Title: Sentence types and complexity of spontaneous discourse productions by Cantonese-speakers with Traumatic Brain Injury – A preliminary report

Dustin Kai-Yan Lau[1]

Anthony Pak-Hin Kong[2]

Michael Siu-Wai Chan[3]

1 Department of Chinese and Bilingual Studies, Hong Kong Polytechnic University
2 School of Communication Sciences and Disorders, University of Central Florida
3 Ruttonjee Hospital, Hong Kong SAR

Correspondence should be addressed to Dustin Kai-Yan Lau, Department of Chinese and Bilingual Studies, Hong Kong Polytechnic University,

AG522, Core A, The Hong Kong Polytechnic University. Email: dustin.lau@polyu.edu.hk

Preferred running head: Syntactic Impairment of Cantonese TBI

Abstract

Previous investigations on sentence production in English-speaking individuals with traumatic brain injury (TBI) have yielded mixed conclusions based on their findings. While some studies found comparable sentence complexity between speakers with TBI and control speakers (Coelho, 2002; Liles, Coelho, Duffy, & Zalagens, 1989; Mentis & Prutting, 1987), others reported more syntactic and lexical errors, reduced sentence complexity (Coelho, Grela, Corso, Gamble, & Feinn, 2005; Glosser & Deser, 1990), and erroneous word order transpositions (Peach & Schaude, 1986) in the sentence production of speakers with TBI. These contradictory findings could possibly be due to the use of language measures that were less sensitive to subtle syntactic impairments among speakers with TBI. In this preliminary report, the language samples obtained from 11 Cantonese-speaking participants with mild-moderate TBI in Guangzhou, with a mean age of 37.6 and mean years of education of 10 years, and nine control speakers with a similar age range and education background were analyzed using in-depth linguistic-oriented frameworks adopted from pervious works in Cantonese (e.g., Cheung, 2007; Matthews & Yip, 2011; Tang, 2010, 2015). The results indicated that the TBI group produced more errors, different varieties of sentence types, and lower syntactic complexity in their sentence production compared with the control group. The findings suggested that the more refined and linguistic-oriented measures used in the present study were more sensitive in identifying the subtle syntactic impairments produced by the participants with TBI.

Keywords: syntax, sentence complexity, traumatic brain injury, Chinese

Introduction

Individuals with traumatic brain injury (TBI) often demonstrate communication problems of different varieties. Their communication impairment is usually considered a result of complex interactions between cognitive and linguistic changes. Instead of demonstrating linguistic impairments in formal language tests, individuals with TBI are usually reported to show evidence of linguistic processing deficits (e.g., Sarno, 1980, 1984). Therefore, clinically, language tests that assess higher-order language processing, such as discourse analysis, are needed to capture the manifestations of the language impairment of individuals with TBI (e.g., Wolfolk, Fucci, Dutka, Herberholz, & Latorre, 1992).

The results of previous studies have indicated that discourse deficits are more pronounced at the macrolinguistic level, such as lower inter-sentential cohesiveness,[1] impaired local and global coherence, and reduced story grammar, but are less apparent at lexical and sentential organization levels, such as fewer errors in sentence formation (Liles, Coelho, Duffy, & Zalagens, 1989; Wolfolk et. al, 1992). According to Coelho, Grela, Corso, Gamble, and Feinn (2005), the macrolinguistic disorganization of spoken output in individuals with TBI tends to manifest across sentential boundaries, and it involves non-specific, higher-order, diffusely represented cognitive processes.

Similar deficits at the macrolinguistic level have also been observed in the discourse produced by Chinese speakers with TBI. For example, with reference to the spoken language samples of two Cantonese-speaking and three Mandarin-speaking TBI survivors, Chow, Kong, and Lau (2016) found that the global coherence of TBI discourse (i.e., how well each sentence relates to the overall theme of the topic of the output; Hough & Barrow, 2003) was more

[1] According to Renkema (2004), cohesion is defined as the connection that exists between elements within a text. Cohesion can be achieved by means of repeating specific elements of the text (such as recurrence or paraphrase) or through the use of ellipsis or cohesive devices (such as morphological and syntactic devices) to express relationships of connection or tense (Bussmann, 1996).

impaired than local coherence (i.e., the well-connectedness between adjacent sentences through the lexical cohesion of the output; Halliday & Hasan, 1976). More recently, Kong, Lau, and Cheng (2020) have further concluded that impaired global coherence in speakers with TBI correlated significantly not only with the sequence of main events produced in their output but also the cognitive functions of attention and visuospatial skills. In addition, it was suggested that poor local coherence in TBI discourse was associated with speakers' overall impaired language integrity.

Nevertheless, recent reports have suggested that although less pronounced, compared with deficits at the macrolinguistic level, individuals with TBI may also demonstrate deficits at the microlinguistic level of discourse production (e.g., Ellis & Peach, 2009; Peach, 2013), with language-specific lexical, syntactic, and/or lexical-syntactic symptoms manifested within the sentences of a spoken text (Coelho et al., 2005). For example, by comparing the pausing patterns in the sentences produced by speakers with TBI and those by the control speakers, Ellis and Peach (2009) reported longer initiation times in the sentences produced by the speakers with TBI. It was concluded that speakers with TBI may have specific impairments in sentence planning, and it was further suggested that besides macrolinguistic impairments, microlinguistic impairments may also be associated with the language profile of individuals with TBI. Similar findings were reported in Peach (2013), who found that speakers with TBI produced longer pauses between clauses and more mazes in their monologue discourse compared with neurotypical controls. Hence, it is possible that apart from deficits at the macrolinguistic level, individuals with TBI also have subtle deficits at the microlinguistic level of discourse production.

The aim of the current study was to test this hypothesis among Cantonese speakers with TBI. It was expected that if the Cantonese speakers with TBI also experienced difficulties with sentence planning, they would demonstrate more syntactic errors or reduced sentence complexity in their language production. In addition, the difficulties would also be manifested in the production of certain types of sentences that required a higher processing load. Given that to our knowledge there are currently no studies in the literature that have documented the sentence types and complexity characteristics of discourse produced by Cantonese speakers with TBI, the aim of the current study was to fill this gap. A review of some characteristics of Cantonese grammar is essential for readers to understand the design of the current study.

Characteristics of Cantonese grammar

Cantonese, a dialect of the Yue group of Chinese, is spoken primarily in the southern Chinese provinces of Guangdong and Guangzi, as well as Hong Kong and Macau. Cantonese is characterized by its grammatical morphology, namely, its relatively rigid word order such as the basic [subject-verb-object], which is usually used in the expression of grammatical relations (Matthews & Yip, 2011). In discourse production, sentences in Cantonese can be classified as simple and composite (Cheung, 2007; Matthews & Yip, 2011; Tang, 2010, 2015; Zhu, 1981, 2012). Simple sentences are the basic units of discourse that serve as independent units to convey complete thoughts, while composite sentences are a combination of simple sentences (Cheung, 2007).

Simple sentences are usually expressed in the form of subject-predicate or its derivatives, such as right-dislocation, topicalization, and ellipsis. Halliday and Hasan (1976) suggested that to achieve the function of emphasis, speakers place the most important information, or the focused information, at the beginning of the sentence. Speakers of Cantonese achieve this by right-dislocation and topicalization.

Right-dislocation refers to the sentence construction in which certain syntactic elements are placed, from the sentence's beginning or internal position to the end of the sentence. Lai, Law, and Kong (2017) suggested that right-dislocation structures are afterthoughts that supplement information from previous productions to reduce the planning load in the production of a sentence. An example of right-dislocation is given in (1) below [2]:

(1) 買 雪糕 囉 個 小朋友。

mai35 syt3 kou55 lɔ55 kɔ33 siu13 pʰɐŋ21 jɐu13.

buy ice-cream SFP Cl kid

In (1), "kid" is relatively unimportant information that could be supplied by context if omitted in Cantonese, or, although unimportant, there could possibly be ambiguity if the subject is omitted. Therefore, the speaker demonstrated the act by adding back the omitted part as an afterthought.

Topicalization, on the other hand, refers to the deliberate placing of certain syntactic elements of a sentence at the beginning of the sentence to make them the topic of the sentence. Tang (2010, 2015) suggested that topicalization is used to put part of a sentence in a focus position, such as at the beginning of the sentence. An example of topicalization in Cantonese is given in (2) below:

(2) 大病 目前 就 仲 未 有

tai22 pɛŋ22 mʊk2 tsʰin21 tsɐu22 tsʊŋ22 mei22 jɐu23

severe illness currently tsɐu not yet have

[2] All examples used to represent different grammatical structures of Cantonese were extracted from the language samples collected in the current study to better illustrate the sentences produced by the participants in this study. Phonetic transcriptions of the examples are represented in IPA format.

In (2), “severe illness,” originally the object of the sentence, is placed at the beginning of the sentence to serve as the topicalized item, probably in response to a question regarding a major illness in a conversation.

Right-dislocation and topicalization are similar in terms of syntactic operations in that they involve the movement of verb arguments to other positions from the canonical word order, despite that the directions of movement are different. The function of right-dislocation and topicalization are also different, as the former is for supplementing additional information and the latter is for marking the focus of a sentence.

Finally, ellipsis is an omission of arguments from canonical sentences, and it serves as a cohesive device (Matthews & Yip, 2011). The most common type of ellipsis in Cantonese is pro-drops. Cantonese utterances with ellipsis are only grammatical when the context or previous utterances can supply the omitted arguments; otherwise, it is considered ungrammatical. Examples of ellipsis are shown in (3) and (4) below:

(3) 兔子 有啲 輕敵 ，自己 跑 ，***(pro-drop)*** 無 留意。

t^hou33 tsi35 jɐu23 ti55 hɪŋ55 tik3, tsi22 kei35 pau35, (pro-drop) mou23 lɐu21 ji33.

‘Rabbit looked down upon the enemy, running on his own, being unaware of the tortoise.’

(4) ****(pro-drop)*** 無 留意

**(pro-drop) mou23 lɐu21 ji33*

**(pro-drop) being unaware of the tortoise*

Example (3) is considered a grammatical ellipsis as the *pro-drop* position is supplied by the subject in the previous sentences. On the other hand, (4) would be considered ungrammatical if this sentence was spoken without a clear context or if the subject was not mentioned before.

Given that these structures result in deviations from the canonical word order, the corresponding processing demands of the productions of these structures may vary. If speakers with TBI have difficulties with sentence planning, it is expected that they will experience greater difficulties in using certain types of sentences, such as those that violate the canonical word order. Such difficulties can be observed in the number of errors produced or in their tendency to produce certain types of sentences in their discourse production. Therefore, in this study, sentences produced by speakers with TBI were compared with sentences produced by neurotypical individuals using these two measures.

Another possible way to capture potential deficits at the microlinguistic level of discourse production among speakers with TBI concerns the complexity of the sentences they produce. Frazier (1987) suggested two possible approaches to parsing sentences. The first approach concerns the parsing of concatenated constituent units into different chunks in a linear way. For example, the sentence 我食飯 (*/ŋɔ23 sik2 fan22/* [I eat rice]) can be parsed as Subject (我 /ŋɔ23/ [I]) – Verb (食 /sik2/ [eat]) – Object (飯 /fan22/ [rice]). This linear parsing gives rise to chunks of words or phrases and their order indicates syntactic relationships. The second approach concerns the arrangement of constituent units hierarchically in different layers according to the assumptions of generative grammar. Using the same example given above, the sentence 我食飯 (*/ŋɔ23 sik2 fan22/* [I eat rice]) can first be parsed as Subject (我 /ŋɔ23/ [I]) – Predicate (食飯 /sik2 fan22/ [eat rice]). Then, the predicate can be further parsed as Verb (食 /sik2/ [eat]) – Object (飯 /fan22/ [rice]).

In the current study, the hierarchical approach was used to measure sentence complexity because it is more sensitive to the syntactic relationships among lexical constituents within sentences. The hierarchical approach proposed by Zhu (1981, 2012) to analyze Chinese sentences was used first to analyze each sentence obtained from the participants. Syntactic complexity was then obtained according to the number of syntactic layers identified in each sentence. A previous study by Law (2001) demonstrated that this measure of syntactic complexity according to the number of syntactic layers is sensitive in distinguishing adults with acquired neurogenic communication disorders and the syntactic deficits of unimpaired speakers. In the current study, it was expected that if speakers with TBI also demonstrated impairments at the microlinguistic level of discourse production, a lower syntactic complexity would be obtained when compared with neurotypical individuals.

Finally, previous studies have reported strong correlations between different cognitive measures and language performance (e.g., Alexander, 2006; Beeson, Bayles, Rubens, & Kaszniak, 1993; Caspari, Parkinson, LaPointe, & Katz, 1998; Frankel, Penn, & Ormond-Brown, 2007; Henderson, Kim, Kintz, Frisco, & Wright, 2017). In addition, there have also been suggestions that syntactic complexity depends on sentence planning abilities (Ellis & Peach, 2009; Frankel et al., 2007). Given that it has been generally agreed that speakers with TBI usually have cognitive deficits after a brain injury, as the lesion site of the TBI could be diffuse and lead to more cognitive disruptions, it was expected that the syntactic complexity obtained from the speakers with TBI in the current study would be associated with their cognitive impairments as well.

To summarize, the current study aimed at investigating whether Cantonese speakers with TBI demonstrated impairments at the microlinguistic level of the discourse language they produced. A group comparison design was used such that the performance of a group of speakers with TBI was compared with that of a group of neurotypical speakers. The following research questions were targeted:

1. Do speakers with TBI produce more syntactic errors compared with neurotypical controls?
2. Do speakers with TBI show different distributions of sentence types in a discourse sample compared with neurotypical controls?
3. Do speakers with TBI produce sentences in a discourse sample with lower syntactic complexity compared with neurotypical controls?
4. If (3) is correct, is the reduced syntactic complexity of the sentences produced by speakers with TBI related to their cognitive impairments?

Method

Participants

Speakers with TBI

Between July 2015 and August 2017, 101 Chinese-speakers with TBI were recruited from Guangdong Rehabilitation Hospital in Guangzhou. All of them met the following criteria: (a) diagnosis of a single TBI (mild or moderate level of severity) by neurologists in the recruiting hospital based on neurological and cognitive tests, CT/MRI scans, and/or reports; (b) no reported history of prior substance abuse, psychiatric illnesses, or learning disabilities; (c) at least three months post-injury at the time of examination; (d) no reported hearing, visual, or visual perceptual deficits; (e) no other neurological conditions, such as CVA, dementia, Parkinson's disease, etc.; and (f) no coexisting motor speech disorders rated as moderate to severe grade or above by the experimenter. Fifty-five patients who spoke Mandarin as their native language were excluded. Of the remaining 46 patients, who were native Cantonese speakers, 35 were further excluded due to their reduced ability to produce all required discourse samples. The final 11 participants were invited to participate in the study.[3] The TBI group consisted of two females and nine males, with ages ranging from 28 to 52 (mean age = 37.6; SD = 9.23) and mean years of education of 10 years (range = 7 to 15 years, SD = 2.21). All of the participants were reported to have TBI caused by a closed-head injury. Time post-onset ranged from seven to 23 months (mean = 12.5; SD = 5.02). Due to the small sample size, the TBI group was not divided into subgroups in accordance with age and education level.

Neurotypical controls

Individuals who did not have a history of neurologic disease or brain injury were recruited as the control group. Nine healthy controls were recruited from Guangzhou and Hong Kong. Specifically, all of them were unimpaired family members of patients (including the TBI participants) at the recruiting hospital. The control group consisted of three females and six males, with an education background similar to the TBI group and aged between 18 and 59 (mean age = 45.4; SD = 14.1) and mean years of education of 11 years (range = 9 to 15 years, SD = 2.78). The results of the t-tests showed that the two groups did not differ in terms of age (p = 0.15) and years of education (p = 0.13). The control group was also not divided into subgroups.

Procedures

Materials

Discourse samples from the participants were collected using tasks and elicitation methods in Cantonese (Kong & Law, 2019; Kong, Law, Kwan, Lai, & Lam, 2015) adapted from the AphasiaBank protocol (MacWhinney, Fromm, Forbes, & Holland, 2011) and Main Concept Analysis (MCA) (Kong, 2016a). The Cognitive Language Quick Test (CLQT; Helm-

[3] Based on the number of participants that were suitable for inclusion as of August 2017, the time this investigation was conducted. This final sample size was comparable to related reported studies of Chinese-speaking individuals with TBI (e.g., Kong et al., 2020) and aphasia (e.g., Kong & Law, 2009; Kong, Linnik, Law, & Shum, 2014; Law, Kong, Lai, & Lai, 2015).

Estabrooks, 2001) and the Cantonese Aphasia Battery (CAB; Yiu, 1992) adapted from the Western Aphasia Battery (WAB; Kertesz, 1982) were also administered.

Language samples

The tasks selected had three levels of difficulty, from the most decontextualized to the least, as follows:

(i) Personal narratives. The task selected for this level was the retelling of the participants' TBI experiences and important events using the Cantonese AphasiaBank.[4] Speech production was elicited by asking the participants probing questions. For their TBI experiences, three major probing questions were asked—"你覺得你自己講嘢講成點呀？, "你記不記得你幾時腦傷？, 請你講吓俾我聽？(*What do you think about your speech production? Do you remember when the brain injury happened? Can you tell me more about the injury?*)"—followed by "請你講吓康復嘅情況。腦傷後你做咗啲乜嘢令自己嘢講好啲呀？ (*Please tell me something about your rehabilitation progress. What did you do to help you speak better after the injury?*)". For the important events, one probing question was asked: "你可唔可以講一件你生命中最重要嘅事情俾我聽？ 哩件事可以係開心或者係唔開心嘅。可以係你細個到宜家嘅事都得。(*Can you tell me an incident that was the most important in your life? It could be something happy or sad, something that happened when you were young, or something that just happened recently*)". If the participants stopped telling their own stories, the participants would be prompted with "講曬喇？ (*Is that all?*)". If the participants had no response, further question prompts with higher specificity would be provided to them (e.g., "你講吓腦傷後第一個印象係乜嘢。(*Please tell me your first impression after the injury.*)"). If

[4] Specifically, with reference to the Cantonese AphasiaBank elicitation protocol (Kong & Law, 2019; Kong et al., 2015), the personal narratives collected using the monologue of telling one's TBI experience was a replacement of the original "stroke story" (which only applied to stroke survivors).

the participants refused to talk about their own stories or gave no response, the task was terminated.

(ii) Story narratives with visual support (pictures). The task selected at this level was the retelling of “the boy who cried wolf” and “the tortoise and the hare” stories using the Cantonese AphasiaBank and pictures. Speech production was elicited by first providing color drawings printed on A6 paper to the participants. They were given as much time as they needed to view the pictures, and then the drawings were taken away and they were asked to begin their storytelling. The participants were prompted with “講曬喇？ (*Is that all?*)” if they stopped telling the story after a few seconds. If the participants had no response, they were prompted with the instruction “你講吓隻烏龜同埋兔仔做乜嘢。你可以講吓你記得嘅故事或者講吓之前啲圖畫嘅內容。(*Please tell me about what happened with the boy/the tortoise and the hare. You can tell the story you remembered or talk about the contents you saw in the picture.*)”. The task was terminated if the participant gave no response after prompting.

(iii) Narratives with visual support (pictures). The task selected for this level was stories from the MCA. The elicitation procedures of the MCA were followed, and the participants could refer to the pictures in the MCA while telling their story. This task was coded as MCA in this study.

The discourse samples were recorded and transcribed into Chinese orthography for analysis. The procedural samples were not selected since there was limited variability of sentence types and structures by the nature of the tasks, and these samples were thus not sensitive to the differences between unimpaired speakers and those in the TBI group in terms of sentence types and complexity.

Measures

Analysis of errors

The sentences were first categorized as erroneous and non-erroneous. The erroneous sentences were further categorized as (1) syntactic errors, (2) inappropriate word choice, and (3) incomplete sentences.

Syntactic complexity

The non-erroneous sentences were parsed into different layers, and the number of layers was counted to obtain a syntactic complexity index. The number of syntactic layers of each utterance was also counted.

Analysis of sentence types

The sentences from the language samples of each participant were first classified into different sentence types in Cantonese, including *Simple*, *Composite*, *Complex*, and *Embedded*. Then, they were further categorized into different subtypes under these major types. Examples of the different subtypes of sentences are shown in Table 1. The frequency of different sentence subtypes was recorded accordingly.

Table 1 about here

Statistical analysis

To compare the number of errors produced and the syntactic complexities between the two groups, Mann-Whitney U-tests were used for the average complexity index and the distribution of errors obtained. To compare the distribution of the variety of sentences produced by the two groups, chi-squared tests were used to identify the differences in the distribution of simple and complex sentences, as well as the distribution of their subtypes between the TBI group and the control group. Finally, Spearman's Rank Correlation analysis was conducted to obtain the correlations among different CLQT scores and the complexity index.

Inter-rater and intra-rater reliability

The results of the computation of the complexity index and the frequency of sentence types were analyzed by one examiner. Of the samples, 20% (two samples from the TBI group and two samples from the control group) were randomly selected. A second and third reviewer were then invited to reanalyze one sample from the TBI group and one sample from the control group that were randomly assigned to them to obtain inter-rater reliability. The same sets of data were also reviewed by the first examiner one month after initial analyses for intra-rater reliability. The inter-rater and intra-rater reliability of the different measures was measured using Pearson's correlations for each pair of centered datasets. High inter-rater and intra-rater reliabilities were obtained, and the results are summarized in Table 2.

Table 2 about here

Results

Comparison of errors produced

Table 3 shows the distribution of the different types of errors produced by the two groups. The results of the Mann-Whitney U tests indicated that significantly more syntactic errors and more inappropriate word choices were observed in the language samples obtained from the TBI group.

Table 3 about here

Comparison of syntactic complexity

The complexity indexes obtained from each group for each of the narrative tasks are summarized in Table 4. The results of the Mann-Whitney U tests showed that the TBI group had significantly lower complexity indexes than the control group in all three narrative tasks, indicating that there were significantly less syntactic layers in the sentences produced by the TBI group.

Table 4 about here

Distribution of sentence types

Figure 1 shows the distribution of the different subtypes of simple sentences. The results of the chi-squared tests indicated that the distribution of the different subtypes of simple sentences were different between the two groups (χ^2 (4) = 17.8, $p < 0.001$). Post-hoc analysis was conducted based on Cox and Key's (1993) pairwise comparison method by comparing the chi-squared values (i.e., Δ[X2]) of each sentence subtype. The results indicated that none of the pairwise comparisons reached a significant value.

Figure 1 about here

Figure 2 shows the distribution of the different subtypes of composite sentences produced by the two groups. The results of the chi-squared tests indicated that there were no significant group differences (χ^2 (3) = 2.012, $p > 0.05$).

Figure 2 about here

Correlation between the complexity index and the different CLQT scores

Table 5 summarizes the means and standard deviations of the complexity index and the CLQT domain scores obtained from the TBI group. The results of the Spearman's Rank Correlation analysis indicated that the complexity index was significantly correlated with the

CLQT scores for executive function (*rho* = 0.738, $p < 0.01$), attention (*rho* = 0.645, $p < 0.05$), and visual spatial skills (*rho* = 0.655, $p < 0.05$).

Table 5 about here

Discussion

The current study compared discourse production between Cantonese speakers with and without TBI at the microlinguistic level. To the best of our knowledge, this study is the first among very few that conducted discourse analysis of microlinguistic structures in Cantonese speakers with TBI using a comprehensive approach of syntactic analyses.

Error production and variety of sentence types

The results indicated that the TBI group made significantly more errors in their production compared with the neurotypical controls. Specifically, the two groups differed in terms of both the number of syntactic errors and incorrect lexical items produced. The significantly more syntactic errors associated with the Cantonese TBI group observed was consistent with previous findings reported about English speakers with TBI (Coelho et al., 2005; Glosser & Deser, 1990). In addition to the difference in terms of the number of errors produced, the two groups also differed in their distribution of a variety of sentence types produced. For example, the distribution of simple sentences produced varied significantly between the two groups; this significant difference potentially indicated a certain tendency by the TBI group to use different types of simple sentences in response to their syntactic impairments. Looking at Figure 1, the TBI group produced more non-subject-predicative sentences. However, as reflected by the results of the post-hoc analysis, none of the pairwise comparisons reached a significant value, suggesting that the differences were attributed to the overall difference in the distribution of the five subtypes of simple sentences (instead of differences in one or two subtypes). Alternatively, it was also possible that due to the limited sample size, the pairwise comparisons did not reach significant values. Further work in this area with a bigger group is warranted.

As for the different subtypes of composite sentences produced, the two groups demonstrated a comparable distribution. Interestingly, this comparable distribution was slightly beyond our expectations. Given that composite sentences are comparatively lengthier (and potentially syntactically more complex) than simple sentences, it was originally expected that any potential syntactic impairments associated with the TBI group would be reflected in the differences in the distribution of the subtypes of composite sentences produced instead. One possible explanation is that although the composite sentences were lengthier than the simple sentences, they were not necessarily syntactically more complex than the simple sentences. For example, two simple sentences were connected with or without the use of connective words to express a causal relation. Hence, the composite sentences may have been only semantically, not syntactically, more complex than the simple sentences.

Syntactic complexity

The results indicated that in all three narrative tasks, the TBI group performed significantly worse than the control group in terms of the complexity index, which was a measure of the number of hierarchical layers in the sentences produced. This indicated that there were on average fewer grammatic relationships coded in the sentences produced by the TBI group. This is consistent with the findings of Glosser and Deser (1990) in which TBI survivors tended to demonstrate a reduced sentence complexity ability.

Finally, the results also revealed that this reduced complexity among the TBI group was strongly associated with attention, executive function, and visuospatial skills obtained in the CLQT test. This observation echoed suggestions from previous studies that different cognitive skills, such as memory and executive functions, are crucial components for discourse production (Alexander et al., 2006; Beeson et al., 1993; Caspari et al., 1998; Frankel et al., 2007; Henderson et al., 2017). It has been suggested that these cognitive skills are needed to initiate, plan, monitor, and correct communicative performance in spoken discourse. Frankel et al. (2007), for example, argued that "planning" is a related ability in executive function that affects the syntactic construction of sentences. Ellis and Peach (2009) also hypothesized that sentence planning deficits would lead to the production of sentences with overall lower syntactic complexity in TBI discourse.

In the current study, the observation of lower syntactic complexity among the participants with mild-moderate TBI indicated that impairments in sentence planning may also be one of the significant deficits in language production following a TBI. Theories on sentence processing (e.g., Bock & Levelt, 1994; Garrett, 1984; Lapointe & Dell, 1989) have suggested that sentence planning involves the processes of idea generation, lexical selection, and syntactic encoding that interact with each other. To achieve this, a good cognitive basis that allows the activation, organization, and maintenance of different language representations (Peach, 2013) is necessary. Any cognitive deficits, therefore, will possibly result in problems with sentence planning. For example, Crosson and Cohen (2012) suggested that impairments in executive functions may affect the selection of the best sentence structure among different candidates to express generated ideas in sentence planning. Similarly, Peach (2013) also highlighted that deficits in focused attention and working memory among patients with TBI might also hinder their performance in handling competing language representations activated by different processes during sentence planning.

Following this line of reasoning, problems in sentence planning may be particularly more prominent in the planning of sentences with greater complexity (Kong, 2016b). The cognitive deficits observed among the participants with mild-moderate TBI in the current study and the association of their cognitive deficits with reduced syntactic complexity in spoken discourse further supported that their impairments in sentence planning could have been the result of their overall cognitive deficits (potentially independent of severity level).

Clinical implications

This study compared the narratives produced by patients with TBI and neurotypical individuals. Overall, the results highlighted the extent to which cognitive deficits associated with patients with TBI could affect language production and thus should not be underestimated. Although problems with macrolinguistic measures of narratives following a TBI have been commonly reported (e.g., Coelho et al., 2005), the results of the present study indicated that problems with microlinguistic measures might also be observed following a TBI. Specifically, it was observed that the participants with TBI produced more errors and sentences with lower complexity than their neurotypical counterparts. Such problems may be particularly prominent in narrative tasks that involve heavy cognitive demands. Therefore, it is suggested that assessments of the language production of patients with TBI should include narrative tasks with varying degrees of cognitive demands followed by detailed microlinguistic analyses. For example, non-contextualized discourse tasks that require more cognitive resources in sentence planning and personal narratives (which are hypothetically more difficult regarding the selection of appropriate contents) should be included in the assessment.

If problems with microlinguistic measures, such as syntactic errors and lower syntactic complexity, are observed, either direct intervention that reduces syntactic errors and promotes syntactic complexity or compensatory intervention that promotes the use of less complex sentences to achieve language production tasks with heavy cognitive demands should be considered.

Limitations and future directions

By using a more comprehensive approach to analyze the syntactic differences between the TBI and control groups, the current study added support to the notion that syntactic impairments are associated with speakers with TBI. However, one major limitation of the current study was the small sample size of both the TBI group and the control group. The limited number of participants resulted in only a limited number of sentences obtained from the language samples. Particularly, the limited number of sentences produced made the search for how the TBI group differed from the control group in their tendency to produce (or avoid) certain sentence types impossible. It is suggested that in addition to a similar comprehensive approach of syntactic analysis, future studies should recruit more participants (in both the TBI group and the control group) so that the subtle, yet important, syntactic impairments associated with speakers with TBI can be better documented. Another limitation concerns the lack of inter-rater reliability of the error analysis. It is suggested that future studies that investigate possible errors made by speakers with TBI should conduct such a test to ensure good reliability.

Moreover, given the success of this study, it is also suggested that other in-depth linguistic frameworks should be used in future syntactic analysis, such as studying the distribution of different verb chains, serial verb constructions, and pivotal grammar, which are important characteristics in Cantonese, to investigate the syntactic impairments associated with different types of neurogenic language disorders. Moreover, previous studies also reported issues of prosodic features, such as more pauses between clauses, associated with language production following a TBI (e.g., Peach, 2013). While this was not the major focus of the current study and thus this analysis was not included, it is suggested that future studies should also investigate this among Cantonese speakers with TBI. Future studies should also look to both the theories of sentence production and the clinical management of individuals with different types of neurogenic language disorders in obtaining their results.

Summary and conclusion

The current study adopted a comprehensive linguistic-oriented approach to compare discourse production between Cantonese speakers with and without TBI at the microlinguistic level. It was observed that the speakers with TBI produced more errors than the control speakers in the language samples obtained. It was also observed that the distributions of the different types of simple sentences produced by the TBI and the control groups were different. This observation was interpreted as a sign that the TBI group may have had some degree of tendency to produce or avoid certain sentence types. Finally, the sentences produced by the TBI group were also observed to have significantly lower syntactic complexity than the sentences produced by the control group. All of these results support the finding that subtle, but important, syntactic impairments are evident among speakers with TBI. The results of the correlation analysis further indicated that syntactic impairments were associated with the cognitive impairments of the TBI participants. It is recommended that more studies using comprehensive linguistic-oriented frameworks should be conducted in the future in this area to warrant and elaborate our findings.

Ethics statement

This study involving human participants was reviewed and approved by the Human Subjects Ethics Sub-committee of The Hong Kong Polytechnic University (HSEARS20150728001). The patients/participants provided written informed consent to participate in this study.

Acknowledgement

The author would like to express the gratitude to Dr. Jie Zhu and clinicians in the Speech Therapy Department of the Guangdong Work Injury Rehabilitation Hospital (Guangzhou, China) for their help in subject recruitment and testing. Last but not least, acknowledgment is also given to all the participants, who were willing to spend hours of time for the study without any monetary compensation.

References

Alexander, M. P. (2006). Impairments of procedures for implementing complex language are due to disruption of frontal attention processes. *Journal of the International Neuropsychological Society, 12*(2), 236–247.

Beeson, P. M., Bayles, K. A., Rubens, A. B., & Kaszniak, A. W. (1993). Memory impairment and executive control in individuals with stroke-induced aphasia. *Brain and Language, 45*(2), 253–275.

Bock, K., & Levelt, W. (1994). Language production, grammatical encoding. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics.* London: Academic Press.

Bussmann, H. (1996). *Routledge dictionary of language and linguistics*. London: Routledge.

Caspari, I., Parkinson, S. R., LaPointe, L. L., & Katz, R. C. (1998). Working memory and aphasia. *Brain and Cognition, 37*(2), 205–223.

Chow, W., Kong, A. P. H., & Lau, D. K. Y. (2016). An investigation of global and local coherence of spontaneous personal versus descriptive narratives in native Chinese speakers with traumatic brain injury: Preliminary data. *Frontiers in Psychology*. doi: 10.3389/conf.fpsyg.2016.68.00018

Cheung, H. N. (2007). *Xianggang Yueyu yufa de yanjiu* [*A grammar of Cantonese spoken in Hong Kong*]. Hong Kong: Chinese University Press.

Coelho, C. A. (2002). Story narratives of adults with closed head injury and non-brain-injured adults: Influence of socioeconomic status, elicitation task, and executive functioning. *Journal of Speech, Language, and Hearing Research, 45*(6), 1232–1248.

Coelho, C. A. (2005). Direct attention training as a treatment for reading impairment in mild aphasia. *Aphasiology, 10*(3/4/5), 275–283.

Coelho, C. A., Grela, B., Corso, M., Gamble, A., & Feinn, R. (2005). Microlinguistic deficits in the narrative discourse of adults with traumatic brain injury. *Brain Injury, 19*(13), 1139–1145.

Cox, M. K., & Key, C. H. (1993). Post hoc pair-wise comparisons for the chi-square test of homogeneity of proportions. *Educational and Psychological Measurement, 53*, 951–962.

Crosson, B., & Cohen, M. L. (2012). Language and communication disorders associated with attentional deficits. In R. K. Peach & L. P. Shapiro (Eds.), *Cognition and acquired language disorders: An information processing approach* (pp. 167–182). St. Louis, MO: Elsevier Mosby.

Ellis, C., & Peach, R. K. (2009). Sentence planning following traumatic brain injury. *NeuroRehabilitation, 24*(3), 255–266.

Frankel, T., Penn, C., & Ormond-Brown, D. (2007). Executive dysfunction as an explanatory basis for conversation symptoms of aphasia: A pilot study. *Aphasiology, 21*(6-8), 814–828.

Frazier, L. (1987). Theories of sentence processing. In J. Garfield (ed.), Modularity in Knowledge Representation and Natural Language Understanding (pp. 291-307). Cambridge, MA: MIT Press.

Garrett, M. F. (1984). The organization of processing structure for language production: Applications to aphasic speech. In D. Caplan, A. R. Lecours, & A. Smith (Eds.) *Biological perspectives on language* (pp. 172–193). Cambridge, MA: MIT Press.

Glosser, G., & Deser, T. (1990). Patterns of discourse production among neurological patients with fluent language disorders. *Brain and Language, 40*, 67–88.

Halliday, M. A. K., & Hasan, R. (1976). *Cohesion in English*. London: Longman.

Helm-Estabrooks, N. (2001). *Cognitive Linguistic Quick Test*: *Examiner's manual*. San Antonio, TX: Psychological Corporation.

Henderson, A., Kim, H., Kintz, S., Frisco, N., & Wright, H. H. (2017). Working memory in aphasia: Considering discourse processing and treatment implications. *Seminars in Speech and Language, 38*(01), 40–51.

Hough, M., & Barrow, I. (2003). Descriptive discourse abilities of traumatic brain-injured adults. *Aphasiology, 17*(2),183–191.

Kemmerer, D. (2014). *Cognitive neuroscience of language*. Hove, UK: Psychology Press.

Kertesz, A. (1982). *Western aphasia battery test manual*. San Antonio, TX: Psychological Corporation.

Kong, A. P. H. (2016a). *The Main Concept Analysis (MCA) for oral discourse production*. Hong Kong: The Commercial Press (H.K.) Ltd.

Kong, A. P. H. (2016b). *Analysis of neurogenic disordered discourse production: From theory to practice*. New York: Psychology Press.

Kong, A. P. H., Lau, D. K.-Y., & Cheng, C. Y.-Y. (2020). Analysing coherence of oral discourse among Cantonese speakers in Mainland China with traumatic brain injury and cerebrovascular accident. *International Journal of Speech-Language Pathology, 22*(1), 37–47. https://doi.org/10.1080/17549507.2019.1581256

Kong, A. P. H., & Law, S. P. (2009). A linguistic communication measure for monitoring changes in Chinese aphasic narrative production. *Clinical Linguistics and Phonetics, 23*(4), 255–269. https://doi.org/10.1080/02699200802673234

Kong, A. P. H. & Law, S. P. (2019). Cantonese AphasiaBank: An annotated database of spoken discourse and co-verbal gestures by healthy and language-impaired native Cantonese speakers. *Behavior Research Methods, 51*(3), 1131–1144. https://doi.org/10.3758/s13428-018-1043-6

Kong, A. P. H., Law, S. P., Kwan, C. C. Y., Lai, C., & Lam, V. (2015) A coding system with independent annotations of gesture forms and functions during verbal communication:

Development of a database of speech and GEsture (DoSaGE). *Journal of Nonverbal Behavior, 39*(1), 93–111.

Kong, A., Linnik, A., Law, S., & Shum, W. (2014). Measuring the coherence of healthy and aphasic discourse production in Chinese using Rhetorical Structure Theory (RST). *Frontiers in Psychology*. doi: 10.3389/conf.fpsyg.2014.64.00028

Lai, C. C. T., Law, S. P., & Kong, A. P. H. (2017). A quantitative study of right dislocation in Cantonese spoken discourse. *Language and Speech, 60*(4), 633–642.

Lapointe, S. G., & Dell, G. S. (1989). A synthesis of some recent work in sentence production. In G. N. Carlson & M. K. Tanenhaus (Eds.), *Linguistic structure in language processing* (pp. 107–156). Dordrecht: Kluwer Academic Publishers.

Law, S. P. (2001). A quantitative analysis of Cantonese aphasic production. *Journal of Psychology in Chinese Society, 2*, 211–237.

Law, S.-P., Kong, A. P. H., Lai, L. W. S., & Lai, C. (2015). Effects of context and word class on lexical retrieval in Chinese speakers with anomic aphasia. *Aphasiology, 29*(1), 81–100. https://doi.org/10.1080/02687038.2014.951598

Liles, B. Z., Coelho, C. A., Duffy, R. J., & Zalagens, M. R. (1989). Effects of elicitation procedures on the narratives of normal and closed head-injured adults. *Journal of Speech and Hearing Disorders, 54*, 356–366.

MacWhinney, B., Fromm, D., Forbes, M., & Holland, A. (2011). AphasiaBank: Methods for studying discourse. *Aphasiology, 25*(11), 1286–1307.

Matthews, S., & Yip, V. (2011). *Cantonese: A comprehensive grammar* (2nd ed.). London: Routledge.

Mentis, M., & Prutting, C. A. (1987). Cohesion in the discourse of normal and head-injured adults. *Journal of Speech and Hearing Research, 30*, 583–595.

Peach, R. K. (2013). The cognitive basis for sentence planning difficulties in discourse after traumatic brain injury. *American Journal of Speech-Language Pathology, 22*(2), 285–297.

Peach, R. K., & Schaude, B. A. (1986). Reformulating the notion of “preserved” syntax following closed head injury. Paper presented at the annual convention of the American Speech-Language-Hearing Association, November 1986.

Renkema, J. J. (2004). *Introduction to discourse studies.* Amsterdam: John Benjamins Publishing Company.

Sarno, M. T. (1980). The nature of verbal impairment after closed head injury. *Journal of Nervous and Mental Disease, 168*, 685–692.

Sarno, M. T. (1984). Verbal impairment after closed head injury: Report of a replication study. *Journal of Nervous and Mental Disease, 172*, 475–479.

Tang, S. W. (2010). *Xingshi hanyu jufaxue* [*Formal Chinese syntax*]. Shanghai: Shanghai Education Press.

Tang, S. W. (2015). *Yueyu yufa jiangyi* [*Lectures on Cantonese grammar*]. Beijing: The Commercial Press.

Wolfolk, W. B., Fucci, D., Dutka, F. E., Herberholz, L. M., & Latorre, T. M. (1992). Differences in narrative productions of closed head-injured adults. *The Bulletin of the Psychonomic Society, 30*, 226–228.

Yiu, E. M. (1992). Linguistic assessment of Chinese-speaking aphasics: Development of a Cantonese aphasia battery. *Journal of Neurolinguistics, 7*(4), 379–424. doi:10.1016/0911-6044(92)90025-r

Zhu, D. X. (1981, 2012). *Yufa jianyi* [*Lectures in Chinese grammar*]. Hong Kong: The Commercial Press Hong Kong.

Table 1. Classification of different sentence types.

Simple sentences	Code	Examples
Subject-predicative	SP	小朋友 喺度 放 羊。 *siu35pʰɐŋ21jɐu23 hɐi35tou22 fɔŋ33 jœŋ21* kid be-here put sheep
Topicalization	TC	啲 水果 跌 晒。 *ti55 sœy35kʷɔ35 tit3 sai33* Cl fruit drop ASP
Non-subject-predicative	NSP	係。 *hɐi22* Yes
Pro-drop	pd	兔子 有 啲 輕敵，自己 跑， *(pro-drop)* 無 留 意。 *tʰou33tsi35 jɐu23 ti55 hɪŋ55tik3, tsi22 kei35 pau35, (pro-drop) mou23 lɐu21 ji33* Rabbit have CL underestimate, self run, not aware.
Existential	exist	哩度 有 狗。 *lei55 tou22 jɐu23 kɐu35* This place have dog.
Composite sentences		
Compound Sentences	cpd	
Cumulative		我哋 係 自己 去 訂 機票 啦，搵 酒店 啦，同埋 自己 去 搵 景點 咁。 *ŋɔ23 tei22 hɐi22 tsi22 kei35 hœy33 tɛŋ22 kei55 pʰiu33 la55, wɐn35 tsɐu35 tim33 la55, tʰʊŋ21 mai21 tsi22 kei35 hœy33 wɐn35 kɪŋ35 tim35 kɐm35* we are self go order ticket PRT, find hotel PRT, and self go find attractions PRT.

Disjunctive		第四 張 呢 就 佢 呢 就 個 腳， 腳 呢 有 病 可能，一 個 白 一 個 黑， **一係** 著襪， 應該 著 襪著 成咁㗎。 *tɐi22sei33 tsœŋ55 le55 tsɐu22 kʰœy23 le55 tsɐu22 kɔ22 kœk3, kœk3 le55 jɐu23 pɛŋ22 hɔ35nɐŋ21, jɐt5 kɔ22 pak2 jɐt5 kɔ22 hɐk5,* ***jɐt5hɐi22*** *tsœk3 mɐt2, jɪŋ55kɔi55 tsœk3 mɐt2 tsœk3 seŋ21 kɐm35 ka33* fourth CL PRT then he PRT then CL leg, leg PRT then have illness perhaps, one CL white one CL black, **or** wear sock, should wear sock wear result so PRT.
Successive		鬧鐘 鬧 醒 佢，佢 至 起身，跟住 就 落 床，刷牙 洗面 梳頭。 *nau22tsʊŋ55 nau22 seŋ35 kʰœy23, kʰœy23 tsi33 hei35sɐn55, kɐn55tsy22 tsɐu22 lɔk2 tsʰɔŋ21, tsʰat2ŋa21 sɐi35min22 sɔ55tʰɐu21* Clock alarm wake him, he then get up, and then down bed, brush teeth wash face comb hair.
Adversatives		中午 嗰陣時 奶奶 喺 廚房 切 嗰啲 紅蘿蔔，**但係** 佢 視力 唔係 幾 好，就 切到 隻 手。 *tsʊŋ55ŋ23 kɔ35tsɐn22si21 nai23nai23 hɐi35 tsʰy21 fɔŋ35 tsʰit3 kɔ35ti55 hʊŋ21lɔ21pak2,* ***tan22hɐi22*** *kʰœy23 si22lik2 m21hɐi22 kei35 hou35, tsɐu22 tsʰit3 tou35 tsɛk3 sɐu35* Noon that-time grandma at kitchen chop that CL carrot, **however** her vision not quite good, then cut V-PRT CL hand.
Complex Sentences	cmplx	
Causal		一個 老 奶奶 就 切 菜 嘅時候 紅蘿蔔 嘅時候，佢 用 左手切 嘅，所以 呢切 得 唔係 好 小心。 *jɐt5 kɔ33 lou23 nai23nai23 tsɐu22 tsʰit3 tsʰɔi33 ke33si21hɐu22 hʊŋ21lɔ21pak2 ke33si21hɐu22, kʰœy23 jʊŋ22 tsɔ35 sɐu35 tsʰit3 ke22, sɔ35ji23 le55 tshit3 tɐk5 m21hɐi22 hou35 siu35sɐm55*

		one CL old grandma then cut vegetable that-time carrot that-time, she use left hand cut PRT, therefore PRT cut V-PRT not very careful
Concession		就算 佢 坐 落嚟，人哋 未 得閒 呢，你 都 唔 可以 食 飯 起 筷子。 *tsɐu22syn22 k^{h}œy23 ts^{h}ɔ23 lɔk2lɐi21, jɐn21tei33 mei22 tɐk5han21 le55, nei23 tou55 m21hɔ35ji23 sik2fan22 hei35 fai33tsi35* even if he sit down, people not free PRT, you still cannot eat rice up chopsticks
Conditional		如果 唔係， 你 就會 輸 喺 人哋 後面 囉。 *jy21k^{w}ɔ35 m21hɐi22, nei23 tsɐu22wui23 sy55 hɐi35 jɐn21tei22 hɐu22min22 lɔ55* If not, you become lose at people back PRT
Time		(pro-drop)梳完(ellipsis)啦，之後 去 衣櫃 搵 衫 黎 著 (pro-drop) *sɔ55 jyn21* (ellipsis) *la33, tsi55hɐu22 hœy33 ji55k^{w}ɐi22 ts^{h}au33 sam55 lɐi21 tsœk3* brush finish PRT, after go wardrobe find clothes come wear
Embedded Sentences	embed	我話**你讀埋兩年先**。 *ŋɔ23 wa22 nei23* ***tʊk2 mai21 lœŋ23 nin21 sin55*** I said you **study V-PRT two year first**

CL = classifier; ASP = aspect marker; PRT = particle; V-PRT = verbal particle

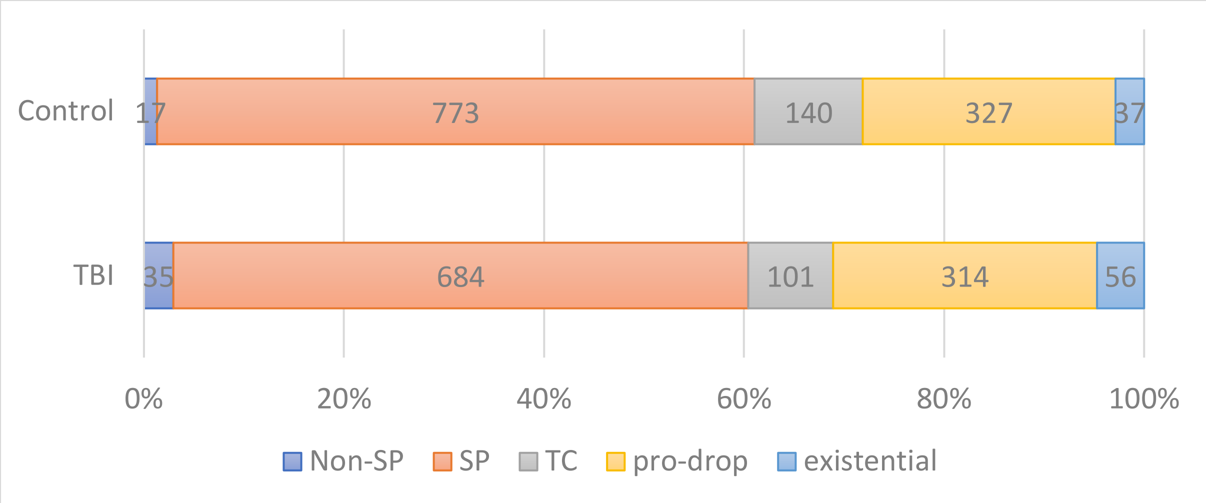

Figure 1. Distribution of different subtypes of simple sentences produced by the two groups. Non-SP = Non-subject-predicative; SP = Subject-predicative; TC = Topicalization

Table 2. Results of inter-rater and intra-rate reliability measures based on Pearson's *r* of each pair of centred dataset.

Measures	Inter-rater	Intra-rater
Complexity Index	0.860**	0.931**
Subject-predicate	0.999**	0.999**
Topicalization	0.831**	0.999**
Non-Subject-Predicate	0.872**	0.941**
Pro-drop	0.921**	0.999**
Existential	0.999**	0.999**
Compound sentences	0.927**	0.972**
Complex sentences	0.903**	0.981**
Embedded sentences	0.917**	0.935**

** correlation was significant at $p<0.01$ level

Table 3. Distributions of different types of errors produced by the two groups.

	Overall				
	TBI	Control	*U*	*Z*	*p*
Mean number of errors					
Syntactic errors	4.918	.000	6.5**	-3.375	**.001**
Inappropriate word choice	1.053	.000	26*	-2.095	**.036**
Incomplete sentences	.000	.000	41	-.356	.356

Table 4. Complexity index obtained in different tasks by the two groups.

Task	Group	Median	n	U	W	Z	p
AB PN	TBI	3.06	11	16*	82	-2.545	**.011**
	Control	4.06	9				
AB Story	TBI	3.29	11	0**	66	-3.769	**.000**
	Control	4.67	9				
MCA	TBI	3.44	11	8**	63	-3.021	**.003**
	Control	4.46	9				
Overall	TBI	3.40	11	4**	70	-3.457	**.001**
	Control	4.52	9				

AB Spon = Personal narrative task of the Cantonese AphasiaBank.

AB Story = Story narrative task of the Cantonese AphasiaBank.

MCA = Main Concept Analysis.

Table 5. Means and standard deviations of complexity index and different domain scores in the CLQT obtained from the TBI group.

	Mean	Standard deviation	Maximum achievable score
Complexity Index	3.327	0.447	N/A
CLQT domains			
Attention	113.455	67.561	215
Memory	92.182	22.131	185
Executive Function	15.636	9.091	40
Language	19.318	3.552	37
Visuospatial	57.000	27.756	37