Analysis

Discourse productions are commonly analyzed based on macrolinguistic, microlinguistic, and fluency variables. Specific measures in these areas allow researchers to describe and highlight differences in what is required for the production and comprehension of specific discourse genres, while simultaneously drawing conclusions about underlying cognitive and linguistic processes. Similarly, these analyses have been used to identify and characterize deficits found in disordered populations.

Macrolinguistics

Macrolinguistic elements describe a discourse sample as a whole, above the word and sentence levels (Caspari & Parkinson, 2000). These can include, for example, measures of overall gist, coherence, and propositions (i.e., complete units of information; Hay & Moran, 2005).

Differences in macrolinguistic measures may be present across discourse genres. In a study comparing narrative and expository discourse production of both typically developing children and those with closed-head injury, Hay and Moran (2005) found both groups to produce more propositions, episodic components, and global story components in a narrative versus expository (i.e., procedural) retell task. Macrostructural differences have also been found between expository discourse types. Ward-Lonergan, Liles, and Anderson (1999) found children with language learning deficits and their peers with typical development recalled more lecture components in a cause-effect lecture when compared to a compare-contrast lecture. Similarly, Lundine et al. (2018) found a group of adolescents with typical development to score higher on measures of gist and text structure when summarizing a cause-effect lecture compared to a compare-contrast lecture. It is possible that different patterns of macrolinguistic measures exist between discourse types. Early evidence suggests improved demonstration of macrolinguistic elements during narratives when compared to procedural discourse, and within the expository genre, during cause-effect when compared to compare-contrast. It is unclear if these macrolinguistic production differences support processing complexity distinctions across discourse genre type.

While the cognitive-communication deficits in children with TBI can be difficult to identify, there is consensus in the literature that macrolinguistic features tend to be the prevailing deficits identified in children with TBI (Brookshire et al., 2000). When compared to peers with typical development, researchers have found children with TBI tend to produce fewer propositions, episodic structure components, and global story components (Hay & Moran, 2005), perform more poorly when recalling overall gist, aim and text structures (Hay & Moran, 2005; Lundine et al., 2018), demonstrate reduced organization of information (Brookshire et al., 2000; Chapman et al., 1998), and produce less informational content (Brookshire et al., 2000; Lundine et al., 2018; Moran et al., 2012). Because preliminary evidence suggests varying levels of macrolinguistic demands exist across discourse types, it is possible that students with TBI will be less successful during the production of discourse genres that require more complex macrolinguistic processing.

Microlinguistics

Unlike macrolinguistic discourse features, microlinguistic elements describe a discourse sample at the word and sentence level. Common microlinguistic measures quantify a person's productivity (i.e., how much language is produced), lexical diversity (i.e., amount of variation in vocabulary), and syntactic or grammatical complexity.

When considering microlinguistic features, certain patterns may be present across discourse genres. Narrative production tends to be more productive than expository discourse, as shown by Scott and Windsor (2000) and Hay and Moran (2005), who compared children with typical development to those with language learning disabilities and TBI respectively. However, syntactic complexity may vary based on the measure used. Comparing expository to narrative productions, both Scott and Windsor (2000) and Lundine et al. (in press) found mean length of utterance (MLCU: the average number of words per utterance; Lundine et al., in press) and subordination index (SI: the average number of clauses per utterance; Lundine et al., in press) scores, common measures of syntactic complexity, to follow different trends, with higher MLCU scores in expository production and higher SI scores in narrative production. Hay and Moran's (2005) measure of syntactic complexity (i.e., number of dependent clauses divided by total number of clauses) was also higher in narrative than expository productions in a group containing children with both TBI and TD. When comparing different types of exposition, Ward-Lonergan et al. (1999) found a group of adolescents with and without language learning difficulties to produce more subordinate clauses during retellings of compare-contrast lectures compared to cause-effect, though no difference was found in SI scores. The lack of consistency around syntactic complexity appears to highlight the complicated interaction between what measure is used, how samples are elicited, and what type of expository discourse is used in studies. However, preliminary evidence suggests possible microlinguistic differences between discourse types.

The literature is not consistent when describing the microlinguistic features of discourse produced by children with TBI. Generally speaking, children with TBI have been shown to exhibit reduced productivity during conversation and narrative production when compared to peers of typical development (Campbell & Dollaghan, 1990; Chapman et al., 1992; Hay and Moran, 2005), and those with severe injuries have shown reduced productivity during narrative production when compared to those with less-severe injuries (Brookshire, 2000; Chapman et al., 1992). Some researchers have noted children with TBI to exhibit significant reduced syntactic complexity when compared to their peers with TD (Hay & Moran, 2005), while others have not (Campbell & Dollaghan, 1990; Chapman et al., 1998; Moran et al., 2012). While ancillary language testing is not always reported, the participants with TBI in the study by Hay and Moran (2005) had language scores greater than 1.5 standard deviations below the mean on the Clinical Evaluation of Language Fundamentals – Fifth Edition (CELF-5; Wiig, Semel, & Secord, 2013a), whereas Moran et al. (2012) included participants with TBI whose average score was in the normal range on the same test. This illustrates the need to assess the microlinguistic abilities of students with TBI, even though productivity appears to be the only microlinguistic measure that consistently differentiates children with and without TBI across discourse types.

Mazing and Pausing

Mazing and silent pausing represent another area of spoken discourse analysis that may show different patterns across discourse genres as well as diagnostic groups. Mazing refers to a number of nonfluent speech patterns that are not part of and detract from the effectiveness of the intended message (Thordardottir & Weismer, 2002). Typical maze disfluencies include filled pauses (e.g., "umm"), repetitions, false starts, abandoned utterances, and revisions (Thordardottir & Weismer, 2002). A certain amount of mazing and silent pausing is part of typical speech. Loban (1976) reported a typical maze density range (number of mazed words divided by the total number of words) to be between 7-10% during the narrative production of 18-year-olds with typical development. Goldman Eisler (1968) categorized silent pauses based on function, including articulatory shifts (i.e., pauses necessary due to articulatory placement sequences), breaths, natural pauses (e.g., end of sentence, before conjunction), and hesitations (e.g., middle of phrases, among mazes). Through a set of seminal studies, she reported that the total amount of pause time is highly variable based on familiarity with and complexity of the elicitation task, and that 45% of all silent pauses do not occur at natural, grammatical breakpoints during spontaneous speech. Preliminary evidence suggests that maze and pause patterning vary across discourse genres, with increases in disfluency found in narrative when compared to conversational production (Navarro-Ruiz & Rallo-Fabra, 2001; Wagner et al., 2000) as well as expository when compared to narrative production (Scott & Windsor, 2000) in both populations of typical developing and specific language impairment or language learning disabilities.

Multiple rationales have been proposed to explain the role typical and atypical disfluencies play in language processing and production. Some suggest mazing behaviors result from the increased demands required for the production of more complex language (Nippold et al., 2005; Thordardottir & Weismer, 2002). Mazing and pausing rates have been shown to increase as individuals produce sentences with greater syntactic complexity (as measured by mean length of utterance [MLU]) and lexical diversity (as measured by number of different words [NDW]) in individuals with typical development and those with TBI (Ellis & Peach, 2009; Rispoli & Hadley, 2001). The literature examining second language acquisition finds an increase of mazing behaviors in the learned-language as compared to the native-language (Gamez, Lesaux & Rizzo, 2016) or a different pattern of mazing based on the specific languages (Bedore et al., 2006). Other authors suggest silent pauses and mazes during speech production reflect language processing difficulties (Fraundorf & Watson, 2014; Peach, 2013). Levelt (1989) attributes mazing to difficulties with attention, as one must simultaneously retrieve information from long term memory while planning each new production. Still, other studies suggest mazing and silent pausing are indicative of a self-monitoring system (Gamez, Lesaux & Rizzo, 2016; Kormos, 1999; Levelt, Roelofs & Meyer, 1999; Navarro-Ruiz & Rallo-Fabra, 2001). This is evidenced by the fact that disfluencies occur more often as children age and in bilingual children, both of whom presumably have a higher level of linguistic skills and knowledge when compared to younger or monolingual peers (e.g., Bedore et al., 2006; Kormos, 1999).

It is possible that the type of maze or pause, as well as the location of the disfluency, may reflect varying underlying mechanisms. Filled pauses (e.g., like, umm) have been shown to occur in places associated with language planning at the message level of language processing (Fraundorf & Watson, 2014); whereas, repetitions suggest difficulty with lexical access (Thordardottir & Weismer, 2002). Similarly, silent pauses that occur between clauses suggest trouble with message planning (Fraundorf & Watson, 2014) or word order (Peach, 2013), and those occurring within clauses suggest word finding difficulties (Peach, 2013).

Little research has been conducted regarding the mazing and pausing patterns exhibited by persons with TBI, and most studies utilize adult participants. For example, Peach and Coelho (2016) found that 30% of intersentential cohesive ties produced by persons with TBI during a picture description task, whether correct or incorrect, had an associated pause or maze at the moment the tie was being produced. Cohesive ties are the bridge between microlingustic and macrolinguistic features of discourse (Peach &Coelho, 2016) because they refer to previously stated content. For example, "Jason is a good tailor. *He* hemmed my pants in 5 minutes." Here, "he" serves as the cohesive tie, linking Jason from the first sentence to the person who fixed my pants in the next sentence. The authors suggested that these findings are evidence that cognitive processes, namely attention, are shared between mirco- and macrolinguistic processing.

When comparing picture descriptions produced by a group of 15 adults with TBI six months post-injury and their matched pairs, Peach (2013) found no difference between the groups on length of narrative, syntactic complexity (i.e., MLU morphemes), number and type of errors, or abandoned utterances. However, the group with TBI, when compared to the group without injury, did exhibit an increased number of pauses per utterance, between-clause pauses (indicating trouble with sentence planning), and mazes. Both groups produced a greater number of within-clause pauses compared to between-clause pauses, suggesting that all adults tested showed a greater difficulty with lexical access than sentence planning.

In two studies comparing the linguistic skills of adults with TBI and matched controls using narrative productions (Stout et el., 2000) and narrative and procedural discourses (Hartley & Jensen, 1991), increased mazing behaviors and decreased target content were found in participants with TBI compared to adults without injury. These findings suggest adults who have experienced a TBI may produce increased pause and mazing patterns that are indicative of language processing deficits.

Some discourse studies involving pediatric TBI and matched control participants provide preliminary information regarding maze and pause patterning in the pediatric population. Though information on where the disfluencies occur is relatively lacking in this literature, differences in the amount of mazing and/or pausing may still imply sentence processing difficulties and/or reduced speech efficiency. In a study of persuasive spoken discourse, eight adolescents with TBI produced a significantly higher proportion of maze words to total words (Moran et al., 2012) when compared to a group of matched peers, even though there were no differences in syntactic complexity or productivity between groups. This may provide evidence of language processing or self-monitoring difficulties in children with TBI.

Biddle, McCabe, and Bliss (1996) analyzed the spontaneous narrative production of 10 adults with TBI, 10 children with TBI, and their matched controls. They reported that the group of adults and children with TBI produced significantly more disfluencies (false starts, filled pauses, silent pauses, and revisions), and also found that the group of children (both with TBI and TD) produced a significantly higher number of disfluencies compared to the adult group. Interaction effects found children with TBI to produce the most filled pauses and be the most disfluent of any group. These finding may suggest that children are particularly susceptible to decreases in language processing following a TBI.

In contrast, a study examining the conversation of adolescents with TBI and matched peers with TD found the group with TBI to produce a significantly lower percentage of utterances containing mazes early in recovery, which rose to similar levels as the group with TD after a year of recovery (Campbell & Dollaghan, 1990). Chapman et al. (1992) reported no difference in mazing behaviors (i.e., repetitions, revisions) during the narrative production of children and adolescents with TBI when compared to matched controls with typical development. The lack of information regarding the pause characteristics of children with TBI combined with the inconsistent mazing reported in discourse studies makes it difficult to draw convincing conclusions about the language processing abilities of children with TBI. It is possible that the inconsistent results are influenced by discourse type and elicitation task. It is also possible that children with TBI show a wide range of language processing abilities regardless of discourse type.

The current state of the literature is inconsistent regarding the characteristics of discourse production by persons with TBI, especially in children and adolescents. Further exploration into these characteristics across discourse genres may lead to a better understanding of and ability to support cognitive-communication deficits in the academic setting.

Overview of this study

The current study is a continuation of the project conducted by Lundine et al. (2018; in press) in which two verbal expository summaries (i.e., compare-contrast, cause-effect) and one verbal narrative summary were collected from each of five adolescents with TBI and 50 adolescents with typical development. While differences in summary quality based on a scoring rubric incorporating global macro- and microlinguistic variables have been reported elsewhere (Lundine et al., 2018), this paper will compare specific microstructural variables in addition to the mazing and pausing patterns exhibited by the five adolescents with TBI and a set of five matched peers with typical development. This additional analysis aims to contribute information to our understanding of narrative and expository discourse production differences in these two groups of adolescents, as well as explore potential language processing differences between adolescents with TBI and a group of matched peers with typical development through the analysis of mazing and pausing patterns. Two specific research questions were asked:

1. Do verbal narrative and expository summaries differ between adolescents with TBI and those with typical development on standard microstructural measures (productivity, lexical diversity, syntactic complexity)?
2. Do verbal narrative and expository summaries differ between adolescents with TBI and those with typical development on the amount or pattern of pauses or mazing behaviors (i.e. fillers, repetitions, and revisions)?

Methods

This protocol for was approved by all relevant Institutional Review Boards before beginning the study. Assent and/or consent forms were signed by participants and/or their parents (if under the age of 18) prior to enrollment. A parking voucher and gift card were given to participants after completion of the study tasks.

Participants

This study incorporated new analyses for discourse summaries produced as part of a study that has been previously described (Lundine et al., 2018; Lundine et al., in press). Briefly, five adolescent students who had experienced TBI were enrolled, in addition to 50 adolescents with typical development (TD). Inclusion criteria for the group of students with TBI were the following: (a) admission for moderate to severe closed head injury as indicated by a score less than 12 or between 13 and 15 with identifying brain legions on the Glasgow Coma Scale (Teasdale & Jannett, 1974), (b) age of nine years or older at time of injury and between 13 and 18 years at time of testing, (c) completion of 4^{th} grade by the time of injury and 7^{th} grade by time of testing, and (d) more than nine-months post injury. Patients were excluded when (a) English was not the primary language spoken at home, (b) child abuse had been documented as the mechanism of injury, (c) they exhibited severe motoric, speech, or language deficits that would inhibit successful participation in study tasks, or (d) there was a history of autism, developmental delay, or severe language or neurological disorders reported prior to the injury. The five students with TBI had a mean age of 16.0 years and a range of 13.6 – 18.0 years.

From the total 50 adolescents with TD who participated in the larger study, five controls were matched to the five participants with TBI based on age, sex, socioeconomic status, and grade. All control participants, had completed 7th grade at the time of study, were English speaking, had never been admitted to a hospital for TBI, and had no history of autism, developmental delay, or severe language or neurological deficits. The five controls used for this study had a mean age of 16.0 years and a range of 13.6 – 17.8 years. A complete description of both participants with TBI and with TD can be found in Table 1.

Participant	**Age (years)**		**Grade**		**Gender**		**Ethnicity**		**Years since injury**	**Lowest GCS**	**Mechanism of injury**
	TBI	**TD**	**TBI**	**TD**	**TBI**	**TD**	**TBI**	**TD**			
P1	13.6	13.6	8	8	F	F	C	C	1.3	7	MVA
P2	16.4	16.8	11	11	M	M	C	C	4.2	7	MVA
P3	18	17.8	12	12	F	F	M	C	4.2	3	MVA
P4	14.8	14.3	9	9	M	M	C	C	0.9	7	Bike vs. Car
P5	17.3	17.3	12	12	F	F	AA	C	2.3	3	MVA

Note: TBI = adolescent with TBI; TD = adolescent with typical development; C = Caucasian; M = Mixed; AA = African American; MVA = motor vehicle accident with ejection; GCS = Glasgow Coma Scale

Table 1: Participant demographics

Materials and Assessment Procedures

A uniform method as described in Lundine et al. (2018; in press) was used to elicit three verbal summaries from each participant: two expository (i.e., compare-contrast, cause-effect) and one narrative. This paper describes the results of an analysis of the 30 total summaries produced by the five students with TBI and 5 matched-controls. Each participant was seen by the primary researcher for a 45-60 minute session in a clinic treatment room of either the local children's hospital or a university Speech and Hearing Department. The researcher described the overall study process, explained how to form a good summary (i.e., the inclusion of the main idea and primary supporting details while excluding minor details)and provided an example summary to each participant. Participants then participated in a trial summary by describing the plot of a recently viewed movie, which was followed by feedback from the primary examiner who reinforced the important features of a good summary.

Discourse Stimuli and Summary Collection

The stimuli used for this project were short lectures presented on a computer monitor. Lectures typified a narrative and two types of exposition (compare-contrast and cause-effect). Attempts were made to make the content and structure of each video lecture equivalent based on commonly used measures of discourse length and complexity (e.g., number of words, sentences, reading level). To account for the potential bias of prior knowledge affecting recall for facts in expository discourse (Best et al., 2008; Wolfe, 2005; Wolfe & Woodwyk, 2010), each lecture was about the fictitious country of

Lifeland. The narrative lecture was about a hero who saved people following a plane crash in Lifeland. It was adapted from an article published in *Time* magazine (Rosenblatt, 1982) to match the length of the expository lectures, but retained full narrative story grammar. The two expository lectures each contained four main ideas with four subordinate details per idea**.** A summary of each lecture can be found in Table 2.

Discourse Genre (and type, if appropriate)	**Description**
Narrative	The good of humankind was observed in the "man in the water," who died after saving people following a plane crash in Lifeland.
Expository (cause-effect)	Early Lifeland inventions affected the development of other nations' early inventions, shipbuilding, written languages, and architecture.
Expository (compare-contrast)	Living in Lifeland has advantages and disadvantages in the areas of housing, education, employment, and population growth.

Table 2: Summary of stimuli lectures

Additionally, efforts were made to make each lecture equivalent based on common linguistic measures (e.g., number of different words/sentences/paragraphs, reading level) as well as the indices of linguistic- and discourse-measures provided by the online computational tool, Coh-Metrix (Graesser, McNamara, Louwerse, & Cai, 2004; McNamara, Graesser, McCarthy, & Cai, 2014; See Table 3). However, expected differences based on discourse genre were considered. For example, narrativity is expected to be higher in a narrative sample compared to an expository sample.

Each video was approximately five minutes in length and presentation order was randomized. The lectures were read by the same person in a neutral tone, with a nondescript backdrop and without visual cues. Participants were asked to summarize each video in a way that a person who had not seen it would learn the main idea and important parts without including unimportant details. Participants were allowed to speak without time constraints. The primary researcher provided nods of encouragement and verbal confirmations that the summary was completed if not otherwise clear. The summaries were recorded with a voice recorder (Olympus WS-823) and video camera (Sony HDR-XR260V).

Discourse stimuli comparison method	Narrative	Cause-Effect	Compare-Contrast
Coh-Metrix			
Narrativity	68%	34%	25%
Syntactic simplicity	42%	64%	72%
Word concreteness	46%	65%	71%
Referential cohesion	15%	45%	24%
Deep cohesion	84%	60%	53%
Grade level	7.3 (range: 7-8)	7.7 (range: 7-8)	8 (range 7-9)
Number of Words	935	731	743
Number of Sentences	57	50	51
Words per Sentence	16.4	14.6	14.5
Paragraphs	8	8	8
Flesch Reading Ease	66.4	66	61.7

See McNamara et al. (2014) for explanation of Coh-Metrix Variables

Table 3: Comparison of narrative and expository discourse stimuli lectures

Cognitive and Expressive Syntax Testing

Each participant completed cognitive and expressive syntax testing following the expository and narrative discourse productions. The order of testing procedures was randomized, and specific scores for both the five participants with TBI and controls can be found in Table 4.

Cognitive Testing

The cognitive abilities of each participant were measured using five subtests of the NIH-Toolbox Cognition Battery (NIH Toolbox CB; see Bauer & Zelazo, 2013 & Weintraub et al., 2013), which assesses executive functioning, episodic memory, processing speed, working memory, and attention. An age-adjusted fluid cognition composite score was calculated using the NIH-Toolbox Assessment Center (http://www.assessmentcenter.net/) and was the primary measure of cognitive ability reported for each participant (Lundine et al., 2018). Testing was given in two blocks and took approximately 25 minutes. One participant (TBI participant 2) was unable to complete all subtests according to the guidelines set forth by the NIH Toolbox CB due to motoric deficits from his TBI resulting in difficulties isolating the arrow buttons on the keyboard. Use of verbal responses or a Big Buddy switch system (AbleNet Inc., Roseville, MN) were accommodations used to help this participant complete cognitive testing.

Expressive Syntax Testing

The recalling sentences subtest of the Clinical Evaluation of Language Fundamentals – Fifth Edition (CELF-5; Wiig, Semel, & Secord, 2013a) was administered to each participant, with testing time lasting approximately 5 minutes. The standard score was the primary measure of expressive syntax reported for each participant, as it has shown to have a moderate positive correlation with core language performance (Wigg, Semel, & Secord, 2013b) and has been used in other studies examining expository discourse (e.g., Nippold, Mansfield, Billow, & Tomblin, 2008).

Participant	**Cognitive Composite Score**		**Expressive Syntax Standard Score**	
	TBI	**TD**	**TBI**	**TD**
P1	99.1	90.29	10	11
P2	46.23	120.08	7	10
P3	60.86	132.84	3	9
P4	89.93	90.9	10	12
P5	67.95	101.85	12	10

Table 4: Cognitive and expressive syntax scores

Summary Transcription and Analysis

All language samples were transcribed using standard Systematic Analysis of Language Transcripts conventions (SALT; Miller & Iglesius, 2010) with high levels of inter-rater reliability (between 96-100%).

Current Study

This paper is part of a larger, preliminary investigation into the cognitive and linguistic characteristics of adolescents with TBI as they relate to varying discourse productions. This paper's author and two undergraduate students reexamined the audio recordings and SALT transcripts produced from the larger study (Lundine et al., 2018; Lundine et al., in press). While all three coders were blinded regarding participant groups, additional measures were taken to blind the paper's author (e.g., renaming participant codes, removal from randomization process) as he had greater familiarity with the project and its aims. Audio files of each participant's narrative and two expository discourse samples were uploaded into Praat software (v.6.0.33; Boersma & Weenink, 2017), which allowed for audio to play while simultaneously displaying the sample's waveform.

Microlinguistic Measures

The SALT program (Miller & Iglesius, 2010) was used to calculate the common microlinguistic measures analyzed in this study.(i.e., number of analyzed utterances [TNCU], number of different words per utterance [NDW-rate], mean length of utterance in words [MLCU], and subordination index [SI]). TNCU is a measure of language productivity and is a count of analyzed c-units per discourse production. A c-unit, or utterance, is defined as "an independent clause and all of its modifiers" (Miller & Iglesius, 2010), which includes dependent clauses. NDW-rate is a count of each unique word produced divided by the total number of utterances. MLCU refers to the average number of words per utterance, and is a measure of syntactic complexity. SI is another measure of syntactic complexity and is defined as the total number of clauses per utterance (independent + dependent).

Pause Coding

While reviewing the SALT transcripts, the three coders used the Praat program to identify silent pauses of .2 seconds or longer by placing cursors on the waveform at the point of voice offset and subsequent point of voice onset. Pause lengths and types were then recorded. Studies of speech science have defined pause lengths between .2 and .3 seconds since a seminal work by Goldman-Eisler (1968), who defined a pause as greater than .25 seconds to account for articulatory shifts. Though some literature suggests that shorter pauses exist and occur due to varying linguistic or cognitive processes (Kirsner et al., 2002), .2 seconds was chosen as the threshold in hopes that it would be sensitive to group differences while being consistent with the majority of the literature. Each pause was classified as one of four pause types based on where it occurred in the sample: (1) Pause between utterances, (2) Pause following introductory phrase or initial conjunction of an utterance, (3) pause between clauses within an utterance (between-clause pause), or (4) pause within a clause (within-clause pause).

Maze Coding

The coders also counted three types of mazing behaviors (i.e., filled pauses, repetitions, and revisions) and differentiated them based on whether they occurred: (1)

following an introductory phrase or initial conjunction of an utterance or (2) within the main portion of the utterance. Maze types were coded on the transcripts and tallies of each type were recorded. The counts of each maze and pause type, as well as their combined counts, were used to calculate the average number of pauses per utterance, within-clause pauses per utterance, between-clause pauses per utterance, mazes per utterance, fillers per utterance, repetitions per utterance, and revisions per utterance. Additionally, the average pause length per utterance was calculated. See Appendix A for the list of pause and maze counting rules provided to coders.

Reliability

Following the initial coding of transcripts, 20% of the transcripts were reanalyzed by the three coders for intra- and interrater reliability checks using Cronbach's alpha. Intra- and interrater reliability for the identification of maze types were 1.00 and .98 respectively. Intra- and interrater reliability for the identification of pause types were .99 and .98 respectively. The average differences in corresponding pause lengths within and between coders were .03 seconds and .06 seconds respectively.

Results

Table 5 displays the means for each analyzed microstructural, mazing, and pausing variable across groups (children with TBI and children with TD) and discourse type (compare-contrast, cause-effect, and narrative). Group means were compared via paired t-tests, and all assumptions were met unless specifically mentioned below. The Holm-Bonferroni Method was utilized to correct for multiple hypothesis testing. All data and charts were analyzed and created by R Studio (Harrell, 2018; Hope, 2013; R Core Team, 2017; Revelle, 2017; Wickham, 2009).

Differences in Microstructural Measures across Discourse Types

When comparing the total number of analyzed c-unit (TNCU) differences between matched pairs, one outlier was identified in the cause-effect genre. Inspection of their values revealed they were reported correctly and were not extreme, so their values were kept in the analysis. In the TD group, the TNCU was highest in compare-contrast discourse production (M=17.2, SD=7.19), followed by cause-effect (M=13.4, SD=3.65) and then narrative (M=10, SD=1.87). Adolescents with TBI followed a different trend, with the greatest TNCU found in narrative production (M=9.0, SD=5.15), followed by compare-contrast (M=5.4, SD=1.52) and cause-effect (M=4.6, SD=3.21). Results of one-sided paired t-tests revealed the TD group to have significantly greater productivity than the TBI group during compare-contrast ($t(4) = -3.88$, $p=0.009$) and cause-effect ($t(4) = -4.27$, $p=0.007$) discourse productions. No statistically significant difference was found between groups during narrative production. Figure 1 contains the TNCU error bar plots for each discourse type.

The group with TBI produced a higher average number of different words per utterance (NDW-rate) than the group with TD during cause-effect (TBI: M=8.4, SD=3.1; TD: M=6.0, SD=1.3) and compare-contrast (TBI: M=7.8, SD=2.6; TD: M=6.0, SD=1.7) productions. In contrast, the group with TD produced a higher average NDW-rate than the group with TBI during narrative discourse (TD: M=7.9, SD=1.0; TBI: M=6.5, SD=1.7). However, these group differences of lexical diversity were not significant (See figure 2).

Similarly, no significant group differences were found in two commonly used measures of syntactic complexity (mean length of utterance in C-units [MLCU] and subordination index [SI]; See Figure 3 and Figure 4). Despite having a low expressive syntax standard score, one participant with TBI (P3) produced relatively high MLCU and SI scores. As such, the MLCU and SI difference scores produced by P3 and her matched pair produced outliers during cause-effect and narrative comparisons. If the outliers were removed, the group with TD was found to produce significantly higher MLCU and SI scores during both narrative and cause-effect productions. Since the data was reported correctly and the outliers produced could be due to the small sample size, a more conservative approach was taken and the data was left in the analysis. Both measures of syntactic complexity (i.e., MLCU and SI) were higher in the TD group during cause-effect narrative production, but higher in the TBI group during compare-contrast production (See Table 5 for means and standard deviations). These differences did not reach levels of statistical significance.

Variable Measure	Compare-Contrast		Cause-Effect		Narrative	
	TBI	TD	TBI	TD	TBI	TD
Microstructure						
TNCU	5.4 (1.5)	17.2 (7.2)	4.6 (3.2)	13.4 (3.7)	9.0 (5.2)	10 (1.9)
NDW-rate	7.8 (2.6)	6.0 (1.7)	8.4 (3.1)	6.9 (1.3)	6.5 (1.7)	7.9 (1.0)
MLCU	12.3 (5.2)	11.2 (1.9)	12.8 (5.4)	14.3 (2.7)	10.7 (3.1)	14.1 (2.0)
SI	1.7 (0.48)	1.4 (0.37)	1.5 (0.69)	1.7 (0.34)	1.5 (0.38)	1.8 (0.43)
Mazing						
Number of mazes/utterance	0.4 (0.5)	0.7 (0.5)	0.6 (0.5)	0.9 (0.3)	0.3 (0.5)	0.6 (0.3)
Filled pauses/ utterance	0.3 (0.4)	0.5 (0.3)	0.2 (0.3)	0.8 (0.2)	0.1 (0.2)	0.4 (0.2)
Revisions/ utterance	0.03 (0.06)	0.1 (0.06)	0.4 (0.4)	0.2 (0.1)	0.08 (0.1)	0.2 (0.07)
Repetitions/ utterance	0.03 (0.7)	0.07 (0.1)	0.0 (0.0)	0.02 (0.03)	0.08 (0.1)	0.09 (0.09)
Pausing						
Pauses/ utterance	3.2 (0.87)	1.9 (0.70)	4.1 (2.3)	2.3 (1.0)	3.0 (1.5)	2.5 (0.84)
Within-clause pauses/utterance	1.9 (0.76)	0.9 (0.45)	2.8 (2.1)	1.2 (0.74)	2.0 (2.0)	1.4 (0.60)
Between-clause pauses/utterance	0.7 (0.14)	0.6 (0.10)	0.5 (0.30)	0.6 (0.14)	0.6 (0.21)	0.6 (0.18)
Average pause length (seconds)	1.18 (0.62)	0.54 (0.066)	1.45 (0.95)	0.59 (0.17)	0.85 (0.35)	0.57 (0.12)

Table 5: Descriptive statistics for microstructural, mazing, and pausing measures by discourse type. Scores are mean (standard deviation).

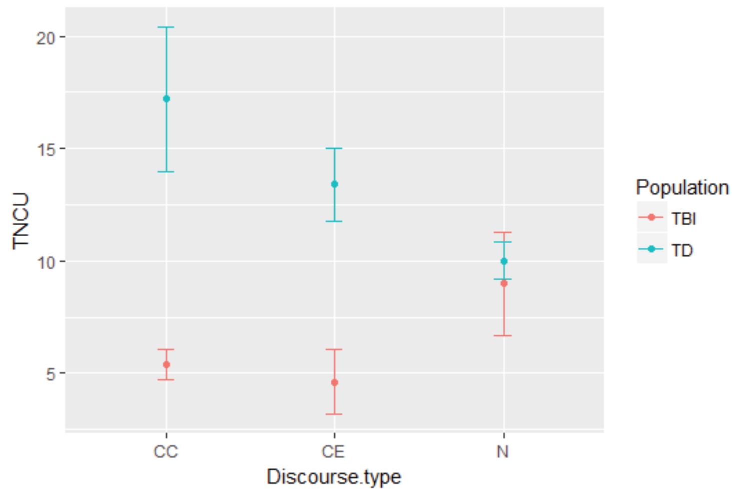

Figure 1: TNCU group averages by discourse type

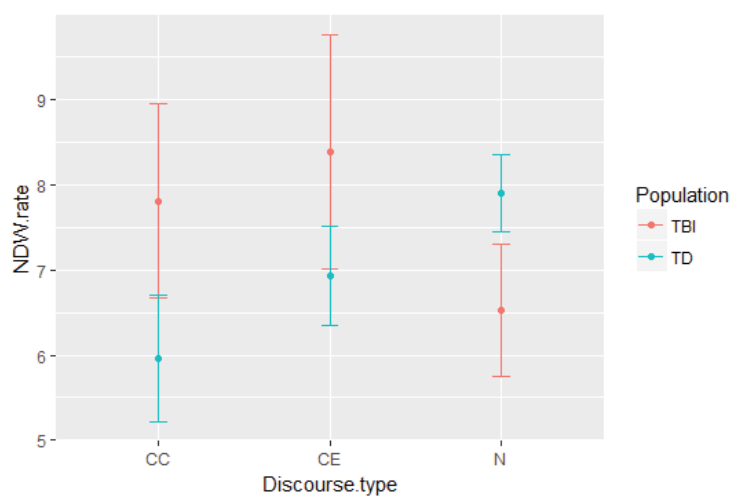

Figure 2: NDW-rate group averages by discourse type

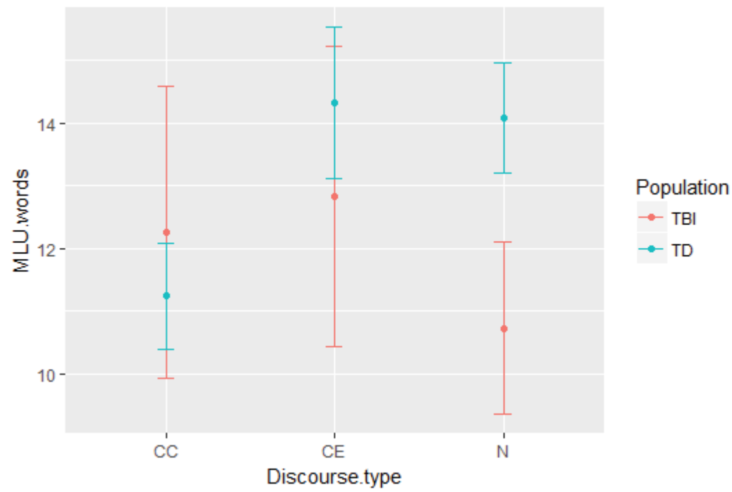

Figure 3: MLCU group averages by discourse type

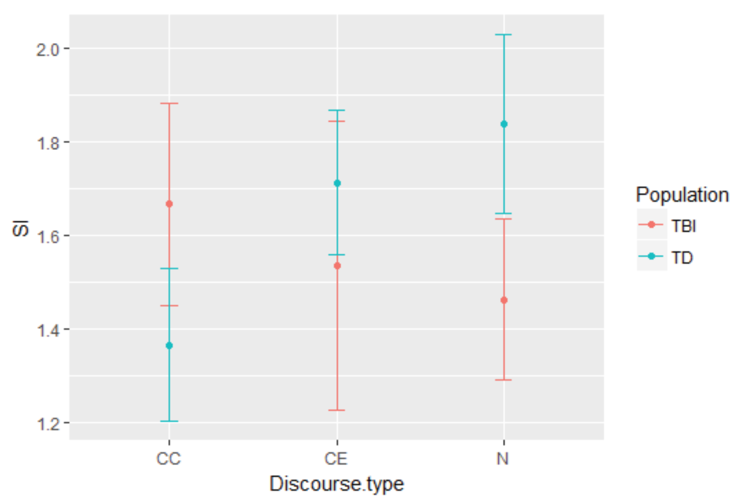

Figure 4: SI group averages by discourse type

Differences in Mazing Patterns across Discourse Types

In each discourse type, the TD group averaged more mazes per utterance than the TBI group (see Figure 5). Counted mazes include filled pauses, revisions, and repetitions. Two outliers were identified when comparing the differences between the TD and TBI groups during cause-effect production, but their removal did not change the lack of significance so they remained in the analysis. Both groups produced the most mazes per utterance during cause-effect production (TD: M=0.9, SD=0.3; TBI: M=0.6, SD=0.5), followed by compare-contrast (TD: M=0.7, SD=0.5, TBI: M=0.4, SD=0.5), then narrative (TD: M=0.6, SD=0.3; TBI: M=0.3, range=0.5). No significant differences were found between groups in any discourse type for total number of mazes per utterance.

When considering specific maze types, the TD group averaged more filled pauses per utterance than the TBI group across all discourse types (see Figure 6). The TD group produced the most filled pauses during cause-effect production (TD: M=0.8, SD=0.2; TBI: M=0.2, SD=0.3), followed by compare-contrast production (TD: M=0.5, SD=0.3; TBI: M=0.3, SD=0.4), and narrative production (TD: M=0.4, SD=0.2; TBI: M=0.1, SD=0.2). One sided paired t-tests revealed the TD group produced a significantly greater number of filled pauses per utterance during cause-effect production only ($t(4)= -4.70$, $p=0.005$) when compared to the students with TBI.

When analyzing the difference in the number of revisions per utterance during compare-contrast production, one outlier was identified and the difference scores were not normally distributed as determined by the Shapiro-Wilk test. Though the removal of the outlier's data produced a significant difference between the two groups (TD>TBI), the data was left in the analysis due to the small sample size. On average, the TD group produced more revisions per utterance than the TBI group during compare-contrast production (TD: M=0.1, SD=0.06; TBI: M=0.03, SD=0.06) and narrative production (TD: M= 0.2, SD=0.07; TBI: M=0.08, SD=0.1; See Figure 7). The number of revisions per utterance during cause-effect production was the only instance in which the TBI group produced a higher maze average than the TD group (TBI: M=0.4, SD=0.4; TD: M=0.2, SD=0.1). However, there were no statistically significant differences in the average number of revisions per utterance between groups.

The number of repetitions produced by both groups was so few that two outliers were present in both compare-contrast and narrative difference scores, and the cause-effect difference scores were not normally distributed. Because of the scarcity of their production by both groups, further statistical analysis was not completed.

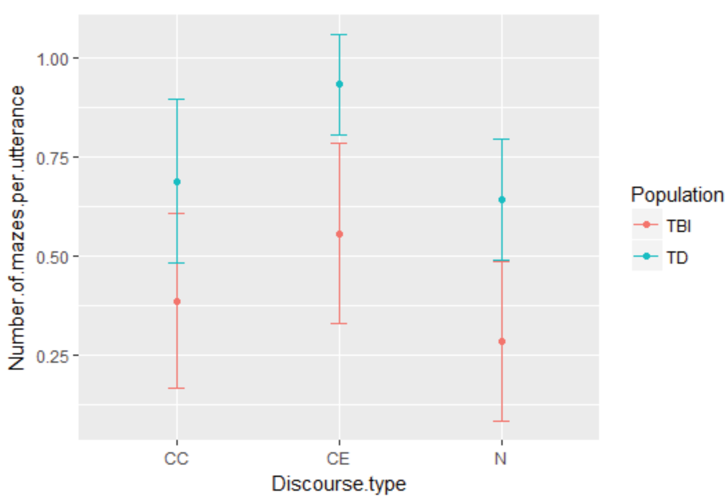

Figure 5: Average number of mazes per utterance by discourse type

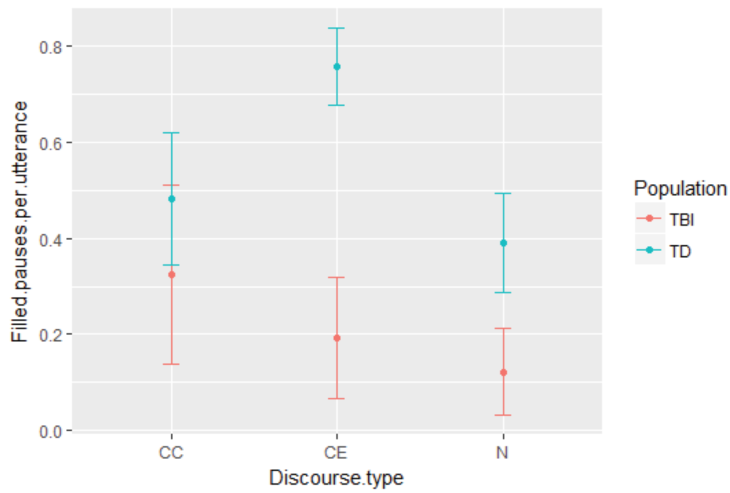

Figure 6: Average number of filled pauses per utterance by discourse type

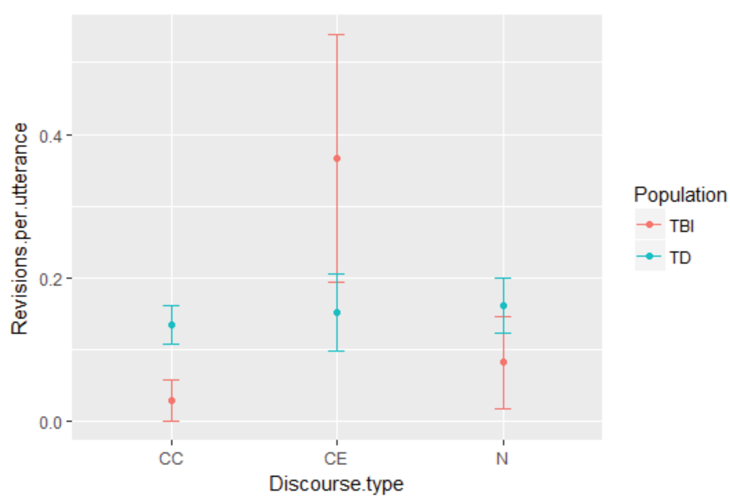

Figure 7: Average number of revisions per utterance by discourse type

Differences in Pausing Characteristics across Discourse Types

Prior to data analysis, one outlier was identified when calculating the difference scores for number of pauses per utterance between groups during narrative production, and two were identified when calculating the number of within-clause pauses per utterance in narrative production. However, their removal did not change the lack of significant findings in both cases, so they remained in the reported analysis.

On average, the TBI group produced more pauses than the TD group in all discourse types (see Figure 8). The average number of pauses per utterance was highest for the TBI group during cause-effect discourse production (M=4.1, SD=2.3), followed by compare-contrast (M=3.2, SD=0.87), then narrative production (M=3.0, SD=1.5). In contrast, the TD group produced the highest average number of pauses per utterances during narrative production (M=2.5, SD=0.84), then cause-effect (M=2.3, SD=1.0) and compare-contrast (M=1.9, SD=0.70) respectively. One sided t-tests revealed that the TBI group produced a significantly greater number of pauses per utterance during compare-contrast discourse production only ($t(4)=9.41$, $p = 0.0004$).

Two types of pauses were of particular interest to this study due to their proposed cognitive and linguistic underpinnings: between-clause pauses and within-clause pauses. There were no statistically significant differences between groups in any discourse type regarding the number of between-clause pauses, and the means were similar across group in compare-contrast (TD: M=0.6, SD=0.10; TBI: M=0.7, SD=0.14), cause-effect (TD: M=0.6, SD=0.14; TBI: M=0.5, SD=0.30), and narrative production (TD: M=0.6, SD=0.18; TBI: M=0.6, SD=0.21; see Figure 9). However, the number of within-clause pauses was higher, on average, for the TBI group when compared to the TD group in all three discourse types (see Figure 10). Students with TBI showed the greatest number of within-clause pauses during cause-effect production (TBI: M=2.8, SD=2.1; TD: M=1.2, SD=0.74), followed by narrative production (TBI: M=2.0, SD=2.0: TD: M=1.4, SD=0.60), then compare-contrast production (TBI: M=1.9, SD=0.76: TD: M=0.9, SD=0.45). Comparisons of group means utilizing paired t-tests revealed the TBI group to produce a significantly greater average number of within-clause pauses per utterance than students with TD when producing compare-contrast summaries (t(4)=4.86, p=0.004) .

The TBI group produced longer pauses on average than the TD group across all discourse types (see Figure 11). The greatest average length (in seconds) occurred during cause-effect discourse production (TBI: M=1.45, SD=0.95; TD: M=0.59, SD=0.17), then compare-contrast (TBI: M=1.18, SD=0.62; TD: M=0.54, SD=0.066) and narrative productions (TBI: M=0.85, SD=0.35; TD: M=0.57, SD=0.12) respectively. The TBI group produced significantly higher average pause lengths during production of expository discourse types (compare-contrast: t(4)=2.26, p=0.04; cause-effect: t(4)=2.46, p=0.034) which failed to maintain significance following corrections for multiple hypothesis testing.

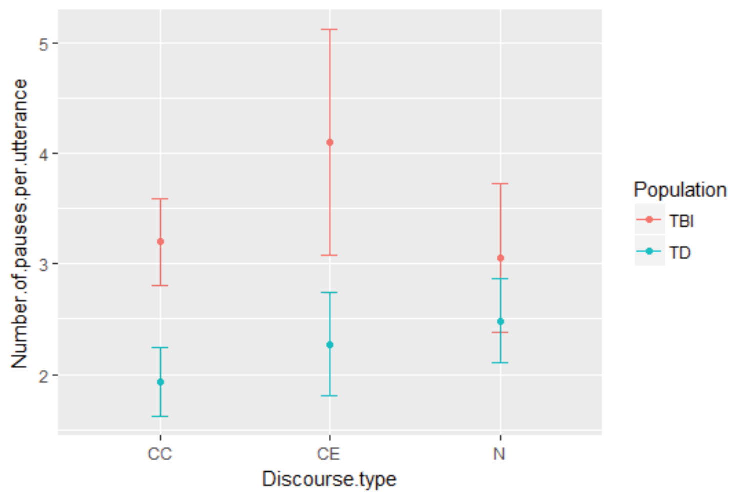

Figure 8: Average number of pauses per utterance by discourse type

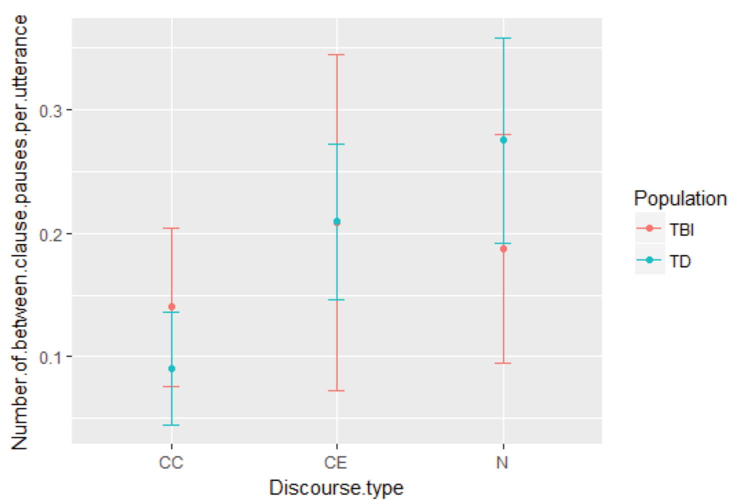

Figure 9: Average number of between-clause pauses per utterance by discourse type

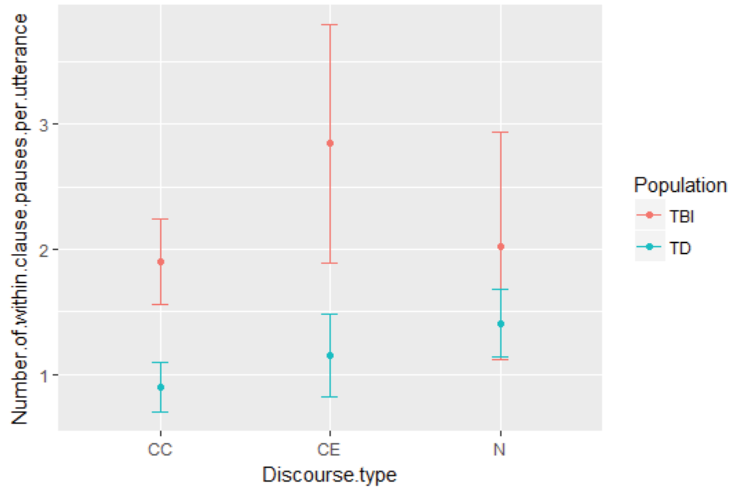

Figure 10: Average number of within-clause pauses per utterance by discourse type

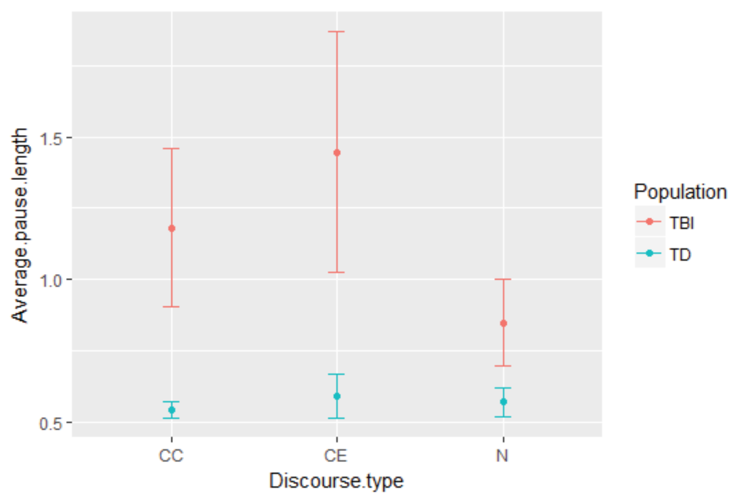

Figure 11: Average pause length by discourse type

Discussion

This exploratory study examined the microstructural, fluency, and pausing characteristics produced by adolescents with and without TBI during verbal summaries of compare-contrast, cause-effect, and narrative discourse stimuli. Group differences were analyzed based on population, and descriptive statistics were used to compare performance across discourse types.

Microstructural Differences

The first research question asked whether there were differences in the narrative and expository discourse production of adolescents with TBI and their matched peers with TD based on commonly used microstructural measures. These microstructural measures are often utilized in discourse studies to provide evidence of production differences for different discourse types well as different clinical groups. This study examined one measure of productivity (TNCU), one measure of lexical diversity (NDW-rate), and two measures of syntactic complexity (MLCU and SI). The current study found children with TBI to exhibit significantly reduced productivity when compared to peers with TD during both types of expository discourse production but not narrative. No other statistically significant microlinguistic differences were found between groups, contributing to the evidence that microlinguistic difference do not occur consistently in adolescents with TBI (Campbell & Dollaghan, 1990; Moran et al., 2012). This is the first discourse study to compare verbal summaries in adolescents with TBI, with past studies utilizing retell or spontaneous generation to elicit samples. Additionally, this study compared within-genre differences (compare-contrast and cause-effect) and between-genre group differences (narrative and expository).

The analysis of microstructural variables provides preliminary evidence that different patterns may exist between narrative and expository discourse production. Both Hay and Moran (2005) and Scott and Windsor (2000) found groups of adolescents (TD+TBI; TD+ Language Learning Disability) to be more productive during narrative discourse than expository discourse. These findings were the same across groups of students. In the current study, the group with TBI was most productive during narrative production as well. In stark contrast, the TD group from the current study was more productive, on average, during both expository discourse types.

In terms of syntactic complexity, past studies have found MLU scores to be higher in expository discourse productions (Lundine et al., in press; Scott & Windsor, 2000) and SI scores to be greater in narrative productions (Hay & Moran, 2005; Lundine et al., in press; Scott & Windsor, 2000) in groups containing adolescents with TD and TBI or language learning disabilities. The group with TBI in the current study followed a similar trend, producing higher average MLCU scores during expository discourse compared to narrative discourse production. Though the group with TD produced the highest average MLCU during cause-effect, the other type of expository production (i.e., compare-contrast) resulted in an average MLCU score that was lower the narrative score.

Similarly, the group with TD produced the highest SI scores during narrative production, which is consistent with past literature. However the group with TBI produced the lowest average SI score during narrative production. It is possible that these results support varying trends of microlinguistic measures during narrative and expository summary production across diagnostic groups. Additional statistical analysis is necessary to determine if the observed difference across discourse genre reach statistical significance.

Within the expository genre specifically, the TD group and TBI group were more productive during compare-contrast summary production than cause-effect. A similar trend was found by Ward-Lonergan et al. (1999), who examined expository retell by adolescents with language impairment and those with typical development. These consistent findings provide preliminary evidence that individual adolescents tend to produce more utterances during compare-contrast discourse when compared to cause-effect productions, even if the elicitation task is different.

The analysis of microstructural differences between adolescents with TBI and peers with TD bring to light some important points. While reduced productivity seems to be a common finding in research studies examining the performance of children with TBI, its interaction with discourse genre and elicitation task is not clear. For example, Chapman et al. (1992) reported reduced productivity by a group of children and adolescents with TBI when compared to matched controls during a narrative *retell* task. The current study found no difference during a narrative *summary* task. Though the students with TD in the current study did not show the highest productivity in narrative discourse as found by Hay and Moran (2005), it is important to note that the type of expository discourse produced as well as the elicitation tasks were different between these two studies (i.e., procedural v. compare-contrast and cause-effect; retell v. summary). This, combined with the inconsistent finding across discourse types in regard to measures of syntactic complexity, may highlight the need to consider each type of expository discourse as having unique cognitive or language demands that result in different patterns of microstructural characteristics during production tasks.

Most importantly, the lack of significant differences in NDW-rate, MLCU, and SI measures between adolescents with TBI and those with TD reinforces the need to explore other methods of discourse assessment for children with TBI. Findings from this study suggest that commonly used microlinguistic measures elicited during a discourse task may not identify differences between groups, at least when students with TBI show expressive syntax abilities that fall within average limits (see Table 4). The lack of significant differences may be due to the large amount of microlinguistic variability produced by adolescents with TBI. With the exception of TNCU in the expository discourse types and SI in narrative production, the group with TBI had higher standard deviations in all other microstructural measures across genres. Alternatively, the lack of significant findings reinforces the idea that TBI does not typically disrupt the microlinguistic features of an individual's expressive communication. This evidence, combined with the inconsistency of the literature, supports the idea that the microlingustic measures traditionally used in studies of discourse following TBI may not effectively differentiate the population of students with TBI from those with TD.

Mazing and Pausing differences

The second research question for this study asked whether there were differences across discourse genres between adolescents with TBI and their peers with TD in regard to mazing and pausing characteristics. Mazes and silent pauses during speech are thought to indicate moments of cognitive-linguistic processing necessary for language planning and production (Caspari & Parkinson, 2000; Ellis & Peach, 2009). As such, differences in rate, length, or placement of mazes or pauses within an utterance may provide insight into potential language processing difficulties in adolescents with TBI. With the exception of revisions during cause-effect discourse production, the adolescents with TD produced more of each type of maze per utterance when compared to the group with TBI. However, the only significant differences identified were in filled pauses during cause-effect production. These results are surprising, as past literature generally notes increased mazing in groups with TBI (Hartley & Jensen, 1991; Hay & Moran, 2005; Moran et al., 2012, Peach, 2013; Stout et al., 2000).

It is possible that the small sample size in the current study resulted in significant differences that would not exist in a larger sample size. If these findings do represent actual differences between groups and not a Type I error, the increased mazing produced by the group with TD could be explained in several ways. Filled pauses are theorized to indicate moments of language planning (Peach 2013), as they occur most frequently at syntactic, semantic, and prosodic boundaries (Fraundorf & Watson, 2014). Fraundorf and Watson (2014) suggested that filled pauses, more than silent pauses and repetitions, indicate a revision of an utterance at the message level of language processing, rather than the syntactic or phonological levels. Perhaps in the current study, the reduced number of mazes per utterance was driven by the reduced number of filled pauses per utterance by the students with TBI, and is indicative of reduced attempts by the students with TBI to edit or correct message-level communication intentions. This is further evidenced by the fact that the previous study by Lundine et al. (2018) showed the same group of adolescents with TBI to have reduced overall summary quality when measured by a scoring rubric comprised of macrostructural and microstructural variables. This group with TBI's poorer ability to incorporate the main idea (or "gist") and link ideas in an organized manner during discourse production (Lundine et al., 2018) may reflect poor message planning that results in a decreased use of filled pauses. Others suggest that mazing is indicative of the self-monitoring of speech across levels of language processing (Levelt, 1989; Navarro-Ruiz & Rallo-Fabra, 2001) and may be a way a speaker lets the conversation partner know that planning difficulties are occurring (Clark & Fox Tree, 2002). From this perspective, filled pauses are thought to be a way for a speaker to indicate they are not finished talking (Navarro-Ruiz & Rallo-Fabra, 2001). The reduced mazing produced by the group with TBI could also be explained by those that relate mazing to cognitive processes like attention (Levelt, 1989) and memory (Caspari & Parkinson, 2000), as the group with TBI produced lower scores on the measure of cognition administered before the elicited discourse samples (see Table 4). Thus, these findings may indicate that the students with TBI have fewer cognitive resources available to monitor their language during summary production. In general terms, adolescents with

TBI may not be planning and monitoring their production in the same way as adolescents with TD, thus, they are less likely to revise their output.

When considering pausing patterns, the group with TBI paused more than the group with TD. Generally speaking, silent pausing is associated with moments of utterance planning, though the location of the silent pause in relation to the utterance as a whole is thought to suggest planning at different levels of language processing. The difference in pausing found between the two groups in this study, while not consistently at levels of statistical significance, was driven by a differences in the number of within-clause pausing. Within-clause pausing is thought to suggest difficulties with lexical access (Peach, 2013) and/or syntactic or phonemic encoding (Fraundorf & Watson, 2013). These findings may suggest that adolescents with TBI struggle with the lower levels of language processing. Because the students with TBI in the current study did not show diferences in the measures of syntactic complexity (i.e., MLCU, SI) or lexical diversity (NDW-rate), it is possible that these lower level processing difficulties, specifically lexical access, manifested as reduced productivity (TNCU). This is further evidenced by the relationship of group differences when considering TNCU and number of within-clause pauses per utterance (see Figures 1 and 10), as large differences were found in both variables during expository discourse production, but not narrative production. Alternatively, it is possible that the adolescents with TBI were able to compensate for syntactic or lexical difficulties by allowing more time for language processing via within-clause pauses.

The patterns of pausing reported by this study support the results of similar research studies. Like Peach (2013), who compared picture descriptions of adults with TBI and adults with TD, the group with TBI from the current study produced more pauses per utterance on average than the group with TD across discourse types, and within-clause pauses were more common than between-clause pauses for both groups. Unlike Peach (2013), the group with TBI in this study did not consistently produce more between-clause pauses when compared to the TD group. While further study is needed to help explain the discrepancy regarding the significance of pause types and the associated cognitive-linguistic underpinnings, these studies provide evidence that people with TBI tend to produce more silent pauses in general than those with TD.

In addition to pausing more than their peers with TD, adolescents with TBI in the current study also paused for longer periods of time. It is thought that the mental processes needed to plan upcoming utterances occur during silent pauses (Ellis & Peach, 2009; Goldman Eisler, 1968). Though the significant difference found in average pause lengths during expository discourse production failed to maintain significance following corrections for multiple hypothesis testing, the group with TBI's average pause lengths were twice as long as the group with TD. This finding is consistent with past research, which found the perceived slowed speaking rate of a group of children and adolescents with TBI could be accounted for by increased within-utterance pause lengths in four of five individuals (Campbell & Dollaghan, 1995). These findings may provide evidence of slower cognitive-linguistic processing for utterance planning during expository summary production in adolescents with TBI, but further study is needed.

In general, pauses are thought to indicate moments of language processing at various levels, and mazes are hypothesized to be processes for self-monitoring. In the current study, the students with TBI produced more, lengthier pauses and fewer mazes than the students with TD. As such, these findings may imply that adolescents with TBI have language processing difficulties, particularly during expository summary productions, resulting in a reduction of cognitive resources available for self-monitoring. These possible language planning and monitoring difficulties could help to explain the poor content and perceived slowness commonly reported during the speech production of adolescents with TBI.

Limitations and future directions

The current exploratory study is limited due to the small sample size and large number of reported variables. While patterns of group averages were found across variables and discourse types, significant findings were limited and were not consistently present in any one discourse type. In addition, some significant findings failed to remain so following Holm-Bonferroni corrections. Repeated testing with a larger sample size would allow for a more accurate representation of measured variables. This would be especially helpful for the characterization of discourse production by adolescents with TBI, who have been studied less and produced much greater variability in microstructural and pausing variables in the current study.

Future research should focus on continued study of expository discourse production. This study adds support to the argument that each type of expository discourse (e.g., compare-contrast, cause-effect) may result in different patterns of microstructural elements, mazing, and pausing. Researchers need to carefully consider and describe the type of discourse they are studying, as well as the elicitation task required of participants, as these variables may highly influence results. This point is also important when making comparisons across studies.

While conclusive findings regarding the cognitive-linguistic implications of language processing and production evidenced by varying types of silent pauses in people with TBI have yet to be found, this study contributes to a body of literature that finds people with TBI to produce more pauses that last longer when compared with matched peers. In the current study, this difference was most prevalent during expository discourse productions. Similarly, individuals with TBI were found to produce significantly less language in verbal summaries of expository lectures, but not a narrative lecture. Together, these findings offer additional support to particular ways students with TBI might be affected in expository discourse tasks. This presents a basis for future inquiry and deserves further examination. Future exploration of fluency characteristics like articulation rate (i.e., how long it takes a person to articulate) and pause patterning (e.g., number and length) of people with TBI could prove to have value as part of the diagnostic process.

Conclusion

This exploratory study examined the microstructural, fluency, and pausing characteristics produced by adolescents with and without TBI during verbal summaries of compare-contrast, cause-effect, and narrative discourse passages. The study was an extension of the work by Lundine et al. (2018; in press), and the findings contribute to our understanding of expository discourse production by both adolescents with typical development and those with TBI. In general, the adolescents with TBI produced fewer mazes, produced more and longer silent pauses, and were less productive than their matched peers with typical development during compare-contrast and/or cause-effect expository discourse production, but not during narrative summary production. Future research is needed to replicate these findings and contribute additional evidence in areas where the results did not align with other studies. The results have implications for educators and clinicians, as adolescents with TBI may not show consistent differences in performance on the standard microstructural measures assessed by common standardized assessments. Educators and clinicians must be aware of the production characteristics of adolescents with TBI and use other means to qualify children for speech-language pathology services, like clinical judgement, classroom observations, and samples of academic work. Findings from this study suggest the use of expository discourse samples may better identify differences in productivity and pausing characteristics than narratives. This study highlights the need for researchers to carefully consider discourse type and elicitation method when designing future discourse studies. In addition, the study revealed that measures related to pause characteristics may be a worthy area of future study for researchers who want to establish reliable and valid methods for identifying cognitive communication challenges in adolescents with TBI.

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Appendix A. Pause and Maze Coding Instructions

Counting Rules	Adapted from Peach (2013) Appendix

1. Pauses
   a. Identify any pause > .200 s and record their specific length.
   b. Label each pause as *within-clause, between-clause, between-utterance,* or part of an *introductory phrase*.
      i. Within-Clause Pause
         "He put the (:.450) bread on the table"
      ii. Between-Clause Pause
         "The girl (:.750) who he wanted to win the race did not compete"
         "Alan went to the store (:.450) although he didn't want to"
      iii. Between-Utterance Pause – any pause between the final offset of an utterance and the subsequent onset of the subsequent utterance.
         "S (:1.234) the story was about…"
      iv. Introductory phrase pause– any pause that occurs as part of or following an initial conjunction or introductory phrase of an utterance.
         "And (:.450) he lost his trophy"
         "After that (:.450) he lost his trophy"
2. Mazes
   a. If multiple attempts at a word or phrase occur, consider the final correct production as correct and all preceding attempts as mazes.
   b. Code mazes as filled pauses [FP], repetitions [REP], or revisions [REV] if they occur during the main portion of an utterance. If they occur at the beginning, following an initial conjunction, or following/within an introductory phrase, code them as introductory by adding an I to each code ([FPI], [REVI], [REPI] and confirm that the utterance that remains complete if the mazes were to be removed.
      i. Repetition – When a word part, word, or phrase is repeated.
         "I want to go to ([REP] the) the store."
      ii. Filled Pause – Any meaningless word or sound used to fill space during production.
         "And ([FPI] like) he went to them ([FP] um) store."
      iii. Revision – When words or a phrase are edited and changed after they have been spoken.
         "And he just ([REP] went) ran home."
3. Do not count:
   a. Pauses or mazes in an utterance that are unintelligible or abandoned/incomplete.
   b. Pauses that occur between mazes.