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(Citation)
Journal of Neurolinguistics,79:101322

(Issue Date)
2026-08

(Resource Type)
journal article

(Version)
Version of Record

Journal of Neurolinguistics 79 (2026) 101322

Contents lists available at ScienceDirect

Journal of Neurolinguistics

journal homepage: www.elsevier.com/locate/jneuroling

Research paper

Discourse analysis of Japanese patients with traumatic brain injury

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A R T I C L E I N F O

Keywords:
Discourse analysis
Traumatic brain injury
Global coherence
Productivity
Japanese speakers
Narrative discourse
Neuropsychological assessment

A B S T R A C T

Discourse after traumatic brain injury (TBI) in Japanese speakers has not been sufficiently investigated, and it remains unclear whether multilevel discourse-analysis procedures devised for Western languages apply to Japanese. Moreover, the specific indices that best capture TBI-related discourse impairments have yet to be fully established. Therefore, our study aimed to apply an established Western framework to a group of native Japanese speakers with TBI to compare their discourse features with those of a group of healthy controls and identify indicators of post-TBI discourse. These participants completed a comic-strip explanation task; their narratives were analyzed at the microstructural, macrostructural, and superstructural levels. Discourse features were compared between the TBI and control groups. Logistic regression was conducted to identify discourse predictors of TBI, and the neuropsychological test scores of the TBI group correlated with the discourse indices. The TBI group performed worse than controls at every discourse level. Reduced global coherence and a smaller total number of clauses independently predicted TBI status. In addition, the global coherence correlated with all neuropsychological measures except the forward digit span, indicating dependence on diverse cognitive functions. These findings show that Japanese speakers exhibit impairments at multiple discourse levels following TBI, similar to Western populations. In particular, the reduced global coherence appears to be a primary factor contributing to disorganized narratives and difficulties in maintaining thematic continuity. These results support the cross-linguistic applicability of multilevel discourse analysis and underscore its importance for guiding language rehabilitation following TBI.

1. Introduction

Traumatic brain injury (TBI) commonly results in impaired discourse comprehension and production (Hirozane, 2021; Steel & Togher, 2019). Discourse-level deficits extend beyond sentence-internal processes to impairments in language use within context (Holland, 1984; Togher, McDonald, & Code, 2014). Consequently, standard aphasia batteries designed to assess within-sentence domains such as phonology and morphology often fail to detect these higher-level communication disorders (Coelho et al., 1991; Sarno, 1980; Togher, McDonald, & Code, 2014). To address this gap, Western researchers have used self-reported measures of

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https://doi.org/10.1016/j.jneuroling.2026.101322
Received 1 October 2025; Received in revised form 20 February 2026; Accepted 5 March 2026
Available online 10 March 2026
0911-6044/

communicative competence (Douglas et al., 2007), assessments of social perception (McDonald et al., 2003), and discourse analysis protocols.

1.1. Multilevel discourse analysis frameworks

Discourse analysis examines language use problems from a linguistic perspective, analyzing narrative discourse across multiple levels: microstructure, macrostructure, and superstructure (Coelho, 2007; Coelho et al., 2023). This multilevel approach has revealed that individuals with TBI exhibit deficits at each level (Hill et al., 2018; Togher, McDonald, & Code, 2014). At the microstructural level, previous studies have shown reduced language productivity and lexical informativeness (Brookshire et al., 2000; Coelho et al., 2013; Hartley & Jensen, 1991; Marini et al., 2011), as well as a decrease in the number of subordinate clauses and an increase in grammatical errors (Ghayoumi et al., 2015; Marini et al., 2017). In addition, some studies have reported impaired cohesive adequacy (Galetto et al., 2013; Marini et al., 2011). However, other studies have found preserved microstructural integrity (Glosser & Deser, 1991; Moran et al., 2012), highlighting inconsistencies in the literature (Hill et al., 2018). At the macrostructural level, researchers have observed omissions of key information units (Biddle et al., 1996) and deviations from the main theme due to tangential content (Marini et al., 2017; McDonald, 1993). At the superstructural level, disruptions to the internal narrative structure, including irregular event sequencing and poorly organized story grammar, have been reported (Coelho, 2002; Mozeiko et al., 2011; Power et al., 2020; Stein & Glenn, 1979). Age has generally not been found to exert a significant effect on discourse performance after TBI (Büttner-Kunert et al., 2022; Matsuoka et al., 2012). In contrast, studies have shown that individuals with more severe injuries tend to produce less informationally rich speech (Brookshire et al., 2000) and exhibit greater disruptions in coherence and cohesion (Marini et al., 2017). Although discourse abilities may improve over time in these patients, reduced production of complete episodes has been observed even 6 months after injury (Power et al., 2020), and some evidence suggests that recovery remains limited even 2 years after injury (Coelho, 2007). Thus, in Western language contexts, discourse analysis can capture the complex structure of discourse and the dynamic interplay of various components of language use (Sherratt, 2007). Additionally, it holds clinical value in detecting subtle communicative deficits that are often overlooked by other discourse assessment approaches (Coelho et al., 1991; Myers et al., 2022).

1.2. Applicability of multilevel discourse analysis in Japanese patients with TBI

Despite extensive research in English-speaking populations, relatively few studies have examined discourse deficits following TBI in Japanese (Hirozane, 2021). The typological features of Japanese, such as flexible word order and frequent omission of subjects and pronouns, may limit the direct application of English-centric assessment methods and complicate cross-linguistic comparisons. These linguistic characteristics raise the question of whether discourse frameworks developed in Western languages can adequately capture discourse impairments in Japanese speakers.

Matsuoka et al. (2012) addressed this by applying Correct Information Unit (CIU) analysis (Nicholas & Brookshire, 1993) to Japanese speakers; this measure extracts content words from spontaneous speech. CIU analysis has demonstrated diagnostic utility in distinguishing individuals with aphasia from neurologically typical speakers in Japanese aphasia populations and has shown high inter-rater reliability (Honda et al., 1999). It has also been applied to TBI populations (Carlomagno et al., 2011).

Matsuoka et al. (2012) found that patients with TBI differed from controls in total speaking time, units per time, and CIUs per time but not in the total number of units or CIUs per unit. Subsequently, Hill et al. (2018) classified “total number of units” as a microstructural metric and “CIUs per unit” as a macrostructural metric, suggesting that reduced speech rate may be a predominant feature of Japanese post-TBI discourse, whereas microstructural and macrostructural deficits may remain undetected. Carlomagno et al. (2011) further reported correlations between CIUs per unit and coherence errors, despite comparable numbers of CIUs between groups. This finding suggests that although CIU analysis is relevant to macrostructural assessment, it may not adequately capture macrostructural deficits and may be insufficient for fully identifying discourse disorders in patients with TBI. Because post-TBI discourse disorganization often spans entire sentences and texts (Hill et al., 2018), comprehensive multilevel analysis is recommended (Coelho et al., 2005a, 2005b; Power et al., 2020). Accordingly, to better characterize post-TBI discourse in Japanese speakers, it is essential to explore alternative or complementary methods to CIU analysis.

1.3. Identification of specific discourse indicators

Moreover, specific discourse indicators that effectively characterize post-TBI impairments remain insufficiently established. It has been proposed that the various levels of discourse analysis are not entirely independent; instead, they interact and use shared cognitive resources such as executive function and attention (Peach & Coelho, 2016). However, the macrostructural level has shown high sensitivity to TBI, particularly regarding global coherence deficits (Büttner-Kunert et al., 2022; Hough & Barrow, 2003; Stubbs et al., 2018; Togher, McDonald, & Code, 2014). Hough and Barrow (2003) reported that impairments in global coherence exceeded those in local coherence or microstructural elements. The findings of the study were not based on statistical methods due to the small sample size ($n = 5$); instead, they were derived from descriptive comparisons with control group means. There remains a lack of research examining measures characterizing discourse after TBI in comparison with other discourse analytic measures.

Additionally, post-TBI discourse performance is influenced by broader neuropsychological functioning, and multiple cognitive domains—including executive function, memory, and working memory—may contribute to performance across various discourse measures (Hill et al., 2018; Togher, McDonald, & Code, 2014). Nevertheless, in the absence of clearly established discourse indicators that specifically characterize post-TBI impairments, the cognitive domains that may underlie such indicators remain difficult to identify.

1.4. Study aims

This study aimed to examine the cross-linguistic applicability of a multilevel discourse analysis framework (Coelho, 2007) to Japanese speakers with TBI. To address this aim, the present study investigated whether the discourse characteristics reported in Western TBI patients can be generalized to Japanese speakers, a typologically distinct language, by comparing the discourse performance of Japanese individuals with traumatic brain injury (TBI) with that of healthy controls (HCs). Furthermore, by using adequate sample sizes and robust statistical methods, this study sought to identify the discourse indicators that best characterize post-TBI discourse impairments and to clarify their neuropsychological foundations.

Based on previous findings from Western language contexts, we hypothesized that Japanese individuals with TBI would show impairments across different levels of discourse organization, including microstructure, macrostructure, and superstructure, compared with HCs. We further hypothesized that macrostructural measures, particularly global coherence, would best distinguish individuals with TBI from HCs and would be associated with multiple neuropsychological functions.

2. Methods

2.1. Participants

Eighty-one individuals with TBI (51 men, 30 women; age range: 18–79 years) and 70 HCs (32 men, 38 women; age range: 18–82 years) participated in the study (Table 1). All participants were native Japanese speakers. The inclusion criterion for the TBI group was (a) Glasgow Coma Scale score ≤14 at admission due to traumatic brain injury or (b) focal or diffuse brain injury confirmed by neuroimaging. The exclusion criteria were: (a) severe disorders of consciousness or aphasia precluding task performance; (b) upper limb motor or audiovisual impairments interfering with tasks; (c) history of pre-injury cognitive impairments; and (d) Galveston Orientation and Amnesia Test score <75 (post-traumatic amnesia criterion [Levin et al., 1979]). There was no significant age difference between the two groups (Wilcoxon rank-sum test: $W = 2950$, $p = .67$); however, the TBI group included a higher proportion of males ($\chi^2(1) = 3.84$, $p = .049$). Additionally, the TBI group included individuals with both penetrating and non-penetrating TBIs. In terms of injury severity, excluding six participants whose GCS scores at the time of injury were unavailable, 10 had severe TBI, 10 had moderate TBI, and 55 had mild TBI, indicating a predominance of mild cases. The median time since injury in the TBI group was 1 month (IQR: 1–1), whereas the mean was 22.05 ± 69.30 months (range: 1–396), indicating that while many participants were in the acute

Table 1
Demographic and clinical characteristics of the TBI and HC groups.

	Characteristics	TBI (n = 81)	HC (n = 70)	p-value
Age				
	Median (Q1-Q3)	48.00 (37.00-64.00)	47.50 (40.25-62.00)	0.67
	Mean ± SD (min-max)	48.12 ± 17.84 (18-79)	50.00 ± 16.08 (18-82)	
Sex				
	Female/Male[b]	30/51	38/32	0.049*
GCS				
	Median (Q1-Q3)	13.00 (12.00-14.00)	-	
	Mean ± SD (min-max)	12.39 ± 2.71 (3-15)	-	
	Severe (3-8)	10	-	
	Moderate (9-12)	10	-	
	Mild (13-15)	55	-	
	Unknown	6	-	
Type of Injury				
	Penetrating	12	-	
	Non-penetrating	65	-	
	Unknown	4	-	
Month post-injury				
	Median (Q1-Q3)	1.00 (1.00-1.00)	-	
	Mean ± SD (min-max)	22.05 ± 69.30 (1-396)	-	
Cause of Injury				
	Traffic Accident	65	-	
	Fall	13	-	
	Other[a]	3	-	

TBI, Traumatic Brain Injury; HC, Healthy Control; GCS = Glasgow Coma Scale. According to the inclusion criteria, patients at Scale 15 are those with confirmed focal or diffuse brain injury based on neurological examination.
*$p < .05$, determined using the Wilcoxon rank-sum test.
Values are presented as medians with interquartile ranges (IQRs), mean ± standard deviation (SD), range (maximum - minimum) or as counts, as appropriate.
[a] Other includes assault and unknown causes.
[b] Chi-square test.

post-injury phase, the overall distribution showed substantial variability.

All participants provided written informed consent. The study protocols were approved by the Clinical Research Ethics Committee of the Kobe University Graduate School of Health Sciences (No. 663-2) and the Ethics Committee of the author's institution (No. 17-049).

2.2. Procedures

2.2.1. Discourse task

Participants completed the “manga explanation” task from the Supplementary Tests for the Standard Language Test of Aphasia (SLTA-ST; Japan Society for Higher Brain Dysfunction, 2011), which comprises four comic-strip sequences. This task evaluates speech production in individuals with various language disorders, including aphasia, and it is one of the most frequently used language assessments in Japan. The task corresponds to the narrative genre involving sequential pictures (Coelho et al., 2023). It requires the integration of linguistic, perceptual, and inferential abilities, as three of the four sequences demand context-based inference to interpret the final panel (Japan Society for Higher Brain Dysfunction, 2011). This task has been used to assess discourse abilities (Matsuoka et al., 2012; Tanemura & Tsubakihara, 2006).

2.2.2. Discourse data collection and transcription

Certified speech-language-hearing therapists (ST) at the affiliated institution administered the discourse and neuropsychological assessments for all participants. For each discourse task, the ST presented the four-panel comic strip, read a sample sentence (e.g., “Here is a man”), and instructed the participant to describe the story. All responses were audio-recorded using a digital IC recorder and transcribed verbatim. During transcription, fillers and hesitations such as *ano* (“um”) and *eeto* (“er”) were removed, and repetitions conveying identical content were retained.

2.2.3. Discourse analysis

The transcripts were segmented into clausal units based on the predicate-argument structure (PAS), a semantic unit widely used in natural language processing (Dipper & Cruice, 2023; Hayashibe et al., 2014; Surdeanu et al., 2003, pp. 8–15). PAS and clauses are generally defined at the sentence level, typically involving a predicate verb (Masuoka & Takubo, 2019b). However, in this study, semantically complete utterances lacking a predicate verb in the clause—for example, “(pointing) *Kuri* [Chestnuts] (exists)”—were considered equivalent to clauses.

Following the framework of Coelho (2007) and Coelho et al. (2023), we analyzed discourse at multiple levels—microstructure, macrostructure, and superstructure—operationalizing four composite constructs. Specifically, the analysis focused on four aspects based on previous studies (Coelho, 2002, 2007; Ghayoumi et al., 2015; Marini et al., 2011, 2014, 2017; Power et al., 2020): “Productivity” and “Grammatical complexity” at the microstructural level, “Coherence” at the macrostructural level, and “Story Grammar” at the superstructural level (Table 2). Metrics related to “Cohesion” were excluded because Japanese permits the omission of personal pronouns—essential markers of cohesion in Western languages—making pronoun-based cohesion indices unreliable.

The discourse indices used for the evaluation of these four domains are discussed below. Productivity was measured using “Clauses” and “%Words”. Clauses were calculated as the sum of all clausal units extracted using the aforementioned methods. %Word, a metric analogous to the mean number of words per utterance or mean length of utterance (Power et al., 2020), was defined as the percentage of independent words relative to the total number of clauses. Based on classifications used in Japanese language education (Matsuzaki, 2021), which follow the traditional framework of Japanese school grammar, words are broadly categorized into independent and dependent words. Independent words are defined as lexical items that can form a phrasal unit on their own, whereas dependent words cannot form a phrasal unit independently and are obligatorily attached to independent words. In the present study, independent words included interjections, conjunctions, prenominal modifiers, adverbs, nouns, adjectives, adjectival verbs, and verbs. Grammatical complexity was assessed using “%Embedded Clauses” and “% Subordinate Clauses”. %Embedded Clauses reflected the proportion of embedded clauses–one of the subordinate clauses that appear within main clauses and semantically modify a noun, thereby increasing syntactic complexity–relative to the total clauses. %Subordinate Clauses represented the proportion of all subordinate clauses (including embedded and adverbial clauses) relative to total clauses.

Although Ghayoumi et al. (2015) used the indicator as the number of subordinate clauses per content unit (i.e., independent clause with its modifier), we operationalized it as the proportion of subordinate clauses relative to the total number of clauses, as the present study used the clause as the unit of analysis. Coherence was assessed using “%Global Coherence” and “%Local Coherence”. Global Coherence evaluated whether each clause maintained the overall meaning and theme of the narrative story (Galetto et al., 2013; Glosser & Deser, 1991; Hill et al., 2018; Marini et al., 2011, 2017; Togher, McDonald, & Code, 2014). We calculated clauses that preserved the narrative's overarching theme and were free from errors defined in a previous study (Galetto et al., 2013)—such as irrelevant content, misinterpretation, or information omissions—as those judged to maintain global coherence, along with their percentage relative to total clauses. Local Coherence assessed the preservation of the semantic relationships between adjacent clauses (Galetto et al., 2013; Glosser & Deser, 1990; Hill et al., 2018; Marini, 2011; Marini et al., 2017; Togher, McDonald, & Code, 2014). Clauses were considered locally coherent if they maintained continuity with preceding utterances and avoided semantic inconsistencies, topic shifts, or disruptions in a narrative order. In contrast to prior studies (e.g., Galetto et al., 2013; Marini et al., 2017), which categorized coherence errors, the present study focused on identifying clauses that preserved coherence. Story grammar was assessed based on the framework proposed by Stein and Glenn (1979). A “Complete Episode” was judged to be complete only if it contained all three components: an Initiating Event, an Action or Attempt, and a Direct Consequence. We counted the number of

Table 2
Discourse measures.

Discourse Level	Discourse Measures	Description	Example
Microstrucrure *(word and sentential level)*	**Productivity**	**Analysis to measure the quantity of language production.**	
	Clauses	Total number of clauses	1.男の人が釣りに来ました 2.当たりが来たので 3.力一杯引き上げました[b] 1. A man came for fishing 2. Because he got a hit 3. He[b] pulled up his rod with all his might. (3 clauses)
	%Words	Total independent words in the story divided by the number of clauses :*(Total independent words/Clauses)×100*	1.男の人(が)[c]/釣り(に)/来まし(た) 2.当たり(が)/来(たので) 3.力一杯/引き上げまし(た) 1. Man/fishing/came 2. Hit/got 3. With all his might/pull up (7 independent words/3 clauses × 100 = 233)
	Grammatical Complexity	**Analysis to measure the syntactic complexity of a speaker's utterance.**	
	%Embedded clauses	Percentage of embedded clauses in the total number of clauses :*(Total number of embedded clauses/Clauses)×100*	1.テーブルクロスを引っ張っている[EMBEDDED CLAUSE(adjective clause)] 2.猫は気づきません 1. pulling hard on the tablecloth [EMBEDDED CLAUSE] 2. the cat did not notice it. (1 embedded clause/2 clauses × 100 = 50)
	%Subordinate clauses	Percentage of subordinate clauses in the total number of clauses :*(Total number of subordinate clauses/Clauses)×100*	1.男の人が釣りに来ました 2.当たりが来たので [SUBORDINATE CLAUSE] 3.力一杯引き上げました 1. A man came for fishing 2. Because he got a hit [SUBORDINATE CLAUSE] 3. He pulled up his rod with all his might. (1 subordinate clause/3 clauses × 100 = 33.33)
Macrostructure *(the broader meaning of discourse)*	**Coherence**	**Analysis to measure the ability of the speaker to maintain the topic and theme**	
	%Global coherence	Percentage of the clauses with content that maintains the theme or main idea of the discourse (appropriate global coherence) in the total number of clauses :*(Total number of appropriate clauses with global coherence/Clauses)×100*	1.男の人が釣りに来ました 2.当たりが来たので 3.力一杯引き上げました 1. A man came for fishing 2. Because he got a hit 3. He pulled up his rod with all his might. (3 global coherence/3 clauses × 100 = 100) 1.男の人が来ました[INFORMATION OMISSION: fishing] 2.当たりが来たので 3.力一杯引き上げました 1. A man came INFORMATION OMISSION: fishing] 2. because he got a hit 3. He pulled up his rod with all his might (2 global coherence/3 clauses × 100 = 66.7) 1.子がいました 2.木の上に石があって [INCONGRUENT UTTERANCE: chestnut] 3.それを残してきました[INCONGRUENT UTTERANCE: tried to pick it] 1. There was a child 2. There was a stone on the tree [INCONGRUENT UTTERANCE: chestnut] 3. He left it [INCONGRUENT UTTERANCE: tried to pick it] (2 incongruent utterances/3 clauses × 100 = 66.67)
	%Local coherence	Percentage of clauses that maintain semantic relationships from the previous utterance (appropriate local coherence) in the total number of clauses :*(Total number of appropriate clauses with local coherence/Clauses)×100*	1.男の人が釣りに来ました 2.当たりが来たので 3.力一杯引き上げました 1. A man came for fishing 2. Because he got a hit 3. He pulled up his rod with all his might. (3 local coherence/3 clauses × 100 = 100) 1.うちの子を思い出すわ [IRRELEVANT UTTERANCE] 2.鳥が海の上を一羽で飛んでいます。 1. Reminds me of my child [IRRELEVANT UTTERANCE] 2. a bird is flying alone over the sea. (1 tangential utterance/2 clauses × 100 = 50)
Superstructure *(structure, schema, and organization of discourse)*	**Story Grammar**	**Analysis to measure regularity in the internal structure of the story**	
	Complete episodes[a]	Total number of complete episodes	**Complete episode**-[INITIATING EVENT]男の人が釣りに来ました. [ATTEMPT]当たりが来たので力一杯引き上げました. しかし釣れたのは魚ではなく長靴でした. [DIRECT CONSQUENCE]長靴を持ってとぼとぼと帰りました [INITIATING EVENT] A man came for fishing. [ATTEMPT] Because he got a hit, he pulled up his rod with all his might. However, what he caught was not a fish but a boot. [DIRECT CONSQUENCE] He trudged home with the boot. (1 complete episode)

Definitions of each indicator based on previous research (Coelho, 2002, 2007; Ghayoumi et al., 2015; Marini et al., 2011, 2014, 2017; Power et al., 2020).

[a] Complete episode: According to Stein and Glenn (1979), an episode is judged to be complete only if it contains all three components: (a) an initiating event that causes a character to formulate a goal-directed behavioral sequence; (b) an action; and (c) a direct consequence marking attainment or non-attainment of the goal.

[b] "He[pronoun]" could be omitted in the Japanese language.

[c] (a) indicates dependent words.

complete episodes. Because each "manga explanation" task was designed as a single narrative episode, the maximum possible number of complete episodes was four.

2.2.4. Neuropsychological assessments

To complement the discourse analyses, the participants with TBI underwent neuropsychological assessment. General cognitive function was assessed using the Mini-Mental State Examination (MMSE). Executive function was assessed using the Frontal Assessment Battery [FAB] (Dubois et al., 2000; Terada et al., 2009) and the Keio version of the Wisconsin Card Sorting Test [KWCST[1]] (Kashima et al., 1985). Attention was evaluated using Part A of the Trail Making Test [TMT-A] (Japan Society for Higher Brain Function Test Committee, 2019). The passive component of phonological working memory was evaluated using the Digit Span Forward (DSF) subtest from the Wechsler Adult Intelligence Scale–Third Edition [WAIS-III] (Fujita et al., 1990). Working memory was assessed using the TMT-B and the Digit Span Backward (DSB) subtest from the WAIS-III. Processing speed was evaluated using the Coding subtest of the WAIS-III. Verbal memory was assessed using the verbal paired-associate learning test [S-PA] (Japan Society for Higher Brain Function Test Committee, 2014), which includes high-association (high) and low-association (low) word-pair conditions. Test performance was assessed according to the normative data and cut-off scores from the official manual or previous studies. Scores below these thresholds indicated cognitive impairment.

2.3. Statistical analysis

An a priori power analysis was conducted using G*Power (version 3.1) to determine the required sample size for group comparisons between the TBI and HC groups. Assuming a two-tailed *t*-test with a medium effect size (Cohen's $d = 0.5$), $\alpha = .05$, and $1 - \beta = 0.80$, the required sample size was estimated to be approximately 64 participants per group. The final sample (81 individuals with TBI and 70 HCs) exceeded this requirement. Although the power analysis was based on parametric assumptions, non-parametric tests were used in the actual analyses because several variables violated normality. Normality of distribution for all discourse variables was analyzed using the Shapiro–Wilk tests. Results did not indicate normal distributions across all measures. Therefore, group comparisons between the participants with TBI and the HCs were conducted using the Wilcoxon rank-sum test. The significance threshold was set at 5%. To identify discourse measures that predicted TBI status, logistic regression analysis was performed with discourse indices as independent variables and group (TBI or HC) as the dependent variable. Furthermore, a post hoc power analysis was conducted for the logistic regression model. Based on the model's Nagelkerke R^2 (0.48), the effect size was computed as $f^2 = 0.93$. Using G*Power (version 3.1). The post hoc analysis indicated that the obtained sample size ($n = 151$) provided a statistical power of 1.00 ($\alpha = .05$) for detecting the observed effect.

Finally, the relationships between discourse indices and neuropsychological test scores within the TBI group were examined using Spearman's rank-order correlation analysis.

3. Results

3.1. Comparison of discourse analysis results between the TBI and HC groups

The comparison of discourse analysis results is presented in Table 3. The TBI group performed significantly worse than the HC group across most discourse measures. At the microstructural level, Clauses was markedly reduced ($W = 3977.5$, $p < .001$) and %Words was significantly lower ($W = 3550.5$, $p = .008$). %Subordinate Clauses was diminished in the TBI group ($W = 3587.5$, $p = .005$), whereas %Embedded Clauses did not differ significantly between the groups ($W = 3215.5$, $p = .156$). At the macrostructural level, both %Global Coherence ($W = 4654.5$, $p < .001$) and %Local Coherence ($W = 4580.0$, $p < .001$) were significantly reduced in the TBI group. At the superstructural level, Complete Episodes were fewer among individuals with TBI compared to controls ($W = 3497.5$, $p = .002$).

3.2. Prediction of TBI using logistic regression analysis

Logistic regression analysis was conducted to identify which discourse indices predicted TBI status (Table 4). The results showed that % Global Coherence ($z = -3.461$, $OR = 0.88$, $p < .001$) and Clauses ($z = -2.452$, $OR = 0.93$, $p = .01$) were significant independent predictors of TBI status. Other indices, including %Words, %Embedded Clauses, %Subordinate Clauses, %Local Coherence, and

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Table 3

Comparison of discourse analysis results in the TBI and HC groups.

Discourse Level	*Discourse Measures*		*TBI (n=81)*			*HC (n=70)*			
			Median	IQR	Mean ± SD (min-max)	Median	IQR	Mean ± SD (min-max)	p-value
Micro-structure	**Productivity**	Clauses[a]	28.00	23.00-35.00	29.43 ± 8.21 (13.00-62.00)	35.00	28.25-42.00	37.59 ± 13.18 (15.00-83.00)	<0.001***
		%Words	194.74	171.79-226.67	206.59 ± 46.16 (126.32-350.00)	210.40	191.67-230.45	213.27 ± 32.76 (136.36-286.49)	0.008**
	Grammatical Complexity	%Embedded clauses	14.29	7.69-18.75	13.55 ± 7.67 (0.00-32.00)	15.53	7.80-23.51	16.07 ± 8.70 (0.00-33.33)	0.156
		%Subordinate clauses	35.90	26.92-45.00	36.19 ± 15.06 (6.25-70.97)	45.55	32.92-54.26	42.88 ± 15.54 (0.00-69.70)	0.005**
Macro-structure	**Coherence**	%Global coherence	82.61	66.67-92.31	78.44 ± 17.06 (36.36-100.00)	98.26	92.17-100	94.24 ± 9.33 (61.90-100.00)	<0.001***
		%Local coherence	86.96	68.75-95.24	80.76 ± 18.13 (26.67-100.00)	100.00	93.65-100	95.06 ± 10.07 (40.00-100.00)	<0.001***
Super-structure	**Story Grammar**	Complete episodes[a]	4.00	3.00-4.00	3.70 ± 0.69 (0.00-4.00)	4.00	4.00-4.00	3.80 ± 0.50 (2.00-4.00)	0.002**

TBI, Traumatic Brain Injury; HC, Healthy Control.

The table represents the proportion of each discourse measure within the total number of clauses (Median and IQR= Interquartile Range, Mean ± SD and (minimum - maximum).

*p < .05, **p < .01, and ***p < .001 for Wilcoxon rank-sum test.

[a] indicates the total number of clauses and complete episodes.

Table 4
Significant factors associated with TBI identified via logistic regression.

	OR	95% CI	p-value
Age	0.97	0.94-1.00	0.06
Sex	0.77	0.32-1.83	0.55
Clauses	0.93	0.88-0.98	0.01*
% Words	0.99	0.98-1	0.17
% Embedded clauses	1.04	0.04-1.11	0.33
% Subordinate clauses	1	0.96-1.04	0.93
% Global coherence	0.88	0.82-0.95	<0.001**
% Local coherence	0.99	0.93-1.05	0.74
Complete episodes	2.38	0.83-7.16	0.11

*p < .05, **p < .01 in logistic regression analysis.
TBI, traumatic brain injury; 95% CI, 95% confidence interval; OR, odds ratio; AIC: 159.21.

Complete Episodes, did not reach significance after accounting for covariates. These results highlight the particular sensitivity of global coherence and the number of clauses to post-TBI discourse impairment. A post hoc power analysis based on the logistic regression model (Nagelkerke $R^2 = 0.48$) indicated that the obtained sample size provided sufficient statistical power ($f^2 = 0.93$, power = 1.00).

3.3. Neuropsychological performance in the TBI group

Neuropsychological tests were administered to the TBI group, and the results were compared with normative means or cutoff scores reported in test manuals and previous studies. The results indicated that the TBI group showed lower scores on the FAB and Coding (processing speed), and on the KWCST, showed lower Categories Achieved and higher Perseverative Errors (executive function). In contrast, the MMSE (general cognition) as well as performance on the TMT-A (attention) and DSF (passive component of phonological working memory) were within the normal limits. With respect to working memory, the DSB was within the normal limits, whereas the TBI group required more time to complete the TMT-B. Additionally, KWCST- Difficulty Maintaining Set scores were within norms relative to age-adjusted references. For verbal memory, S-PA high was within the normal range, whereas S-PA low was reduced (Table 5).

3.4. Correlations between discourse indices and neuropsychological tests in the TBI group

All discourse indices, except %Words, were significantly correlated with at least one neuropsychological test assessing general cognition, executive function, working memory, attention, processing speed, or verbal memory. Notably, %Global Coherence was significantly associated with all neuropsychological tests except DSF. Although correlations with some measures, such as the MMSE ($r = 0.35$, $p < .05$), KWCST- Categories Achieved ($r = 0.32$, $p < .05$), KWCST- Perseverative Errors ($r = -0.36$, $p < .05$), KWCST- Difficulty Maintaining Set ($r = 0.22$, $p < .05$), S-PA high ($r = 0.33$, $p < .05$), and S-PA low ($r = 0.33$, $p < .05$), were modest, relatively

Table 5
Neuropsychological assessment results in the TBI Group with reference to normative data.

Neuropsychological Assessments		*TBI (n=81)*		*Control data*[a]	*Comparison*
		Median (IQR)	Mean ± SD (min-max)		
General cognition	MMSE	28 (25-29)	26.83 ± 3.64 (14-30)	≦27	
Executive function	FAB	14.5 (12-16)	13.64 ± 3.47 (5-18)	16.1(1.0)	▾
	KWCST-CA	3 (1-5)	3.07 ± 2.27 (0-6)	5.20(1.26)	▾
	KWCST-PEN	5 (2-12)	7.28 ± 6.67 (0-23)	0.96(1.56)	▾
	KWCST-DMS	1 (0-2)	1.58 ± 2.15 (0-10)	0.47(0.83)	
Attention	TMT-A(sec)	45 (34.5-59.5)	57.75 ± 50.44 (15-325)	40.3(7.3)	
Passive component of phonological working memory	DSF	6 (6-8)	6.64 ± 1.53 (3-9)	6.49(1.25)	
Working memory	TMT-B(sec)	91.5 (58-140.75)	117.0 ± 93.62 (29-500)	49.0(11.9)	▾
	DSB	5 (4-5)	4.67 ± 1.45 (2-8)	4.92(1.22)	
Processing speed	Coding	62 (45-74)	61.34 ± 22.01 (10-113)	≦78	▾
Verbal memory	S-PA high	10 (8-10)	8.68 ± 2.30 (1-10)	≦ 9	
	S-PA low	2 (1-5)	3.17 ± 3.26 (0-10)	≦ 3	▾

Values represent the median (interquartile range: IQR) and the mean ± standard deviation; SD (minimum - maximum) of neuropsychological assessment results for the TBI group.
Cut-off scores or mean values (±1 standard deviation) are shown.
The downward arrow (▾) denotes the median performance below the normative range TBI, traumatic brain injury; MMSE, Mini-Mental State Examination; FAB, Frontal Assessment Battery; KWCST, Keio Version of the Wisconsin Card Sorting Test; CA, Categories Achieved; PEN, Perseverative Errors of Nelson; DMS, Difficulty Maintaining Set; TMT-A, Trail Making Test–J Part A; TMT-B, Trail Making Test–J Part B; DSF, Digit Span Forward; DSB, Digit Span Backward; Coding, Coding subtest from WAIS-III; S-PA, Standard Verbal Paired-Associate Learning Test; high, high-associate; low, low-associate.
[a] Control data: Indicates normative performance for each test based on the corresponding age group.

stronger associations were observed with the FAB (r = 0.47, p < .05), TMT-A (r = −0.40, p < .05), TMT-B (r = −0.55, p < .05), DSB (r = 0.43, p < .05), and Coding (r = 0.50, p < .05). %Words was not significantly correlated with any neuropsychological measures. DSF was not significantly correlated with any neuropsychological measures. (Table 6).

4. Discussion

In the present study, we applied a multilevel discourse analysis framework proposed by Coelho (2007) to Japanese-speaking individuals with TBI and compared their performance with that of HCs to identify similarities and differences from findings in Western language contexts. In addition, we examined specific discourse indices that characterize narrative discourse following the emergence of TBI symptoms. Consistent with our hypotheses, the results demonstrated that individuals with TBI showed significant impairments in narrative discourse at the microstructural, macrostructural, and superstructural levels compared with HCs. These findings are consistent with previous studies in Western languages employing similar analytic approaches.

Furthermore, as hypothesized, macrostructural measures—particularly global coherence—and, notably, the total number of clauses most effectively distinguished individuals with TBI from HCs and showed robust associations with multiple neuropsychological functions.

4.1. Discourse analysis in patients with TBI and HCs

At the microstructural level, although some aspects were preserved in patients with TBI, several impairments were identified. Regarding "Productivity," the total number of clauses and the percentage of independent words were lower in the TBI group, indicating reduced verbal output. Previous studies have reported similar reductions in meaningful word production post-TBI (Brookshire et al., 2000; Hartley & Jensen, 1991). Power et al. (2020) noted that reductions in productivity compromise clause construction, resulting in impoverished and simplified discourse. Our findings suggest that individuals with TBI face difficulty verbalizing multiple ideas and conveying essential information (Douglas et al., 2007; Togher, McDonald, & Code, 2014), culminating in lexically impoverished discourse. Regarding "Grammatical Complexity," contrasting patterns were observed between the embedded and subordinate clauses. No significant difference was found between groups for embedded clauses, demonstrating that the structural complexity within main clauses may be preserved post-TBI, as supported by Glosser and Deser (1991). In contrast, the proportion of subordinate clauses was significantly lower in the TBI group, consistent with the findings of Ghayoumi et al. (2015). This discrepancy may reflect the functional characteristics of the adverbial clauses. Embedded clauses modify nouns within the main clause, whereas adverbial clauses describe causal or explanatory relations through conjunctions [e.g., "because"] (Masuoka & Takubo, 2019a), thereby contributing not only to syntactic complexity but also to cohesion or local coherence. Moreover, Japanese adverbial clauses tend to be less syntactically dependent than embedded clauses and share properties more closely aligned with main clauses (Masuoka & Takubo, 2019a). Therefore, although embedded clause structures may be maintained following TBI, the use of subordinate clauses to express logical relations across clauses appears to decline.

At the macrostructural level, the TBI group showed significantly impaired coherence abilities in global and local coherence indices compared to the HC group. This finding indicates reduced ability to maintain the semantic connectedness of narrative themes and meanings (Coelho et al., 2023; Patry & Nespoulous, 1990). Previous studies have reported coherence problems in the discourse of individuals with TBI (Coelho, Grela, et al., 2005), such as topic shifts and perseverations in local coherence (Marini et al., 2014), and irrelevant insertions (Marini et al., 2017; McDonald, 1993; Turkstra et al., 1996) or information omissions (Biddle et al., 1996; Galetto et al., 2013; Kintz et al., 2018) in global coherence. Frequent topic shifts fragment information and reduce communicative efficiency. Likewise, inserting irrelevant information or omitting essential content can disrupt context, potentially leading to misunderstanding or

Table 6
Spearman correlation coefficients between neuropsychological tests and discourse measures in the TBI group.

	Clauses	%Words	%Embedded clauses	%Subordinate clauses	%Global coherence	%Local coherence	Complete episodes
MMSE	0.19	−0.02	0.15	0.12	0.35*	0.29*	0.35*
FAB	0.14	−0.2	0.17	0.36*	0.47*	0.52*	0.43*
KWCST-CA	0.23*	0.08	0.28*	0.22*	0.32*	0.27*	0.21
KWCST-PEN	−0.23*	−0.03	−0.34*	−0.27*	−0.36*	−0.29*	−0.22*
KWCST-DMS	−0.26*	0.08	−0.25*	−0.22*	−0.22*	−0.17	−0.14
TMT-A	−0.13	0.16	−0.22*	−0.29*	−0.40*	−0.38*	−0.42*
TMT-B	−0.16	0.08	−0.22*	−0.40*	−0.55*	−0.59*	−0.46*
DSF	0.11	0.03	0.12	0.19	0.22	0.15	0.22
DSB	0.24*	−0.14	0.17	0.30*	0.43*	0.40*	0.43*
Coding	0.29*	−0.04	0.26*	0.30*	0.50*	0.44*	0.44*
S-PA high	0.15	−0.06	0.16	0.09	0.33*	0.23*	0.40*
S-PA low	0.13	0.01	0.29*	0.24*	0.33*	0.32*	0.28*

*p < .05 for Spearman's rank correlation coefficient.
TBI, traumatic brain injury; MMSE, Mini-Mental State Examination; FAB, Frontal Assessment Battery; KWCST, Keio Version of the Wisconsin Card Sorting Test; CA, Categories Achieved; PEN, Perseverative Errors of Nelson; DMS, Difficulty Maintaining Set; TMT-A, Trail Making Test–J Part A; TMT-B, Trail Making Test–J Part B; DSF, Digit Span Forward; DSB, Digit Span Backward; Coding, Coding subtest from WAIS-III; S-PA, Standard Verbal Paired-Associate Learning Test; high, high-associate; low, low-associate.

incomplete comprehension by the listener. This disruption degrades the overall quality and comprehensibility of discourse. Thus, the discourse of Japanese speakers with TBI appears marked by diminished semantic connectivity and thematic deviation due to impaired coherence.

At the superstructural level, the number of complete episodes was significantly lower in the TBI group than in the HC group, indicating diminished story grammar competence. This reflects deficits in narrative structure and logical sequencing (Coelho, 2002; Mozeiko et al., 2011; Stein & Glenn, 1979). TBI often results in disorganization and impaired regularities in the internal structure of stories (Mozeiko et al., 2011), with incomplete episodes due to omitted episode components, defined as statements containing information about stated goals, attempts at solutions, and the consequences of these attempts (Chapman et al., 1992). In the present study, the omission of essential episode components in the discourse of individuals with TBI appeared to disrupt the logical structure, resulting in incomplete and incoherent episodes. These results demonstrate that narrative discourse among Japanese patients with TBI is significantly impaired across all discourse levels, consistent with findings from Western language studies (Hill et al., 2018; Togher, McDonald, & Code, 2014).

Our findings of impairments at the microstructural and macrostructural levels differ from those of Matsuoka et al. (2012), who applied CIU analysis to a similar Japanese TBI population. CIU analysis, which evaluates speech output based on content units defined at the word level (Nicholas & Brookshire, 1993), is effective for assessing lexical accuracy. However, it may not sufficiently capture discourse deficits that extend beyond the sentence level, particularly in terms of coherence and story structure. In contrast, our comprehensive discourse analysis– spanning from the lexical-level features to narrative-level organization–provides a more detailed understanding of discourse impairments in patients with TBI.

Furthermore, the present study clarified the relationship between neuropsychological performances and discourse characteristics. The TBI group demonstrated below-normal performance in several cognitive domains, except for general cognition and attention. Discourse indices across all analytical levels were significantly correlated with at least one measure of general cognition, executive function, working memory, attentional function, processing speed, or verbal memory. Previous studies have similarly reported the impact of executive dysfunction, working memory deficits, and verbal memory impairment on discourse abilities following TBI (Mar, 2004; Hill et al., 2018; Matsuoka et al., 2012; Tucker & Hanlon, 1998). The present findings support these prior results and provide evidence that cognitive dysfunction following TBI plays a crucial role in discourse impairments among Japanese participants with TBI.

4.2. Discourse indicators strongly associated with TBI

Global coherence emerged as a sensitive indicator of discourse impairment following TBI. This finding aligns with Hough and Barrow (2003), who reported that deficits in global coherence were more pronounced than those in local coherence. They argued that organizing discourse as a whole poses a greater challenge than maintaining semantic connections between adjacent utterances. Although their findings were based on a small sample of five participants, our results supported their claims through statistical analysis involving a larger cohort.

The particular vulnerability of global coherence in TBI narratives can be explained by the cognitive processes required to maintain the theme of narrative stories. First, participants must interpret the content and infer the overarching theme from a four-panel comic (Büttner-Kunert et al., 2022; van Dijk, 1980). Furthermore, they must plan and organize their utterance while inhibiting irrelevant or redundant content (Büttner-Kunert et al., 2022). During speech production, individuals must continuously monitor the alignment of their narrative with the intended theme and revise it, as needed, to avoid irrelevant content or omissions. This process relies on a top-down framework of planning and organization that supports semantic continuity, fills informational gaps, and suppresses extraneous content (Büttner-Kunert et al., 2022; Togher, McDonald, & Code, 2014). In this context, maintaining semantic continuity between adjacent utterances constitutes only one component of thematic maintenance (Galetto et al., 2013). Thus, global coherence may have shown greater sensitivity than local coherence in capturing discourse disturbances in individuals with TBI.

Additionally, global coherence was the only measure significantly correlated with all neuropsychological test scores except for the DFS. This finding supports the view that global coherence relies on a broad range of cognitive abilities (Galetto et al., 2013; Tucker & Hanlon, 1998). The process of integrating essential information while inhibiting irrelevant content during planning and organization reflects executive functioning (Büttner-Kunert et al., 2022; Galetto et al., 2013). Furthermore, self-monitoring during speech production depends on working memory (Togher, McDonald, & Code, 2014). Maintaining attention to the task, retaining narrative content, and flexibly updating the discourse structure require the involvement of memory, attentional control, and processing speed (Hill et al., 2018). These findings suggest that global coherence serves as a comprehensive indicator of impairments across multiple cognitive domains.

Moreover, the total number of clauses predicted TBI status, which may likewise reflect the influence of reduced global coherence. According to Hartley and Jensen (1992), individuals with TBI who exhibit low productivity tend to provide only a few salient elements from a picture while failing to convey important sequential relationships. In other words, reduced productivity may result in the omission of essential information and disrupt global coherence by impairing the expression of abstract relationships and thematic connections necessary to maintain the overall structure of narratives. Therefore, our observation of reduced clause production suggests a close association between diminished productivity and impaired global coherence.

4.3. Limitations

This study has several limitations. First, the specific locations of brain lesions in the TBI group could not be determined. Lesion location is associated with discourse characteristics; for example, diffuse axonal injury following closed head injury is related to reduced discourse efficiency and cohesion (Tanemura & Tsubakihara, 2006), whereas focal lesions in the left hemisphere are associated with an increased risk of aphasic symptoms (Coelho et al., 2013). However, because detailed neuroimaging data were unavailable, the analysis of the effect of lesion characteristics on discourse performance was limited. Future studies incorporating precise neuroimaging data are needed to clarify the relationships between lesion location and specific discourse impairments. Second, because the TBI group predominantly comprised individuals with mild injuries, this sample characteristic may have influenced both the discourse and neuropsychological outcomes. Future studies should incorporate sampling and analyses that account for injury severity. Third, the TBI group included many participants in the acute post-injury phase, and the time since injury varied widely. Because discourse abilities may change across recovery stages, this sample characteristic may have influenced the results. Future studies should control for recovery stage when examining post-TBI discourse performance. Fourth, neuropsychological test data were unavailable for the HC group, which precluded direct comparisons of cognitive function profiles and their effect on discourse performance between groups. Future research integrating detailed neuroimaging data with comprehensive neuropsychological assessments in clinical and control populations will allow for more refined analyses of the neural and cognitive underpinnings of discourse impairments following TBI.

5. Conclusion

This study applied the multilevel discourse analysis framework proposed by Coelho (2007) to Japanese participants with TBI, revealing impairments at the microstructural, macrostructural, and superstructural levels. Among the various discourse measures, reduced global coherence and a lower total number of clauses were identified as significant predictors of TBI. In particular, global coherence was associated with a broad range of cognitive functions, highlighting its value as a sensitive indicator of discourse breakdown. These findings demonstrate the cross-linguistic applicability of multilevel discourse analysis to Japanese speakers and underscore its importance in the assessment and rehabilitation of cognitive-communication disorders following TBI.

CRediT authorship contribution statement

Mamiko Fujiwara: Writing – original draft, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Rumi Tanemura:** Supervision, Conceptualization. **Atsuko Hayashi:** Writing – review & editing, Supervision, Conceptualization.

Funding sources

This study received partial support from a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (grant number 24K02765).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

I am grateful to all the individuals and organizations that supported this study. Special thanks go to Kansai Medical University, Kansai University of Welfare Sciences, Naya Clinic, Headway-Sakai, SHIP HEALTHCARE, and the Bando Neighborhood Association for their assistance with data collection. I also thank Dr. Junji Kumasawa for his valuable advice on data analysis.

Data availability

Data will be made available on request.

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