AJSLP

OPEN ACCESS | American Journal of Speech-Language Pathology | Research Article | 15 Dec 2023

Correct Information Unit Analysis in Different Discourse Tasks Among Persons With Anomic Aphasia Based on Mandarin AphasiaBank

Bao-Mei Deng, Li-Si Liang, Jia-Xin Zhao, Hai-Qing Zheng and Xi-Quan Hu

https://doi.org/10.1044/2023_AJSLP-23-00217

Abstract

Purpose: This study aimed to explore how well persons with anomic aphasia communicate information during discourse regarding quantity, quality, and efficiency compared to neurotypical controls, to investigate the influence of discourse tasks on informativeness and efficiency and to examine impact factors like aphasia severity and cognitive ability.

Method: Language samples of four discourse tasks from 31 persons with anomic aphasia and 31 neurotypical controls were collected from Mandarin AphasiaBank. Correct information unit (CIU) analysis measures including the total number of CIUs, percentage of CIUs, CIUs per minute, and words per minute were calculated. Group differences and the effects of discourse tasks on informativeness and efficiency were investigated. Correlations of CIU analysis measures with aphasia severity and cognitive ability were examined.

Results: Persons with anomic aphasia showed lower efficiency in conveying information than controls. They underperformed controls on all CIU analysis measures when executing story narrative tasks. Discourse tasks influenced the informativeness and efficiency of both groups. Neurotypical controls delivered the greatest quantity of information most efficiently when narrating

stories. Persons with anomic aphasia exhibited reduced quantity of information during procedural discourse and displayed superior information quality in sequential-picture descriptions. Discourse information may be impacted by aphasia severity and cognitive ability, with varying effects depending on the task.

Conclusions: Persons with anomic aphasia are inefficient in communicating discourse messages and perform poorly on all measures in story narratives. When measuring discourse information, the effects of discourse tasks and factors like aphasia severity and cognitive ability should be considered.

The ultimate goal of therapy for persons with aphasia is an improvement in communication skills. The ability to use language at the discourse level is essential for them to engage in everyday activities and meet social needs (**Fergadiotis et al., 2019**). Discourse is defined as language beyond the sentence level and is employed for a specific purpose or function (**Armstrong, 2000**). It is the basis for most of the routine communication (**Davidson et al., 2003**; **Pritchard et al., 2017**).

Discourse impairments, such as those experienced by persons with aphasia, can hinder their ability to engage in and enjoy life (**Stark, Dutta, Murray, Bryant, et al., 2021**). Anomic aphasia is one of the most common aphasia types. Persons with anomic aphasia have relatively preserved speech fluency, repetition, comprehension, and grammatical speech. They are able to speak fluently and communicate in complete sentences. However, even though they represent the mildest subtype within aphasia, persons with anomic aphasia complain of communication difficulties, especially during connected speech such as telling stories, recounting personal experiences, and explaining procedures (**Jiang et al., 2023**). This hinders their ability to work and maintain social relationships. Standardized tests, such as the Western Aphasia Battery (WAB), may not be sensitive enough to detect their subtle language deficits because they even encounter ceiling effects on these tests (**Bryant et al., 2016**). Accordingly, discourse-based measures provide insight into evaluating how persons with aphasia can use language in more natural conditions and allow for the development of individualized treatment measured at the "bio-psycho-social" level (**Bryant et al., 2016**; **Worrall, 2006**; **Worrall et al., 2011**). Discourse treatment can help persons with anomic aphasia not only communicate better in daily contexts such as recounting events or expressing feelings but also engage more fully in social connections with family and friends (**Boyle, 2020**; **Dipper & Pritchard, 2017**). Moreover, they may become more confident and gain more self-esteem while conversing with others if they can communicate in discourse, which is important for their mental health (**Wallace et al., 2017**).

Persons with aphasia and their families are likely more concerned with how well persons with aphasia can communicate messages to listeners, rather than the grammar and form of the words being delivered. It is the useful information conveyed in the discourse rather than the language's grammatical rules or patterns that contribute more to the success of the communication. The

informativeness and efficiency of the connected speech are regarded to be related to communication success (**Oelschlaeger & Thorne, 1999**). Informativeness refers to how successfully

a person is able to convey their intended message (**Fink et al., 2008**; **Nicholas & Brookshire, 1993**; **Webster & Morris, 2019**). It looks at the degree to which a speaker's speech imparts the desired information, either through objective linguistic measures (e.g., content units) or subjective linguistic measures (e.g., listeners ratings; **Fink et al., 2008**; **Webster et al., 2018**). Efficiency is defined as the rate at which messages are conveyed (i.e., informativeness over time; **Edmonds, 2013**). According to **Nicholas and Brookshire (1993)**, a more efficient speaker is one who can provide more information in the same amount of time. The informativeness and efficiency of discourse are crucial as they represent the speakers' ability to use language in a practical way. Therefore, measures that quantify the informativeness and efficiency of discourse are useful for assessing the functional communication skills of persons with aphasia.

Measures used to characterize discourse ability can be classified into three categories: microstructure, macrostructure, and a mixture of both (**Stark, Dutta, Murray, Fromm, et al., 2021**). Microstructural measures concentrate on lexical, semantic, syntactic, or grammatical aspects of discourse, such as word errors, mean length of utterance, and word classes. Macrostructural measures are more concerned with the overall meaning of the text and how meanings are arranged within the discourse, such as story grammar and coherence. The combination of micro- and macrostructural measures often quantifies certain structures to evaluate the transactional success of the discourse, such as main concept analysis and correct information unit (CIU; **Armstrong, 2000**; **Leaman & Edmonds, 2019**). CIU analysis is a standardized rule-based scoring system that was designed to quantify the informativeness and efficiency of connected speech for persons with aphasia (**Leaman & Edmonds, 2019**). It was devised by **Nicholas and Brookshire (1993)** and has been reported to be among the strongest of the discourse information measures in terms of psychometric properties (**Marini et al., 2011**; **Pritchard et al., 2017**). CIUs are defined as "words that are intelligible in context, accurate in relation to the picture(s) or topic, and relevant to and informative about the content of the picture(s) or the topic" (**Nicholas & Brookshire, 1993**, p. 348). Every CIU is composed of a single word. For words to be counted as CIUs, grammatical correctness is not required. Words that do not adhere to the rules of standard grammar are still regarded as valid CIUs unless their improper use could lead to confusion or ambiguity. For example, in the given sentence, "The friends is here," the word "is" will be classified as a CIU. However, the "boys" and "girls" will not be counted as CIU in the sentence, "The boys and girls are arriving," because the targeted picture only depicts one boy and one girl arriving. In addition to counting the total number of CIUs (#CIUs), CIU analysis obtained three calculated measures, including the percentage of CIUs (%CIUs), correct information units per minute (CIUs/min), and words per minute (WPM; **Boyle et al., 2023**; **Carlomagno et al., 2011**; **Matsuoka et al., 2012**). #CIUs and three derived measures used collectively can be of clinical value for identifying communicative difficulties as they indicate three different aspects of discourse information: (a) The #CIUs represent the quantity of information content, that is, the overall amount of useful messages conveyed by a speaker; (b) the %CIUs represent the quality of information content, that is, the accuracy and effectiveness of speakers in delivering meaningful and desired messages; and (c) the CIUs/min and WPM represent the efficiency of information transmission, that is, the effort and time speakers manage to encode information and communicate messages. In this study, the term "informativeness" is used to denote the quantity and quality of information content as measured

by #CIUs and %CIUs, respectively, whereas "efficiency" refers to the rate of information transmission as measured by CIUs/min and WPM. The definition and property of CIU analysis

measures are illustrated in **Table 1**. We choose CIU analysis as it has been considered to have ecological value, and studies have suggested that CIU measures adequately reflect listeners' perceptions of informative discourse (**Webster & Morris, 2019**). Moreover, CIU measures have been shown to have excellent diagnostic sensitivity, high inter- and intrarater scoring reliability, and acceptable test–retest reliability (**Boyle, 2014**; **Pritchard et al., 2017**). Furthermore, CIU analysis can be used to analyze language samples about which the expected content is unknown, unlike main concept analysis, which requires a list of known and established main concepts for scoring. This is advantageous for analyzing discourse tasks where normative data of main concepts have not yet been established.

Table 1. Definition and property of CIU analysis measures.

Variable	Definition	Property
#CIUs	The total number of correct information units. Correct information units refer to words that are intelligible, accurate in context, and relevant to and informative about the content of the picture(s) or the topic.	The quantity of informativeness
%CIUs	The percentage of words that were correct information units. It is calculated by the number of words that were correct information units divided by the total number of count words in the language sample.	The quality (i.e., accuracy and effectiveness) of informativeness
CIUs/min	The number of correct information units per minute. It is calculated by the total number of correct information units divided by the duration (converted from seconds to minutes).	The efficiency of information transmission (i.e., informativeness over time)
WPM	It is defined by the total number of tokens divided by the duration (converted from seconds to minutes).	The efficiency (i.e., rate) of discourse production

Note. CIU = correct information unit; WPM = words per minute.

Nevertheless, the assessment of discourse information is complicated by which elicitation task to use. A variety of tasks can be used to elicit connected speech samples. Conversation is an ecologically valid elicitation method to capture everyday interactions and treatment responses but with low reliability due to the unpredictable nature of the content. Elicitation tasks that are more constrained and structured provide some predetermined targets, such as pictures or certain topics,

to attain more reliable and comparable language samples, such as picture descriptions, personal recounts, procedural discourse, and story narratives. For clinical management purposes, a

common but very simplistic approach such as a single-picture description has been used to measure informativeness (**Bryant et al., 2017**). To take the WAB as an example, for the "spontaneous speech" subtest, a single picture of Picnic Scene is used to qualitatively evaluate the discourse performance of persons with aphasia, where a 1–10 scale is applied to rate their information content. However, it is unclear whether the performance on conveying information demonstrated by the single-picture description task is representative, that is, whether the capacity for communicating information obtained from the single-picture description task is equivalent to that of other discourse tasks. There is considerable evidence indicating that the elicitation tasks employed can modify the language produced during discourse. Previous studies have demonstrated the impacts of elicitation methods on the micro- and macrostructural properties of discourse. Regarding discourse at the microstructural level, **Stark (2019)** investigated the microlinguistics of spoken language across four different discourse tasks, finding that for both those with and without aphasia, story narrative elicited the highest propositional density, whereas procedural discourse generated the least complicated syntax. Narrating a story or describing a sequence of pictures has been found to prompt a greater lexical diversity than describing a single image in persons with and without aphasia (**Alyahya et al., 2020**; **Fergadiotis & Wright, 2011**). In terms of macrolinguistics, **Marini et al. (2005)** found that the use of sequential pictures encouraged a greater degree of coherence in discourse as opposed to a single picture among neurotypical speakers. Personal recounts were reported to have the lowest global coherence scores compared to procedural discourse, storytelling, and picture description tasks in neurotypical adults (**Wright et al., 2014**). However, measurements that connect the micro- and macrostructural levels, such as CIU analysis, have not been well studied in terms of task-specific informativeness and efficacy. The current study aimed to assess communicative informativeness and efficiency using CIU analysis in order to determine the effect of discourse tasks on these measures and identify potential impact factors.

The severity of aphasia and cognitive ability are possible factors contributing to the informativeness and efficiency conveyed in different discourse tasks. On the one hand, the requirements for language ability may differ depending on the discourse task. A recent study using main concept analysis suggested that the overall aphasia severity may interact with the task (**Dalton & Richardson, 2019**). Aphasia severity has been proposed to affect narrative production, yet this was not applicable to picture descriptions (**Olness, 2006**). On the other hand, cognitive demands, such as executive dysfunction, inferencing, and cognitive planning, vary between distinct discourse tasks. Fictional story narratives probably depend more on semantic memory, whereas personal recounts rely more on episodic memory (**Bliss & McCabe, 2006**). Narratives without pictures supported may be more cognitively taxing in comparison to those that do, as they necessitate the assembly of multiple concepts without visual aid. Therefore, exploring how aphasia severity and cognitive ability relate to informativeness and efficiency in specific discourse tasks is important to guide clinical assessment and treatment.

The development of AphasiaBank, a large database of multimedia language samples of aphasia and controls performing various standardized discourse tasks, has paved the way internationally for discourse analysis studies (**Forbes et al., 2012**; **Fromm et al., 2020**; **MacWhinney & Fromm, 2016**). A preliminary data set of Mandarin AphasiaBank has been consequently established in recent years, and it is available on the international AphasiaBank website (**https://aphasia.talkbank.org/**). In this study, we aimed to leverage the Mandarin AphasiaBank

database to evaluate communicative informativeness and efficiency in persons with anomic aphasia and neurotypical controls. The aims of the study were threefold: The first aim was to determine which aspects of discourse information persons with anomic aphasia differ from those of neurotypical controls across various discourse tasks. We hypothesized that the anomic aphasia group would demonstrate a lower level of efficiency in transmitting information than the control group. The second aim was to explore how discourse tasks affected the information conveyed by both the aphasia and control groups. It was anticipated that the type of discourse task would influence informativeness and efficiency in both groups. Specially, story narratives may elicit a larger quantity of informativeness and facilitate higher efficiency of information transmission than other tasks for neurotypical controls, whereas sequential-picture descriptions may promote higher quality of informativeness than single-picture descriptions or tasks without picture aids for persons with aphasia. The third aim was to investigate the degree to which informativeness and efficiency were attributable to aphasia severity and cognitive abilities in the anomic aphasia group, stratified by discourse task. We expected that aphasia severity and cognitive abilities would correlate with CIU analysis measures and that the pattern may differ as a function of the discourse task.

Method

Participants

The study was approved by the ethical committee of The Third Affiliated Hospital of Sun Yat-Sen University (approval number: [2019]02-585-01). Language samples of persons with anomic aphasia and neurotypical controls were collected from the Mandarin AphasiaBank database. The aphasia group included 31 persons with anomic aphasia in the study. The control group was selected from 31 age- and education-matched neurotypical adults.

The inclusion criteria for the anomic aphasia group were (a) people who developed aphasia resulting from stroke, as supported via neuroimaging or a clear medical diagnosis; (b) persons with aphasia who were classified as anomic aphasia through standard behavioral criteria based on the Chinese version of Western Aphasia Battery–Revised (WAB-R; **J. Li et al., 2022**; **Wang, 1997**); (c) Mandarin as the primary language; (d) normal or corrected-to-normal vision and hearing; and (e) right-handed. The exclusion criteria were (a) a history of dementia or comorbidities associated with serious cognitive consequences (e.g., brain trauma or brain tumor), (b) dysarthria and apraxia of speech, (c) any history and presence of depression or other neurological conditions, and (d) any history of drug abuse or alcoholism.

The inclusion criteria for the control group were (a) no neurological condition (e.g., stroke, head injury), (b) hearing and vision (aided or unaided) adequate for testing, (c) native Mandarin Chinese speakers, (d) right-handed, (e) no history of cognitively deteriorating conditions based on self-report, (f) pass the Mini-Mental State Examination (MMSE; i.e., MMSE score > 26; **Huo et al., 2021**; **H. Li et al., 2016**; **Mellor et al., 2016**), and (g) no depression at the time of testing. The

exclusion criteria were (a) dysarthria; (b) serious heart, lung, kidney, and other diseases or other serious physical diseases that may cause poor physical endurance and mental fatigue and affect

evaluation results; and (c) mental disorders.

Baseline Assessment

Prior to discourse elicitation, all participants of the aphasia and control groups completed the Chinese version of WAB-R to assess language ability for baseline information. They also completed the MMSE to assess cognitive conditions. The WAB-R is a comprehensive evaluation of communication function that includes subtests for spontaneous speech, auditory comprehension, repetition, and naming that are used to create a composite aphasia quotient (AQ; **Kertesz, 2022**; **J. Li et al., 2022**; **Wang, 1997**). The AQ reflects a person's capacity for auditory–verbal communication and is commonly used as an index of overall aphasia severity, with lower scores indicating more severe language impairment. The maximum AQ score is 100, and the normal range is 98.4–99.6 (**Wang, 1997**). An AQ score < 93.8 is considered to indicate aphasia. The MMSE is a widely used brief test of global cognition functioning that measures cognitive domains of orientation, registration, attention and calculation, recall, and language (**H. Li et al., 2016**). The total MMSE score ranges from 0 to 30, with a higher score indicating better cognitive performance (**Jia et al., 2021**).

Discourse Elicitation

The elicitation of language samples followed the Mandarin AphasiaBank protocol (**https://aphasia.talkbank.org/protocol/languages/Mandarin/**). The discourse tasks in the Mandarin AphasiaBank protocol include greeting, picture descriptions, story narratives, procedural discourse, and free speech. In this study, four different discourse tasks were chosen from the database for analysis, namely, (a) the sequential-picture description task of "Refused Umbrella," (b) the single-picture description task of "Cat Rescue," (c) the story narrative task of "The Tortoise and the Hare," and (d) the procedural discourse task of making ham and egg fried rice.

The sequential-picture description was elicited by a series of black-and-white line-drawing pictures presented in sequential order to the participants, who were then instructed to describe a story with a beginning, a middle, and an end looking at the stimuli. The "Refused Umbrella" is composed of six images, illustrating a child refusing the umbrella given to him by his mother as he set off for school and consequently getting drenched in the rain.

The single-picture description was provided with a single image in which various objects implying a timeline of events were combined to create a central theme. Participants were asked to create a story that was based on temporal sequencing while looking at the picture. "Cat Rescue" is a single black-and-white line-drawing picture depicting a young girl trying to rescue her cat from a tree, with her father failing to do so, necessitating the fire department to be brought in.

The story narrative was elicited by initially providing color drawings to the participants, who were allowed to view sequential pictures as long as they wished. After the pictures were taken away, they were asked to begin their storytelling. "The Tortoise and the Hare" is a traditional fable telling the story of a competition between the slow and steady tortoise and the quick and cocky hare,

with the hare's overconfidence causing him to take a nap mid-race, allowing the plodding tortoise to cross the finish line first.

The procedural discourse required participants to explain the procedures step by step to complete an activity. Photos and written texts were provided when the participant was unable to respond. The task required participants to explain the process necessary to make ham and egg fried rice.

All participants were tested individually in a laboratory setting, and the language samples were recorded using a video recorder for further analysis. Discourse task instructions and pictures are accessible in the Mandarin protocol on the AphasiaBank website (**https://aphasia.talkbank.org/protocol/languages/Mandarin/discourse_Ttsks**). The examiners followed a uniform set of instructions to keep the prompts consistent across discourse sample collections and provided participants with sufficient time to deliver a comprehensive response to the discourse tasks. Prompts specific to the content of the discourse tasks were avoided. The examiners used nonverbal encouragement (e.g., head nods, facial expressions, eye contact) instead of verbal encouragement (e.g., "I see," "mhm," "yeah") whenever possible to keep the examiner's speech to a minimum.

Language Sample Preparation

Computerized Language Analysis (CLAN) was used to transcribe the language samples orthographically in the Codes for the Human Analysis of Transcripts (CHAT) format. Detailed instructions on how to execute commands in CLAN and the codes used for the analysis are available at AphasiaBank (**https://talkbank.org/manuals/Clin-CLAN.pdf**).

To pull out the specific discourse tasks of transcripts we designed to analyze, the GEM program associated with CLAN was applied. The GEM command serves to extract specific task blocks from a larger CHAT file containing multiple task blocks for further analysis. It can be used to isolate and analyze previously tagged selections or "gems" (e.g., the procedural discourse task, a particular picture description task) within the transcript. If combined with the +f parameter, a new CHAT file can be generated and saved, which is equivalent to obtaining clips of certain specific task blocks from the larger file. The gems of interest in this study (i.e., the four discourse tasks) were extracted from transcripts using the following GEM commands:

```
gem +s"umbrella "+t*PAR + d1 + fumbrella *.cha

gem +s"cat" + t*PAR + d1 + fcat *.cha

gem +s"tortoise_hare" + t*PAR + d1 + f tortoise_hare *.cha

gem +s" egg_ham_fried_rice " +t*PAR + d1 + f egg_ham_fried_rice *.cha
```

These commands output files with the specified gem for each participant into a specified directory. The files included the participant's utterances and header information with age, gender, and other

pertinent demographic information. This procedure yielded four transcript files (one for each of the above-named tasks) for each participant.

CIU Analysis

The CIU analysis developed by **Nicholas and Brookshire (1993)** was employed to measure discourse informativeness and efficiency conveyed in each task. The definitions of CIU analysis measures and the properties they represent are listed in **Table 1**. After CHAT transcripts were retrieved for four discourse tasks, the language samples were scored for count words and CIUs using published rules (**Brookshire & Nicholas, 1995**; **Nicholas & Brookshire, 1993**). First, words that did not qualify as count words based on the rules of CIU analysis were deleted. Statements were deleted if they were made before or after the speaker performed the discourse task or suggested that the speaker was prepared to start or had finished the task but did not give information related to the picture(s) or the topic itself. Words or partial words that are not intelligible and nonword fillers ("um," "er," "uh") were also eliminated. After the deletion, all transcripts were only left with words that were qualified as count words. Second, we duplicated the transcripts and added the CIU filename suffix to the copied ones. In the duplicate CIU files, we deleted all the non-CIU words (words that qualify as count words but did not qualify as CIUs, e.g., inaccurate words, nonspecific or vague words, and off-task or irrelevant words) according to Nicholas and Brookshire's rules, leaving only CIUs in the duplicate transcripts. Third, we ran the command on the speaker tier shown below for the original files to calculate the total count words and WPM:

```
freq +t*PAR + r6 + d2 *.cha

timedur +t*PAR + r6 + d10 *.cha
```

The following commands on the speaker tiers were conducted for copied files (files that were added with the CIU filename suffix) to calculate the #CIUs and CIUs/min:

```
freq +t*PAR + d2 *.cha

timedur +t*PAR + d10 *.cha
```

Following the above commands, the total number of count words, #CIUs, CIUs/min, and WPM for each sample were obtained. The percentage of CIUs (%CIUs) was then calculated by the total number of CIUs divided by the total count words in each language sample. Finally, the #CIUs, %CIUs, CIUs/min, and WPM were all calculated for further analysis.

Inter- and Intrarater Reliability

Inter- and Intrarater Reliability

Inter- and intrarater reliability for transcription, count words, and CIU counts were estimated by randomly selecting 25.8% of samples from each group (i.e., eight samples from the aphasia and control groups, respectively). The selected samples were retranscribed by the same transcriber and another experienced trained rater to obtain intra- and interrater reliability for transcription. To obtain rater reliability for scoring of count words and CIU counts, the selected 16 transcripts were rescored for count words and CIU counts by the same rater and another experienced trained rater. The point-to-point agreement, calculated by the formula (total agreements / [total agreements + total disagreements] × 100%), was used to assess reliability. Interrater reliability for transcription, count words, and CIU counts for the control group were 95%, 94%, and 92%, respectively, and for the anomic aphasia group were 93%, 91%, and 90%, respectively. Intrarater reliability for transcription, count words, and CIU counts for the control group were 97%, 96%, and 95%, respectively, and for the aphasia group were 94%, 94%, and 92%, respectively.

Statistical Analysis

All statistical procedures were conducted using the Statistical Package for the Social Sciences Version 27.0 for Windows. The statistical significance level was set at $p < .05$. The Shapiro–Wilk normality test was used to determine if a variable was normally distributed. Variables were normally distributed if the Shapiro–Wilk test p values were greater than .05. Continuous variables with a normal distribution are presented as the mean (standard deviation), and non-normal variables are reported as the median (interquartile range). The independent-samples t test, Mann–Whitney U test, and Pearson chi-square test were used to evaluate between-groups differences with respect to baseline characteristics.

As WPM in the aphasia group and #CIUs in both the aphasia and control groups were found to be non-normally distributed ($p < .05$), we applied generalized estimated equations (GEE) in the study. GEE is a commonly used method with less stringent requirements on normality assumptions for factorial analysis. GEE with an exchangeable correlation structure was implemented with group (the control group and aphasia group) as the between-participants factor, discourse task (sequential-picture description, single-picture description, storytelling, and procedural discourse) as the within-participant factor, and AQ and MMSE scores as covariates to determine (a) group differences in measures (#CIUs, %CIUs, CIUs/min, and WPM) and (b) the effect of discourse task on measures. The Group × Discourse Task interaction was tested first. If significant, the simple effect of between-groups differences within each discourse task and within-group differences among different discourse tasks was tested. If not significant, the main effects of the group and discourse task were tested next. Otherwise, an adjustment of the significance level was performed using Bonferroni's method for multiple comparisons of post hoc tests.

To identify potential factors affecting communicative informativeness and efficiency in the anomic aphasia group, Spearman partial correlation was used within each discourse task to examine correlations between CIU analysis measures (#CIUs, %CIUs, CIUs/min, and WPM) and aphasia severity and cognitive ability. The effect of AQ was controlled while examining the relationships between CIU analysis measures and the MMSE score, whereas the MMSE score was controlled when analyzing the correlations between CIU analysis measures and AQ.

Results

Demographic Information

The baseline characteristics of the aphasia and control groups are summarized in **Table 2**. There were no persons with aphasia in the hyperacute (< 24 hr poststroke) or acute stage of stroke (1~7 days poststroke). Sixteen persons with aphasia were in the subacute phase (7 days ~6 months poststroke), and 15 were in the chronic stage of the stroke (> 6 months poststroke). The two groups did not differ significantly in age ($t(60) = -0.020$, $p = .984$), education ($U = 467.000$, $p = .847$), or gender ratio ($\chi^2(1) = 1.728$, $p = .189$). The aphasia group exhibited significantly lower scores on the MMSE ($U = 21.00$, $p < .001$) and AQ ($U < .001$, $p < .001$) compared to the control group.

Table 2. Demographic information of the aphasia and control groups.

Group	Aphasia (n = 31)	Control (n = 31)	Comparisons	Effect size
Age (years)	42.26 (13.01)	42.32 (12.92)	$t(60) = -0.020$, $p = .984$	Cohen's $d = 12.96$
Education (years)	15 (11–16)	15 (12–16)	$U = 467.000$, $p = .847$	$\eta^2 = .001$
Gender (male/female)	22/9	17/14	$\chi^2(1) = 1.728$, $p = .189$	$\phi = 0.17$
Time post-onset (months)	6.00 (2.87–9.00)	—	—	
AQ	86.90 (80.50–90.30)	99.60 (99.2–100)	$U < .0001$, $p < .001$**	$\eta^2 = .74$
MMSE score	23(16–26)	30(29–30)	$U = 21.00$, $p < .001$**	$\eta^2 = .67$

Note. Values shown are means (standard deviation) and median (interquartile range) unless stated otherwise. Statistical comparisons are two tailed. Em dashes indicate that data are not applicable. t = independent-samples t test; U = Mann–Whitney U test; χ^2 = Pearson chi-square test; AQ = Aphasia Quotient from the Western Aphasia Battery–Revised; MMSE = Mini-Mental State Examination.

**Significant effect at $p < .001$.

GEE Analysis

GEE analysis showed significant interaction effects between group and discourse task for all CIU analysis measures (#CIUs: Wald $\chi^2 = 15.948$, $p = .001$; %CIUs: Wald $\chi^2 = 16.371$, $p = .001$; CIUs/min: Wald $\chi^2 = 12.218$, $p = .007$; WPM: Wald $\chi^2 = 7.849$, $p = .049$). This indicates that the effect of discourse task on CIU analysis measures shows different patterns in the control and aphasia groups. Therefore, the simple effects of between-groups differences within each discourse task and within-group differences among different discourse tasks were further tested and reported below.

Between-Groups Differences

Those with anomic aphasia (average duration [seconds]: *Mdn* = 70.00, interquartile range: 45.50–108.50) took significantly longer than those in the control group (average duration [seconds]: *Mdn* = 55.00, interquartile range: 39.25–83.50) to finish each discourse task ($U = 5{,}987.000$, $p = .003$). Compared to the control group (average tokens: *Mdn* = 107.00, interquartile range: 74.25–171.00), the anomic aphasia group (average tokens: *Mdn* = 61.00, interquartile range: 37.25–97.50) used fewer words overall in each discourse task ($U = 3{,}855.000$, $p < .001$). The descriptive statistics of CIU analysis measures for the two groups across four discourse tasks are provided in Table 3. Simple effect analysis revealed that persons with anomic aphasia underperformed controls on all CIU analysis measures in story narrative (#CIUs: Wald $\chi^2 = 5.93$, $p = .015$; %CIUs: Wald $\chi^2 = 4.97$, $p = .026$; CIUs/min: Wald $\chi^2 = 21.28$, $p < .001$; WPM: Wald $\chi^2 = 7.68$, $p = .006$). The anomic aphasia group was significantly less efficient at delivering information than the control group was in all discourse tasks, except for WPM in single-picture description (Wald $\chi^2 = 2.15$, $p = .143$).

Table 3. Between-groups comparison of CIU analysis measures within each discourse task.

Measures	Discourse tasks	Aphasia (*n* = 31)	Control (*n* = 31)	Wald χ^2	*p*	Cohen's *d*
#CIUs	Sequential	46.00 (31.00, 72.00)	83.00 (60.00, 105.00)	0.27	.602	−1.06
	Single	46.00 (26.00, 61.00)	87.00 (55.00, 122.00)	0.07	.795	−1.16
	Story	38.00 (28.00, 80.00)	145.00 (82.00, 188.00)	5.93	**.015***	−1.32
Measures	**Discourse tasks**	**Aphasia (*n* =**		**Wald**		**Cohen's**

Measures	tasks	31)	Control (n = 31)	χ	p	d
	Procedural	22.00 (16.00, 37.00)	56.00 (40.00, 98.00)	0.13	.716	−1.25
%CIUs	Sequential	0.72 (0.57, 0.80)	0.81 (0.72, 0.90)	0.07	.786	−0.62
	Single	0.58 (0.50, 0.70)	0.81 (0.77, 0.89)	2.43	.119	−1.60
	Story	0.57 (0.44, 0.72)	0.87 (0.76, 0.92)	4.97	**.026***	−1.52
	Procedural	0.60 (0.50, 0.76)	0.80 (0.73, 0.83)	0.90	.342	−1.09
CIUs/min	Sequential	45.00 (24.71, 58.64)	101.74 (76.60, 128.57)	6.27	**.012***	−1.84
	Single	34.29 (23.79, 47.89)	100.80 (65.95, 117.78)	8.93	**.003***	−2.25
	Story	42.22 (14.42, 60.00)	119.02 (101.45, 144.86)	21.28	**< .001****	−2.64
	Procedural	37.71 (22.65, 53.33)	110.00 (83.33, 122.18)	16.10	**< .001****	−2.79
WPM	Sequential	64.46 (46.29, 92.65)	131.22 (96.29, 148.65)	3.86	**.049***	−1.67
	Single	59.46 (39.64, 82.22)	127.58 (85.36, 140.70)	2.15	.143	−1.59
	Story	68.60 (52.31, 98.91)	152.68 (124.96, 169.15)	7.68	**.006***	−2.22
	Procedural	60.68 (45.44, 87.22)	133.47 (118.39, 156.07)	8.42	**.004***	−2.42

Note. Values are presented as median (interquartile range) unless otherwise noted. #CIUs = the total number of correct information units; Sequential = sequential-picture description; Single = single-picture description; Story = story narrative; procedural = Procedural discourse; %CIUs = percentage of correct information units; CIUs/min = correct information units per minute; WPM = words per minute.

*Significant effect at p < .05.

**Significant effect at p < .001; items in bold indicate significant effect.

Within-Group Differences Among Discourse Tasks

Within-Group Differences Among Discourse Tasks

The distribution of CIU analysis measures by four discourse tasks for the control and aphasia groups is illustrated in **Figure 1**. Further analysis of the simple effect of the discourse task for the control and aphasia groups was statistically significant on all CIU analysis measures, except for %CIUs in the control group. In the control group, story narrative demonstrated the highest values on #CIUs, CIUs/min, and WPM among all discourse tasks. In addition, procedural discourse elicited significantly fewer #CIUs than either single-picture descriptions or story narratives. In the anomic aphasia group, procedural discourse generated the fewest #CIUs of all tasks. The highest %CIUs were provided by persons with anomic aphasia when they described sequences of pictures. Moreover, their CIUs/min values were significantly lower in the single-picture description than in the sequential-picture description. The WPM generated during the single-picture description was significantly slower than during the story narrative.

Figure 1. Comparison of CIU analysis measures across four discourse tasks within each group (aphasia and control). The center lines within the box plots represent the median; box plot bounds represent the interquartile range; whiskers refer to minimum and maximum values. Asterisks indicate a significant difference (*$p < .05$, **$p < .001$). #CIUs = the total number of correct information units; %CIUs = percentage of correct information units; CIUs/min = correct information units per minute; Procedural = Procedural discourse; Sequential = Sequential-picture description; Single = Single-picture description; Story = Story narrative; WPM = words per minute.

Download figure | Download PowerPoint

Correlations Between CIU Analysis Measures and AQ and MMSE Score

Table 4 demonstrates the correlations between CIU analysis measures and AQ and MMSE score using Spearman partial correlation analysis within four discourse tasks in the aphasia group. After controlling for MMSE score, the results of the Spearman partial correlation revealed that for each discourse task (except procedural discourse), aphasia severity as measured by AQ was moderately positively correlated with CIUs/min (sequential-picture description: $r = .569$, $p = .001$; single-picture description: $r = .424$, $p = .022$; story narrative: $r = .433$, $p = .019$). These results indicated that a higher level of efficiency in conveying information was correlated with less severe aphasia in these three discourse tasks. There was a moderate positive correlation between AQ and WPM in both sequential-picture ($r = .428$, $p = .021$) and single-picture ($r = .411$, $p = .027$) descriptions, indicating that persons with milder anomic aphasia were able to produce faster speech rates when describing pictures. AQ was also moderately positively correlated with #CIUs in sequential-picture description ($r = .498$, $p = .006$, and story narrative ($r = .660$, $p < .001$). Notably, no significant correlations were found between AQ and %CIUs for all discourse tasks. After controlling for AQ, there was only a weak positive correlation between MMSE score and %CIUs in story narratives ($r = .387$, $p = .038$).

Table 4. Correlations between correct information unit (CIU) analysis measures and AQ and

Table 4. Correlations between correct information unit (CIU) analysis measures and AQ and MMSE score in each discourse task for the aphasia group (n = 31).

		Correlation coefficient (r)	
Discourse tasks	**Measures**	**AQ**	**MMSE score**
Sequential	#CIUs	**.498***	−.040
	%CIUs	.204	.150
	CIUs/min	**.569***	.192
	WPM	**.428***	.096
Single	#CIUs	.252	.258
	%CIUs	−.034	.140
	CIUs/min	**.424***	−.021
	WPM	**.411***	−.095
Story	#CIUs	**.660****	.358
	%CIUs	.117	**.387***
	CIUs/min	**.433***	.226
	WPM	.334	.016
Procedural	#CIUs	.288	.143
	%CIUs	.139	−.152
	CIUs/min	.303	−.008
	WPM	.265	.007

Note. AQ = Aphasia Quotient from the Western Aphasia Battery–Revised; MMSE = Mini-Mental State Examination; Sequential = Sequential-picture description; #CIUs = the total number of correct information units; %CIUs = percentage of correct information units; CIUs/min = correct information units per minute; WPM = words per minute; Single = Single-picture description; Story = Story narrative; Procedural = Procedural discourse.

*Significant effect at $p < .05$.

**Significant effect at $p < .001$; items in bold indicate significant effect.

Discussion

Discussion

In this study, we employed the Mandarin AphasiaBank database to examine the quantity, quality, and efficiency of discourse information produced by persons with anomic aphasia and age- and education-matched controls in response to four different elicitation tasks using CIU analysis. Three main findings were documented in this study in reference to our original hypotheses. First, persons with anomic aphasia displayed decreased efficiency in transmitting information across all discourse tasks (except for WPM in single-picture description) and overall performed worse than neurotypical adults across all measures in the story narrative task. Second, the discourse task affected all CIU analysis measures for both groups in different patterns, with the exception of the quality of informativeness in the control group. For the control group, story narratives exhibited the greatest quantity and efficiency of information among all discourse tasks. The aphasia group generated the least amount of information when carrying out the procedural discourse. Moreover, they performed with the greatest accuracy while describing sequential pictures compared to other tasks. Third, while the quantity and efficiency of discourse information were moderately positively correlated with aphasia severity to some extent (apart from procedural tasks), no correlation was found between the quality of discourse information and the severity of aphasia in all tasks. The cognitive ability only showed a weak positive correlation with the quality of informativeness in story narratives.

Between-Groups Differences

The first aim of this study was to identify whether discourse information conveyed by persons with anomic aphasia differs from that of neurotypical individuals during various discourse tasks. The results of the study indicated that persons with anomic aphasia had a notably reduced efficiency in transmitting information compared to neurotypical individuals across all discourse tasks (except for WPM in single-picture description). The slowness of communication and speech rate observed in persons with anomic aphasia indicated that they had difficulty conveying relevant information in a timely fashion. This could be attributed to a diminished ability to manage information simultaneously and sustain activation across multiple domains when processing demands increased during discourse (**DeDe & Salis, 2020**). In accordance with previous studies, aphasia demonstrated a slowness in connected speech compared to neurotypical adults in all discourse genres (**Alyahya et al., 2020**; **Stark, 2019**). Even though people who have recovered from aphasia have greatly improved their expressive vocabulary, they may still display delayed lexical retrieval latencies or prolonged language processing (**DeDe & Salis, 2020**; **Neto & Emília Santos, 2012**). It has been proposed that interventions focused on speed and accuracy rather than accuracy alone would generate greater improvements in generalization to connected speech (**Conroy et al., 2018**). These findings reminded us of speed as an important factor in both aphasia assessment and treatment (**Crerar, 2004**; **Galletta & Goral, 2018**). In addition, the results revealed that persons with anomic aphasia exhibited considerably poorer performance than neurotypical controls on all measures of informativeness and efficiency in the context of story narrative tasks. This indicated that story narrative may be more effective than other tasks for detecting deficits in communicating discourse information in persons with anomic aphasia. Though persons with anomic aphasia may even encounter ceiling effects on standardized assessments (**Bryant et al., 2016**) and show a comparable amount and accuracy of discourse information to neurotypical individuals when

describing pictures and depicting procedures, they still demonstrated considerable impoverished information in terms of quantity, quality, and efficiency when performing story narrative task. In the study, participants were not visually aided when telling stories. It may impose a greater cognitive load on them and necessitate a higher level of memory to recall the plot of the story (**DeDe & Salis, 2020**; **Fergadiotis & Wright, 2011**). As a consequence, persons with anomic aphasia may have more difficulty extracting relevant target words and omit a greater number of episodes compared to neurotypical controls (**DeDe & Salis, 2020**), causing a decrease in the amount of informativeness. They may also be more likely to talk off-topic, use more unnecessary filler words, repeat and revise their sentences more often, and produce more vague information when narrating stories, all of which lower the quality of informativeness.

Effects of Discourse Tasks

The second aim of this study was to explore whether the type of discourse task had an impact on communicative informativeness and efficiency. The interaction between the task and the group indicated that discourse tasks affected informativeness and efficiency in different ways for persons with and without aphasia. Within the control group, story narratives generated the highest quantity (as measured by #CIUs) and efficiency (as measured by CIUs/min and WPM) of discourse information compared to other tasks. This finding extends previous studies looking into the microstructure of discourse, demonstrating story narratives as rich data sources, as they provide higher quantities of content words, lexical diversity, and propositional density compared to picture descriptions or procedural discourse (**Alyahya et al., 2020**; **Fergadiotis & Wright, 2011**; **Stark, 2019**). Interestingly to note, persons with anomic aphasia failed to exhibit this pattern; that is, the quantity and efficiency of information generated by story narrative was significantly greater than that of other tasks. Neurotypical speakers may find learned or well-known storytelling without visuals more flexible, open ended, and creative than visual tasks, allowing them to deliver a rich and expanded language output more efficiently. It is possible, however, that the situation could be reversed for persons with aphasia. Persons with aphasia may be more vulnerable to the demands associated with story narrative (**Fergadiotis & Wright, 2011**), which relies more heavily on processes of memory, planning, and organization compared to expositional discourse. Open-ended story narrative tasks may challenge anomic aphasics who need temporal and causal information to structure stories. Additionally, it is interesting that the control group showed no significant variation in %CIUs across tasks, suggesting that neurotypical speakers are similarly precise in conveying information in all discourse tasks.

Within the aphasia group, the procedural discourse elicited the least quantity of informativeness among all tasks. We can visualize the overall pattern of task-specific informativeness and efficiency produced by the two groups in **Figure 1**. It can be seen that both the aphasia and the control groups elicited fewer #CIUs when performing the procedural discourse compared to other tasks, although there was no significant difference between the procedural discourse and sequential-picture description for controls. It seems that procedural discourse, typically involving a tightly constrained topic, tends to be characterized by reduced information, limited vocabulary, and

simplified sentence structure. **Fergadiotis and Wright (2011)** suggested that procedural discourse produced the least amount of lexical diversity when compared to single-picture descriptions,

storytelling, and personal recounts. According to **Stark (2019)**, the syntax of procedural discourse was simpler than that of picture description and story narratives in both persons with and without aphasia. Our results indicated that procedural discourse was not an effective technique to elicit a large amount of information and necessitated more research. Regarding the quality of informativeness, persons with anomic aphasia performed best on sequential-picture descriptions compared to other tasks. As suggested by **Capilouto et al. (2005)**, using sequential pictures can help speakers deliver their message more precisely and effectively by giving them greater temporal and causal insights into the story being depicted. Regarding efficiency, persons with anomic aphasia communicated more slowly when describing a single picture compared to narrating a story (as measured by WPM) or describing a sequence of pictures (as measured by CIUs/min). The single-picture description requires speakers to deduce potential storylines and recognize the associations between characters and events in a scene to form a correct and plausible story, which may take longer for persons with anomic aphasia to reason and process their thoughts.

Correlations Between CIU Analysis Measures and AQ and MMSE Score

The third aim of this study was to determine how the factors of aphasia severity and cognitive ability may affect informativeness and efficiency in the anomic aphasia group. Because the relationship of CIU analysis measures with AQ and MMSE score may also differ by discourse task, Spearman partial correlations were examined stratified by tasks. The results revealed that the severity of aphasia had at least some impact on the quantity and efficiency of information for tasks excluding procedural discourse. These suggested that individuals with less severe anomic aphasia might be able to provide more information and deliver it more efficiently. Notably, we did not identify a significant correlation between aphasia severity and the quality of informativeness (as measured by %CIUs) on any task, which might indicate that the accuracy of discourse information may not be related to the severity within the same subtype of anomic aphasia, as they are relatively mild in severity and may perform similarly in relation to precision. Regarding cognitive ability, it was found that MMSE score was weakly associated with the quality of informativeness (as measured by %CIUs) during story narratives, suggesting that the accuracy of information in story narratives may be affected, at least in part, by the cognitive functioning of persons with aphasia. More studies are needed to include participants with a range of aphasia types, aphasia severity levels, and cognitive capacities.

Clinical Implications

Our findings have several clinical implications. First, persons with anomic aphasia are less efficient at communicating information in connected speech, suggesting that more consideration should be given to temporal measures and speed training in discourse assessment and treatment. Second,

this study broadened previous findings on micro- or macrolinguistics, using CIU analysis to provide evidence at both micro- and macrostructure that discourse tasks did affect the discourse

information for anomic aphasia. These underscored the need to consider the impact of discourse tasks when assessing communicative success. As suggested by **Stark and Fukuyama (2021)**, it is an ideal practice to gather multiple and various discourse samples for a comprehensive and reliable discourse analysis. However, in many cases, it may be difficult to fully implement due to busy and time-constrained clinical settings. In this situation, it might be plausible and feasible to prioritize efficient discourse tasks that best represent the properties we are meant to analyze. For example, to identify communication difficulties regarding discourse information in persons with anomic aphasia, story narrative may be more useful than other tasks. If we wish to increase the accuracy of discourse information for anomic aphasia, we should be aware that it might be easier for them to describe sequential pictures than a single picture. It may not be the most effective strategy to use procedural discourse if we want to elicit more utterances of anomic aphasia.

Limitations

We recognize limitations in the current study. First, the CIU analysis applied in this study does not take into account whether the messages that are relatively essential to the overall gist of a picture or story are conveyed or omitted by speakers. Main concept analysis resolves this issue by establishing a checklist of the main concepts to provide an outline of the essential information about a picture or topic. However, no normative data of the main concepts have yet been established for the Mandarin AphasiaBank protocol from Mandarin Chinese speakers, which hindered us from utilizing this analysis method, making it an area that deserves further research. Second, we used the MMSE score to represent overall cognitive abilities. However, the MMSE relies heavily on verbal cognitive skills and is not as effective in detecting cognitive abilities such as executive function. Moreover, this study did not investigate which specific cognitive subskills (such as orientation, attention, memory, and executive function) are required for certain discourse tasks and how they contribute to discourse informativeness and efficiency. Since Mandarin AphasiaBank did not incorporate these fine-grained cognitive assessments, our current study failed to obtain these data. Future studies mining the AphasiaBank database should consider preregistering assessments covering a wider range of cognitive components to examine how specific cognitive elements may affect information across discourse tasks. Third, we focused on anomic aphasia in our study, and our findings may not be equally applicable to other types of aphasia. Future studies investigating other types of aphasia would be a valuable addition to the current literature. Finally, we evaluated discourse information elicited by monologic connected speech tasks in this study as it is time efficient and can be repeated with uniformity. However, language production within monologues may differ from language within unstructured conversations, which involve more interaction between speakers and listeners. Future research incorporating conversations is needed to better understand the communicative informativeness and efficiency conveyed by persons with aphasia in more ecologically valid discourse contexts.

Conclusions

Persons with anomic aphasia exhibit reduced efficiency in expressing correct information. Assessments using different discourse task types provide methods for profiling both health

condition-specific properties and task type-specific attributes. Aphasia severity and cognitive ability may have some impact on discourse information, and the effect may vary depending on the task. This study increased our understanding of communicative informativeness and efficiency across different discourse tasks, which is meaningful for the standardization of discourse in clinical assessment and treatment.

Author Contributions

Bao-Mei Deng: Conceptualization (Equal), Data curation (Equal), Formal analysis (Lead), Investigation (Lead), Methodology (Lead), Project administration (Equal), Resources (Equal), Supervision (Lead), Validation (Equal), Visualization (Lead), Writing – original draft (Lead), Writing – review & editing (Lead). **Li-Si Liang:** Investigation (Equal), Project administration (Supporting), Resources (Supporting), Writing – review & editing (Supporting). **Jia-Xin Zhao:** Data curation (Supporting), Investigation (Equal), Project administration (Supporting), Writing – review & editing (Supporting). **Hai-Qing Zheng:** Project administration (Supporting), Validation (Equal), Writing – review & editing (Supporting). **Xi-Quan Hu:** Conceptualization (Supporting), Funding acquisition (Supporting), Project administration (Supporting), Supervision (Equal), Writing – review & editing (Supporting).

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy/ethical restrictions.

Acknowledgments

This work was supported by National Key R&D Program of China (No. 2022YFC3601200). The authors sincerely appreciate the hard work and devotion put out by AphasiaBank's developers and contributors.

Author Notes

Disclosure: *The authors have declared that no competing financial or nonfinancial interests existed at the time of publication.*

Correspondence to Xi-Quan Hu: huxiquan@mail.sysu.edu.cn

Editor-in-Chief: Katherine C. Hustad

Editor: Anthony Pak-Hin Kong

Additional Resources

AJSLP

ASHA
American
Speech-Language-Hearing
Association

JOURNALS

American Journal of Audiology (AJA)

American Journal of Speech-Language Pathology (AJSLP)

Journal of Speech, Language, and Hearing Research (JSLHR)

Language, Speech, and Hearing Services in Schools (LSHSS)

Perspectives of the ASHA Special Interest Groups

Contemporary Issues in Communication Science and Disorders (CICSD)

The ASHA Leader

RESOURCES

For Authors

For Reviewers

For Librarians

Rights and Permissions

TOPIC COLLECTIONS

Speech, Voice & Prosody

Hearing Disorders

Language Disorders

School-Based Settings

EXPLORE MORE

Special Collections

ASHAWire Connections

STAY CONNECTED

Subscribe

Contact Us

My Account