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BRIEF REPORT



Linguistic characteristics of primary progressive aphasia in a verb-final language

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ABSTRACT

Purpose: The current study aimed to examine the linguistic characteristics of Korean-speaking individuals diagnosed with primary progressive aphasia (PPA).

Methods: Two individuals with agrammatic/non-fluent variants of nfvPPA and two with semantic variants of svPPA participated in this study. Picture description tasks were used to collect connected speech samples. Analysis focused on linguistic variables, including quantitative (number of utterances, words, nouns, and verbs), syntactic (mean length of utterance in morphemes, case markers per utterance, predicates per utterance), and semantic variables (correct information units, verb types). Additionally, participants completed two types of confrontation naming tasks.

Results: The nfvPPA group exhibited fewer linguistic units overall compared to the svPPA group, with noun-verb dissociation apparent only in the nfvPPA group. The svPPA group showed poorer performance in content-related linguistic variables. A notable clinical symptom specific to Korean, case marker deficits, was observed in the nfvPPA group.

Discussion: The study identified distinct linguistic patterns associated with the subtype of PPA in Korean speakers. The evaluation and interpretation of Korean-specific linguistic variables are crucial for classifying Korean-speaking individuals with PPA. Understanding these variables can enhance our comprehension of the unique linguistic deficits present in Korean PPA, particularly in relation to confrontation naming tasks and their implications for diagnosis and classification.

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Primary progressive aphasia (PPA); agrammatic variant of PPA; semantic variant of PPA; linguistic characteristics; verb-final language

Introduction

Primary progressive aphasia (PPA) encapsulates heterogeneous groups of clinical and pathological syndromes traditionally classified into “fluent” vs. “nonfluent” types (Mesulam, 2001). Gorno-Tempini and colleagues proposed more specified diagnostic features for each subtype of PPA, such as the nonfluent/agrammatic variant (nfvPPA), semantic variant (svPPA), and logopenic variant (lvPPA) (Gorno-Tempini et al., 2011). The authors suggested that nfvPPA should demonstrate agrammatism in language production and difficulties in comprehending sentences with complex syntactic structures, though comprehension of single words and object knowledge are relatively unaffected. The criteria for the svPPA include impaired confrontation naming, single-word comprehension, and object knowledge, particularly for items of low frequency or familiarity, along with relative preservation of repetition and grammatical structure in speech production. The core features of lvPPA are single-word retrieval and sentence or phrase repetition deficits due to a phonological short-term memory deficit.

Linguistic features that influence clinical symptoms and diagnostic criteria within PPA subtypes may differ significantly across languages (Gorno-Tempini et al., 2011). Thus, it is important to understand and consider language-general and -specific symptoms in establishing diagnostic criteria of PPA. Yet, much of the literature and clinical diagnostic criteria for

categorizing the subtypes of PPA have been framed predominantly around English-speaking individuals with PPA. This approach might not capture the intricacies and unique patterns exhibited by speakers of other languages or across languages (e.g., Canu et al., 2020; Sung et al., 2016). Cross-linguistic differences and language-specific features must be considered when evaluating aphasia symptoms to better establish diagnostic criteria and understand the distinct characteristics of linguistic deficits in each language (Sung et al., 2024). Thus, there’s an evident gap in our understanding, as diagnostic criteria, when based solely on English-centric observations, might miss or misinterpret symptoms in non-English speakers (Bates et al., 1991; Sung et al., 2024). Therefore, it’s imperative to extend our knowledge and refine diagnostic criteria by incorporating linguistic features observed in a range of languages. This would pave the way for more holistic and accurate diagnostic tools that can cater to diverse language users. The current paper seeks to address this gap, at least in part, by focusing on PPA cases of individuals whose native language is Korean. We investigated the linguistic features of impairments in morpho-syntactic and lexical-semantic domains in Korean-speaking individuals with PPA. This initiative will offer a more comprehensive understanding of varied deficit patterns, reflecting the language-specific diagnosis of PPA subtypes.

Korean predominantly adopts a verb-final structure, adhering to a canonical word order of Subject-Object-Verb (SOV), in contrast to the SVO structure seen in English. Additionally, Korean employs a case-marking system, which designates the thematic roles tied to verbs within a sentence (Sung et al., 2020, 2024). Due to this system, Korean offers flexibility in scrambling word orders, such as SOV or OSV, provided the predicates are placed in a sentence-final position. A notable linguistic attribute of Korean is the pro(noun)-drop phenomenon, wherein pronouns and subjects are frequently omitted within sentences. This aspect accentuates Korean as a more verb- or predicate-salient language. Given the distinct characteristics of the Korean language, it is posited that agrammatic manifestations of linguistic deficits may display different patterns in Korean PPA cases. To encapsulate these linguistic features, the current study analyzed connected speech samples using picture description tasks and examined performance on noun and verb naming tasks.

Materials and methods

Case presentations

A total of four patients with Korean-speaking PPA participated in this study. Specifically, half of them were diagnosed with nfvPPA and the other half with svPPA by trained neurologists and all met the diagnostic criteria for PPA based on Gorno-Tempini et al. (2011). All participants underwent a diagnosis of aphasia using the Screening Test for Aphasia and Neurologic-communication Disorders (STAND; Kim et al., 2009). Additionally, the Korean Mini-Mental State Examination (K-MMSE; Kang, 2006) was conducted to assess general neuropsychological abilities, and the Clinical Dementia Rating (CDR) was administered to evaluate the severity and staging of dementia (Table 1).

Case 1. nfvPPA-01

An 82-year-old right-handed male patient with a high school education level visited the neurology clinic with difficulties in word retrieval and speech hesitations that started around the age of 78. His chief complaints were awkward intonation while speaking, frequent use of incorrect words, and experiencing efforts and delays in initiating speech. His grammar was often incorrect, and he frequently repeated phrases like “I am, I am, I am...” or “the, the...” at the start of his sentences. When responding, he mostly repeated short words like “yes, yes.” or

“uh, um...” He had difficulties recalling the names of familiar people or objects in his daily life. However, he had no difficulty understanding others’ language. His episodic memory, spatial-temporal functions, and judgment appeared normal, and he did not experience significant disruptions in managing his business. There were no notable findings in his medical or family history. Neuropsychological tests revealed a Korean-Mini Mental State Examination (K-MMSE; Kang, 2006) score of 26/30 and a Clinical Dementia Rating (CDR) of 0.5 and identified naming difficulties, verbal memory impairments, and frontal lobe dysfunctions. Brain Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) scans showed notable atrophy and reduced glucose metabolism in the left opercular area (Figure 1(a)).

Case 2. nfvPPA-02

A 70-year-old right-handed male with postgraduate education began experiencing progressive speech hesitations and dysarthria at about 67 years of age. He had difficulty quickly articulating specific words, which reduced his attempts to speak. In conversation, he often relied on certain words, frequently omitting case markers and other sentence components. Nevertheless, his comprehension of others’ speech remained intact. With the onset of expressive language disorder, he began experiencing memory loss for minor details, though he retained a fairly good memory for significant events. No problems with his sense of direction or spatial-temporal skills were observed. His daily living activities, including personal hygiene, remained unimpaired. He had been undergoing treatment for hypertension for over 10 years, with both parents having a history of stroke. Neuropsychological assessments showed declines in verbal and visual memory, naming difficulties, reduced spatial-temporal abilities, and frontal lobe dysfunction. His scores were 22/30 on the K-MMSE and 0.5 on the CDR. Brain MRI and PET scans indicated significant atrophy and decreased glucose metabolism in the left opercular area (Figure 1(b)).

Case 3. svPPA-01

A 63-year-old right-handed female patient with a high school education level presented with reduced vocabulary and difficulty understanding the meanings of words. These symptoms began around the age of 61. She often struggled to name objects and had increased difficulty understanding others, frequently asking, “What do you mean?” However, she remembered important personal events well and had no significant

Table 1. Demographic information and oral language index scores from STAND.

	nfvPPA-01	nfvPPA-02	svPPA-01	svPPA-02
Gender	Male	Male	Female	Male
Age (yrs)	82	70	63	75
Education (yrs)	16	18	12	6
K-MMSE score (/30)	26	22	25	21
CDR score	0.5	0.5	0.5	1
STAND score (/20)	15	14	12	9
Fluency (/3)	1	2	2	1
Naming (/4)	2	2	0	0
Comprehension (/10)	9	7	7	5
Repetition (/3)	3	3	3	3

nfvPPA = nonfluent/agrammatic variant primary progressive aphasia; svPPA = semantic variant Primary progressive aphasia; K-MMSE = Korean-mini mental state examination (Kang, 2006); CDR = Clinical dementia rating; STAND = Screening test for aphasia and neurologic-communication disorders (Kim et al., 2009).

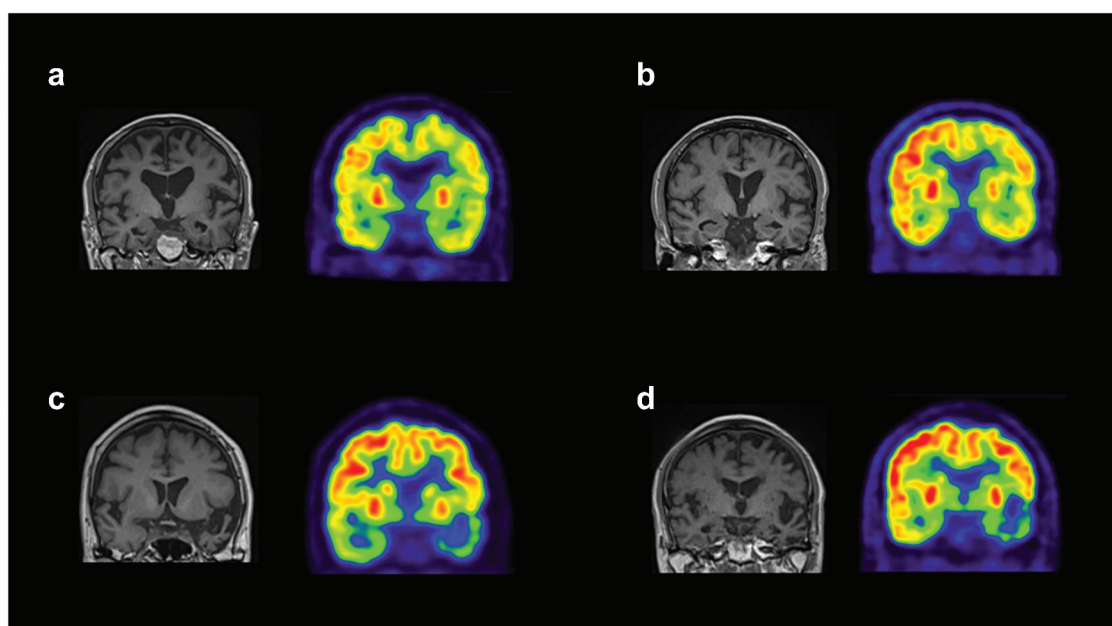


Figure 1. Brain MRI and PET images for each participant (T1 coronal brain MRI corresponding F-DG PET image of nvPPA-01 (a) and nvPPA-02 (b) show cortical atrophy and glucose hypometabolism in the left frontal and peripercular area. T1 coronal brain MRI corresponding F-DG PET image of svPPA-01 (c) and svPPA-02 (d) demonstrate severe cortical atrophy and glucose hypometabolism in the left anterior temporal areas).

issues finding her way or sense of direction compared to before. She managed her basic hygiene and household chores that she could do. Notably, she developed a fixation on reciting Buddhist scriptures and showed a decrease in motivation and increased detachment compared to her previous state. She was undergoing treatment for hypothyroidism and had a history of Guillain-Barré syndrome. It was reported that her mother had dementia and had passed away. Neuropsychological tests revealed severe naming difficulties, confrontational naming impairments, and declines in verbal and memory skills, with scores of 25/30 on the K-MMSE and 0.5 on the CDR. Brain MRI and PET scans showed severe atrophy and reduced glucose metabolism in the left anterior temporal lobe (Figure 1(c)).

Case 4. svPPA-02

A 75-year-old right-handed male with an elementary school education began experiencing difficulties around the age of 72 in immediately recalling the names of objects or words, often using pronouns or incorrect words. He also showed signs of misunderstanding others, sometimes bringing the wrong items when asked for specific things. He struggled to understand television programs, requiring his wife to explain them again, and stopped reading books or newspapers altogether. Assessing his memory was challenging due to his language disorder, but he could remember events from the previous day and managed his medication on time. He was able to travel alone by subway to attend meetings and had no difficulties with handling money. He has been taking medication for hypertension and has no family history of dementia or stroke. Neuropsychological tests revealed a K-MMSE score of 21/30 and a CDR of 1, with identified difficulties in naming, verbal/visual memory impairments, and frontal lobe dysfunction. Brain MRI and PET scans showed severe atrophy and

reduced glucose metabolism in the left anterior temporal lobe (Figure 1(d)).

Procedures

Picture description tasks

Connected speech samples were obtained from two picture description tasks, using the STAND and the Paradise Korean-Western Aphasia Battery-Revised (PK-WAB-R; Kim & Na, 2012). Participants were asked to describe the pictures in detail, following the protocols from AphasiaBank (MacWhinney et al., 2011) and DementiaBank (Becker et al., 1994), using the prompt: "Please explain in detail what is happening in the picture, and try to express it in full sentences as much as possible." The participants' responses were video recorded and manually transcribed by the authors. Only the narrative content was analyzed, excluding any comments related to the task itself or participants' performance (e.g., "I can't remember" or "Is this correct?").

The connected speech samples were analyzed using linguistic outcome measures based on the aphasia picture description analysis method from Sung et al. (2016) cross-linguistic study. Sung et al. (2016) demonstrated that quantitative measures, such as the number of utterances, words, nouns, and verbs, serve as key linguistic factors for distinguishing aphasia symptoms between English and Korean. Accordingly, this study employed a quantitative analysis focusing on these aspects. Especially, utterances were defined according to Kim et al.'s (1998) study on spontaneous speech in Korean-speaking individuals with aphasia, as follows: 1) when a sentence ends with a predicate, 2) when a conjunction continues a sentence but a new utterance is marked by significant intonation change or a pause of more than 2 seconds, and 3) when a pause of more

than 2 seconds occurs between words, even if the context remains connected.

For syntactic analysis, morpho-syntactic characteristics were examined, such as Mean Length of Utterance in Morphemes (MLU-m), case markers per utterance, and predicates per utterance. Given that Korean, unlike English, uses a case-marking system and is a verb-salient language, analyzing predicates is crucial (Sung et al., 2024). To minimize the impact of strictly quantitative factors, case markers and predicates were normalized by utterances for analysis.

Finally, to identify semantic differences based on PPA type, a semantic analysis was performed by calculating the percentage of Correct Information Units (CIUs) to assess the informativeness and efficiency of speech (Nicholas & Brookshire, 1993). Additionally, the semantic weight of verbs was analyzed by categorizing them into light and heavy verbs. Light verbs include auxiliary verbs like “do,” which have fewer semantic components, whereas heavy verbs, such as “bark” or “eat,” carry richer semantic features (Barde et al., 2006). For the picture description analyses, we averaged the values from each linguistic measure across both pictures.

In the error analysis of connected speech samples, instances where speech or phonological errors retained the original form of the word but were produced with dysarthric speech characteristics were included in the analysis based on the original word. However, in cases where semantic errors (or semantic paraphasia) resulted in unclear meanings or significantly altered the original word form, those responses were excluded from the analysis. Additionally, morphosyntactic errors were included in the analysis, but if these errors led to a change in the meaning of the sentence, they were excluded from the CIU analysis.

Naming tasks

The confrontation naming tests, specifically the noun (Choi et al., 2013) and verb (Sung & Kwag, 2012) tasks, were conducted to assess participants' naming abilities. Each task consisted of 40 items. The scores were then converted into accurate percentages for analysis.

Results

Linguistic outcomes from picture description tasks

Quantitative measures

- (1) Number of utterances: The average number of utterances in the picture description tasks for the nvfPPA group (mean: 7) is lower than that of the svPPA group (mean: 11.5), indicating that the svPPA group produced more utterances in the connected speech (Figure 2(a)).
- (2) Number of words: The average number of words in the nvfPPA group was 28, compared to 84.5 for the svPPA group, highlighting a difference in word usage between the groups (Figure 2(b)).
- (3) Number of nouns and verbs: The svPPA group produced more nouns ($n = 15$) and verbs ($n = 15$) compared to the nvfPPA group, which produced 9 nouns and 5.5 verbs.

A greater dissociation between nouns and verbs was observed in the nvfPPA group (Figure 2(c,d)).

Syntactic measures

- (1) MLU-m: The average MLU-m for the nvfPPA group was 6.29, compared to 10.66 for the svPPA group, suggesting that the svPPA group produced longer sentences (Figure 3(a)).
- (2) Case markers per utterance: The average number of case markers per utterance for the nvfPPA group was 0.8, indicating that this group typically used fewer than one case marker per utterance. In contrast, the svPPA group had an average of 1.48 case markers per utterance (Figure 3(b)).
- (3) Predicates per utterance: On average, the nvfPPA group used less than one predicate per utterance (mean: 0.94), in contrast to the svPPA group, which demonstrated a higher average score of 1.54 predicates per utterance (Figure 3(c)).

Semantic measures

- (1) CIU: The nvfPPA group had a higher CIU percentage (mean: 26) compared to the svPPA group (mean: 6.25), nearly four times higher (Figure 4(a)).
- (2) Number of verbs by semantic weight: The svPPA group demonstrated a higher average number of heavy verbs (mean: 8) compared to the nvfPPA group (mean: 3.25). Similarly, the average number of light verbs was also greater in the svPPA group (mean: 7) than in the nvfPPA group (mean: 3), Figure 4(b).

Naming accuracy (%) from confrontation naming tasks

- (1) Noun naming performance: In the noun naming task, the nvfPPA group demonstrated markedly higher accuracy with an average score of 90%, in contrast to the svPPA group's average of 36.25%. This suggested that the svPPA group demonstrated greater deficits in noun naming than the nvfPPA group (Figure 5(a)).
- (2) Verb naming performance: Similarly, in the verb naming task, the accuracy was higher in the nvfPPA group (mean: 75%) compared to the svPPA group (mean: 33.75%). This pattern is consistent with the noun naming task, suggesting that the svPPA group has more impaired overall naming abilities than the nvfPPA group (Figure 5(b)).

Discussion

This study investigated the linguistic characteristics of Korean speakers with PPA. Based on the subtest scores from the standardized screening language test (e.g., STAND) (Table 1), it is not clear to identify distinct patterns of linguistic impairments between the nvfPPA and svPPA groups. However, more fine-

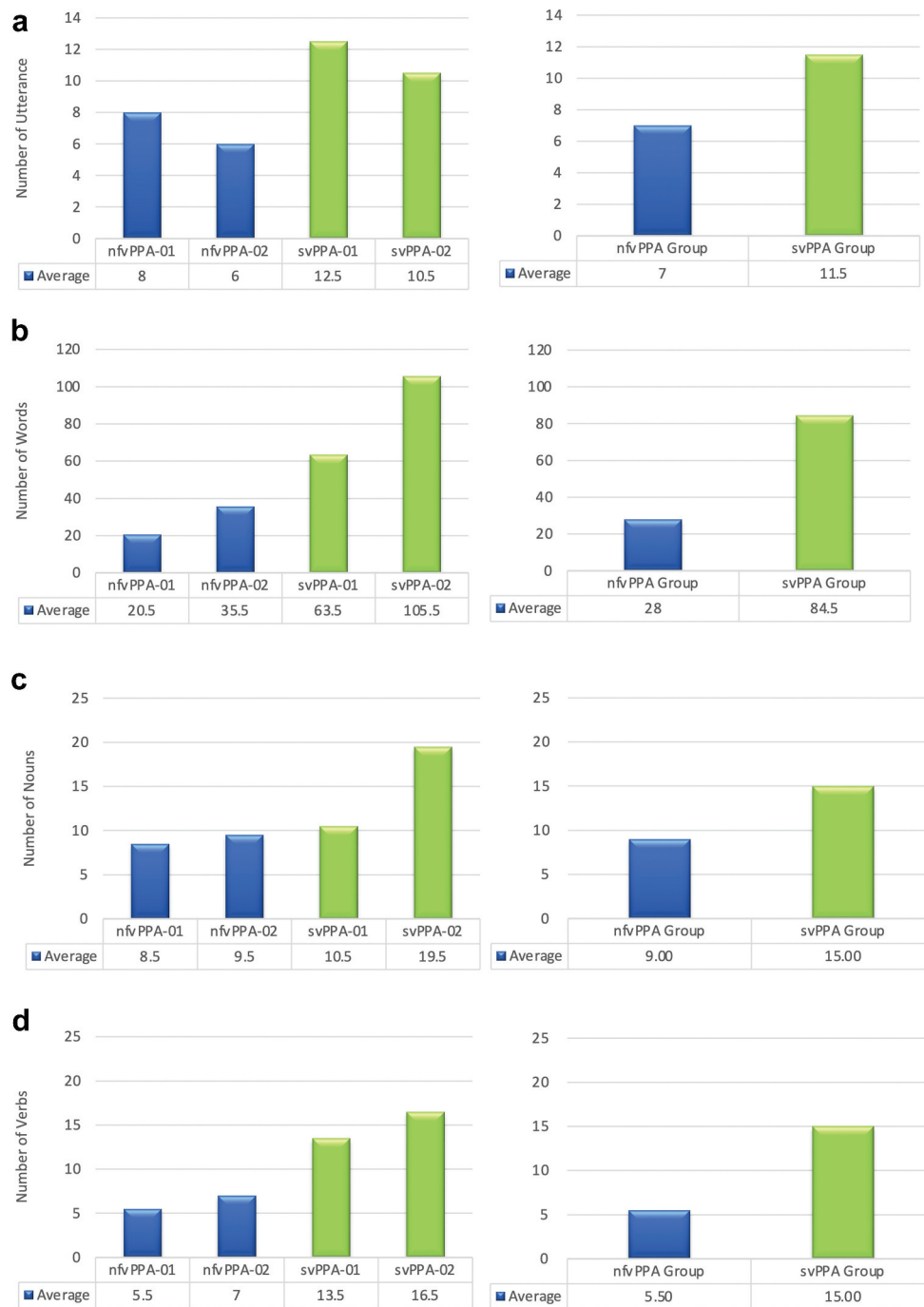


Figure 2. Quantitative analysis of linguistic variables by participant and group (a) the number of utterances per participant (left) and the group average (right), (b) the number of words per participant (left) and group average (right), (c) the number of nouns per participant (left) and group average (right), (d) the number of verbs per participants (left) and group average (right).

grained analyses of connected speech samples yielded clear group differences.

The quantitative analyses revealed that the nfvPPA group produced overall fewer linguistic units compared to the svPPA group. Notably, a noun-verb dissociation is only evident for the nfvPPA, who showed greater difficulty producing verbs than nouns in connected speech. However, despite the overall reduced verbal output, the nfvPPA group produced higher CIU compared to the svPPA group. This suggests that the nfvPPA group employs an economical approach to language

production, effectively conveying essential information with fewer words (Rezaii et al., 2023).

The syntactic analyses revealed that the nfvPPA group produced shorter sentences with fewer predicates compared to the svPPA group, aligning with findings observed in English-speaking individuals with PPA (Thompson et al., 2012). However, in this Korean-specific analysis, an additional clinical symptom was observed in the case marker deficits for the nfvPPA group. Case markers denote the thematic roles of nouns within sentences. The nfvPPA group produced fewer

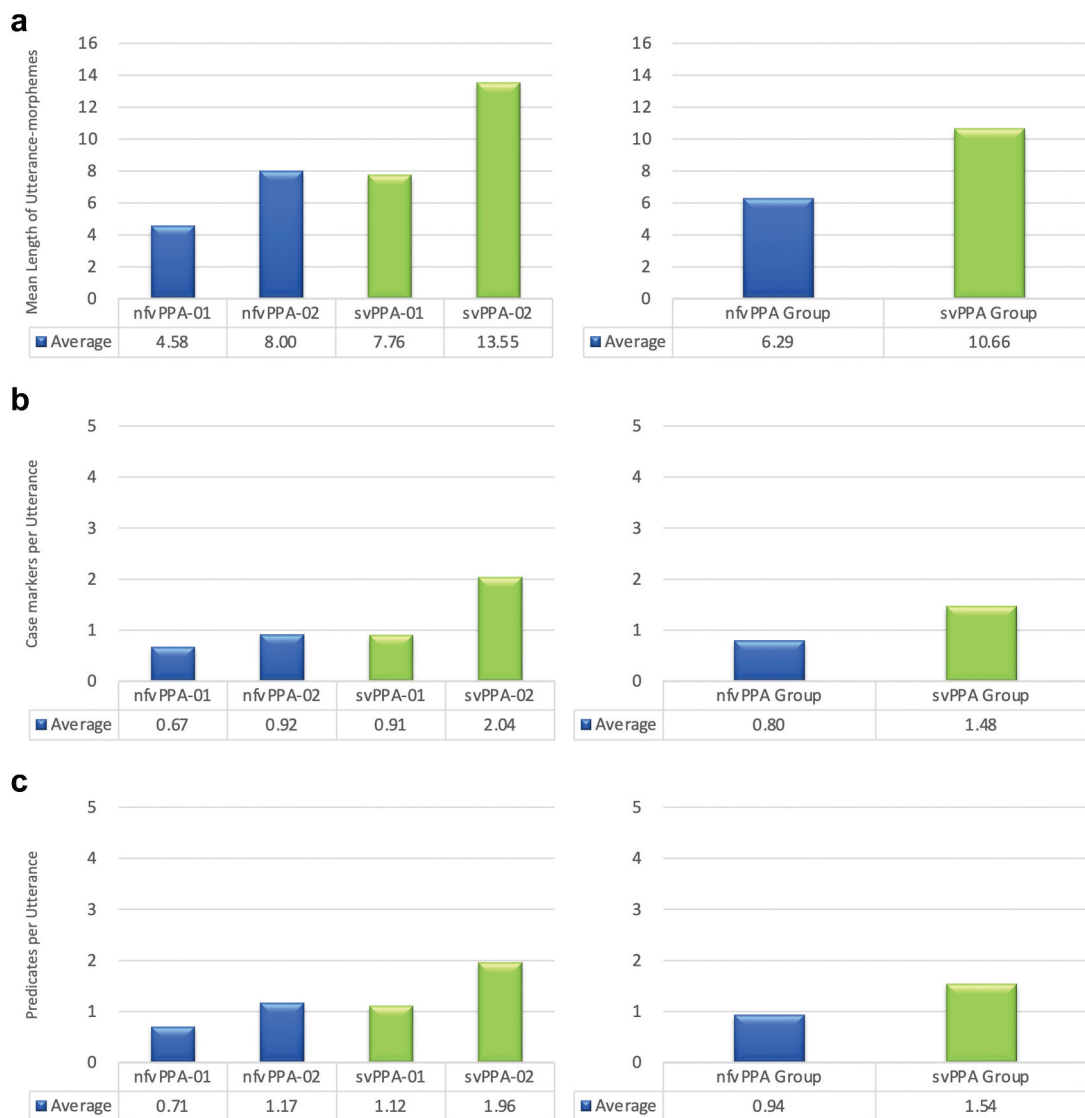


Figure 3. Syntactic analysis of linguistic variables by participant and group (a) the mean length of utterance-morphemes per participant (left) and group average (right), (b) the case markers per utterance per participant (left) and group average (right), (c) the predicates per utterance for individual participants (left) and group average (right).

number of case markers than the svPPA group. This suggests that the deletion of case markers represents another key agrammatic component to consider when evaluating clinical symptoms of PPA in case marking languages like Korean. The case-marking system is a crucial, language-specific feature that differentiates cross-linguistic symptoms between English- and Korean-speaking individuals with aphasia (Sung et al., 2024). Case markers, which are specific to agglutinative languages like Korean, are not present in non-agglutinative languages such as English. Consequently, English-centric diagnostic criteria may overlook these features. Our study strongly emphasizes the critical importance of incorporating language-specific criteria, particularly for Korean, and clearly demonstrates that morpho-syntactic measures are essential for identifying the unique linguistic symptoms associated with different PPA types.

In contrast, for the semantic aspects, the svPPA group displayed lower CIUs in the semantic analyses, despite using syntactically longer sentences and more case markers,

indicating greater semantic impairments compared to the nfvPPA group. This dissociation between the PPA groups highlights the need for multifaceted linguistic assessment.

However, some lexical and morpho-syntactic measures of svPPA-01 exhibited patterns that were more aligned with the nfvPPA group, raising the possibility that the group differences observed in the svPPA group may have been influenced by the performance of svPPA-02. Nevertheless, other variables continued to reveal distinct differences between the PPA types. Future research with larger sample sizes would be valuable in providing a more precise understanding of the linguistic characteristics and group differences across the different PPA types. Additionally, a more detailed analysis of error types in connected speech could offer further insights into the linguistic characteristics unique to each PPA subtype. Future studies that focus on classifying and examining these error types – such as phonological, semantic, and morpho-syntactic errors – would contribute to a more nuanced understanding of how different

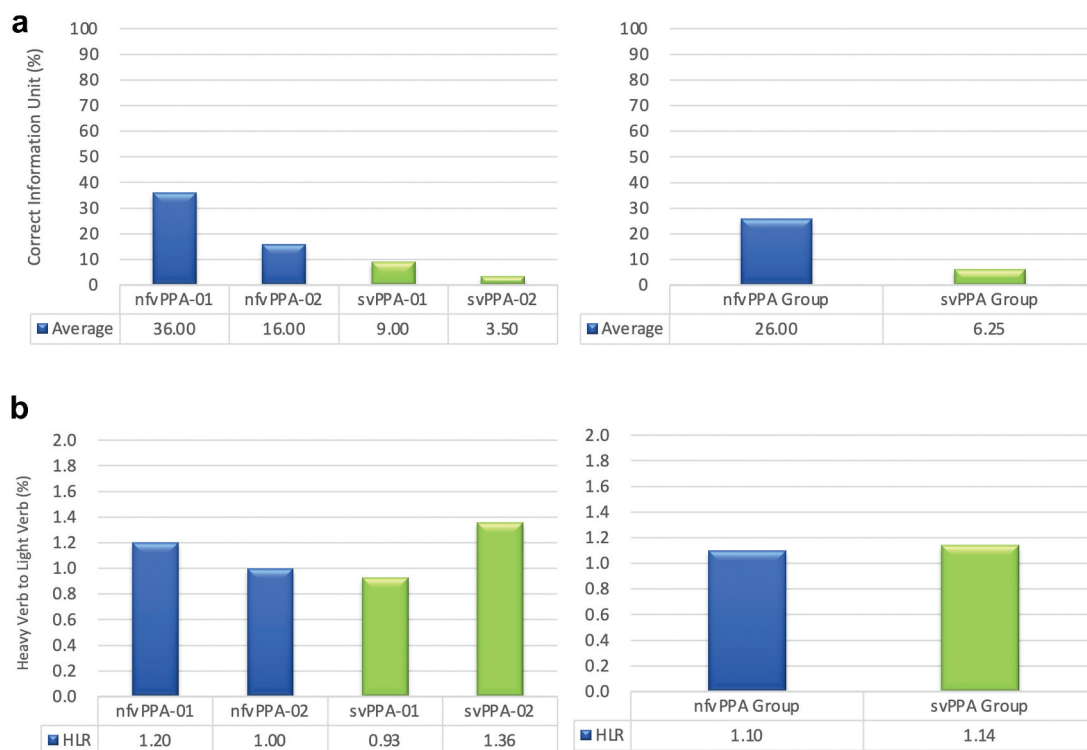


Figure 4. Semantic analysis of linguistic variables by participant and group (a) the percentage of correct information unit per participant (left) and group average (right), (b) the ratio of heavy to light verb (left) and group average (right).

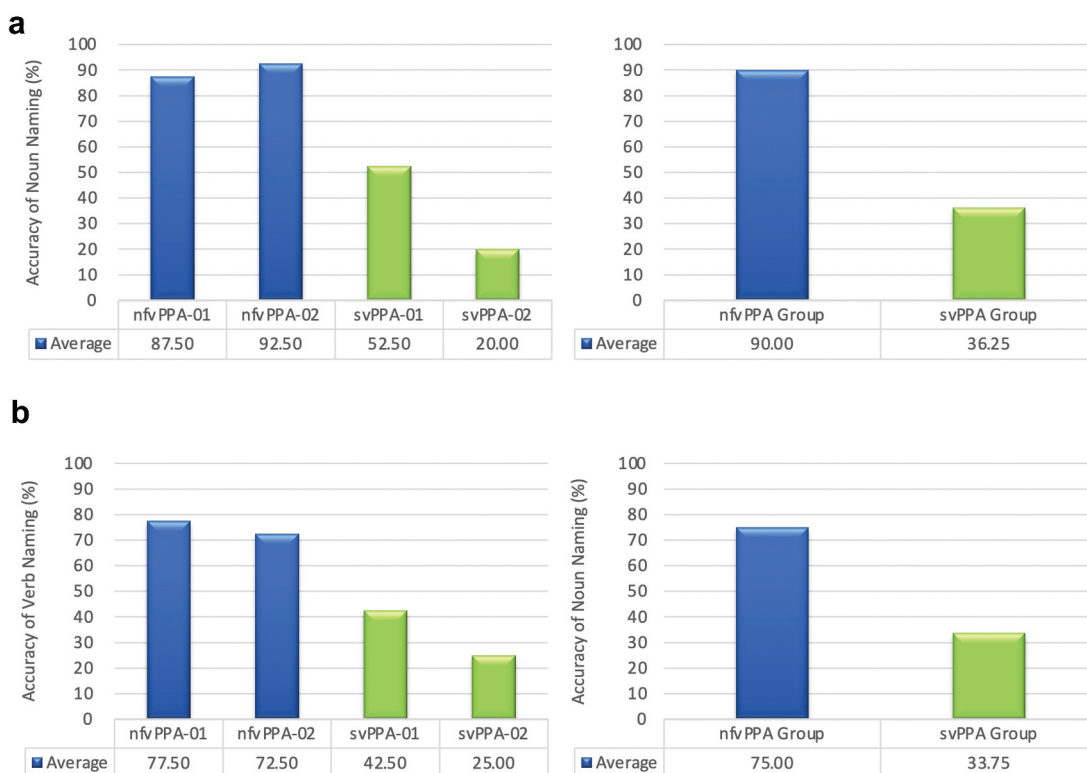


Figure 5. Performance of noun and verb naming tasks (a) the accuracy of noun naming task per participant (left) and group average (right), (b) the accuracy of verb naming task per participant (left) and group average (right).

PPA types manifest in connected speech and could enhance clinical assessment and diagnosis.

The scope of this paper does not focus on distinguishing motor speech symptoms related to planning, execution, and linguistic segmentation, as reflected in apraxia of speech, dysarthria, and phonological paraphasias. However, we suggest that further research on how these phonological speech characteristics affect connected speech in Korean speakers with PPA would enhance understanding of the distinct features of PPA.

The fine-grained linguistic analyses elicited more pronounced differences in linguistic symptoms between the two types of PPA, reflecting both language-specific and language-general patterns of impairments depending on the semantic and syntactic features. These findings underscore the need for clinicians to incorporate detailed linguistic analyses, including language-specific phenomena, when defining clinical symptoms of PPA. Further research is necessary to translate these cross-linguistic findings into improved clinical classification systems of PPA diagnosis.

Data availability statement

The data that support the findings of this study are available from the corresponding author, JES, upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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