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RESEARCH REPORT

Applying core lexicon analysis in patients with anomic aphasia: Based on Mandarin AphasiaBank

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Abstract

Background: Patients with anomic aphasia experience difficulties in narrative processing. General discourse measures are time consuming and require necessary skills. Core lexicon analysis has been proposed as an effort-saving approach but has not been developed in Mandarin discourse.

Aims: This exploratory study was aimed (1) to apply core lexicon analysis in Mandarin patients with anomic aphasia at the discourse level and (2) to verify the problems with core words among people with anomic aphasia.

Methods & Procedure: The core nouns and verbs were extracted from narrative language samples from 88 healthy participants. The production of core words for 12 anomic aphasia and 12 age- and education-matched controls were then calculated and compared. The correlation between the percentages and the Aphasia Quotients of the revised Western Aphasia Battery was analyzed as well.

Outcomes & Results: The core nouns and verbs were successfully extracted. Patients with anomic aphasia produced fewer core words than healthy people, and the percentages differed significantly in different tasks as well as word classes. There was no correlation between the core lexicon use and the severity of aphasia in patients with anomic aphasia.

Conclusions & Implications: Core lexicon analysis may potentially serve as a clinician-friendly manner of quantifying core words produced at the discourse level in Mandarin patients with anomic aphasia.

KEYWORDS
anomic aphasia, core lexicon analysis, core words, discourse, Mandarin AphasiaBank

WHAT THIS PAPER ADDS

What is already known on the subject

- Discourse analyses in aphasia assessment and treatment have increasingly garnered attention. Core lexicon analysis based on English AphasiaBank has been

reported in recent years. It is correlated with microlinguistic and macrolinguistic measures in aphasia narratives. Nevertheless, the application based on Mandarin AphasiaBank is still under development in healthy individuals and patients with anomic aphasia.

What this paper adds to existing knowledge

- A Mandarin core lexicon set was developed for different tasks. The feasibility of core lexicon analysis to evaluate the corpus of patients with anomic aphasia was preliminarily discussed and the speech performance of patients and healthy people was then compared to provide a reference for the evaluation and treatment of clinical aphasia corpus.

What are the potential or actual clinical implications of this work?

- The purpose of this exploratory study was to consider the potential use of core lexicon analysis to evaluate core word production in narrative discourse. Moreover, normative and aphasia data were provided for comparison to develop clinical use for Mandarin patients with anomic aphasia.

INTRODUCTION

Aphasia involves the loss of language abilities, often arising from stroke or tumour that blocks the blood supply to an area of the brain (Cunningham & Haley, 2020; MacWhinney, 2019; Silkes *et al.*, 2019). Virtually one-third of worldwide stroke survivors suffer from aphasia, making it the most common communication disorder (Brady *et al.*, 2016; Le *et al.*, 2018). Patients whose primary language problem is confined to word retrieval are diagnosed as having anomic aphasia (Kong et al., 2019). Despite the fact that anomic aphasia is the mildest subtype within aphasia, patients with this dysfunction still complain of difficulties in communication such as word-finding and vague clarity which hinder them from talking freely, especially during interpersonal communications such as telling stories, sharing memories and giving advice (Cunningham & Haley, 2020; Kong *et al.*, 2018).

Discourse errors in patients with anomic aphasia

When retrieving target words while speaking, patients with anomic aphasia tend to paraphrase with readily obtained words and avoid diverse expressions. For instance, a patient could name the 'cup' as 'the thing used for drinking' due to an impairment in the semantic and/or phonological processes (Salis et al., 2021). In fact, circumlocutions and halting speech are the characteristic features of impaired word production seen in oral narratives for patients with anomic aphasia, which hinders their ability to work and maintain a social life. Thus, even the mildest form of aphasia requires assessment and treatment (Galletta & Goral, 2018; Hickin et al., 2015; Stark et al., 2021).

Current clinical evaluation measures of aphasia such as the revised Western Aphasia Battery (WAB-R), the Boston Diagnostic Aphasia Examination and the Standard Language Test of Aphasia are primarily limited to the single-sentence level or the single-picture description using expositional narrative (Stark, 2019; Westerveld & Claessen, 2014). Moreover, many patients with anomic aphasia experience ceiling effects on standardized assessments (Bryant et al., 2016). It is insufficient to reflect the actual language ability and predict daily communication and social participation because their dysfunction is mainly concentrated at the discourse level (Bryant et al., 2016; DeDe & Salis, 2020; Linnik et al., 2016). Therefore, narrative-based measures are indispensable for language assessment because they provide a window into understanding how patients with anomic aphasia perform their daily communicative tasks. The common method of discourse elicitation is narrative discourse, which involves

the recounting of a personal event or the retelling of a well-known story. Due to its reliance on memory and macrolinguistic structures such as story grammar and coherence, narrative discourse may elicit more complex language compared to expositional narrative (Stark, 2019).

In fact, it has garnered attention in recent years to extend the evaluation to the level of discourse because word retrieval problems in patients with anomic aphasia have been proven to be more apparent during narrative production (Boschi et al., 2017; Cruice et al., 2020; Kim et al., 2019; Kong & Law, 2019; Law et al., 2018; Linnik et al., 2016). For example, the selection of pronouns is deeply linked with semantic information of thematic roles that have been previously introduced in discourse. Additionally, the narrative is an important natural form of language comprising utterances and phrases which requires the interaction between phonology, morphology, syntax and semantics (Bryant et al., 2016; Hsu & Thompson, 2018; Kim et al., 2019, 2021; Kintz & Wright, 2018; Silkes et al., 2019; Harris Wright & Capilouto, 2012).

However, infrequent use of discourse analysis in clinical settings has been reported, owing to the complexity of heavy preparatory work and post-processing for traditional narrative assessment (Bryant et al., 2017; Maddy et al., 2015). The common methods for discourse analysis such as coherence (Hazamy & Obermeyer, 2020; Kong et al., 2018; Linnik et al., 2021; Olness & Ulatowska, 2011; Harris Wright & Capilouto, 2012; Zhang et al., 2021), main concept analysis (Dalton & Richardson, 2015, 2019; Dillow, 2013; Richardson & Dalton, 2016, 2020; Richardson et al., 2021), story grammar (Greenslade et al., 2020; Richardson et al., 2021) and systemic functional linguistic analysis (Groenewold & Armstrong, 2018; Law et al., 2018) could reflect the structural and linguistic components of language, while the transcriptions may cost much more time. To some extent, it is unrealistic for clinicians to complete a complex transcription of language samples and define grammatical categories and errors.

Core lexicon analysis as a discourse assessment

Due to the aforementioned limitations, AphasiaBank, a corpus gathering hundreds of transcripts of patients with aphasia and healthy people contributed by researchers worldwide came to our consideration (Kong & Law, 2019; Li et al., 2019; MacWhinney et al., 2011). AphasiaBank collects high-definition multimedia samples over a wide range of tasks at the discourse level to assist in the assessment and treatment of patients with aphasia. Evaluations of these language samples may be better at detecting language deficits, as well as guide and track the efficacy of treatment (Bryant et al., 2016). In contrast to conventional discourse analysis procedures, a novel approach was taken to quantify core words in order to ease the burden on clinicians. Based on AphasiaBank, researchers have developed and applied core lexicon measures in aphasia narratives to reveal the ability of target word acquisition and informative discourse performance (Dalton & Richardson, 2015; Dillow, 2013; Fromm et al., 2017; Kim et al., 2019; MacWhinney et al., 2010). Core lexical analysis, which consists of critical lexical items that play an important role in constructing a semantically coherent narrative, has been proposed to provide clinicians with a way to quantify the ability of word retrieval at the discourse level (MacWhinney *et al.*, 2010).

MacWhinney et al. introduced the core lexicon measure as a method for the first time to demonstrate the use of the AphasiaBank database (MacWhinney et al., 2010). They extracted the 10 most frequent nouns and verbs produced during the narrative task, Cinderella, from 25 neurotypical adults. Then 24 patients with aphasia were enrolled and compared. Group differences were found in core lexicon analysis that the aphasia group presented with reduced lexical diversity and greater use of frequently occurring verbs. Dillow created core noun and verb lists following the procedures of MacWhinney et al. and analyzed the core lexicon lists for the same story (Dillow, 2013). The scores for the core nouns, the core verbs and the entire core lexicon lists differentiated patients with aphasia from healthy people. In the same year, Fromm et al. collected the transcriptions of 144 healthy individuals and 141 patients with aphasia to retrieve the top 10 nouns and verbs for both groups (Fromm et al., 2013). It was found that the frequency of core items differed, although the essential words were fairly similar. Dalton and Richardson considered core words including adjectives and adverbs in the core lexicon list (Dalton & Richardson, 2015). Their study enrolled 92 cognitively healthy adults to build core lexicon items, and then 166 transcripts of healthy participants and 235 patients with aphasia were examined to determine if the core lexicon analysis could distinguish the two groups. It turned out that the control group produced more items on the core lexicon list compared to the aphasia group. Within the aphasia group, patients with fluent aphasia performed better than those with non-fluent aphasia. In a more recent series of studies applying core lexicon analysis, Kim et al. considered age and word class when developing core lexicon lists and qualified word retrieval impairments at the discourse level in patients with aphasia (Kim et al., 2019). The core lists extracted from 470 healthy participants were identified for four word classes (nouns, verbs, adjectives and adverbs) among the seven age groups (20s, 30s, 40s, 50s, 60s, 70s, 80s). Discourse samples from 11 aphasic patients were compared

with the core lists respectively by the percent agreement. Their findings suggested that the retrieval ability of target words may be reduced in the elderly, and this ability may be selectively interfered with by different classes. What is more, language samples collected from 11 patients verified the concurrent validity and reliability of core lexicon analysis in aphasia narratives correlated with microlinguistic and macrolinguistic measures (Kim & Wright, 2020b). The further analysis from Kim et al. confirmed that core word use was strongly correlated with aphasia severity, and patients with non-fluent aphasia produced fewer core words than patients with fluent aphasia (Kim et al., 2021).

Aims of the study

Despite the necessity of core word production being brought to the attention of researchers nowadays, the application of core lexicon analysis in Mandarin patients have received little attention to date. The purpose of this exploratory study was to examine the potential use of core lexicon analysis to evaluate core word production in narrative discourse. Moreover, normative data and aphasia data were provided for comparison to develop the clinical use for patients with anomic aphasia. The key questions addressed in this study were as follows:

1. Is core lexicon analysis applicable to Mandarin AphasiaBank?
2. Do patients with anomic aphasia have problems with core words?

METHODS

Data

Data for this study were drawn from the Mandarin protocol of the AphasiaBank database located in the TalkBank System (Chen et al., 2018; Deng et al., 2021). AphasiaBank is a shared database that offers researchers a large corpus with a definitive goal to improve the treatment of aphasia by comparing discourse natures from patients with aphasia and individuals without aphasia (Fromm et al., 2020; MacWhinney & Fromm, 2016; MacWhinney et al., 2011; Sharma et al., 2019). The database emphasizes the collection of data based on a specified elicitation protocol that requires the investigator to follow a script for asking questions and eliciting narratives, which offers multimedia information including transcripts of discourse by specific tasks (Fromm et al., 2020; MacWhinney, 2019; MacWhinney & Fromm, 2016). Audio and video recordings are obtained from all the participants for further analysis. Detailed information about the AphasiaBank and standard protocols is available at the official website (http://aphasia.talkbank.org).

Participants

The preliminary study included language samples from 88 healthy participants. Inclusion criteria for the control group were (i) no history of central nervous system diseases; (ii) no history of medication that affected speech and language performance; (iii) native Mandarin Chinese speakers; (iv) passed hearing and vision screenings; (v) right-handed; (vi) presented with normal speech function indicated by the WAB-R (Jacobs et al., 2021) and normal cognitive functioning indicated by the Mini-Mental State Exam (MMSE) (Salvadori et al., 2020); and (vii) participants were informed and signed informed consent. Exclusion criteria were (i) dysarthria; (ii) serious heart, lung, kidney, and other diseases or other serious physical diseases; and (iii) depression and mental disorders.

The primary study included language samples from 12 patients with anomic aphasia (six females, six males) and 12 age- and education-matched healthy participants from the preliminary study (six females, six males). Inclusion criteria for participants with aphasia were (i) a single stroke resulting in left hemisphere lesions, (ii) an aphasia duration of at least 30 days, (iii) Mandarin as the primary language, (iv) diagnosed as anomic aphasia, (v) vision and hearing adequate for testing, and (vi) right-handed. Exclusion criteria included (i) dysarthria, (ii) dementia or brain trauma or brain tumor, (iii) any history and presence of depression or other neurological conditions, and (iv) any history of drug abuse or alcoholism.

The study protocol was approved by the Institutional Research Ethics Committee (ethical approval code 2016-SR-007), and all the participants or guardians had signed informed consent.

Experimental procedures

Baseline assessment

Prior to corpus collection, all participants underwent MMSE and WAB-R evaluation to measure cognitive and speech functions. MMSE consists of five aspects: orientation, memory, attention and computation, recall ability, and language ability, which can reflect the basic cognitive function of the subjects (Milman et al., 2018; Salvadori et al., 2020). WAB-R is an internationally accepted aphasia test scale (Dekhtyar et al., 2020; Jacobs et al., 2021). The subjects with Aphasia Quotient (AQ) < 93.8 were classified

TABLE 1 Demographic information for main analysis

Group	N (male:female)	Age (SD) (years)	Education (SD) (years)	WAB-R (SD)	MMSE (SD)
Patients	12 (6:6)	39.58 (11.33)	11.67 (5.45)	82.48 (7.16)	23.92 (4.03)
Controls	12 (6:6)	39.67 (11.73)	12.08 (5.30)	98.81 (1.45)	28.50 (1.45)

TABLE 2 Discourse tasks collected

Small Talk	Greetings to initiate a conversation. (The healthy subjects can skip this part.)
Picture Descriptions	The Broken Window and the Refused Umbrella are formed from a set of pictures while the Cat Rescue and the Flood include a single picture to induce descriptions.
Story Narratives	The Tortoise and the Hare as well as Cry Wolf are included.
Procedural Discourse	Participants are required to talk about the process of cooking egg and ham fried rice.
Free Speech	The most important event and the stroke story are covered. (The healthy participants can skip the latter part).

as patients with aphasia. The subtype of aphasia was determined by the WAB-R taxonomic system. Demographic information for primary analysis was in Table 1.

Abbreviations: MMSE, Mini-Mental State Exam; WAB-R, Western Aphasia Battery

Corpus collection

Corpus collection referred to international AphasiaBank standards (MacWhinney & Fromm, 2016) and took Chinese cultural traditions into account. The method and compilation techniques have been adopted by AphasiaBank and reported (Chen et al., 2018; Deng et al., 2021). Corpus tasks include five parts: Small Talk, Picture Descriptions, Story Narratives, Procedural Discourse and Free Speech (Bryant et al., 2016; Zhang et al., 2021). The common and variable tasks that participants were required to perform were listed in Table 2. Small Talk was a brief greeting as an initiation. Then four subtasks were followed to describe a set of pictures or a single picture including the Broken Window, the Refused Umbrella, the Cat Rescue and the Flood. Participants were instructed to narrate The Tortoise and the Hare as well as Cry Wolf as informatively as possible. The process of cooking egg and ham fried rice was required as the third part. Finally, both groups were asked to talk about the most important events in their lives, and Free Speech specifically covered the stroke process and recovery.

All participants were tested individually in a laboratory setting and the corpus in the tasks was recorded by multimedia video. The collectors were speech therapists who received specialized training. Unified instructions were used to guide subjects to complete the assessment tasks.

Data processing

Language sample preparation

The first task (Small Talk) and the last task (Free Speech) were eliminated in the analyses because healthy subjects may not complete these parts. The preserved tasks (Picture Descriptions, Story Narratives and Procedural Discourse) went to the next analysis. The Computerized Language Analysis (CLAN) was used to transcribe the corpus into Codes for the Human Analysis of Transcripts (CHAT) format according to the instructions at the official website (http://aphasia.talkbank.org).

Two verification steps were required for the transcribed text. The first step was to validate the document format, and the second was to check the morphology. The former referred to the verification of the transcribed document itself, including the mandatory matching of data headers, the format of transcribed text, the marking of punctuation marks, the position of the dot when breaking sentences and the label of various error words. The latter grammar check could be used to analyze parts of speech and sentence patterns (Dalton & Richardson, 2015). The verified text contained another two lines of %mor and %gra. On the mainline of the transcribed text (excluding nonverbal parts), line %mor marked the parts of speech overall characters, and line %gra carried out an in-depth grammatical analysis on the basis of %mor. To generate the core words through core lexicon analysis based on the normative data, the FREQ program associated with CLAN was applied, which was produced within the transcripts along with the frequency information. For the discourse task, the top 25 of the most high-frequency words were used to create the core word lists for each group according to the cutoff of previous studies (Dalton & Richardson, 2015; Kim et al., 2021).

Core word percentage

In core lexicon analysis, the Broken Window, the Refused Umbrella, the Cat Rescue and the Flood were merged as the Picture Description task. The Tortoise and the Hare as well as Cry Wolf were also combined as the Story Narrative task. The core words were determined by the number of times the core lexicon was used for each task. Once the core word lists including 25 core nouns and 25 core verbs were generated, the existence for each core word as part of the list could be determined for each participant. All the synonyms were not accepted to correspond with the procedures of previous study (Dalton & Richardson, 2015). The percentage was accumulated by giving 1 point for each core word. As a result, frequency problems were transferred to all-or-none questions. The percent agreement was calculated by adding the numerator throughout the list, then multiplying by four times as 100 was the full mark (Kim et al., 2021).

Statistics

R statistical package "lme4" was used for statistics analyses (Bates *et al.*, 2015). Linear mixed effects models were used to compare the core verb percentage and core noun percentage between patients with anomic aphasia and controls among three tasks. Subject was treated as a random factor.

To investigate the relationship between the AQs and the percentages of core lexicon agreement, similar linear mixed-effects models were performed treating the factors AQ and task as fixed effects and subject as a random factor. Percentage of nouns and verbs, respectively, served as the dependent variables. Results were assumed to be statistically significant at $p < 0.05$.

RESULTS

The first purpose of the current study was to apply core lexicon analysis to the Mandarin AphasiaBank. The core noun lists (Table 3) and core verb lists (Table 4) were extracted from three tasks respectively.

Then, linear mixed effects models analyses were conducted to test whether the percentages of core words differ significantly between patients with aphasia and controls. 12 patients and 12 age-matched ($p = 0.986$) and education-matched ($p = 0.851$) control participants were selected as shown in Table 5. Significant differences were found between groups ($\chi^2(1) = 22.432$, $p = 2.177e^{-06}$), tasks ($\chi^2(2) = 168.14$, $p < 2.2e^{-16}$) and word classes ($\chi^2(1) = 21.8$, $p = 3.025e^{-06}$). Percentages of controls were significantly higher than patients with anomic aphasia among three tasks for both nouns ($\chi^2(1) = 18.753$, $p = 1.488e^{-05}$) (Figure 1) and verbs ($\chi^2(1) = 17.227$, $p = 3.318e^{-05}$) (Figure 2). There were no significant correlations between the percentages and AQs in patients with anomic aphasia ($\chi^2(1) = 2.0694$, $p = 0.1503$).

DISCUSSION

Discourse assessment in aphasia is becoming one of the priority focuses (Cruice et al., 2020). Core lexicon analysis has been reported in recent years based on English AphasiaBank (Dalton et al., 2020a, 2020b; Kim & Wright, 2020a, 2020b). However, in spite of the fact that Chinese is one of the most spoken languages in the world, and the overwhelming majority of native speakers receive speech assessment and treatment in Mandarin, the actual utility and clinical capacity of Mandarin AphasiaBank has been neglected for a considerable time (Neergaard et al., 2021). Therefore, the current study aimed to develop core lexicon analysis for Mandarin patients with anomic aphasia and explore the potential use of core words. The feasibility of core lexicon analysis to evaluate the corpus was preliminarily discussed, and the speech performance of patients with anomic aphasia and healthy people was then compared, thus providing a reference for the evaluation and treatment of clinical aphasia corpus.

The results of the preliminary analysis indicated that the core word measure was applicable to Mandarin discourse. Core lexicon analysis is proposed to provide a new perspective for the corpus evaluation of clinical aphasia, focused on the patterns of lexical use in the narratives lying with the core word production contributing to elaborative phrasing or sentence structure (MacWhinney *et al.*, 2010). There is no doubt that core word use should be evaluated at the discourse level due to its contextual requirements. High-frequency words can be retrieved more easily than low-frequency words at the discourse level. Furthermore, the use of core lexicon measures has been created with computational language analysis programs, which can reduce analysis errors (Dalton et al., 2020a; 2020b; Kim et al., 2019, 2021; Kim & Wright, 2020a, 2020b). Core word lists of nouns and verbs were successfully extracted in preliminary analysis and applied to further analyses. This was partly due to the fact that we enrolled patients with anomic aphasia and healthy individuals to ensure that enough core lexicon could be produced for analyses. Patients with other subtypes of aphasia (e.g., Broca aphasia or transcortical motor aphasia) may not provide adequate core words. By using core lexicon measures with the lists, clinicians may potentially devote less time to completing narrative-based analysis on account that the simple binary scoring system of checking the presence and absence of core lexicon items does not require specific training.

TABLE 3 Core noun lists in the picture description task, the story narrative task and the procedural discourse task

	Picture Descriptions		Story Narratives		Procedural Discourse	
Rank	Word	Pronunciation	Word	Pronunciation	Word	Pronunciation
1	tree	shu4	wolf	lang2	egg	ji1dan4
2	mother	ma1ma	tortoise	wu1gui1	oil	you2
3	cat	mao1	hare	tu4zi	pot	guo1
4	person	ren2	sheep	yang2	rice	fan4
5	umbrella	san3	time	shi2hou	fried rice with egg and ham	huo3tui3chang2dan4 chao3fan4
6	football	zu2qiu2	mountain	shan1	rice	mi3fan4
7	girl	nv3hai2	person	ren2	salt	yan2
8	ball	qiu2	match	bi3sai4	egg	dan4
9	home	jia1	kid	xiao4hai2	time	shi2hou
10	time	shi2hou	boy	nan2hai2	fried rice with egg	dan4chao3fan4
11	rain	yu3	race	sai4pao3	dice	ding1
12	ladder	ti1zi	day	tian1	chopped scallion	cong1hua1
13	window	chuang1hu	villager	cun1min2	slice	pian4
14	dog	gou3	destination	zhong1dian3	bowl	wan3
15	kid	xiao3hai2	sleep	jiao4	scallion	cong1
16	umbrella	yu3san3	story	gu4shi	ajinomoto	wei4jing1
17	flood	hong2shui3	animal	dong4wu4	ham	huo3tui3
18	father	ba4ba	forest	sen1lin2	cube	kuai4
19	boy	nan2hai2	child	hai1zi	sausage	xiang1chang2
20	branch	shu4zhi1	adult	da4ren2	fire	huo3
21	glass	bo1li	turtle	gui1	rice	mi3
22	picture	tu2	sports meet	yun4dong4hui4	home	jia1
23	uncle	shu1shu	thing	shi4qing	sauce	jiang4you2
24	day	tian1	tree	shu4	method	zuo4fa3
25	child	xiao3peng2you3	step	bu4	egg	ji1dan4

In the primary analyses, we first confirmed the differences in core words between Mandarin patients with anomic aphasia and healthy people. A similar conclusion was reached in the research which included 11 patients with different types of aphasia (five fluent and six non-fluent) (Kim et al., 2021). The present study went further by including 12 patients with anomic aphasia to ensure homogeneity of subjects and quality of task completion. A review of previous studies revealed the differential performance of core word production at the discourse level, but the findings were mixed across different subtypes of aphasia (Dillow, 2013; Dalton et al., 2020a, 2020b; Dalton & Richardson, 2015; Fromm et al., 2020; Kim et al., 2019, 2021; Kim & Wright, 2020a, 2020b). This study singly enrolled patients with anomic aphasia and compared with healthy people, in reason of the high-grade dysfunction in patients with more fluency (Kim et al., 2021). Secondly, patients with anomic aphasia produced more verbs than nouns in both picture description and storytelling tasks, while the opposite was the case in the procedural discourse task. This may be determined by the characteristics of experimental tasks. For example, the pictures in Broken Window had explicit verb requirements such as 'kick', but the nouns were interchangeable, such as 'ball' and 'football'. The same was true for the storytelling task. In the language process of procedural discourse, the homogeneity of the verbs decreased significantly because the pictures no longer had action cues and the participants could retrieve only their own common vocabulary to complete the expressions, while the items presented in the pictures gave noun cues, so the percentage of nouns was higher than that of verbs.

At the task level, we found that Picture Descriptions yielded the highest percentage of core words, followed by Story Narratives and finally Procedural Discourse. This may reflect the difficulty of the tasks. Each Picture Description subtask gave a picture or a set of pictures with a clear sequence of occurrence and development or offered a cue. Moreover, the number of subtasks may have led to differences in the percentages of the three types of tasks. The higher the number of subtasks, the higher the tolerance for words output and the better the homogeneity of

TABLE 4 Core verb lists in the picture description task, the story narrative task and the procedural discourse task

	Picture Descriptions		Story Narratives		Procedural Discourse	
Rank	**Word**	**Pronunciation**	**Word**	**Pronunciation**	**Word**	**Pronunciation**
1	is	shi4	come	lai2	fry	chao3
2	have	you3	have	you3	put	fang4
3	arrive	dao4	run	pao3	pour	dao4
4	go	qu4	is	shi4	is	shi4
5	kick	ti4	say	shuo1	do	zuo4
6	relief	jiu4	arrive	dao4	cut	qie1
7	bring	dai4	shout	han3	need	yao4
8	come	lai2	put	fang4	prepare	zhun3bei4
9	look	kan4	look	kan4	hit	da3
10	say	shuo1	climb	pa2	have	you3
11	should	yao4	listen	ting1	cut into	qie1cheng2
12	come down	xia4lai2	sleep	shui4	serve	cheng2
13	take	na2	go	qu4	turn	fan1
14	attend school	shang4xue2	think	xiang3	use	yong4
15	rain	xia4yu3	need	yao4	add	jia1
16	give	gei3	talk	jiang3	stir	jiao3
17	walk	zou3	walk	zou3	wait	deng3
18	climb	pa2	feel	jue2de	say	shuo1
19	think	xiang3	begin	kai1shi3	decoct	jian1
20	call	jiao4	eat	chi1	give	gei3
21	run	pao3	wait	deng3	eat	chi1
22	drench	lin2	find	fa1xian4	make	nong4
23	use	da3	slumber	shui4jiao4	grill	shao1
24	speak	jiang3	lie	shuo1huang3	open	da3kai1
25	observe	kan4dao4	come over	guo4lai2	stir and mix	jiao3ban4

TABLE 5 Percentages of core lexicon (%) in the picture description task, the story narrative task and the procedural discourse task

Group	Percentages of nouns			Percentages of verbs		
	Picture Descriptions (SD)	**Story Narratives (SD)**	**Procedural Discourse (SD)**	**Picture Descriptions (SD)**	**Story Narratives (SD)**	**Procedural Discourse (SD)**
Patients **(*N* = 12)**	42.33(9.57)	26.33(11.37)	15.33(7.40)	54.67(14.30)	38.00(19.11)	13.00(7.46)
Controls **(*N* = 12)**	58.67(13.68)	49.33(9.08)	20.67(8.15)	72.00(9.34)	58.33(7.13)	25.67(8.08)

core lexicon. In addition, owing to the relative brevity of Mandarin, some participants were unable to produce the required 25 core words per stimulus. For example, in the description of the Broken Window, there may be only four nouns of 'boy', 'ball', 'window' and 'man'. In the narrative of the Tortoise and the Hare, some participants may produce three verbs: 'run', 'sleep and 'win'. To ensure the number of words produced, we combined subtask during analysis. On all accounts, it is possible to distinguish between patients with anomic aphasia and healthy people by all tasks. This suggests that we can select corresponding tasks according to the individualized condition to ensure the quality of task completion. When we conduct subsequent analyses of non-fluent aphasia, we will give priority to the Picture Description task to ensure the extraction of the high-frequency core words.

Previous studies concluded that the word production using these core word lists significantly correlated with aphasia severity (Kim et al., 2019). Unlike the literature, the present study did not conclude a statistically significant correlation between core word production and the general severity of aphasia for either nouns or verbs.

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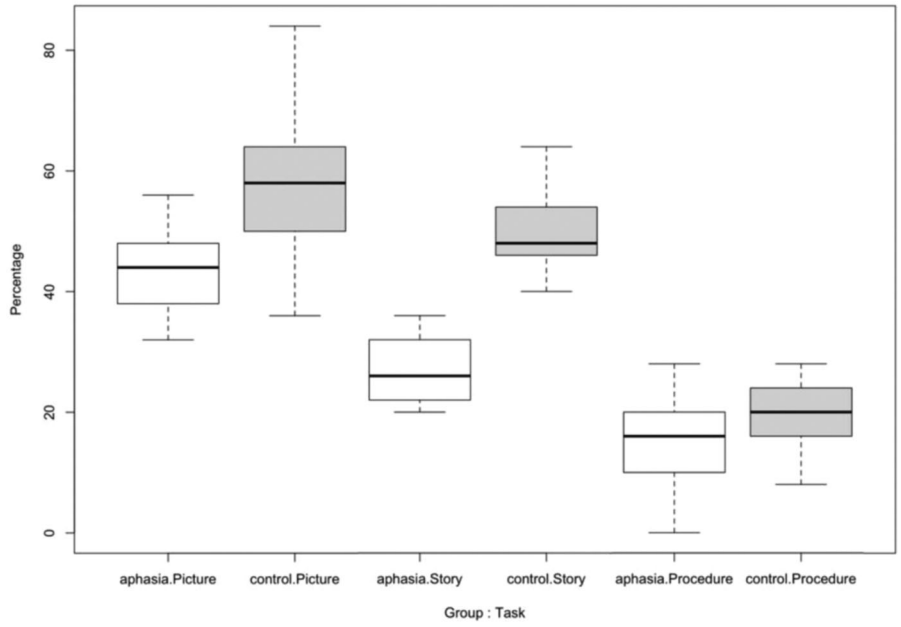

FIGURE 1 Percentages of core nouns in patients with anomic aphasia and healthy individuals in the picture description task, the story narrative task and the procedural discourse task. *Note*: aphasia, patients with anomic aphasia; control, healthy individuals; Picture, the picture description task; Story, the story narrative task; Procedure, the procedural discourse task.

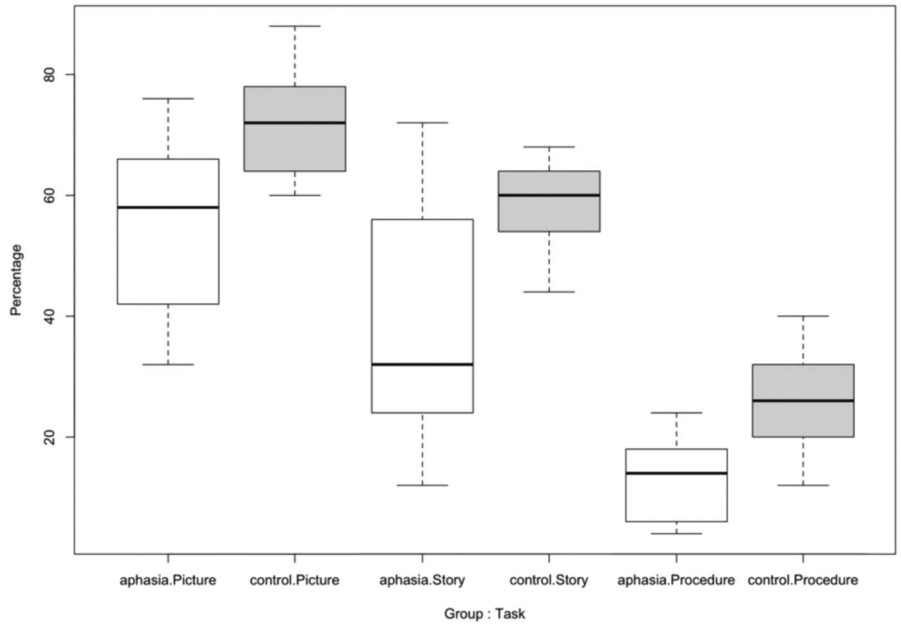

FIGURE 2 Percentages of core verbs in patients with anomic aphasia and healthy individuals in the picture description task, the story narrative task and the procedural discourse task. *Note*: aphasia, patients with anomic aphasia; control, healthy individuals; Picture, the picture description task; Story, the story narrative task; Procedure, the procedural discourse task.

This may be due to the discrepancy of aphasia subtype in studies. On the one hand, the subtype of aphasia was not specified in the previous study, which could lead to the existence of different clinical manifestations. What is more, the previous study also suggested that only verb percentages had a positive correlation with WAB, while nouns, adjectives and adverbs did not. This is partially consistent with the findings of the present study. On the other hand, WAB does have a ceiling effect in the assessment of anomic aphasia and can reflect only a very limited number of discourse-level problems. During spoken language production, people need to manufacture meaningfully organized output constantly suppressing alternatives at multiple linguistic levels instead of simply naming objects or single words (Stark & Fukuyama, 2021).

Clinical implications

From the view of discourse, there have been adequate pieces of evidence from the English corpus with coherence, main concept analysis, story grammar and systemic functional linguistics analysis (Richardson et al., 2021; Zhang et al., 2021). As for Mandarin, no one has studied it so far. This exploratory study confirmed the efficiency of the core lexicon used to distinguish patients with anomic aphasia in Mandarin. It is valuable because the speech function of patients with anomic aphasia is very close to normal. A rapid and effective screening method is of great significance for clinical differential diagnosis.

Limitations of the study

In fact, several limitations of our study remain to be demonstrated. It needs to be noted that we did not extract other word classes such as adjective and adverb, as Mandarin is one of the oldest languages that exists all over the world (Neergaard et al., 2021). The long history of development has given it more exchangeable words to express exactly the same meaning (Tsung & Gong, 2021). For example, to describe quiet, 'an1jing4de', 'ping2jing4de', 'ning2jing4de', 'ji4jing4de', 'wen2jing4de', 'wu2sheng1de' and so on are available in Mandarin. As a result, participants would attempt to use different expressions, especially when describing characters. Referring to previous literature, we did not award words with similar meanings as correct (Dalton & Richardson, 2015). Therefore, other word classes such as adjective and adverb were avoided. In addition, the single-institution design and the small sample size of this study should be disclosed. However, our participants were from regions all over the country, and its statistical significance provided valuable evidence of the feasibility and effectiveness of core lexicon analysis at the course level for Mandarin patients with anomic aphasia. Patients with all types of aphasia and from different Mandarin-speaking regions will be included in further investigations and analyses, divided by age groups and specific tasks.

CONCLUSIONS

This study verified the feasibility of core lexicon analysis in a Mandarin population and clarifies that it can distinguish between patients with anomic aphasia and healthy people. We constructed core lists of nouns and verbs and conducted inter-task comparisons to inform the next step in task selection for inclusion of different types of aphasia.

Patients with anomic aphasia produced fewer core words than healthy people, and the percentages differed markedly in different tasks as well as word classes. The Picture Description task accounted for the highest proportion of core lexicon, followed by the Story Narrative task, and the Procedural Discourse task accounted for the least. This provides a basis for the selection of tasks and word classes in the future discourse measures of Mandarin patients with anomic aphasia.

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from AphasiaBank (http://aphasia.talkbank.org).

PATIENT CONSENT STATEMENT

All the participants or guardians had signed informed consent.

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