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Research Note

Microstructural and Fluency Characteristics of Narrative and Expository Discourse in Adolescents With Traumatic Brain Injury

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Purpose: The purpose of this exploratory study was to identify specific microstructural and fluency differences in expository and narrative summaries produced by students with a traumatic brain injury (TBI) compared to students with typical development (TD).
Method: Five adolescents with TBI and 5 matched peers with TD verbally summarized 1 narrative and 2 expository (compare–contrast, cause–effect) lectures, creating 30 summaries. Researchers transcribed summaries and used paired *t* tests to analyze between-group differences in microstructural measures (productivity, lexical diversity, syntactic complexity), mazing behaviors, and pausing patterns.
Results: Youth with TBI produced significantly fewer utterances than teens with TD in both expository contexts, whereas youth with TD produced a significantly greater mean length of C-unit than teens with TBI in the narrative summary only. Youth with TBI produced significantly fewer filled pauses per utterance than did youth with TD during the cause–effect summary only and significantly more pauses per utterance and within-clause pauses per utterance during the compare–contrast summary. Where findings were statistically significant, effect sizes were large. There were no statistically significant between-group differences in mazing or pausing behaviors during narrative summary production.
Conclusions: This study is the 1st to compare microstructural and fluency characteristics in teens with TBI and those without when producing verbal summaries of a narrative and 2 types of expository passages. Findings from this study reinforce the need to expand research focusing on expository discourse tasks and identify variables that may be prone to disruption following TBI. Future work is needed to confirm whether identified differences correspond to true discourse difficulties.
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A traumatic brain injury (TBI) experienced during childhood can result in lasting deficits in physical, behavioral, social, linguistic, and cognitive functioning that can impede success both in and out of the classroom (Catroppa, Anderson, Morse, Haritou, & Rosenfeld, 2008; Fuentes et al., 2018; Sullivan & Riccio, 2010; Yeates et al., 2005, 2004). Yet, even for children and adolescents who sustain a severe TBI, these deficits may not be evident on formal speech-language or neuropsychological assessments (Coelho, 2007; Cook, DePompei, & Chapman, 2011). As a result, many students may not have the documentation necessary to qualify them for support services at school (Glang et al., 2008; Haarbauer-Krupa et al., 2017), helping to explain why many students with TBI report unmet academic needs years after their injury (Fuentes et al., 2018; Kingery et al., 2017).

To augment standardized testing for persons with TBI, it is recommended that discourse tasks be included as part of a formal assessment (Coelho, Liles, & Duffy, 1991). Competence in the production and comprehension of discourse-level language is crucial for a student's academic success (Gillam, Peña, & Miller, 1999). Most research examining discourse following TBI in children focuses on narrative production or comprehension (e.g., Biddle, McCabe, & Bliss, 1996; Chapman et al., 1992, 1997; Ewing-Cobbs, Brookshire, Scott, & Fletcher, 1998; Walz, Yeates, Taylor, Stancin, & Wade, 2012). Expository or informational

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discourse is considered the "language of the curriculum" (Ward-Lonergan, 2010), but few studies have explored how students with TBI produce or comprehend expository passages (e.g., Chapman et al., 2006; Hartley & Jensen, 1991; Hay & Moran, 2005; Lundine, Harnish, McCauley, Zezinka, et al., 2018), despite the ecological validity of such a task for school-age individuals.

Much of the published discourse-related research related to young persons with TBI focuses on microstructure variables. More commonly with adults than with children who have TBI, discourse studies may also analyze fluency variables. Thus, as we expand discourse research into the expository genre, an examination of microstructure and fluency elements allows for some comparison to past work. Microstructural analyses focus on sentence-level lexical and syntactic features within a discourse passage, as opposed to macrostructural analyses that focus on passage-level features, such as overall coherence and main idea (Davis & Coelho, 2004). Macrostructural features of discourse are an essential component to consider in comprehension and production tasks, especially in expository contexts where students are expected to integrate new information with previously learned facts to expand their understanding of a given topic. As researchers move forward in the expository genre, it is important to identify the key variables that may help clinicians and educators identify students who struggle within this genre. As one step in this process, this article specifically focuses on microstructural variables and fluency.

Microstructural variables frequently incorporated into discourse analyses include (a) productivity (a measure of the amount of language produced in a discourse passage), (b) lexical diversity (a measure of the variability of vocabulary used throughout a passage), and (c) syntactic complexity (a measure of the complexity of individual utterances). Fluency in spoken discourse is measured by the frequency of disruptive behaviors, typically divided into mazing and pausing behaviors. Examples of mazes include filled pauses (e.g., umm, like), partial- or whole-word repetitions, false starts, and revisions (Loban, 1976).

Studies examining microstructural variables in discourse produced by children and adolescents with brain injury compared to peers without injury have produced mixed results. Campbell and Dollaghan (1990) found that nine children (aged 5;6–16;2 [years;months]) with TBI showed significantly decreased productivity (number of words and utterances), lexical diversity (number of different words), and syntactic complexity (mean length of utterance) compared to age-matched peers in a conversational discourse task when tested upon their admission to inpatient rehabilitation. However, 1 year after their injury, the only significant microstructural difference that remained between groups was the total number of utterances produced during conversation. Thus, differences in the microstructural characteristics of conversational discourse nearly disappeared for children with TBI 1 year after their injury. Chapman et al. (1992) found that children grouped into severe and mild TBI groups had significantly decreased productivity, but not syntactic complexity, when they retold lengthy narratives 1 year postinjury compared to children without injury. Conclusions from these studies are limited by the large age span within participant groups (11 and 9 years, respectively). In the study by Chapman et al., participants ranged from 1 to 5 years postinjury, which leads to potential confounds related to recovery and/or late effects of injury. Furthermore, Chapman et al. include one measure of vocabulary and one measure of working memory (for which children in TBI and non-TBI groups did not differ at levels of statistical significance), making it difficult to draw complete between-groups comparisons related to cognitive and language abilities.

In a study examining narrative and procedural expository discourse, Hay and Moran (2005) found that children with brain injury showed decreased productivity and syntactic complexity compared to matched controls, at levels of statistical significance. Additionally, both groups of children showed increased productivity and syntactic complexity on the narrative retell task compared to the procedural expository discourse task. The authors suggested that these differences indicated that the expository retell task was more challenging for both groups of children, but especially challenging for students with brain injury. Notably, in this study, all participants with brain injury demonstrated significant language deficits (with performance 1.5–2 *SD*s below the mean on standardized tests of language and vocabulary); thus, it is not surprising that the participants with TBI would underperform age-matched peers on discourse tasks. Further complicating the conclusions from this study is the fact that participants with TBI ranged from 2 to 15 years postinjury and had a mix of traumatic and nontraumatic injury mechanisms, complicating within-groups comparisons. An additional study (Brookshire, Chapman, Song, & Levin, 2000) also found reduced productivity and syntactic complexity for narratives retold by 8- to 16-year-old children 3 years following a severe TBI compared to those who experienced a mild TBI. Other studies have not consistently found microstructural differences between young persons with and without TBI (e.g., persuasive discourse: Moran, Kirk, & Powell, 2012; personal narrative: Turkstra & Holland, 1998).

In a discourse production task, both mazing (i.e., filled pauses, revisions, repetitions) and pausing behaviors can disrupt language flow. Thus, it is important to know if even subtle cognitive–communication deficits that can occur following a TBI might impede a student's ability to produce discourse fluently. The small number of studies that examined fluency in the discourse of children post-TBI has shown inconsistent results. Two studies that examined mazing behaviors in children 1 year following TBI found no significant differences compared to those without TBI (Campbell & Dollaghan, 1990; Chapman et al., 1992). However, Biddle et al. (1996) and Moran et al. (2012) evaluated spontaneously produced narrative and persuasive passages, respectively, finding that children who were more than 1 year post-TBI demonstrated increased mazing behaviors compared to noninjured peers. It is suggested that mazing allows a speaker to monitor and make corrections within a language sample (Levelt, 1983), but the paucity of research in young persons with TBI makes it difficult to draw conclusions about mazing behaviors that are typical or atypical when compared to peers without injury.

An analysis of pause time has been proposed as an online method to measure sentence planning in persons with TBI (Peach, 2013). Campbell and Dollaghan (1995) suggested that cognitive processing speed (measured as percentage of within-utterance pause time) should be dissociated from articulation speed (measured as average syllable duration) in children and adolescents with TBI, because the origins of these difficulties may be distinct—which means differences noted between persons with and without a TBI could be cognitive–communication related (in the former) versus motor related (in the latter). In a study of adults with TBI, Peach (2013) further proposed that studying the location of a pause within an utterance could point to two distinct processes. Namely, pauses occurring between clauses indicate challenges with the long-term planning of future clauses (i.e., word order and syntactic rules), whereas within-clause pauses reflect difficulties with lexical retrieval (Kircher, Brammer, Levelt, Bartels, & McGuire, 2004; Levelt, 1983; Peach, 2013). Peach found that adults with TBI produced more between-clauses pauses and more mazes than did adults without injury. Furthermore, these maze and pause behaviors were associated with measures of working memory, organization, and monitoring, which Peach inferred related to the individual's "preparation to use language" (Peach, 2013, p. S294). These types of analyses have not yet been used to examine the discourse productions of children or adolescents with TBI but could prove valuable as clinicians and educators seek to identify target variables that might help assess discourse abilities in children with TBI.

Many factors could lead to inconsistent microstructural and fluency findings among past studies, including the discourse genre (i.e., narrative, expository, conversation, persuasion), method of elicitation (e.g., retell, spontaneous generation, summary), and language and cognitive abilities of the participants as documented on formal assessments. Additionally, heterogeneity of cognitive and communication outcomes is a hallmark of TBI recovery, which likely contributes to the variability reported in past research. Further complicating this issue is the inclusion of participants within a wide range of ages, injury severities, or time since injury (as mentioned in many of the past studies cited previously). The discrepancies in the existing literature make it difficult to draw conclusions about how TBI might affect a student's productivity, lexical diversity, and syntactic complexity, as well as overall fluency, in different discourse genres. Specifically, we lack information about the microstructural and fluency performance of adolescents with TBI in academically relevant, expository discourse tasks. As research focusing on expository discourse seeks to identify relevant variables for assessment and intervention, it would be helpful to determine which key microstructural and fluency variables differentiate the discourse performance of students with TBI from those without injury.

In order to begin to address these gaps in knowledge, this study compared narrative summaries to two types of expository discourse not previously studied in young people with TBI: cause–effect and compare–contrast. Furthermore, it incorporated commonly used microstructural analyses, with the addition of an analysis of mazing and pausing behaviors. This project focused on two specific research questions:

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

We hypothesized that adolescents with TD would show greater productivity, lexical diversity, and syntactic complexity than adolescents with TBI on all summaries. Alternatively, we hypothesized that adolescents with TBI would show increased mazing and pausing behaviors compared to adolescents with TD.

Method

All relevant review boards approved this protocol prior to its initiation. Participants and/or their parents signed assent and/or consent forms. Participants received a parking voucher and a gift card following the completion of study tasks.

Participants

This study expands on the analysis of discourse summaries produced as part of a larger study that has been previously described (Lundine, Harnish, McCauley, Blackett, et al., 2018; Lundine, Harnish, McCauley, Zezinka, et al., 2018). Briefly, five adolescent students who had experienced TBI were enrolled, in addition to 50 adolescents with TD. Students with TBI met the following inclusion criteria: (a) hospital admission for moderate-to-severe closed-head injury as indicated by a score of less than 12 on the Glasgow Coma Scale (Teasdale & Jennett, 1974), (b) age of 9 years or older at the time of injury and between 13 and 18 years at the time of testing, (c) completion of fourth grade by the time of injury and seventh grade by the time of testing, and (d) more than 9 months postinjury. Persons were excluded if (a) English was not the primary language spoken at home; (b) child abuse was documented as the mechanism of injury; (c) there were documented 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 (range: 13.6–18.0 years). Table 1 displays demographic and injury-related information about these five participants.

To create a matched pair for each participant with TBI, the authors chose five control participants from the

Table 1. Participant demographics and test results.

Participant pair	Age (years)		Grade		Gender		Ethnicity		Cognitive composite score (NIH Toolbox Cognitive Battery)[a]		Expressive syntax score (Recalling Sentences; CELF-5)[b]		Years since injury	Lowest GCS	Mechanism of injury
	TBI	TD	TBI	TD	TBI	TD	TBI	TD	TBI	TD	TBI	TD	Participants with TBI only		
P1	13.6	13.6	8	8	F	F	C	C	99.1	90.3	10	11	1.3	7	MVA
P2	16.4	16.8	11	11	M	M	C	C	46.2	120.1	7	10	4.2	7	MVA
P3	18	17.8	12	12	F	F	Mi	C	60.9	132.8	3	9	4.2	3	MVA
P4	14.8	14.3	9	9	M	M	C	C	89.9	90.9	10	12	0.9	7	Bike vs. car
P5	17.3	17.3	12	12	F	F	AA	C	68.0	101.9	12	10	2.3	3	MVA

Note. CELF-5 = Clinical Evaluation of Language Fundamentals–Fifth Edition; GCS = Glasgow Coma Scale; TBI = traumatic brain injury; TD = typical development; F = female; C = Caucasian; MVA = motor vehicle accident with ejection; M = male; Mi = mixed; AA = African American.

[a]*M* = 100, *SD* = 15. [b]*M* = 10, *SD* = 3.

total 50 adolescents with TD who participated in the larger study. Participant pairs matched on age, sex, socioeconomic status, and grade (see Table 1). A matching variable for socioeconomic status (representing race and income) was included because it was a significant predictor for summary quality in the larger study (Lundine, Harnish, McCauley, Blackett, et al., 2018).

Assessment Procedure and Variables of Interest

Participants viewed three short lectures that typified a narrative and two types of expository (compare–contrast and cause–effect) structures. Lectures were closely matched for standard measures such as number of words, sentences, main and supporting ideas, and reading level (see Supplemental Material S1). To account for the potential bias of prior knowledge that is known to affect recall for facts in expository discourse (Best, Floyd, & McNamara, 2008; Wolfe, 2005; Wolfe & Woodwyk, 2010), each lecture was about the fictitious country of Lifeland. A uniform procedure elicited three verbal summaries of these lectures from each participant. The principal investigator explained the qualities of a good summary and read an example summary of a recent teen movie (Spiderman). For practice, each participant then summarized his or her favorite movie, and the researcher reinforced the incorporation of important details and elimination of irrelevant details. Participants viewed the lecture videos on a computer monitor. Each lecture was read by the same speaker in front of a neutral background. Lecture order was randomized to control for order effects. Following each video, the researcher asked the participant to summarize the preceding lecture. Summaries were audio- and video-recorded and later transcribed using standard conventions for the Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2010).

Between each of the lecture summaries, participants completed expressive syntax and cognitive testing. The Recalling Sentences subtest from the Clinical Evaluation of Language Fundamentals–Fifth Edition (Wiig, Semel, & Secord, 2013) measured expressive syntax. The standard score for each participant is shown in Table 1. The Flanker task, picture sequence memory test, list sorting working memory test, dimensional change card sort test, and pattern comparison processing speed test from the NIH Toolbox Cognitive Battery (Bauer & Zelazo, 2013; Weintraub et al., 2013) assessed the cognitive abilities of each participant. The age-adjusted fluid cognition composite score is the score reported for each participant in Table 1.

Microstructural Variables

This article describes the microstructural, mazing, and pausing analysis of the 30 total summaries produced by the five students with TBI and five matched controls. Summaries were transcribed and segmented into C-units (an independent clause and its accompanying dependent clauses; Hunt, 1965). Commonly reported microstructural measures representing language productivity, lexical diversity, and syntactic complexity were assessed using SALT. Productivity was measured by determining the total number of analyzed C-units (TNCU) per discourse sample, excluding incomplete or unintelligible utterances. To control for the length of each sample, the ratio of the number of different word (NDW) roots to the TNCU (NDW rate) served as a measure of lexical diversity. Syntactic complexity was measured using two commonly reported variables: mean length of C-unit in words (MLCU) and subordination index (SI). MLCU refers to the average number of words per C-unit, and SI represents the total number of clauses per C-unit (i.e., independent + accompanying dependent clauses).

Fluency Variables: Mazing and Pausing

Within each summary, three trained coders counted and recorded the three types of mazing behaviors analyzed for this study: filled pauses, repetitions, and revisions. For the three summaries produced by every participant, the counts of each maze type, as well as their combined count, were used to calculate the average number of mazes per utterance, filled pauses per utterance, repetitions per utterance, and revisions per utterance.

To facilitate the analysis of pausing behaviors, audio files of each participant's discourse samples were uploaded into Praat software (Version 6.0.33; Boersma & Weenink, 2017), which displayed each sample's waveform during audio playback. While reviewing the SALT transcripts, trained coders used Praat to identify silent pauses of 0.2 s or longer by placing cursors on the waveform at the point of voice offset and subsequent point of voice onset. Studies of speech science have defined pause lengths between 0.2 and 0.3 s since a seminal work by Goldman Eisler (1968), who defined a pause in running speech as greater than 0.25 s to account for articulatory shifts. Though some literature suggests that shorter pauses can occur due to varying linguistic or cognitive processes (Kirsner, Dunn, Hird, Parkin, & Clark, 2002), 0.2 s was chosen as the threshold in hopes that it would be sensitive to group differences while being consistent with the majority of the literature. Coders classified pauses as one of two types based on its location in an utterance: (a) pause between clauses within an utterance (between-clauses pause) or (b) pause within a clause (within-clause pause). Coders tallied the number and type of pauses and determined averages for the following variables of interest: number of pauses per utterance, number of between-clause pauses per utterance, number of within-clause pauses per utterance, and average pause length. See Supplemental Material S2 for the list of maze and pause counting rules provided to coders.

Following the initial coding of transcripts, coders reanalyzed 20% of the transcripts for intrarater and interrater reliability checks. Using Cronbach's alpha, intrarater and interrater reliability calculations (respectively) were as follows: (a) identification of maze types = 1.00 and .98, (b) identification of pause types = .99 and .98, and (c) average differences in corresponding pause lengths = .03 and .06 s.

Analysis

Researchers used descriptive statistics to compare the microstructural, mazing, and pausing variables between groups (adolescents with TBI and adolescents with TD) and discourse type (compare–contrast, cause–effect, and narrative). Group means were compared via paired *t* tests (one-tailed) with alpha corrected for multiple comparisons (alpha .05 / 4 for the four comparisons made within each discourse type for microstructure, mazing, and pausing variables = .0125). For cases where data had a nonnormal distribution, we used a nonparametric analysis as an alternative. Researchers identified outliers for several variables, but because of the exploratory nature of this study, its small sample size, and the fact that data points were accurately reported, they were not removed from the analyses. Cohen's *d* statistic (Cohen, 1988) was used to interpret effect size for any findings of statistical significance.

Results

Statistical analyses were completed using SPSS-24 (SPSS, Inc.). Table 2 shows the means and standard deviations for each outcome variable by group and discourse type. Unless noted below, the between-group difference scores for variables were normally distributed, as assessed by Shapiro–Wilk's test ($p > .05$). Examples of cause–effect summaries produced by each participant are included as Supplemental Material S3.

Participants: Cognitive and Expressive Syntax Scores

The average cognitive composite score for students with TD was 107.2 ($SD = 18.7$), and for students with TBI, it was 72.8 ($SD = 21.5$). The average expressive syntax score for students with TD was 10.4 ($SD = 1.1$), and for students with TBI, it was 8.4 ($SD = 3.5$). Paired *t* tests (one-tailed) examining between-group differences in cognitive and expressive syntax scores revealed no significant difference between groups: cognition, $t(4) = 2.0$, $p = .06$, $d = 0.9$ (pooled $SD = 38.6$); expressive syntax, $t(4) = 1.5$, $p = .1$, $d = 0.7$ (pooled $SD = 2.9$). In our sample, only one participant with TBI (P3) fell more than 1 *SD* below the age-expected mean on a test of expressive syntax (see Table 1). While three of the five participants (i.e., P2, P3, and P5) showed pronounced cognitive differences when compared to peers with TD, two of the five participants with TBI (i.e., P1 and P4) had cognitive composite scores within the average range (and comparable to their matched peers). As shown in participant-level data (see Supplemental Material S4), the performance of these three individuals does not appear to drive the statistical significance of any of the results discussed below. For example, despite her impaired score on expressive syntax and cognitive testing, the participant with TBI in Pair 3 does not perform notably worse on identified outcome variables compared to the other participants with TBI. In fact, on the MLCU variable, she produced more words per utterance than any of the other participants with TBI (and equivalent to that of her matched pair).

Between-Group Differences in Microstructural Measures Across Discourse Types

Microstructural variables analyzed in this study included productivity, lexical diversity, and syntactic complexity. We hypothesized that students with TD would outperform students with TBI on all variables. For participants with TD, TNCU was the highest in compare–contrast summaries ($M = 17.0$, $SD = 6.8$), followed by cause–effect ($M = 13.4$, $SD = 3.6$) and then narrative ($M = 10.0$, $SD = 1.9$). Adolescents with TBI followed a different trend, with the greatest TNCU produced during narrative summaries ($M = 9.2$, $SD = 5.1$), followed by compare–contrast ($M = 5.0$, $SD = 1.2$) and cause–effect ($M = 5.0$, $SD = 3.1$). Results of paired *t* tests revealed the TD group to have significantly greater

Table 2. Descriptive statistics for microstructural, mazing, and pausing measures by discourse type.

	Compare–contrast		Cause–effect		Narrative	
Variable measured	**TBI**	**TD**	**TBI**	**TD**	**TBI**	**TD**
Microstructure						
Total number of C-units	5.0* (1.2)	17.0 (6.8)	5.0* (3.1)	13.4 (3.6)	9.2 (5.1)	10.0 (1.9)
Number of different words rate	7.6 (2.3)	6.0 (1.6)	7.7 (2.6)	6.9 (1.3)	6.6 (1.5)	7.8 (1.0)
Mean length of C-unit	11.6 (4.9)	11.3 (1.8)	10.5 (2.0)	14.3 (2.7)	9.9* (1.8)	14.0 (1.9)
Subordination index	1.4 (0.5)	1.4 (0.4)	1.3 (0.3)	1.7 (0.3)	1.3 (0.2)	1.8 (0.4)
Mazing						
Number of mazes per utterance	0.5 (0.6)	0.7 (0.5)	0.7 (0.4)	0.9 (0.3)	0.3 (0.5)	0.3 (0.5)
Filled pauses per utterance	0.4 (0.5)	0.5 (0.3)	0.2* (0.3)	0.8 (0.2)	0.1 (0.2)	0.4 (0.2)
Revisions per utterance	0.0 (0.1)	0.1 (0.1)	0.3 (0.4)	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)
Repetitions per utterance	0.0 (0.1)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.1 (0.1)
Pausing						
Pauses per utterance	3.4** (0.8)	1.9 (0.7)	3.6 (2.0)	2.3 (1.0)	3.0 (1.5)	2.5 (0.9)
Between-clauses pauses per utterance	0.1 (0.1)	0.1 (0.1)	0.2 (0.2)	0.2 (0.1)	0.2 (0.2)	0.3 (0.2)
Within-clause pauses per utterance	2.0** (0.7)	0.9 (0.4)	2.5 (2.0)	1.2 (0.7)	2.0 (2.0)	1.5 (0.7)
Average pause length (s)	1.2 (0.6)	0.5 (0.1)	1.4 (0.9)	0.6 (0.2)	0.8 (0.3)	0.6 (0.1)

Note. Scores are mean (standard deviation). TBI = traumatic brain injury; TD = typical development.
*$p < .0125$. **$p < .005$.

productivity than the TBI group during compare–contrast productions, $t(4) = 3.9$, $p = .01$, $d = 1.8$ (pooled $SD = 6.7$). Participants with TBI produced, on average, 12.0 fewer C-units (95% CI [3.6, 20.4]) than did participants with TD during compare–contrast summaries. Group differences were also statistically significant for TNCU in cause–effect summaries, $t(4) = 4.0$, $p = .01$, $d = 1.8$ (pooled $SD = 4.7$). For cause–effect summaries, participants with TBI produced, on average, 8.4 fewer C-units (95% CI [2.6, 14.2]) than did participants with TD. There was no statistically significant difference in productivity between groups during narrative production. While the average number of C-units produced in narrative summaries was very close between groups (TBI = 9.2, TD = 10), the participants with TBI showed greater variability in performance than did participants with TD (as reflected by a larger standard deviation).

Participants with TBI produced greater lexical diversity across utterances (NDW rate) than the group with TD during cause–effect (TBI: $M = 7.6$, $SD = 2.3$; TD: $M = 6.0$, $SD = 1.6$) and compare–contrast (TBI: $M = 7.7$, $SD = 2.6$; TD: $M = 6.9$, $SD = 1.3$) productions. In contrast, participants with TD produced a higher average NDW rate than the group with TBI during narrative discourse only (TD: $M = 7.8$, $SD = 1.0$; TBI: $M = 6.6$, $SD = 1.5$). For lexical diversity, no group differences were statistically significant.

Commonly used measures of syntactic complexity showed divergent findings between groups and discourse types. Both MLCU and SI were higher in the TD group during cause–effect (MLCU TD: $M = 14.3$, $SD = 2.7$ and TBI: $M = 10.5$, $SD = 2.0$; SI TD: $M = 1.7$, $SD = 0.3$ and TBI: $M = 1.3$, $SD = 0.3$) and narrative (MLCU TD: $M = 14.0$, $SD = 1.9$ and TBI: $M = 9.9$, $SD = 1.8$; SI TD: $M = 1.8$, $SD = 0.4$ and TBI: $M = 1.3$, $SD = 0.2$) productions. MLCU was marginally higher in the TBI group during compare–contrast production (MLCU TBI: $M = 11.6$, $SD = 4.9$; TD: $M = 11.3$, $SD = 1.8$), but students with TBI demonstrated greater variability in production, as noted by differences in standard deviation between groups. During compare–contrast production, average SI was equivalent between groups (TBI: $M = 1.4$, $SD = 0.5$; TD: $M = 1.4$, $SD = 0.4$). For MLCU, group differences were statistically significant in narrative summaries only, $t(4) = 3.7$, $p = .01$, $d = 1.7$. Participants with TD produced an average of 4.1 more words per C-unit (95% CI [1.0, 7.1]) than students with TBI. For SI, no group differences were statistically significant.

Between-Group Differences in Mazing Patterns Across Discourse Types

Mazes analyzed in this study included filled pauses, revisions, and repetitions. We hypothesized that students with TBI would produce more mazes than students with TD. However, in both expository summaries, the students with TD averaged more mazes per utterance than students with TBI (see Table 2), though the overall occurrence of mazes was, on average, less than one per utterance for participants in both groups across all three discourse types. Both groups produced the most mazes per utterance during cause–effect production (TBI: M = 0.7, SD = 0.4; TD: M = 0.9, SD = 0.3), followed by compare–contrast (TBI: M = 0.5, SD = 0.6; TD: M = 0.7, SD = 0.5) and then narrative (TBI: M = 0.3, SD = 0.5; TD: M = 0.3, SD = 0.5). For mazes per utterance, no group differences were statistically significant.

When considering specific maze types, the students with TD averaged more filled pauses per utterance than did the students with TBI across all discourse types. 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 = 0.4, SD = 0.5) and narrative production (TD: M = 0.4, SD = 0.2; TBI: M = 0.1, SD = 0.2). Group differences were statistically significant in cause–effect summaries only, $t(4) = -4.7$, p = .005, d = 2.1 (pooled SD = 0.27). Participants with TD produced an average of 0.6 more filled pauses per utterance (95% CI [0.2, 0.9]) than students with TBI.

On average, the TD group produced more revisions per utterance than the TBI group during compare−contrast production (TD: M = 0.1, SD = 0.1; TBI: M = 0.0, SD = 0.1) and narrative production (TD: M = 0.2, SD = 0.1; TBI: M = 0.1, SD = 0.1). The number of revisions per utterance during cause−effect production was the only instance in which the TBI group produced a higher number of revisions than the TD group (TBI: M = 0.3, SD = 0.4; TD: M = 0.2, SD = 0.1). Notably, there is greater variability in the number of revisions produced by students with TBI compared to those with TD specifically during cause−effect summary production, compared to compare−contrast and narrative summaries. On the other hand, students with TD showed consistency in use of revisions across discourse types. Paired t tests found no statistically significant differences between groups on revisions per utterance in cause−effect or narrative summaries. Difference scores for revisions per utterance in the compare–contrast summaries were not normally distributed (Shapiro–Wilk's test, p = .01); thus, the exact sign test was employed as the nonparametric alternative (due to nonsymmetrical distribution). The sign test found no statistically significant difference between groups.

Participants from both groups rarely produced repetitions within an utterance. Means and standard deviations of these analyses are shown in Table 2, but because of the scarcity of their production by both groups, further statistical analysis was not completed.

Between-Group Differences in Pausing Characteristics Across Discourse Types

On average, the TBI group produced more pauses than the TD group across discourse types, as hypothesized. The average number of pauses per utterance was highest for the participants with TBI during cause–effect discourse production (M = 3.6, SD = 2.0), followed by compare–contrast (M = 3.4, SD = 0.8) and then narrative (M = 3.0, SD = 1.5) productions. In contrast, students with TD produced the highest average number of pauses per utterance during narrative production (M = 2.5, SD = 0.9), then cause–effect (M = 2.3, SD = 1.0), and compare–contrast (M = 1.9, SD = 0.7). Paired t tests revealed that adolescents with TBI produced a greater number of pauses per utterance, at levels of statistical significance, during compare–contrast discourse production only, $t(4) = 9.2$, p = .0005, d = 4.1 (pooled SD = 0.35), compared to participants with TD. Students with TBI produced an average of 1.4 more pauses per utterance (95% CI [1.0, 1.9]) than students with TD.

Two types of pauses were of interest to this study due to their proposed cognitive and linguistic underpinnings: between-clauses pauses and within-clause pauses. In all summaries for both groups, participants averaged less than one between-clauses pause per utterance. The average number of between-clauses pauses was similar between groups and across discourse types (see Table 2). As such, no statistically significant differences were found.

Students with TBI showed the greatest number of within-clause pauses during cause–effect production (M = 2.5, SD = 2.0). They showed similar numbers of within-clause pauses for narrative production (M = 2.0, SD = 2.0) and compare–contrast production (M = 2.0, SD = 0.7). Students with TD showed the greatest number of within-clause pauses during narrative production (M = 1.5, SD = 0.7), followed by cause–effect production (M = 1.2, SD = 0.7) and then compare–contrast production (M = 0.9, SD = 0.4). Paired t tests revealed that the TBI group produced a greater average number of within-clause pauses per utterance, at levels of statistical significance, than students with TD when producing compare–contrast summaries, $t(4) = 5.7$, p = .0025, d = 2.5 (pooled SD = 0.43). Students with TBI produced an average of 1.0 more within-clause pauses per utterance (95% CI [0.6, 1.6]) than students with TD.

Across all discourse types, students with TBI produced longer pauses on average than did the students with TD. For participants with TBI, pauses were longest during cause–effect discourse production (M = 1.4, SD = 0.9), then compare–contrast production (M = 1.2, SD = 0.6), and narrative production (M = 0.8, SD = 0.3). For participants with TD, pauses were longest during narrative (M = 0.6, SD = 0.1) and cause–effect (M = 0.6, SD = 0.2) productions, followed by compare–contrast (M = 0.5, SD = 0.1). The average length of pauses for students with TBI was nearly double that of students with TD during both types of expository summaries. Differences between groups for pause lengths in narrative summaries were not as pronounced. T tests revealed no significant differences between groups in any discourse type for average pause length.

Discussion and Conclusions

This is the first study to compare the microstructural and fluency characteristics of a narrative and two types of expository summaries produced by adolescents with TBI and those with TD. The goal of this exploratory study was to inform future discourse studies by identifying specific microstructural and fluency variables that might differentiate students with TBI from their uninjured peers. Ultimately, follow-up studies must confirm that any identified differences actually relate to discourse difficulties. Variables that differentiate performance and relate to discourse difficulties could be used to create new assessment tools to identify students with TBI who struggle with discourse within the academic setting.

In studies that compare the discourse performance of students with TBI to students without injury, it is important to consider cognitive and language factors that might explain any specific between-group differences. In studies that include participants with TBI who score greater than 1.5 *SD*s below the norm on a developmental language test (i.e., Hay & Moran, 2005), it is not surprising to find microstructural discourse differences between students with and without injury. Students who perform poorly on developmental language tests that typically assess language form (e.g., syntax, morphology) would similarly be expected to demonstrate difficulties in these same areas during discourse production. Certainly, some students with a TBI do exhibit substantial cognitive–communication impairments that would be expected to negatively influence discourse abilities. However, many students with TBI perform within average limits on tests of developmental language, because these students do not show specific deficits in language form (Coelho, 2007; Cook et al., 2011). However, these students may exhibit functional cognitive–communication impairments in challenging environments such as the classroom (e.g., Haarbauer-Krupa et al., 2017).

In this study, between-group differences for cognitive and expressive syntax testing did not reach levels of statistical significance, though between-group differences in cognitive scores approached significance ($p = .06$). An additional exploration with a larger sample of participants is warranted. Due to similar between-group performance on an expressive syntax measure, differences identified in the summaries produced for this study may represent actual differences in higher level discourse activities not solely attributed to a student's ability to produce grammatically correct and syntactically complex sentences. An additional analysis of how a student's performance in different cognitive domains might predict expository discourse production could clarify the relationship between cognition and discourse performance. For example, research by Wolfe and colleagues (Wolfe & Mienko, 2007; Wolfe & Woodwyk, 2010) found that attention and working memory were especially important for comprehension of expository compared to narrative passages. These cognitive domains are specifically vulnerable to the effects of TBI (e.g., Walz et al., 2012) and deserve consideration in future studies.

No past studies have compared the summary production of persons with TBI in a narrative passage and across different types of expository passages. In the context of a discourse summary, adolescents with TBI produced significantly less content in two expository summaries than did adolescents with TD. No between-group differences were noted in narrative productivity. If replicated in future studies with more participants, productivity in expository summary production may be a means to differentiate discourse performance of students with TBI from their peers with TD. Though productivity is considered a microstructural component of discourse, for persons with TBI, it is possible that reduced language content is related to cognitive challenges (e.g., memory, attention), rather than domain-specific language problems. Specifically in a summarizing task, reduced productivity in an expository context may reflect poor recall of facts from the stimulus passage.

Adolescents with TD produced greater syntactic complexity (as measured by MLCU) at levels of statistical significance only in the narrative context, demonstrating that the adolescents with TBI in this study could produce syntactically complex utterances comparable to peers without injury. Notably, participants with TBI produced slightly higher syntactic complexity (as measured by MLCU) in a compare–contrast expository context compared to their peers without injury. This finding held true even for the participant (P3) who had the lowest score on a test of expressive syntax. Syntactic complexity may not consistently show between-group differences, thus reinforcing the idea that students with TBI who perform well on tests of language form may not have trouble producing syntactically complex sentences that match those of their peers without injury. Furthermore, because P3 was able to produce syntactically complex utterances comparable to her matched peer, her score on the expressive syntax task may be a truer indication of her working memory ability than her expressive syntax ability.

In studies investigating children's discourse after TBI, few have included fluency as a variable. It is pertinent to consider mazing behaviors in persons with TBI, because literature suggests that mazes serve as a monitoring mechanism during speech production (Levelt, 1983; Navarro-Ruiz & Rallo-Fabra, 2001). It is conceivable that students with TBI do not monitor their discourse in the same manner that adolescents with TD do, potentially due to the common cognitive challenges associated with a TBI, such as impulsivity and decreased awareness (e.g., Peach, 2013). In the current study, the overall number of mazes per utterance was small across groups and discourse types (< 1 per utterance on average). In both expository contexts, adolescents with TD produced more mazes per utterance than did students with TBI, but between-group differences were only statistically significant for filled pauses per utterance (e.g., "ummmm, uhhhh") in the cause–effect summary context. For students with TBI, producing fewer mazes may be an indication of poor self-monitoring, though we do not yet have enough information to hypothesize about why a cause–effect context might elicit these differences when a compare–contrast context does not. Future studies with more participants should incorporate cognitive testing to examine whether increased impulsivity or decreased self-awareness is related to the use of mazing during discourse tasks for persons with TBI. Specifically, it is important to understand different demands that exist between various types of exposition.

This study also examined pausing behaviors as a marker of fluency during discourse summary production. Pausing behavior may be a diagnostically appropriate variable to consider for students with TBI, because recent studies proposed that pause (and maze) behaviors can indicate difficulties in sentence planning, even for individuals with TBI who do not exhibit more obvious syntactic or lexical errors in their expressive discourse (Peach, 2013; Peach & Coelho, 2016). On average, students with TBI exhibited more pauses per utterance across all three summary contexts, specifically more within-clause pauses per utterance, than did participants without injury. These differences were only at levels of statistical significance for compare–contrast summaries. Additionally, for participants with TBI, average pause length was twice that of adolescents with TD for both expository passages, though this difference did not reach levels of statistical significance for any specific discourse type. Differences in average pause length between groups for narrative summaries were marginal. Again, the fact that pronounced differences between groups were seen in both expository contexts, but not narrative, may indicate that summarizing expository passages places a greater processing burden on adolescents with TBI than does a narrative passage. Together, the results of maze and pause analyses from this study could be taken to suggest that students with TBI may not be monitoring their verbal output (resulting in fewer mazes) but that they are demonstrating difficulties planning upcoming utterances (resulting in increased and lengthier pauses). These findings reinforce the need for further research to investigate the relationship between discourse genre and processing demands. Future studies looking at how these variables relate to the quality of or content included within a discourse production may also give valuable information to inform where breakdown may be occurring.

Several limitations present in this study should be addressed in future work. First, while this study was meant to be exploratory in nature, the small sample size clearly limits the generalizability of findings. Relatedly, lack of statistically significant differences may be due to variability within the TBI group. Future studies with more participants will assist in replicating the findings from this study and should explore more sophisticated statistical modeling to analyze discourse variables. Alternatively, a larger sample could help determine if the variability noted for some outcome variables is indeed a trend associated with TBI, as heterogeneity continues to be a hallmark of cognitive–communication deficits in discourse tasks following TBI (e.g., Campbell & Dollaghan, 1990). Additionally, future studies should include cognitive and language-focused assessment batteries to elucidate what component skills may help explain differences between groups or whether performance that deviates substantially from that of students with TD is clinically or academically relevant.

Conclusions

This study adds to the sparse literature exploring expository discourse production in adolescents with TBI. There is mounting evidence to indicate that we need additional methods to evaluate the cognitive–communication skills of students with TBI in order to capture areas of deficit that are not evident on standardized assessments. Additionally, while expository discourse is understudied in general, this is particularly true in regard to persons with TBI. Because of these large gaps in knowledge and the ecological validity of expository discourse in general, researchers need to identify specific areas on which to focus future research efforts targeting expository abilities in students with TBI. Results from this exploratory study indicate that further investigation into the production differences that occur among types of exposition and between school-age persons with TBI and their peers without injury is warranted. When examining microstructural and fluency variables in discourse production, productivity, total pauses per utterance, filled pauses per utterance, and within-clause pauses per utterance may be specific variables upon which to build the foundation of this research. Commonly used microstructural analysis related to lexical diversity and syntactic complexity may fail to identify discourse difficulties for students with TBI on academically relevant tasks incorporating expository discourse, just as use of narrative discourse alone may fail to recognize discourse differences in students with TBI compared to their peers.

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