

Research Article

What Types of Noun– and Verb–Semantic Feature Analysis Treatment Are More Effective in Eliciting Treatment and Transfer Effects in Korean-Speaking People With Aphasia?

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ABSTRACT

Purpose: People with aphasia (PWA) experience lexical retrieval impairments, hindering effective communication. The semantic feature analysis (SFA) protocol, a specific semantically based lexical retrieval treatment, is widely used to improve naming abilities. This study applied SFA treatment to Korean-speaking PWA, a verb-final language, to compare the efficacy of noun-SFA and verb-SFA across various linguistic levels.

Method: A total of 10 Korean-speaking PWA participated in this study. Participants were randomly assigned to either the noun-SFA or verb-SFA group. Pre- and post-assessments were conducted before and after 20 treatment sessions to evaluate the treatment and transfer effects across various linguistic domains.

Results: Group comparisons indicated that near transfer effects to untreated items within the treated word class and nonverbal semantic association abilities were more robust in the verb-SFA group. Within-group analysis showed that both SFA treatments demonstrated significant direct treatment and near transfer effects on treated word class tests. However, near transfer effects to untreated word class tests were not significant in either group. For far transfer effects, the verb-SFA group showed greater gains in sentence-level tests. Aphasia severity improved in both groups, with more pronounced recovery in the verb-SFA group.

Conclusions: The efficacy of verb-SFA treatment for Korean-speaking PWA can be attributed to the unique verb-final structure of the Korean language, where verbs and their thematic roles are emphasized at the end of sentences. This underscores the importance of considering language-specific factors when developing and implementing semantic-based treatments for PWA, particularly in verb-final languages.

People with aphasia (PWA) experience neurogenic language impairments affecting input and output modalities such as listening, reading, and writing (McNeil & Pratt, 2001). These impairments, often resulting from left hemisphere strokes, commonly lead to anomia, a difficulty in word finding (G. A. Davis, 2000; Goodglass & Wingfield, 1997). Anomia disrupts lexical retrieval, impacting semantic processing (linking concepts to meanings) or phonological processing (connecting meanings to word forms; Dell et al.,

2004; Levelt et al., 1999). This naming difficulty hinders communication, leading to failed conversations, emotional and social isolation, and reduced quality of life (Fotiadou et al., 2014; Lesser & Algar, 1995; Northcott et al., 2017).

To address these challenges, various treatments have been developed to improve the naming abilities of PWA. Among these, semantic feature analysis (SFA) is a widely used protocol for noun naming treatment. Based on the spreading activation theory of semantic processing (Collins & Loftus, 1975), SFA enhances lexical retrieval by emphasizing the semantic features of target items. This approach activates related networks within the semantic system, aiding the recovery of conceptual and semantic information

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(Boyle & Coelho, 1995). SFA incorporates both restitutive and substitutive mechanisms (Scholl et al., 2021). The restitutive mechanism stimulates lexical access and strengthens semantic connections, while the substitutive mechanism promotes compensatory strategies, such as using feature descriptions, to aid self-retrieval or cue a listener when lexical access is impaired (DeLong et al., 2015; Scholl et al., 2021).

Extensive research has demonstrated the efficacy of noun-SFA treatment, particularly in English-speaking contexts. Most studies have reported direct treatment effects on lexical retrieval for treated nouns. (Boyle, 2010; L. A. Davis & Stanton, 2005; Evans et al., 2021; Gravier et al., 2018; Rider et al., 2008). Given SFA's potential to enhance the lexical-semantic processing across broader linguistic domains (DeLong et al., 2015), most research has increasingly focused on investigating its transfer effects (Boyle & Coelho, 1995; Evans et al., 2021; Gravier et al., 2018; Rider et al., 2008). Transfer effects refer to the ability to apply learned knowledge and skills to new contexts, such as improvements in untreated items or domains following treatment (Weng et al., 2019). Researchers often categorize these effects into near and far transfers. *Near transfer* effects involve improvements closely related to the treated levels such as generalization to untreated items that share the same linguistic level as the treated items (e.g., word level to other words). In contrast, *far transfer* effects refer to broader improvements, including response generalization across linguistic domains, such as sentence and discourse levels, semantic associations, and overall aphasia severity (Barnett & Ceci, 2002).

Several studies on noun-SFA treatment have demonstrated positive near transfer effects on the word level for both semantically related items, which share semantic features with treated items (Evans et al., 2021; Gravier et al., 2018), and semantically unrelated items, which do not share semantic features (Boyle, 2004; Boyle & Coelho, 1995). However, Rider et al. (2008) reported no significant near transfer effects for untreated items after noun-SFA treatment for PWA. These mixed findings suggest that near transfer effects for untreated items remain inconclusive. While some studies have observed transfer to items without shared semantic features, others, such as Rider et al. (2008), have not reported such effects. This discrepancy may stem from variations in study design or item selection methods across studies. Rider et al. (2008) did not consider semantic relatedness when selecting untreated items, which could have influenced their results. Regarding far transfer effects, research indicates that noun-SFA treatment enhances the ability to convey more meaningful information in picture descriptions (Boyle & Coelho, 1995), as reflected by an increase in correct information units (CIUs; Nicholas & Brookshire, 1993). Additionally, SFA treatment has been shown to positively impact word usage in connected speech by increasing the number of words

produced (Rider et al., 2008). These findings are further supported by systematic reviews that have confirmed the extension of far transfer effects to the discourse level (Efstratiadou et al., 2018; Oh et al., 2016). The fluid nature of discourse allows for diverse word choices in sentence construction, and the expanded lexical retrieval ability from SFA treatment supports effective application in discourse contexts (Rider et al., 2008).

Although previous studies have demonstrated that noun-SFA treatment can improve lexical retrieval and promote near and far transfer effects across various linguistic domains, findings have been mixed across studies (Efstratiadou et al., 2018; Gravier et al., 2018; Quique et al., 2019; Rider et al., 2008). Verbs have long been a focus in aphasia research due to their critical role in sentence construction, and recent studies have continued to emphasize their importance. Verbs not only encode detailed intentions but also exhibit more complex semantic, morphological, and syntactic properties compared to nouns (Bird et al., 2001; Vigliocco et al., 2011). In the context of spreading activation theory, nouns and verbs demonstrate distinct patterns of semantic and syntactic activation (Dell, 1986). While nouns activate stable networks associated with concrete entities or categorical associations, verbs engage dynamic and relational semantic networks that include thematic roles and grammatical dependencies (Dell, 1986). These additional layers of activation make verbs essential for encoding the structure of messages, as outlined in Levelt's (1989) speech production model.

Considering these distinct features of nouns and verbs, recent research has increasingly focused on the efficacy of verb-focused SFA treatment. Several studies have reported increased accuracy on treated verbs for English-speaking PWA (Wambaugh & Ferguson, 2007; Wambaugh et al., 2014). These studies also examined near transfer effects on untreated verbs, categorizing them into two types. The first type included untreated verbs from the probe sets that were passively exposed during treatment and showed improvement. The second type consisted of untreated verbs assessed only during pre- and posttreatment phases, but their improvement did not meet the pre-established criterion. These findings suggest that verb-SFA treatment can facilitate lexical retrieval beyond directly treated items, promoting near transfer effects within the same linguistic domain. Building on this, evidence also indicates that verb-SFA treatment elicits far transfer effects at the discourse level, particularly in the increased use of words and semantic informativeness, as evidenced by higher CIUs (Wambaugh & Ferguson, 2007; Wambaugh et al., 2014). These positive far transfer effects likely result from verb-SFA facilitating the semantic generation and integration of words associated with the thematic roles assigned to verbs within a sentence (McRae et al., 2005). This strategy enhances participants' ability to apply thematically related semantic features in discourse, ultimately contributing to the production of more meaningful and rich

content. In recent years, verb-SFA treatment has been explored in studies involving bilingual PWA (Knoph et al., 2015; Li & Kiran, 2023). Knoph et al. (2015) demonstrated significant improvements in treated verbs and narrative production, with cross-language generalization enhancing verb use, semantics, and syntax in untreated languages. Li and Kiran (2023) compared noun- and verb-SFA in Mandarin–English bilingual PWA, finding that both approaches enhanced far transfer effects to sentence-level processing and cross-language generalization. Notably, noun-SFA resulted in greater single-word and discourse-level gains, whereas verb-SFA demonstrated stronger cross-language generalization, highlighting its potential for broader levels of transfer.

Previous SFA treatment studies have primarily focused on languages such as English, Spanish, and Mandarin, whereas research on verb-final languages like Korean remains limited. English and Korean differ substantially in both word order and the role of verbs. In English, which follows a head-initial “subject (S) + verb (V) + object (O)” structure, word order determines grammatical functions, making it critical for conveying syntactic relationships. The SVO structure places the verb in a central role, where it governs the syntactic relationships between sentence constituents, such as the subject and object, by assigning grammatical functions and thematic roles (Britt, 1994; Garnsey et al., 1997; Hwang & Kaiser, 2014). By contrast, Korean adopts a head-final “S + O + V” structure where grammatical relationships, such as argument structure and thematic role assignment, are primarily marked by case markers, allowing for flexible word order. This reduces the verb’s role in directly assigning syntactic roles but highlights its importance in finalizing event structures (Hwang & Kaiser, 2014). Korean verbs integrate the thematic roles of preceding noun phrases, such as subjects and objects, which appear before the verb itself (Sung et al., 2016, 2024). This process underscores the critical role of verbs in constructing coherent event structures by integrating thematic roles and syntactic relationships to achieve both semantic clarity and grammatical completeness. Additionally, Korean verbs can stand alone to convey complete grammatical and semantic meaning, emphasizing their salience in the language (Sung et al., 2016, 2024). These unique features suggest that verb-SFA may be particularly effective in Korean, as it leverages the language’s focus on integrating syntax and semantics through verbs, which play a central role in activating thematic roles and completing event structures.

Considering the importance of verbs at the verb-final language structure, verb-focused naming treatments for Korean-speaking PWA have been explored using the Verb Network Strengthening Treatment (VNeST; Edmonds et al., 2009). This protocol aims to reinforce the thematic roles associated with target verbs, thereby strengthening semantic and syntactic connections. Following the treatment, Korean-speaking PWA demonstrated improvements in naming treated verbs, as well as near transfer effects on the naming of both untreated nouns

and verbs (S. E. Kim et al., 2022; Kwag et al., 2014). Despite the growing interest in verb-focused naming treatment, studies examining verb-SFA for Korean-speaking PWA remain scarce. Most SFA studies in Korean examined the positive treatment effects, as well as near transfer effects to untreated items, for individuals with Alzheimer’s disease (J. E. Kim & Sung, 2024; Mo et al., 2015). However, these studies targeted the noun-SFA protocol and focused on individuals with degenerative diseases, making it challenging to generalize the findings to other neurogenic populations with anomia. As previously mentioned, Korean is a verb-salient language, highlighting the importance of evaluating whether verb-focused SFA treatments are effective in this linguistic context.

The purpose of this study is to compare verb-SFA and noun-SFA treatments across various linguistic domains, examining differences in their treatment and transfer effects. Finally, we aim to develop an SFA treatment protocol optimized for verb-final languages like Korean, with the goal of providing more tailored and effective intervention for Korean-speaking individuals with aphasia. To address these aims, we formulated the following primary hypothesis and research questions.

The primary hypothesis is that both noun- and verb-SFA treatment are expected to show treatment effects on the treated items and near transfer effects to semantically related items. Particularly, verb-SFA may yield broader near transfer effects to untreated items, including control items in the probe set that were not directly treated but repeatedly presented during probe naming tests, as well as to items in the untreated naming tests. In addition, verb-SFA may lead to far transfer effects across different linguistic domains, compared to noun-SFA. The verb-salient characteristics of Korean suggest that verb-SFA could more effectively strengthen semantic processing mechanisms, leading to greater transfer effects across linguistic domains. Building on this hypothesis, we addressed the following research questions. First, we compare noun-SFA and verb-SFA treatments to determine which approach yields greater treatment and near transfer effects on the probe sets (treated items, semantically related items, and control items), as well as near (untreated nouns and verbs) and far (sentence production, discourse, nonverbal semantic access ability, and aphasia severity) transfer effects. In addition, we examine whether each treatment group—noun-SFA and verb-SFA—demonstrates significant within-group improvements across these same outcome domains.

Method

Participants

Ten native Korean-speaking individuals with chronic aphasia (nine men and one woman), all at least 6 months

post-onset, participated in this study. Apraxia of speech and oral apraxia were assessed using the Screening Test for Aphasia and Neurologic-Communication Disorders (STAND; H. Kim et al., 2009). Participants with mild dysarthria, which did not significantly affect speech intelligibility, were also included. The participants were randomly assigned to either the noun-SFA or verb-SFA group, with five individuals in each group. There were no statistically significant differences between groups in terms of age (noun-SFA group: $M = 59.6$, $SD = 12.6$, verb-SFA group: $M = 52.4$, $SD = 15.35$, $t(8) = 0.769$, $p = .46$), years of education (noun-SFA group: $M = 12.6$, $SD = 4.09$, verb-SFA group: $M = 14$, $SD = 2$, $t(8) = -0.686$, $p = .51$), and months post-onset (noun-SFA group: $M = 88$, $SD = 55.96$, verb-SFA group: $M = 125.8$, $SD = 78.95$, $t(8) = -0.873$, $p = .4$). For seven out of the 10 participants, brain lesion locations were confirmed through hospital-provided medical records. For the remaining three participants, detailed neuroimaging data were not available; however, left-hemisphere stroke was reported based on caregiver information and/or brief hospital summaries. Aphasia diagnoses were made by certified speech-language pathologists, and all participants exhibited clinical profiles consistent with left-hemisphere damage. The demographic information for each group is provided in Table 1.

All participants met the following inclusion criteria: (a) diagnosed with aphasia by a speech-language pathologist using the Paradise Korean-Western Aphasia Battery-Revised (PK-WAB-R; H. Kim & Na, 2012); (b) history of stroke (infarction or hemorrhage) in the left hemisphere or subcortical area; (c) right-handed before the stroke; (d) no other neurological diseases such as dementia; (e) no self-reported or caregiver-reported hearing problems and visual neglect; and (f) no history of developmental disabilities, premorbid intellectual disability, cerebral palsy, learning disorders, or autism spectrum disorder, based on medical records or self/caregiver reports. Additionally, participants were required to pass a reading screening

using sections from the “Reading” portion of the STAND (H. Kim et al., 2009) and the “Written Commands” and “Picture-Written Word Choice” tests from Part 2 of the PK-WAB-R to confirm basic reading skills for SFA treatment eligibility.

The current study was approved by the institutional review board (IRB) of Ewha Womans University (Approval No. 2022-0140). Written consent was obtained from all participants and their caregivers. Participants were recruited from university hospital clinics, community welfare centers, and online communities for patients with stroke using IRB-approved flyers.

Stimuli

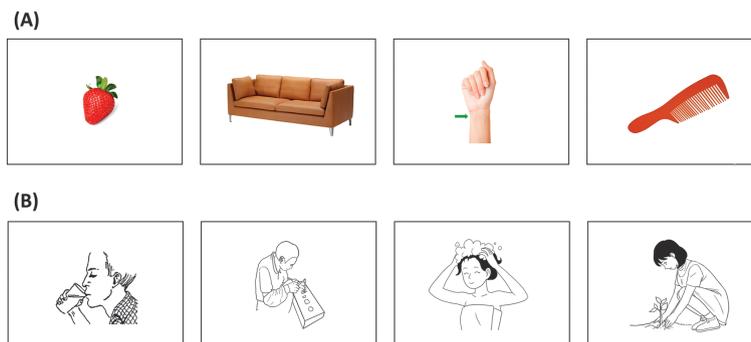
To select the treated and untreated items (e.g., semantically related items, control items) for the probe sets, we used the Korean-adapted version of the Item Selection Naming Test (ISNT), which was developed by the authors in 2023 (S. Choi et al., 2023) based on the English version used in Li and Kiran’s (2023) study. The Korean version includes 213 noun items and 157 verb items that do not overlap the pre- and postnaming assessment tools used in this study. The picture stimuli for the noun items were initially collected from the Bank of Standardized Stimuli (Brodeur et al., 2014), and inappropriate images for Korean culture were replaced with ones from Google Images. For verb stimuli preparation, the pictures were initially sourced from Li and Kiran (2023). Verbs deemed inappropriate for Korean culture were excluded, or the pictures were redrawn to better align with the cultural context while retaining their original meanings. Examples of the picture stimuli for each noun and verb ISNT are presented in Figure 1.

Both groups conducted the ISNT to select probe sets based on incorrect items, with the noun-SFA group using the noun ISNT and the verb-SFA group using the verb ISNT. Incorrect responses included any answer other than the target word, such as “I don’t know” or no response.

Table 1. Demographic information of each semantic feature analysis (SFA) group.

Group	ID	Gender	Age (years)	Education (years)	MPO	Brain lesion	AQ	Aphasia type
Noun-SFA group	S1-N	Male	40	16	82	L. MCA infarction	55.9	Wernicke’s
	S2-N	Female	49	12	39	L. MCA infarction	24.6	Broca’s
	S3-N	Male	71	16	88	L. hemisphere hemorrhage	84.5	Anomic
	S4-N	Male	71	6	181	L. fronto-parietal ICH	69	Anomic
	S5-N	Male	67	13	50	L. temporo-parietal lobe infarction	70.6	Anomic
Verb-SFA group	S6-V	Male	35	16	105	L. subarachnoid hemorrhage	58.5	Conduction
	S7-V	Male	47	12	151	L. hemisphere infarction	78.4	Anomic
	S8-V	Male	77	14	28	L. MCA infarction	52.4	Wernicke’s
	S9-V	Male	50	16	102	L. hemisphere infarction	84.5	Anomic
	S10-V	Male	53	12	243	L. BG infarction	78.9	Anomic

Note. MPO = months post onset; AQ = Aphasia Quotient; SFA = semantic feature analysis; L = left; MCA = middle cerebral artery; ICH = intracerebral hemorrhage; BG = basal ganglia.

Figure 1. Examples of noun-ISNT (A) and verb-ISNT (B) picture stimuli. ISNT = Item Selection Naming Test.

While no strict time limit was imposed, responses exceeding 15 s were deemed incorrect, following the cueing threshold of the Korean version of the Boston Naming Test (K-BNT; H. Kim & Na, 1997). If participants revised their answers, the final response was scored.

The probe sets consisted of (a) 15 treated items, (b) 15 semantically related items that share similar semantic properties with the treated items, and (c) 15 control items that were semantically unrelated to the treated items. The clinician first selected the treated items. Next, another set of 15 semantically related word pairs was chosen from the ISNT list of incorrectly answered words. The selection of semantically related items involved two key steps. The target item was first translated into English and entered the WordNet database at Princeton University (<http://wordnetweb.princeton.edu/>), following the criteria used by Li and Kiran (2023). From the list of sister terms, words with similar semantic properties were chosen. If no appropriate words were found in the sister term list, Korean dictionary definitions were used to identify words with shared semantic features. The remaining 15 words, comprising the control items, were also selected from the ISNT list of incorrect responses.

For example, if a participant failed to correctly name the noun “strawberry” (“ttalki” in Korean) in the fruit category, we selected that word as a treated item. Next, we reviewed all the fruits that the participant was unable to name correctly on the ISNT. The semantically related word “grape” (“podo” in Korean), which belongs to the same semantic category, was then selected as a semantically related item, while the control word was chosen as the animal “lion” (“saja” in Korean). When control items from different semantic categories were limited, we selected them from the same semantic category as the treated items, ensuring they differed in semantic features. We also considered minimizing phonological similarity among the items within the probe sets, although this was not strictly controlled. All words in each probe set were randomized and presented in a different order during the

pretreatment phase and the post-assessment for probe set naming tests.

SFA Treatment

The Korean version of the noun- and verb-SFA treatment was developed based on previous studies by Li and Kiran (2023). We began by translating the English SFA treatment, including its semantic features and feature charts, and then adapted it to reflect the unique linguistic characteristics and cultural context of the Korean language. The treatment was structured into three stages, each comprising specific steps. The first stage, the lexical retrieval phase, involved the naming step (Step 1). The second stage, the semantic activation phase, included feature selection (Step 2), word association (Step 3), and feature verification (Step 4). The final stage, the integrative lexical retrieval phase, consisted of renaming (Step 5) and sentence construction (Step 6).

For the noun-SFA treatment, the steps are as follows:

1. Step 1: “Naming”: Participants name the target noun displayed on the screen. Regardless of their response, the clinician provides the correct name and general feedback, such as “Good job.”
2. Step 2: “Feature Selection”: The target picture appears at the top left of the monitor, with 15 semantic features displayed on the left (11 matching the target item and four unrelated). On the right, six feature charts are displayed (e.g., Does Not Match, Function, Characteristics, Physical Attributes, Location, and Category). Participants drag the four unrelated features into the “Does Not Match” chart first. If a mistake is made, the clinician provides the correct answer. Next, the remaining 11 semantically related features are sorted into the other five charts. Once sorting is complete, the clinician reviews the responses, provides corrections for errors, and offers feedback.

3. Step 3: “Word Association”: The target picture is displayed on the monitor, and participants are prompted, “Please share experiences or memories related to the word.” They are encouraged to think of features, items, experiences, or memories associated with the target word to enhance recall and understanding. The clinician provides clarification or additional instructions as needed.
4. In Step 4: “Feature Verification”: The target picture and the 15 features from Step 2 are displayed one by one in random order. Participants click “Yes” or “No” to judge whether each feature is related to the target word. After answering all 15 questions, a performance summary is shown on the screen. The clinician reviews the results, corrects errors, and provides feedback by offering the correct response.
5. Step 5: “Re-naming”: Participants attempt to name the target word again. If participants fail to name the target word or produce an incorrect response, the clinician provides the correct answer and asks them to repeat the target word.
6. Step 6: “Sentence Construction”: Participants create a sentence using the target word while viewing the picture. The clinician records their response and provides feedback by presenting a grammatically and semantically corrected version of the sentence. If participants fail to construct a sentence, the clinician provides an example of an appropriate sentence and asks them to either repeat it or attempt to construct a new sentence.

For the verb-SFA treatment, participants are asked to name the target verb, and all the steps are the same as the noun-SFA treatment except for Step 2. In Step 2 of the verb-SFA treatment, participants classify features into six feature charts as follows: (a) Does Not Match, (b) Subject (“Who usually does this?”), (c) Object/Purpose (“Why does this happen?”), (d) Method (“What part of the body or what tool is used?”), (e) Physical Attributes (“What does this action look like?”), and (f) Location (“Where does this action take place?”).

Pre- and Post-Assessments

Assessments to Examine the Treatment and Near Transfer Effects on the Probe Sets

The accuracy of treated items was assessed to identify direct treatment effects. Semantically related items included in the probe set were used to examine near transfer effects, as they shared semantic features with the treated items. Finally, control items, which were neither directly treated nor semantically related, were also included in the probe set. Although these items were not targeted during treatment sessions, they

were consistently presented during each probe naming test, providing repeated exposure across sessions.

Accuracy was defined as the number of correctly named items. Probes naming tests were conducted 3 times before treatment (baseline) and 3 times after treatment (posttreatment). During the treatment period, probes were administered before every second session, totaling 10 probes. In total, 16 probe set naming tests were conducted throughout the study.

Assessments to Examine the Near Transfer Effects on the Untreated Nouns and Verbs

To capture changes in word-level comprehension and naming abilities, both noun- and verb-related tests were conducted. For assessing untreated noun naming abilities, we administered the K-BNT. For untreated verb abilities, we used the Action Comprehension Test (ACT; Sung et al., 2014) and the Action Naming Test (ANT; S. Choi et al., 2021; Sung et al., 2014). Additionally, verbal fluency tests, which are sensitive tools for detecting cognitive function and evaluating the executive function of the prefrontal lobe and semantic memory (Brucki & Rocha, 2004; McDonnell et al., 2020; Troyer, 2000), were administered before and after treatment. Specifically, we conducted a semantic fluency test for nouns using categories such as “animals” and “supermarket.” For verbs, an action fluency test asked participants to name as many words as possible related to actions or movements within 1 min.

Assessments to Examine the Far Transfer Effects

Sentence-level tests. The PWA completed the Sentence Comprehension Test (SCT; Sung et al., 2021) and the Sentence Production Test (SPT; Sung et al., 2018). The SCT, a sentence–picture matching paradigm, consists of 36 items, each worth 1 point, and includes semantically reversible sentences across three types: active sentences with two-place verbs, active sentences with three-place verbs, and passive sentences. These sentences vary in word order (canonical and noncanonical), resulting in a total of six different sentence types. During the SCT, participants listen to a sentence presented by the clinician and select the picture that matches the sentence from two options.

The SPT consists of syntactic priming (SPT-priming) and completion (SPT-completion) tests. Both tests involved two syntactic structures (active and passive) and two-word order types (canonical and noncanonical), with a total of 24 items: six for each syntactic structure and word order type. In the SPT-priming, clinicians described the left side of a prime picture, and participants were asked to produce a sentence based on the right side. Each picture depicted an event involving an agent, a patient, and an action, using transitive verbs with two-place arguments. Responses were marked correct if participants used the appropriate syntactic structure, word order, grammatical markers, and verb inflections.

In the SPT-completion, clinicians provided the first part of a sentence, starting with a noun phrase that had either a nominative or dative (by-phrase) marker. Participants then completed the sentence to match the picture. Responses were considered correct if they followed the target syntactic structure, word order, and used the appropriate grammatical markers and verb inflections.

Discourse-level tests. Discourse speech samples were collected through picture description tasks using a single picture, a sequential picture, and a storytelling picture stimulus. The single picture, “cat rescue,” and a six-frame sequential picture about a “refused umbrella” from the AphasiaBank (MacWhinney et al., 2011) were used. Additionally, storytelling samples were gathered from the eight-frame Korean folktale “Heungbu-Nolbu” (Y. Choi et al., 2022). All responses from the three tasks were combined into a single speech sample and analyzed using the following outcome variables: number of utterances, noun- and verb-related measures (token count, type count, type–token ratio [TTR], nouns/verbs per utterance), and noun-to-verb ratio (NVR), according to the criteria established by Sung et al. (2016). Utterances were defined based on the guidelines provided in H. Kim et al.’s (1998) study on spontaneous speech in Korean-speaking PWA. Specifically, an utterance was considered to occur in the following cases: (a) when a sentence ends with a predicate; (b) when a conjunction extended the sentence but a new utterance was signaled by a noticeable change in intonation or a pause lasting more than 2 s; and (c) when a pause of over 2 s separated words, even if the context remained coherent. Additionally, the proportion of CIUs was used to assess semantic content. CIUs measure semantic accuracy and relevance, reflecting the informativeness and sufficiency of connected speech for PWA (Nicholas & Brookshire, 1993).

Nonverbal semantic association test. We used the Pyramids and Palm Trees Test (PPTT; Howard & Patterson, 1992), a widely used semantic association task designed to assess semantic processing abilities. To specifically evaluate nonverbal semantic association, we employed the three-picture version of the PPTT, which consists of 52 items. In this version, participants are required to match a stimulus picture (e.g., a pyramid) with one of two target pictures (e.g., a palm tree, pine tree) based on shared semantic features, without providing a spoken response.

Severity and type of aphasia. The severity and type of aphasia were assessed using the PK-WAB-R. The assessment provided information on the Aphasia Quotient (AQ) and the specific type of aphasia.

Experimental Design and Procedures

We conducted a randomized controlled trial using a parallel-group design, comparing pre- and postperformance

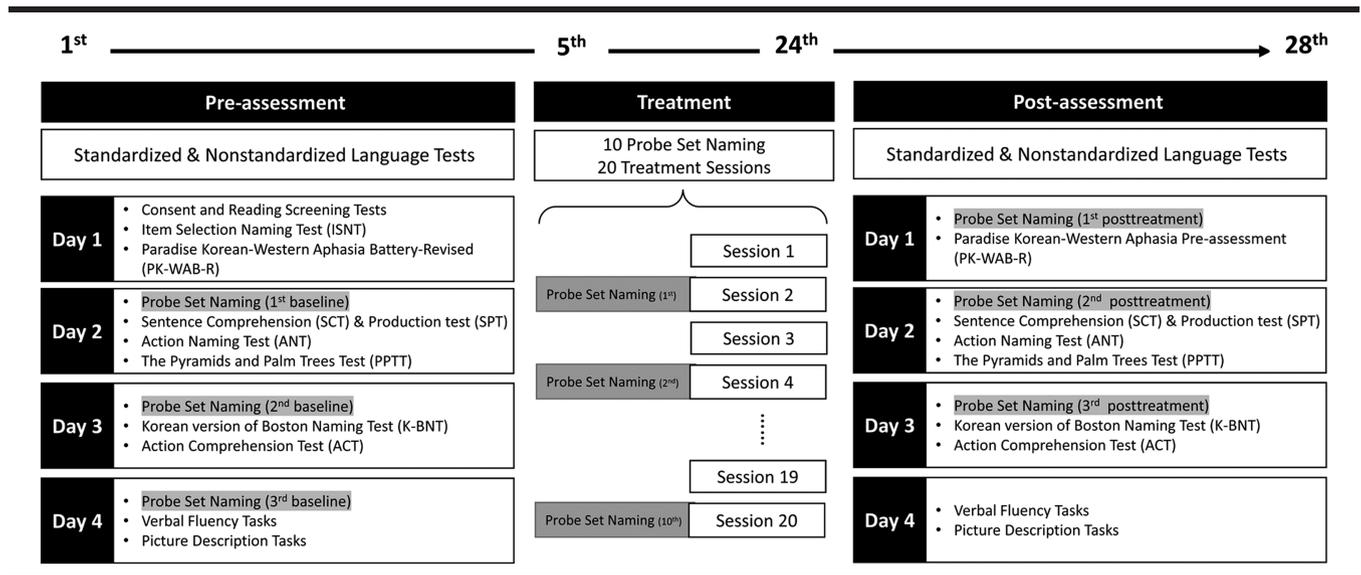
across baseline, treatment, and posttreatment phases over time. The pre-assessments and baseline probes were conducted over three in-person sessions across 2 weeks. During the SFA treatment phase, PWA engaged in treatments twice a week for 1-hr sessions, totaling 20 hr. The treatment sessions were administered using Pavlovia, a platform widely used for online behavioral experiments (Li & Kiran, 2023; <https://pavlovia.org>). Sessions were conducted either in person or remotely via Zoom, depending on the participant’s location, mobility, and preferences. Regardless of the format, the treatment protocol remained consistent, utilizing computer-based tasks. For participants unable to operate a computer independently, a caregiver assisted during sessions. Additionally, for participants who had difficulty with manual responses such as clicking or dragging, the clinician utilized Zoom’s remote-control function to perform these actions. Once all treatment sessions were completed, post-assessments were conducted in person across 2 weeks. A detailed diagram of the assessment and treatment phases is provided in Figure 2.

Reliability and Fidelity

To ensure the fidelity of the treatment, two independent raters evaluated 50 treatment sessions, representing 25% of all sessions. Each rater reviewed the treatment steps from video recordings to determine whether the protocol was accurately followed. The raters reported fidelity scores of 97% and 98%, respectively, resulting in an average fidelity of 97.5%. For the probe set naming test, both scoring fidelity and interrater reliability were assessed across 70 sessions (25% of all sessions). Prior to scoring, the first author provided a one-time training session to both raters, explaining the scoring criteria using one probe set consisting of 45 items. This set was excluded from final fidelity and reliability analyses. Raters transcribed the final response produced for each item and scored each response as correct (1) or incorrect (0). Scoring fidelity was confirmed by comparing the raters’ scores to the reference scores provided by the first author, with both raters achieving 100% agreement.

For discourse transcription and scoring of discourse measures, both intra- and interrater reliability were evaluated. For intrarater reliability, all discourse samples were initially transcribed and coded by the first author and then reanalyzed independently within approximately 1 week of the initial transcription. Agreement between the two sets of transcripts and coded measures was calculated point-to-point, yielding 98.0% agreement. To establish interrater reliability, an independent rater (a doctoral student in speech-language pathology) was trained on transcription and discourse coding according to published criteria (H. Kim et al., 1998; Nicholas & Brookshire, 1993; Sung et al., 2016). The first author’s coding, established according to these published

Figure 2. The overall diagram of the assessment and treatment phases.



criteria, served as the reference standard during training. The independent rater practiced on one participant's pre-treatment discourse sample, and agreement was calculated point-to-point against the reference. Training continued until $\geq 80\%$ agreement was achieved, after which the training sample was excluded from subsequent analyses. For the interrater assessment, 40% of the total discourse samples (20% from each treatment group) were randomly selected, including both pre- and posttreatment sessions across all three picture tasks. Results showed 98.2% agreement for transcription and 93.8% agreement across discourse measures, indicating high reliability of the transcription and coding procedures.

Statistical Analysis

This study employed either the generalized linear mixed-effects model (GLMM) or the linear mixed-effects model (LMM), depending on the nature of the dependent variables. The GLMM was applied when the dependent variable was binary, coded as 1 (correct) or 0 (incorrect) based on individual item responses. In this study, the GLMM was conducted to examine the treatment and transfer effects on probe sets, K-BNT, ACT, ANT, SCT, SPT, and PPTT, while the LMM was used for other types of dependent measures, such as ratios, percentages, or countable variables in verbal fluency tests and discourse-level measures. These models were implemented using the "glmer" and "lmer" functions from the "lme4" package (Bates et al., 2015; Kuznetsova et al., 2014) in R software Version 4.3.1 (R Core Team, 2019), with the AQ of each individual set as a covariate. In our analysis, we specifically applied sum coding for contrast coding. Unlike treatment coding, where the

intercept represents the reference level, sum coding adjusts the model intercept to reflect the grand mean of all levels. This method provides a more balanced interpretation of the effects. With "-1, 1" sum coding, the predictor term represents half the change in the outcome between the two levels, allowing for a clearer understanding of the relative effects of the predictors (Brehm & Alday, 2022).

Results

Group Comparisons of Treatment and Transfer Effects Between Noun-SFA and Verb-SFA Treatments

Group Comparisons of Treatment and Near Transfer Effects on the Probe Sets

For the main effect, the effect of the group was not significant ($\beta = -0.111$, $SE = 0.132$, $p = .399$, odds ratio [OR] = 0.89, 95% CI [0.69, 1.16]), indicating that there was no overall difference in performance between the groups. The mixed-effects model results showed that the interaction between the group and treated items was not significant ($\beta = -0.093$, $SE = 0.122$, $p = .445$, OR = 0.91, 95% CI [0.72, 1.16]). Additionally, the three-way interaction between Session \times Treated Item \times Group was not statistically significant ($\beta = -0.003$, $SE = 0.012$, $p = .8$, OR = 0.99, 95% CI [0.97, 1.01]). These results indicated that there were no differences in treatment effects on treated items between the noun-SFA and verb-SFA groups across the treatment sessions.

Interestingly, the mixed-effects model revealed significant two-way interactions between groups for both the

semantically related items ($\beta = 0.397$, $SE = 0.012$, $p = .001$, $OR = 1.49$, 95% CI [1.29, 1.73]) and the control items ($\beta = 0.304$, $SE = 0.131$, $p = .02$, $OR = 1.49$, 95% CI [1.17, 1.9]), indicating greater improvement in the verb-SFA group compared to the noun-SFA group. This pattern was supported by estimated marginal means, with the verb-SFA group showing higher model-predicted accuracy for both semantically related items (verb-SFA = 0.065 vs. noun-SFA = 0.044) and control items (verb-SFA = 0.07 vs. noun-SFA = 0.04). However, the three-way interactions Session \times Semantically Related Items \times Group ($\beta = -0.01$, $SE = 0.012$, $p = .402$, $OR = 0.99$, 95% CI [0.97, 1.02]) and Session \times Control Items \times Group ($\beta = 0.013$, $SE = 0.013$, $p = .304$, $OR = 1.01$, 95% CI [0.98, 1.03]) were not statistically significant. The results indicated greater improvement in the near transfer effects on semantically related and control items in the verb-SFA group compared to the noun-SFA group, although the improvements across treatment sessions were not significantly different between the groups. The mixed-effects model results are presented in Table 2, and Figure 3 provides a visual representation to help clarify the group differences.

Group Comparisons of Near Transfer Effects on the Untreated Nouns and Verbs Tests

For the K-BNT, the main effect of the group was not significant ($\beta = 0.393$, $SE = 0.226$, $p = .082$, $OR = 1.48$, CI [0.95, 2.31]). In addition, the results showed no statistically significant two-way interactions, indicating no differences in K-BNT accuracy between the two groups when compared to pretreatment scores ($\beta = -0.048$, $SE = 0.074$, $p = .514$, $OR = 0.95$, CI [0.82, 1.1]). For the noun fluency tests, there were no significant differences between

groups, including the animal fluency ($\beta = -0.118$, $SE = 0.083$, $p = .153$, incidence rate ratio [IRR] = 0.89, CI [0.75, 1.05]) and the supermarket fluency ($\beta = 0.081$, $SE = 0.102$, $p = .426$, IRR = 1.08, CI [0.88, 1.32]) tests. These findings suggest that the noun-SFA group did not exhibit near transfer to untreated nouns.

For the verb-related tests, the main effect of the group was not significant in either the ACT ($\beta = 0.488$, $SE = 0.345$, $p = .157$, $OR = 1.62$, CI [0.82, 3.2]) or the ANT ($\beta = 0.331$, $SE = 0.229$, $p = .147$, $OR = 1.39$, CI [0.88, 2.18]). For the ACT, results indicated that the verb-SFA group experienced significantly larger near transfer on verb comprehension abilities ($\beta = 0.709$, $SE = 0.281$, $p = .011$, $OR = 2.03$, CI [1.17, 3.53]) and on verb naming abilities as measured by the ANT ($\beta = 0.254$, $SE = 0.097$, $p = .008$, $OR = 1.28$, CI [1.06, 1.56]) compared to the noun-SFA group. For the verb fluency tests, a significant main effect of the group ($\beta = 0.534$, $SE = 0.250$, $p = .033$, IRR = 1.71, CI [1.04, 2.81]) indicated that the verb-SFA group produced more verbs within 1 min. However, there was no statistically significant interaction between assessment point and group for the action fluency test ($\beta = 0.149$, $SE = 0.164$, $p = .366$, IRR = 1.85, CI [0.62, 1.18]). This suggests that, interestingly, only the verb-SFA group exhibited near transfer effects on the untreated verbs. The mixed-effects model results of near transfer effects to untreated nouns and verbs are presented in Figures 4 and 5.

Group Comparisons of Far Transfer Effects Beyond the Word-Level Tests

To compare the far transfer effects at the sentence level, we conducted mixed-effects models examining the interaction between group and timepoint for each sentence-level

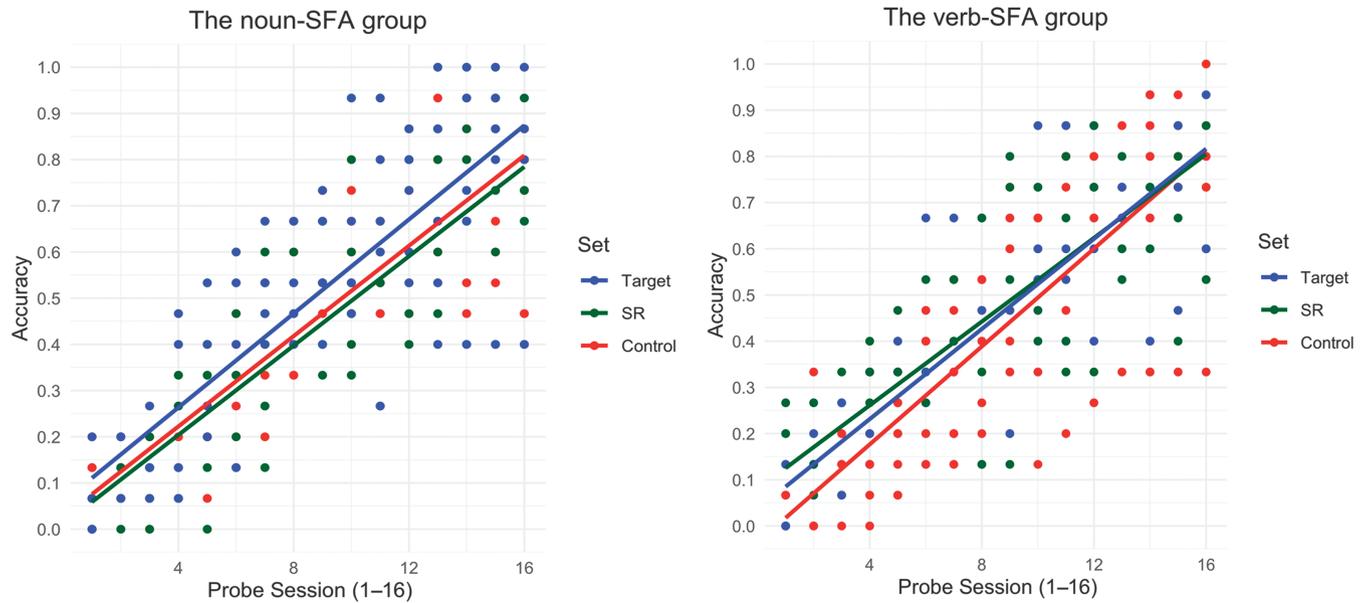
Table 2. Mixed-effects model results of treated and untreated items in the probe set naming tests between groups.

Predictor	Estimate	SE	<i>z</i>	<i>p</i>
Intercept	-4.775	0.424	-11.148	< .001***
Group	-0.111	0.132	-0.843	.399
Session	0.324	0.024	13.343	< .001***
Session \times Treated Words	-0.011	0.012	-0.869	.385
Session \times Semantically Related Words	-0.011	0.012	-0.863	.388
Session \times Control Words	0.022	0.013	1.631	.102
Group \times Treated Words	-0.093	0.122	-0.763	.445
Group \times Semantically Related Words	0.397	0.124	3.202	.001**
Group \times Control Words	0.304	0.131	2.31	.02*
Session \times Group \times Treated Words	-0.003	0.012	-0.253	.8
Session \times Group \times Semantically Related Words	-0.01	0.012	-0.836	.402
Session \times Group \times Control Words	0.013	0.013	1.027	.304

Note. R model equation: Accuracy \sim Session \times Item Set \times Group + AQ + (1 + Session | Subject) + (1 + Session | Item). Accuracy was coded as a binary variable (1 = correct, 0 = incorrect) for each individual item response. Aphasia Quotient (AQ) was set as the covariate. The predictors were sum-coded (Group: +1 verb-SFA group, -1 noun-SFA group, Session: + posttreatment, -1 pretreatment). SE = standard error; SFA = semantic feature analysis.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 3. Accuracy across sessions for each group in the probe sets. SR refers to semantically related items in the probe set naming tests. SFA = semantic feature analysis.



task. For the main effect of group, there was no significant difference in the SCT ($\beta = 0.119$, $SE = 0.088$, $p = .177$, $OR = 1.12$, $CI [0.94, 1.34]$), while the verb-SFA group performed significantly better in both the SPT-priming ($\beta = 13.797$, $SE = 4.206$, $p = .001$, $OR = 1.24$, $CI [1.12, 2.7]$) and SPT-completion ($\beta = 1.591$, $SE = 0.672$, $p = .017$, $OR = 0.88$, $CI [0.75, 1.04]$) tests. No significant interaction was found in any of the tasks, including the SCT ($\beta = -0.018$, $SE = 0.078$, $p = .817$, $OR = 0.98$, $CI [0.84, 1.14]$), SPT-priming ($\beta = 2.697$, $SE = 4.588$, $p = .554$, $OR = 1.17$, $CI [1.08, 1.27]$), and SPT-completion ($\beta = 0.078$, $SE = 0.201$, $p = .697$, $OR = 1.08$, $CI [1.32, 1.6]$). These results indicate that there was no differential far transfer effects between groups at the sentence level (see Figure 6).

The results for far transfer effects at the discourse production revealed that there were no significant differences in all linguistic variables between groups. We provide the mixed-effects model results in Table 3 and the performance of the outcome measures at the discourse level in Figure 7.

This study compared the semantic association performance using the PPTT before and after treatment between groups. The main effect of group was significant ($\beta = 13.502$, $SE = 4.9895$, $p = .021$, $OR = 1$, $CI [0.99, 1.02]$), indicating that the PPTT performance was higher in the verb-SFA group than in the noun-SFA group. The mixed-effects model revealed a statistically significant interaction between

Figure 4. Performance on noun tests before and after semantic feature analysis (SFA) treatment across groups: (A) Korean version of Boston Naming Test, (B) Animal Fluency Test, and (C) Supermarket Fluency Test. The cross (x) indicates the mean value for each group. Asterisks (*) indicate statistically significant within-group differences between pre- and posttreatment ($*p < .05$).

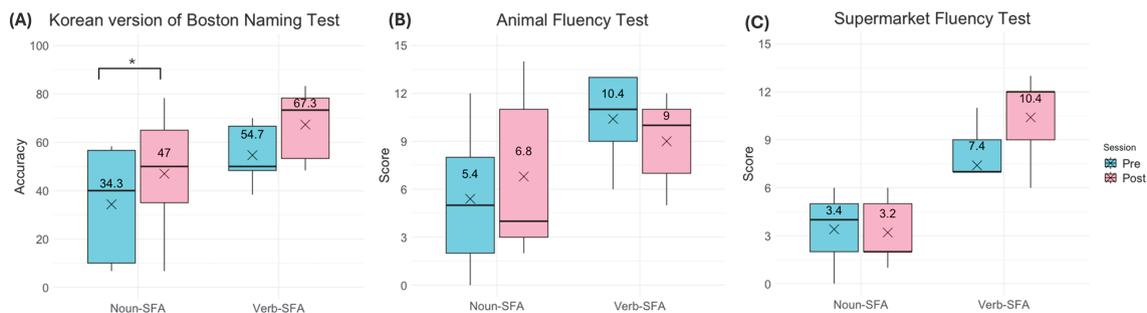
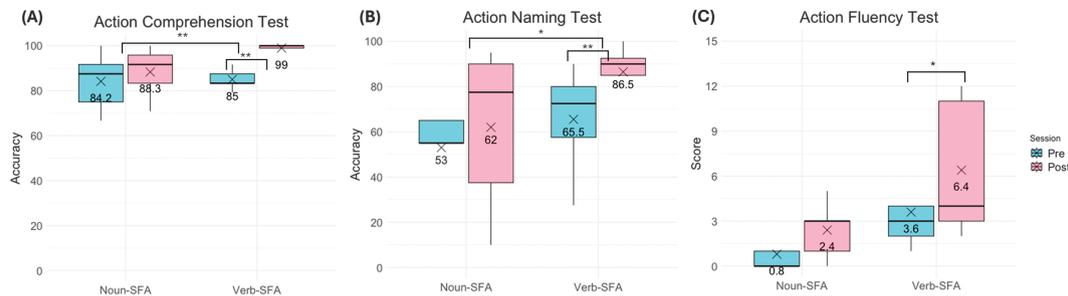


Figure 5. Performance on verb tests before and after semantic feature analysis (SFA) treatment across groups: (A) Action Comprehension Test, (B) Action Naming Test, and (C) Action Fluency Test. The cross (x) indicates the mean value for each group. Asterisks (*) indicate statistically significant differences either within groups (pre vs. post) or between groups at each timepoint (* $p < .05$, ** $p < .01$).



the assessment point and the group ($\beta = 1.63$, $SE = 0.49$, $p < .001$), suggesting that the accuracy of the PPTT improved more in the verb-SFA group than in the noun-SFA group after treatment. Although the difference at the pretreatment timepoint was marginal ($p = .054$), with the verb-SFA group showing slightly higher scores, it was not statistically significant, indicating generally comparable baseline performance across groups (see Figure 8).

The overall summary of treatment and transfer effects based on the assessment domains in the groups is presented in Table 4. Additionally, we provide the individual raw scores for the pre- and posttreatment assessments across various linguistic domains of each group in Appendix A.

Treatment and Transfer Effects Within the Noun-SFA Group

Treatment and Near Transfer Effects on the Probe Sets

The mixed-effects model revealed a significant main effect for treated nouns ($\beta = 0.372$, $SE = 0.178$, $p = .037$, $OR = 1.5$, $CI [1.05, 2.13]$), indicating improved accuracy relative to the grand mean. However, the Session \times Treated

Noun interaction was not significant ($\beta = -0.014$, $SE = 0.019$, $p = .441$, $OR = 0.98$, $CI [0.95, 1.02]$). For semantically related nouns, a significant main effect was found ($\beta = -0.37$, $SE = 0.188$, $p = .049$, $OR = 0.64$, $CI [0.44, 0.93]$), reflecting lower accuracy than the grand mean. No significant effects were observed for control items ($\beta = -0.01$, $SE = 0.188$, $p = .957$, $OR = 1.02$, $CI [0.71, 1.47]$), nor were there significant interactions for Session \times Semantically Related Nouns ($\beta = 0.000$, $SE = 0.019$, $p = .967$, $OR = 0.99$, $CI [0.96, 1.03]$) or Session \times Control Nouns ($\beta = 0.041$, $SE = 0.02$, $p = .463$, $OR = 1.01$, $CI [0.97, 1.05]$; see Figure 3).

Near Transfer Effects on the Untreated Nouns and Verbs Tests

The K-BNT results revealed a statistically significant main effect, indicating that near transfer effects on untreated nouns occurred following noun-SFA treatment ($\beta = 0.278$, $SE = 0.118$, $p = .018$, $OR = 1.32$, $CI [1.04, 1.66]$). However, no significant improvements were observed in the animal fluency ($\beta = 0.088$, $SE = 0.133$, $p = .507$, $IRR = 1.09$, $CI [0.84, 1.41]$) or supermarket fluency ($\beta = -0.04$, $SE = 0.176$, $p = .818$, $IRR = 0.96$, $CI [0.67, 1.35]$; see Figure 4) tests. Regarding near transfer to untreated verb tests, no significant effects

Figure 6. The performance of the sentence-level tests before and after semantic feature analysis (SFA) treatment between groups: (A) Sentence Comprehension Test, (B) Sentence Production Test–Priming, and (C) Sentence Production Test–Completion. The cross (x) indicates the mean value for each group. Asterisks (*) indicate statistically significant within-group differences between pre- and posttreatment (* $p < .05$, ** $p < .01$, *** $p < .001$).

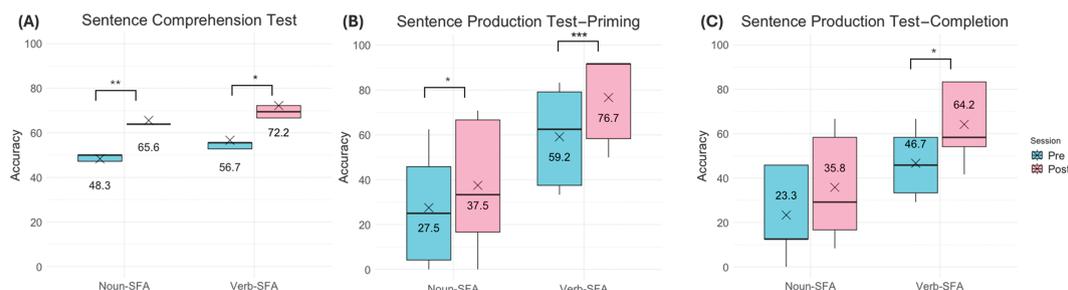


Table 3. Mixed-effects model results of the discourse production between groups.

Outcome variable	Predictor	Estimate	SE	z	p
Number of utterances	Intercept	2.482	0.585	4.243	< .001***
	Assessment Point × Group	0.027	0.046	0.592	.554
Noun token	Intercept	3.413	0.655	5.207	< .001***
	Assessment Point × Group	0.013	0.028	0.454	.649
Noun type	Intercept	2.534	0.638	3.97	< .001***
	Assessment Point × Group	-0.022	0.037	-0.606	.545
Nouns per utterance	Intercept	1.227	0.848	<i>t</i> = 1.447	.174
	Assessment Point × Group	-0.048	0.058	<i>t</i> = -0.821	.44
Noun TTR	Intercept	0.933	0.11	<i>t</i> = 8.431	< .001***
	Assessment Point × Group	-0.008	0.016	<i>t</i> = -0.501	.63
Verb token	Intercept	4.366	0.815	5.353	< .001***
	Assessment Point × Group	0.001	0.03	0.052	.959
Verb type	Intercept	2.61	0.856	3.048	.002**
	Assessment Point × Group	0.008	0.04	0.214	.83
Verbs per utterance	Intercept	0.508	1.228	<i>t</i> = 0.414	.69
	Assessment Point × Group	-0.086	0.123	<i>t</i> = -0.702	.505
Verb TTR	Intercept	0.519	0.195	<i>t</i> = 2.657	.017*
	Assessment Point × Group	0.077	0.044	<i>t</i> = 1.767	.097
NVR	Intercept	3.766	0.96	<i>t</i> = 3.923	.001**
	Assessment Point × Group	-0.053	0.216	<i>t</i> = -0.247	.808
CIU	Intercept	0.581	0.127	<i>t</i> = 4.575	< .001***
	Assessment Point × Group	-0.018	0.007	<i>t</i> = -2.453	.053

Note. R model equation: Dependent variable ~ Session × Group + AQ + (1 | Subject). Aphasia Quotient (AQ) was set as the covariate. The *z* values were reported for generalized linear mixed-effects model analyses, and the *t* values were reported for linear mixed-effects model analyses. The predictor for the assessment point was sum-coded (+1 for post-assessment, -1 for pre-assessment), and the group variable was sum-coded as well (+1 for the verb-SFA group, -1 for the noun-SFA group). *SE* = standard error; TTR = type-token ratio; NVR = noun-to-verb ratio; CIU = correct information unit; SFA = semantic feature analysis.

p* < .05. *p* < .01. ****p* < .001.

were found in any of the verb-related tests, including the ANT ($\beta = -0.065$, $SE = 0.131$, $p = .618$, $OR = 0.93$, $CI [0.72, 1.21]$), the ACT ($\beta = 0.013$, $SE = 0.239$, $p = .956$, $OR = 1.01$, $CI [0.63, 1.62]$), or the action fluency test ($\beta = 0.501$, $SE = 0.292$, $p = .086$, $IRR = 1.65$, $CI [0.93, 2.92]$; see Figure 5).

Far Transfer Effects Beyond the Word-Level Tests

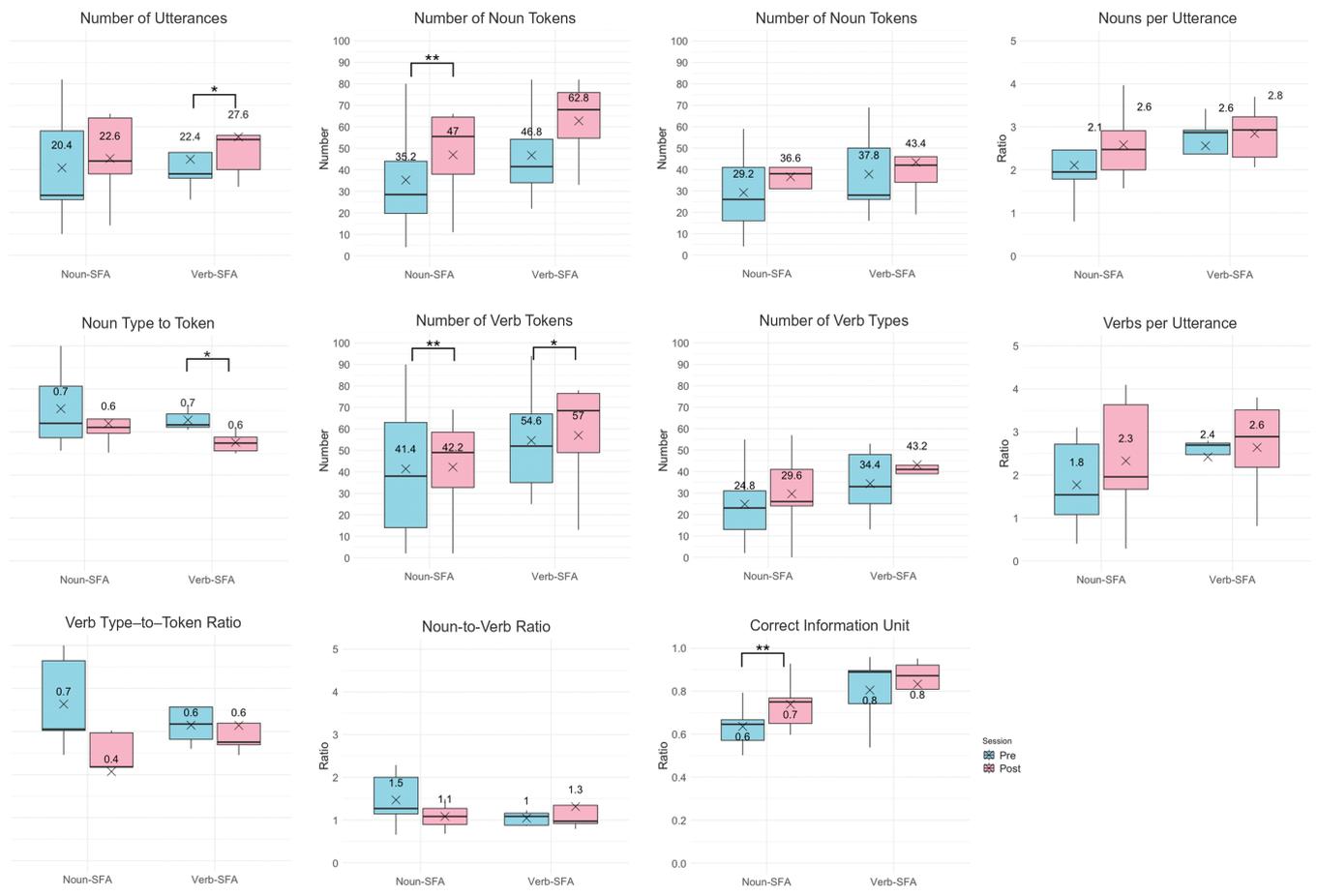
To assess far transfer effects at the sentence level, mixed-effects model analyses revealed a significant improvement in sentence comprehension (SCT; $\beta = 0.322$, $SE = 0.115$, $p = .005$, $OR = 1.38$, $CI [1.10, 1.73]$) and in sentence production under the SPT-priming condition ($\beta = 2.495$, $SE = 1.085$, $p = .021$, $OR = 1.01$, $CI [0.99, 1.02]$). However, no significant improvement was found in the SPT-completion test ($\beta = 0.402$, $SE = 0.269$, $p = .134$, $OR = 1.49$, $CI [1.05, 1.24]$; see Figure 6).

At the discourse level, Poisson GLMM results showed no significant change in the number of utterances ($\beta = -0.001$, $SE = 0.076$, $p = .986$, $IRR = 0.99$, $CI [0.85, 1.16]$). However, there was a significant increase in noun tokens ($\beta = 0.18$, $SE = 0.057$, $p = .01$, $IRR = 1.19$, $CI [1.06, 1.34]$),

while other noun-related measures—noun types ($p = .63$), nouns per utterance ($p = .384$), and noun TTR ($p = .684$)—did not show significant changes. For verbs, a significant increase was observed in verb tokens ($\beta = 0.236$, $SE = 0.054$, $p < .001$, $IRR = 1.26$, $CI [1.13, 1.41]$), but no significant effects were found in verb types ($p = .078$), verbs per utterance ($p = .427$), verb TTR ($p = .086$), or the NVR ($p = .342$). Notably, the CIU ratio significantly increased post-treatment ($\beta = 0.052$, $SE = 0.006$, $p = .003$, $IRR = 1.05$, $CI [1.04, 1.06]$), suggesting improved informativeness in discourse (see Figure 7).

Regarding nonverbal semantic association, participants showed a significant improvement on the PPTT ($\beta = 4.323$, $SE = 1.321$, $p = .001$, $OR = 1.04$, $CI [1.01, 1.18]$), indicating far transfer effects of the noun-SFA treatment (see Figure 8). In terms of aphasia severity, three out of five participants (60%) in the noun-SFA group demonstrated clinically meaningful improvement in AQ scores, exceeding the benchmark of 5.03 points (Gilmore et al., 2019). Notably, participant S1-N showed a change in aphasia type from Wernicke's to anomic following a 14.9-point gain in AQ (see Appendix B).

Figure 7. The performance of discourse production before and after semantic feature analysis (SFA) treatment between groups. The cross (x) indicates the mean value for each group. Asterisks (*) indicate statistically significant within-group differences between pre- and post-treatment (* $p < .05$, ** $p < .01$).



Treatment and Transfer Effects Within the Verb-SFA Group

Treatment and Near Transfer Effects on the Probe Sets

Although the effect was not statistically significant ($\beta = 0.164$, $SE = 0.168$, $p = .326$, $OR = 1.17$, $CI [0.84, 1.63]$), the positive beta coefficient and the increasing pattern of accuracy across sessions (as shown in Figure 3) suggest a possible trend toward improvement in the treated items. Additionally, the two-way interaction between the treated items and session was not significant ($\beta = -0.013$, $SE = 0.016$, $p = .429$, $OR = 0.98$, $CI [0.95, 1.02]$; see Figure 3). In addition, significant main effects were observed for semantically related ($\beta = 0.392$, $SE = 0.164$, $p = .016$, $OR = 1.47$, $CI [1.07, 2.03]$) and control ($\beta = -0.557$, $SE = 0.184$, $p = .002$, $OR = 1.02$, $CI [0.99, 1.04]$) items, indicating that near transfer effects occurred following verb-SFA treatment. However, the interaction between semantically related items and session

Figure 8. The performance of Pyramids and Palm Trees Test before and after semantic feature analysis (SFA) treatment between groups. The cross (x) indicates the mean value for each group. Asterisks (*) indicate statistically significant differences either within groups (pre vs. post) or between groups at each timepoint (* $p < .05$, ** $p < .01$, *** $p < .001$).

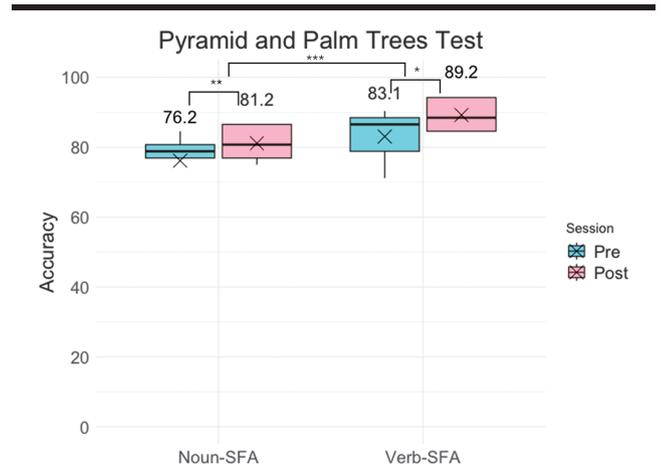


Table 4. Summary of the treatment and transfer effects based on the assessment domain in the groups.

Assessment domain	Noun-SFA group	Verb-SFA group	Between-group comparisons
Treatment effects of the treated on the probe set naming test	Sig.	Not sig.	Not sig.
Near transfer effects of the untreated items on the probe set naming test	Sig. <ul style="list-style-type: none"> Semantically related words 	Sig. <ul style="list-style-type: none"> Semantically related words Control words 	Sig. (noun-SFA < verb-SFA) <ul style="list-style-type: none"> Semantically related words Control words
Near transfer effects of the untreated items on the treated word class tests	Sig. (nouns to nouns) <ul style="list-style-type: none"> Noun naming test 	Sig. (verbs to verbs) <ul style="list-style-type: none"> Action naming test Action comprehension test Action fluency test 	Sig. (noun-SFA < verb-SFA) <ul style="list-style-type: none"> Action naming test Action comprehension test
Near transfer effects of the untreated items on the untreated word-class tests	Not sig. (nouns to verbs)	Not sig. (verbs to nouns)	
Far transfer effects on the sentence comprehension and production tests	Sig. <ul style="list-style-type: none"> Sentence comprehension Sentence priming 	Sig. <ul style="list-style-type: none"> Sentence comprehension Sentence priming Sentence completion 	Not sig.
Far transfer effects on the discourse production tasks	Sig. <ul style="list-style-type: none"> Noun/verb token Correct information units 	Sig. <ul style="list-style-type: none"> Number of utterances Verb token Noun TTR 	Not sig.
Far transfer effects on the semantic association test	Sig.	Sig.	Sig. (noun-SFA < verb-SFA)

Note. "Sig." indicates statistically significant improvement ($p < .05$); "Not sig." indicates nonsignificant results. The < and > signs denote relatively greater improvement in the indicated group in between-group comparisons. SFA = semantic feature analysis.

was not significant ($\beta = -0.022$, $SE = 0.016$, $p = .174$, $OR = 0.97$, $CI [0.94, 1.01]$). Notably, the interaction between control items and session was statistically significant ($\beta = 0.036$, $SE = 0.018$, $p = .047$, $OR = 1.34$, $CI [1.28, 1.41]$), suggesting that the accuracy of control items improved over the course of treatment (see Figure 3).

Near Transfer Effects on the Untreated Nouns and Verbs Tests

The ACT ($\beta = 1.487$, $SE = 0.567$, $p = .008$, $OR = 4.42$, $CI [1.45, 13.45]$) and the ANT ($\beta = 0.522$, $SE = 0.169$, $p = .002$, $OR = 1.68$, $CI [1.20, 2.34]$) both showed significant improvements after verb-SFA treatment. Additionally, the action fluency test demonstrated a statistically significant improvement following treatment ($\beta = 0.324$, $SE = 0.163$, $p = .047$, $IRR = 1.38$, $CI [1.00, 1.9]$; see Figure 5). These findings suggest that verb-SFA treatment effectively facilitated near transfer effects, enhancing verb comprehension, production, and fluency. However, when assessing potential near transfer to untreated nouns, the results differed. No significant improvements were observed in the K-BNT ($\beta = 0.19$, $SE = 0.103$, $p = .064$, $OR = 1.21$, $CI [0.98, 1.48]$), animal fluency ($\beta = -0.105$, $SE = 0.105$, $p = .316$, $IRR = 0.89$, $CI [0.73, 1.1]$), or supermarket fluency ($\beta = 0.169$, $SE = 0.111$, $p = .128$, $IRR = 1.18$, $CI [0.95, 1.47]$) tests following verb-SFA treatment. The results of the noun-related tests are presented in Figure 4.

Far Transfer Effects Beyond the Word-Level Tests

The far transfer effects on sentence-level abilities were all statistically significant. Accuracy on the SCT significantly improved after verb-SFA treatment ($\beta = 0.27$, $SE = 0.12$, $p = .025$, $OR = 1.31$, $CI [1.03, 1.65]$). In addition, significant improvements were observed in both the priming ($\beta = 5.999$, $SE = 1.66$, $p < .001$, $OR = 0.98$, $CI [0.94, 1.03]$) and completion ($\beta = 2.138$, $SE = 0.935$, $p = .022$, $OR = 1.34$, $CI [0.08, 1]$) conditions of the SPT (see Figure 6).

At the discourse level, the number of utterances significantly increased after verb-SFA treatment ($\beta = 0.141$, $SE = 0.07$, $p = .046$, $IRR = 1.15$, $CI [1.00, 1.32]$). However, no significant changes were observed in noun tokens ($p = .579$), noun types ($p = .407$), or the nouns-per-utterance ratio ($p = .414$). Notably, noun TTR significantly increased ($\beta = 0.05$, $SE = 0.017$, $p = .035$, $IRR = 0.95$, $CI [0.91, 0.98]$), suggesting greater lexical diversity in noun use posttreatment. Among verb-related measures, only verb tokens showed a significant increase ($\beta = 0.183$, $SE = 0.068$, $p = .007$, $IRR = 1.2$, $CI [1.05, 1.37]$). No significant changes were found for verb types ($p = .232$), verbs per utterance ($p = .657$), verb TTR ($p = .904$), or the NVR ($p = .385$). In addition, the CIU ratio did not significantly change after treatment ($p = .677$; see Figure 7). The LMM analysis revealed a significant improvement in nonverbal semantic association following

verb-SFA treatment, as reflected in the PPTT accuracy ($\beta = 2.757$, $SE = 1.152$, $p = .016$, $OR = 1.2$, $CI [0.81, 1.31]$; see Figure 8). Additionally, all participants in the verb-SFA group showed an increase of 5.4–11.8 points in AQ scores, indicating that 100% of the group experienced clinically meaningful improvements in aphasia severity, based on established criteria (Gilmore et al., 2019; see Appendix C). We provide a summary of the treatment and transfer effects based on the assessment domains for each group in Table 4.

Discussion

This study aimed to explore the treatment and transfer effects of noun-SFA and verb-SFA in Korean-speaking PWA. Through between-group comparisons, we sought to identify which type of SFA treatment more effectively promoted lexical and language recovery. Additionally, we examined the treatment effects within the noun-SFA and verb-SFA groups and evaluated both the near and far transfer effects across various linguistic levels for each treatment.

Treatment and Transfer Effects: Between-Group Comparison of SFA Treatments

The main focus of this study was to identify which type of SFA treatment—noun-SFA or verb-SFA—is more effective in enhancing treatment and transfer effects for Korean-speaking PWA. Although no statistically significant group difference was found in the treatment effect for the trained items, the overall results indicate that verb-SFA treatment was more effective than noun-SFA treatment, particularly in producing both near and far transfer effects. For the near transfer effects on the probe sets, verb-SFA was more successful in improving performance on semantically related items. These findings may reflect mechanisms consistent with the spreading activation theory, which posits that activating semantic features of treated items strengthens connections to related words within the semantic network. This result aligns with the study by Li and Kiran (2023), which compared noun- and verb-SFA treatments in English–Mandarin bilingual PWA. Their research demonstrated that both treatments improved performance on treated and semantically related items within the treated language, but the effect size was greater for the verb-SFA group. Although previous studies did not specifically examine the near transfer effects on control items in probe sets, our findings suggest that the verb-SFA group exhibited stronger near transfer effects on these control items compared to the noun-SFA group. This suggests that verb-SFA not only strengthens connections within the semantic processing for related items but also enhances overall lexical activation, leading to improvements in items outside the direct semantic field. This broader impact of verb-SFA is particularly

noteworthy, as it highlights the unique role that verbs play in the Korean language, potentially making this approach more universally effective across different linguistic contexts where verbs hold similar importance.

For the near transfer effects within untreated nouns (K-BNT, noun fluency tests) and verbs (ACT, ANT, action fluency test), we hypothesized that the verb-SFA group would exhibit greater near transfer across both untreated nouns and verbs. Our findings partially supported this hypothesis, as significant differences between groups were observed only in the treated word class tests (e.g., noun-SFA = nouns to nouns, verb-SFA = verbs to verbs). Specifically, on the group comparisons, the noun-SFA group did not show significant improvement in noun-related naming tests, whereas the verb-SFA group demonstrated significant near transfer effects in both verb naming and comprehension tests. These results suggest stronger near transfer effects within the treated word class for the verb-SFA group, while the noun-SFA group did not exhibit similarly strong near transfer effects within the noun word class. Regarding cross word class transfer (i.e., noun-SFA = nouns to verbs, verb-SFA = verbs to nouns), neither group showed statistically significant improvements. This contrasts with the findings of Li and Kiran (2023), who reported that both noun-SFA and verb-SFA led to significant transfer to the untreated word class. However, in our study, although the effect was not statistically significant, both directions showed nonsignificant numerical gains, which may reflect a descriptive trend toward cross word class transfer. This pattern warrants further investigation with increased treatment intensity or duration.

When comparing the two groups at the sentence and discourse levels, no statistically significant differences were observed. However, within-group analyses revealed that the verb-SFA group showed significant improvements across all three sentence-level tasks, whereas the noun-SFA group demonstrated significant gains in two out of three. In contrast, both groups showed comparable within-group gains across the discourse tasks. These patterns suggest that while group-level effects were not evident, verb-SFA may have led to more consistent improvements at the sentence level. Notably, the verb-SFA group demonstrated significantly greater improvement in nonverbal semantic association performance compared to the noun-SFA group. All participants in the verb-SFA group improved their PPTT performance, compared to three out of five participants in the noun-SFA group. Despite the PPTT focusing solely on nouns, the verb-SFA group showed significant gains without specific noun training. The PPTT requires recognizing, retrieving, activating, and comparing semantic information to identify associates (Humphreys & Riddoch, 2006). According to spreading activation models, verbs are thought to activate broader conceptual and lexical connections, facilitating efficient processing and generalization (Dell, 1986). Verb-SFA likely strengthens

these connections, enhancing performance even on nonverb-specific tasks like the PPTT.

In summary, the efficacy of verb-SFA treatment across various linguistic domains for Korean-speaking PWA may be influenced by the unique properties of Korean, a verb-final language where verbs and their thematic roles are processed later in the sentences. This structure may affect how semantic information is integrated during lexical retrieval, potentially increasing the salience and semantic activation of verbs positioned at the sentence-final point (Sung et al., 2016). While this may impose greater cognitive demands such as working memory or integration load, it may also create opportunities for enhanced semantic activation. Supporting this view, prior studies on VNeST in Korean-speaking PWA have shown that strengthening thematic role representations can significantly improve lexical retrieval for both treated and untreated verbs (S. E. Kim et al., 2022; Kwag et al., 2014). Although this study did not directly compare Korean with non-SOV languages, these findings suggest that verb-focused treatment may hold particular promise in verb-final languages. Further cross-linguistic research is needed to clarify the extent to which language structure mediates treatment outcomes.

Treatment and Transfer Effects: Within-Group Analysis of SFA Treatments

A secondary aim of this study was to assess the treatment and transfer effects of noun-SFA and verb-SFA within each group. The within-group analyses showed that both treatments were effective in eliciting direct and transfer effects in Korean-speaking individuals with aphasia, although the areas of improvement differed. Notably, verb-SFA treatment resulted in broader linguistic benefits across tests and modalities.

The noun-SFA group showed a statistically significant improvement in the accuracy of treated items, whereas the verb-SFA group exhibited a nonsignificant pattern of improvement. Near transfer effects to semantically related and control items were observed in both groups, consistent with previous studies supporting the efficacy of SFA in enhancing lexical retrieval (Edmonds & Kiran, 2006; Efstratiadou et al., 2019; Kiran et al., 2013; Li & Kiran, 2023).

In addition to near transfer effects on untreated word naming tests, both groups showed improvements in treated word classes (noun-SFA group = K-BNT, noun fluency tests, verb-SFT group = ACT, ANT, and action fluency test), consistent with prior studies (Edmonds & Kiran, 2006; Efstratiadou et al., 2019; Kiran et al., 2013; Li & Kiran, 2023). The verb-SFA group also showed gains in verb comprehension, suggesting that enhanced semantic activation for verbs may support both production and comprehension. Meanwhile, the verb-SFA group demonstrated near transfer effects in the action fluency test. However, as this test likely

included verbs directly targeted during treatment, the observed improvement may partly reflect practice effects rather than transfer effects alone. Neither group showed significant near transfer to the untreated word class (noun-SFA group = verb tests, verb-SFT group = noun tests), which contrasts with prior findings (Li & Kiran, 2023; Wambaugh & Ferguson, 2007).

At the sentence level, both treatments led to significant improvements in comprehension and production (SCT-priming), supporting the role of SFA in strengthening semantic processing for thematic role assignment and syntactic integration (Lerman et al., 2019; Li & Kiran, 2023). Interestingly, only the verb-SFA group showed significant gains in the sentence completion test, likely due to training in verb retrieval and argument structure mapping (Conroy et al., 2006; Webster & Whitworth, 2012).

At the discourse level, both groups improved in connected speech, aligning with prior findings that SFA enhances discourse informativeness (Conroy et al., 2009; Li & Kiran, 2023). Specifically, the noun-SFA group showed gains in %CIU, suggesting improved semantic informativeness (Nicholas & Brookshire, 1993), whereas the verb-SFA group showed increased utterance production. This may reflect Korean-specific syntactic features, where verbs alone can constitute complete utterances. Thus, the rise in utterance count after verb-SFA treatment may indicate more frequent and effective verb use in discourse.

Additionally, we hypothesized that strengthening semantic processing through SFA would enhance nonverbal semantic association. Both SFA treatments improved nonverbal semantic association abilities, consistent with previous findings that semantic and multimodal treatments enhance semantic access in PWA (Wallace & Kayode, 2017). Our results also align with Morris and Franklin (2012), who reported that semantic-based therapy improved both PPTT performance and naming abilities, supporting a far transfer effect from verbal to nonverbal semantic domains. Finally, the positive shift in aphasia severity scores following SFA treatment suggests that this approach effectively targets specific linguistic deficits and may also have broader implications beyond linguistic rehabilitation.

This study faced several limitations. First, the small sample size, resulting from challenges in recruiting participants for long-term involvement, limits the generalizability of the findings. Second, detailed neuroimaging data were not available for all participants. While lesion laterality was confirmed through hospital records for most individuals, the absence of comprehensive lesion information in some cases limits the precision of lesion-specific interpretation. Future research should include larger participant samples with comprehensive neuroimaging verification to better evaluate the effects of each SFA treatment and to enable more fine-grained lesion-based analyses.

Third, the study did not account for the influence of different aphasia types on treatment and transfer effects. Since lexico-semantic associations may vary across aphasia subtypes, considering these differences could reveal stronger treatment effects for certain subtypes. Furthermore, lexical retrieval deficits in PWA can arise from impairments in either the semantic or phonological phase, or both. Distinguishing between these deficit profiles may help refine SFA treatment strategies in future studies. Fourth, limitations exist in the selection of probe items. Although phonological similarity across probe sets was considered during the design process, it was not strictly controlled, which may have influenced the results. Addressing this issue could enhance the robustness of future findings. Fifth, the use of different picture styles for noun and verb stimuli—color drawings for nouns and line drawings for verbs—might have introduced unintended variability. Ensuring consistent visual presentation across stimuli could help eliminate this potential confound. Finally, while we established both intrarater (98.0%) and interrater (98.2% for transcription/segmentation and 93.8% for discourse measures) reliability with high percent agreement, we did not calculate statistical indices such as intraclass correlation coefficients or Cohen's kappa. This may limit the precision and comparability of our reliability estimates across studies. Future research should incorporate these statistical indices in addition to percent agreement to provide a more robust and standardized evaluation of transcription and coding reliability.

Conclusions

Both noun-SFA and verb-SFA treatments demonstrated positive treatment and transfer effects for Korean-speaking PWA. While the verb-SFA group appeared to show broader effects across certain linguistic domains, as well as in aphasia severity and nonverbal semantic association, the noun-SFA group also exhibited meaningful gains across multiple linguistic domains. These findings contrast somewhat with previous studies conducted in English-speaking contexts. For instance, Li and Kiran's (2023) research on English-Mandarin bilinguals revealed distinct treatment and transfer effects for both noun-SFA and verb-SFA, with cross-language generalization effects being more pronounced in the verb-SFA group, while the noun-SFA group exhibited greater improvements in discourse and verb naming tasks.

In the present study, the relatively strong outcomes observed in the verb-SFA group may be influenced by the linguistic characteristics of Korean, a verb-final language in which verbs play a salient role in sentence construction. While such structural features may facilitate semantic activation in certain contexts, especially those involving thematic role assignment and sentence processing, further

cross-linguistic research is needed to clarify how language structure interacts with treatment efficacy. These findings underscore the necessity of tailoring SFA treatments to the specific linguistic structures of the target language.

This suggests that SFA treatments should be adapted not just to the individual needs of patients but also to the linguistic characteristics of the target language. Future research should continue to explore the efficacy of verb-SFA in other languages with verb-final word order structures, as well as its potential applications in other neurogenic language disorder groups. Furthermore, this study highlights the importance of linguistic consideration in clinical treatment. While the positive effects of verb-SFA in Korean-speaking PWA are evident, it is crucial to recognize that the effectiveness of language treatments may vary significantly depending on the language's syntactic and semantic structures, as well as across individuals and aphasia subtypes. Therefore, continued research and adaptation of these treatment methods across different languages and patient populations are essential for optimizing outcomes in aphasia rehabilitation.

Author Contributions

Sujin Choi: Conceptualization, Formal analysis, Investigation, Writing – original draft. **Jee Eun Sung:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Data Availability Statement

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Appendix A
Individual Scores of Pre- and Post-Assessments for Each Group

Assessment	Noun-SFA group										Verb-SFA group											
	S1-N		S2-N		S3-N		S4-N		S5-N		S1-V		S2-V		S3-V		S4-V		S5-V			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post		
Near transfer effects	Korean version of Boston Naming Test (/60)		35	39	4	4	34	47	6	30	24	21	29	32	40	50	23	29	42	44	30	47
	Animal Fluency Test		12	14	0	3	8	11	2	4	5	2	6	5	13	12	13	7	9	11	11	10
	Supermarket Fluency Test		5	6	2	2	6	5	4	2	0	1	11	12	7	12	7	6	3	13	9	9
	Action Comprehension Test (/24)		21	22	16	20	24	24	22	23	18	17	20	24	22	24	19	23	21	26	20	24
	Action Naming Test (/40)		22	15	1	4	35	38	22	36	26	31	11	26	32	37	23	34	29	36	24	36
Far transfer effects	Action Fluency Test		1	3	0	1	3	5	0	3	0	0	1	3	8	11	3	12	2	2	4	4
	Sentence Comprehension Test (/36)		18	23	18	19	22	30	12	23	17	23	19	24	20	26	19	24	20	25	24	31
	Sentence Production Test-Priming (/24)		6	8	0	0	15	17	11	16	1	4	8	12	19	22	9	14	20	22	15	22
	Sentence Production Test-Completion (/24)		3	7	0	2	11	14	11	14	3	4	8	10	16	20	7	13	11	14	14	20
	Number of utterances		41	33	5	7	29	32	13	22	14	19	18	19	24	20	38	47	19	27	13	28
	Noun token		80	66	4	11	103	127	32	64	25	47	22	33	82	74	109	152	45	65	38	82
	Noun type		41	41	4	9	59	64	26	38	16	31	16	19	50	46	69	76	28	34	26	42
	Nouns per utterance		1.95	2	0.8	1.57	3.55	3.96	2.46	2.9	1.78	2.47	1.22	2.06	3.41	1.7	2.86	3.23	3.36	2.29	2.92	2.92
	Noun type-token ratio		0.51	0.62	1	0.81	0.5	0.81	0.81	0.59	0.64	0.66	0.72	0.57	0.61	0.62	0.63	0.5	0.62	0.54	0.68	0.51
	Verb token		63	55	2	2	90	131	14	43	38	69	25	13	67	76	97	165	52	78	35	61
	Verb type		31	24	2	0	55	57	13	26	23	41	13	12	48	43	53	81	33	43	25	37
	Verbs per utterance		1.53	1.66	0.4	0.28	3.1	4.09	1.07	1.95	2.71	3.63	1.38	0.81	2.79	3.8	2.47	3.51	2.73	2.88	2.69	2.17
Verb type-token ratio		0.49	0.43	1	0	0.61	0.43	0.92	0.6	0.6	0.59	0.52	0.92	0.71	0.53	0.56	0.49	0.63	0.55	0.71	0.63	
Noun-to-verb ratio		1.27	1.2	2	5.5	1.14	0.96	2.28	1.48	0.65	0.68	0.88	2.53	1.22	0.97	1.16	0.92	0.86	0.76	1.08	1.34	
Correct information unit		0.5	0.59	0.57	0.65	0.79	0.92	0.66	0.76	0.64	0.75	0.53	0.61	0.89	0.87	0.74	0.8	0.88	0.95	0.95	0.92	
Pyramids and Palm Trees Test (/52)		44	42	41	40	42	45	40	45	31	39	37	44	47	49	46	49	41	44	45	46	

Note. SFA = semantic feature analysis.

Appendix B

Individual Performance on Paradise Korean-Western Aphasia Battery–Revised Scores Before and After Noun–Semantic Feature Analysis Treatment

ID	AQ		Type		Information content		Fluency		Auditory comprehension		Repetition		Naming	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S1-N	55.9	70.8	Wernicke's → Anomic		7	8	6	6	4.75	7.4	2.3	5.6	7.9	8.4
S2-N	24.6	37.1	Broca's		4	4	1	3	3.9	5.25	0.8	1.6	2.6	4.7
S3-N	84.5	87.8	Anomic		8	9	8	8	9.05	9.4	9	9	8.2	8.5
S4-N	69	77.6	Anomic		7	8	5	6	7.7	8.6	8	8.4	6.8	7.8
S5-N	70.6	65	Anomic		7	6	5	6	8.7	7.1	8.2	7.6	7	5.8

Note. AQ = Aphasia Quotient.

Appendix C

Individual Performance on Paradise Korean-Western Aphasia Battery–Revised Scores Before and After Verb–Semantic Feature Analysis Treatment

ID	AQ		Type		Information content		Fluency		Auditory comprehension		Repetition		Naming	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S6-V	58.5	67.4	Conduction		6	7	6	6	7.25	8.6	2.8	4	7.2	8.1
S7-V	78.4	82.6	Anomic		9	9	9	9	7.8	8.9	4.3	6	9.1	8.4
S8-V	52.4	58	Wernicke's		7	8	6	7	5.2	5.3	2.2	2.6	5.8	6.1
S9-V	84.5	89.3	Anomic		8	9	8	8	8.75	9.15	9.2	9.6	8.3	8.9
S10-V	78.9	90.7	Anomic		8	9	7	8	8.05	9.85	8.1	9.7	8.3	8.8

Note. AQ = Aphasia Quotient.