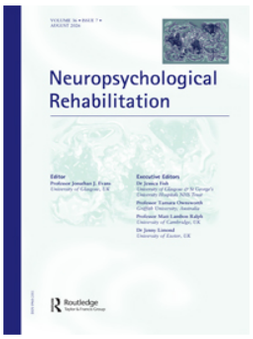

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Verb-Semantic Feature Analysis for Alzheimer's Dementia in a verb-final language: evidence from Korean

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ABSTRACT

This study examined the effects of Verb-Semantic Feature Analysis (Verb-SFA) on verb naming, noun retrieval, sentence comprehension, and discourse production in individuals with Dementia of the Alzheimer's Type (DAT). Given the lexical–semantic degradation characteristic of DAT and the central role of verbs in Korean, a verb-final language, this study evaluated whether Verb-SFA facilitates treatment, near-transfer, and far-transfer effects. Three male participants, aged 60 or older with 16 years of education, completed 17 sessions: pre-treatment (4 sessions), treatment (10 sessions), and post-treatment (3 sessions). Treatment effects were assessed using 45-item probe sets derived from the Korean Item Selection Naming Test. Results showed significant improvement in naming accuracy for treated verbs, with a robust interaction between treatment sessions and treated items. No significant near-transfer effects were found for untreated verbs in the probe set or on the Action Naming Test. However, significant near-transfer effects were observed for noun retrieval on the Korean-Boston Naming Test, although verbal fluency tasks showed no improvement. Far-transfer effects emerged in sentence comprehension, suggesting strengthened verb–semantic processing supports higher-level linguistic abilities. No measurable gains were observed in discourse production. Overall, Verb-SFA treatment enhanced verb naming and sentence comprehension in individuals with DAT.

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Verb-SFA(Semantic feature analysis); dementia of the Alzheimer's type (DAT); near-transfer effects; far-transfer effects; verb-final language

Introduction

Dementia of the Alzheimer's Type (DAT) is a progressive neurodegenerative disorder characterized by deterioration of memory, conceptual knowledge, and language, ultimately resulting in profound communication challenges and functional decline (McKhann et al., 1984; Mohs et al., 1986; Nussbaum & Ellis, 2003). These linguistic impairments arise primarily from widespread degradation of the

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lexical–semantic system, as DAT leads to neuronal loss in cortical regions critical for semantic memory and language processing. Consequently, individuals with DAT show pronounced naming difficulties – a hallmark symptom that emerges early and worsens as semantic representations undergo hierarchical degradation, with specific item-level knowledge declining earlier than general categorical information (Appell et al., 1982; Bayles & Trosset, 1992; Chertkow & Bub, 1990; Hodges et al., 1992). Naming attempts frequently include circumlocutions, vague or unrelated descriptions, personal-experience–based explanations, and semantic paraphasias (Bowles et al., 1987; Parks & Haxby, 1993), reflecting the progressive loss of conceptual detail.

Although naming impairments in DAT are well documented, much of the existing literature has focused disproportionately on nouns, offering extensive insight into how semantic deterioration affects concrete object naming (Efstratiadou et al., 2018; Kiran et al., 2013; Massaro & Tompkins, 1994; Peñaloza et al., 2020). However, naming deficits are not uniform across word classes. Research indicates that verbs often place greater demands on the semantic and syntactic systems due to their relational structure and argument complexity (Kim & Thompson, 2000; Marshall et al., 1998; Thompson, 2003). This pattern underscores a critical yet underexplored need: understanding verb retrieval deficits in DAT and incorporating them into intervention frameworks.

Despite the clinical importance of lexical–semantic impairments in DAT, naming treatment research in this population remains limited, especially compared to the extensive aphasia literature. Existing DAT studies have primarily targeted noun-retrieval processing, with few addressing verb naming or broader linguistic outcomes. Moreover, even noun-focused treatments have shown inconsistent generalization, with improvements often restricted to trained items (Jelcic et al., 2012; Jokel & Anderson, 2012). These limitations underscore the need for treatment approaches that more effectively strengthen underlying semantic networks and thereby facilitate generalization beyond trained items.

Semantic Feature Analysis (SFA) is a semantic-based naming approach in which a target word is introduced and the individual is guided to activate semantically related information associated with that word. Early SFA work (Ylvisaker & Szekeres, 1985) organized semantic information into several feature categories, and later aphasia studies adopted similar procedures by encouraging participants to identify or sort features related to a given target, thereby strengthening semantic network activation (Boyle & Coelho, 1995; Efstratiadou et al., 2018; Kiran & Thompson, 2003; Peñaloza et al., 2020; Sandberg et al., 2020). More recent research has refined SFA into a structured, multi-step protocol and emphasized that processes such as generating, selecting, and verifying semantic features serve as key mechanisms driving treatment effects (Li et al., 2022; Peñaloza et al., 2020; Sandberg et al., 2020). Building on these mechanisms, Li and Kiran (2023) extended SFA to verbs and demonstrated that Verb-SFA improved both noun and verb naming in individuals with aphasia. Choi

and Sung (2026) further adapted Verb-SFA for Korean by integrating verb-specific semantic features and utilizing the Korean Item Selection Naming Test (ISNT; Choi et al., 2023) to construct individualized probe sets. Their findings similarly showed significant gains in verb and noun retrieval in Korean speakers with aphasia.

A major gap in prior research concerns the linguistic characteristics of Korean, a verb-salient, verb-final, agglutinative language in which verbs carry extensive grammatical and semantic information and obligatorily appear in sentence-final position (Choi, 2020; Sohn, 1999; Sung et al., 2016). Because verbs function as the core predicates of sentences, successful verb retrieval may also support broader discourse organization by facilitating the integration of semantic and syntactic information during connected speech production. Previous research has suggested that improved access to verbs may contribute to sentence generation and discourse-level language processing by supporting the organization of thematic relationships and predicate structures during communication (Wambaugh & Ferguson, 2007). This linguistic profile suggests that verb-focused interventions may have particularly strong potential to influence broader communication abilities in Korean-speaking individuals.

In treatment studies, transfer effects are essential indicators of whether therapeutic gains extend beyond trained stimuli. Transfer effects refer to the application of knowledge or skills learned in one context to new items or tasks (Weng et al., 2019). Based on domain similarity, transfer is typically categorized into near transfer, referring to improvements in linguistically similar, untrained items (e.g., untreated nouns/verbs at the word level), and far transfer, referring to improvements in broader linguistic domains such as sentence comprehension or discourse production (Barnett & Ceci, 2002). Evaluating both levels of transfer is particularly important for DAT, where communication difficulties extend beyond isolated lexical deficits.

Building on these theoretical and empirical foundations, the present study is one of the first to apply Verb-SFA to Korean-speaking individuals with DAT. This study aims to evaluate (1) treatment effects on treated verbs using a probe set naming test, (2) near-transfer effects on untreated semantically related and unrelated verbs and nouns, and (3) far-transfer effects on sentence comprehension and discourse production. By examining both lexical and higher-level outcomes, including sentence comprehension and discourse production, this study seeks to expand understanding of how verb-centered semantic treatment can support communication in individuals with DAT and address critical gaps in the intervention literature.

This study focuses on addressing the following questions:

1. Primary outcome measures (verb naming measures)
   A. Does the Verb-SFA treatment improve naming accuracy for treated verbs in the probe set naming test?

B. Does the Verb-SFA treatment improve naming accuracy for untreated verbs (semantically related, control) in the probe set naming test?

2. Secondary outcome measures
   A. Does the Verb-SFA treatment improve the Action Naming Test (ANT; Sung et al., 2014)?
   B. Does the Verb-SFA treatment improve standardized noun naming accuracy (e.g., Korean-BNT, Kim & Na, 1997)?
   C. Does the Verb-SFA treatment improve noun and action verbal fluency tasks?
   D. Does the Verb-SFA treatment improve on sentence comprehension and discourse production abilities?

Materials and methods

Participants

Dementia a total of three Korean-speaking individuals with DAT participated in this study. All participants were diagnosed with DAT by neurologists, based on the criteria established by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984). To determine eligibility, participants completed a series of screening assessments. This included the Korean Version of the Short Form Geriatric Depression Scale (SGDS-K; Jung et al., 1997), with all participants scoring below 8, indicating no clinical depression. A History Form and Health Screening Questionnaire (Christensen et al., 1991) were also administered to collect essential demographic, medical, and cognitive background information.

The specific inclusion criteria for participant selection were as follows: (1) aged 60 years or older; (2) self-reported no significant difficulties with vision or hearing in daily life; (3) ability to read words, as verified by the reading items of the Korean-Mini Mental State Examination (K-MMSE; Kang, 2006); (4) a score of 1 on the Clinical Dementia Rating Scale (CDR; Morris, 1993), indicating mild dementia; and (5) a Global Deterioration Scale (GDS; Reisberg et al., 1982) score of either stage 4 (mild) or stage 5 (moderate). The demographic information is provided in Table 1.

Table 1. Demographic information of participants.

P	Age (Yrs)	Gender	Education (Yrs)	CDR	GDS	K-MMSE (/30) (%ile)	SGDS-K (/15)
P1	74	Male	16	1	4	27 (11.95%ile)	4
P2	66	Male	16	1	4	24 (0.01%ile)	4
P3	84	Male	16	1	5	23 (0.27%ile)	1

Note: *P* = Participant; GDS = Global Deterioration Scale (Reisberg et al., 1982); SGDS-K = Korean Version of the Short Form Geriatric Depression Scale (SGDS-K; Jung et al., 1997); CDR = Clinical Dementia Rating Scale (Morris, 1993); K-MMSE = Korean-Mini Mental State Examination (Kang, 2006)

Before participation, all individuals were fully informed about the study procedures and provided written informed consent. Ethical approval for this study was obtained from the Institutional Review Board of Ewha Womans University (IRB No. 2022-0112), in accordance with established guidelines for research involving human participants.

Procedures

To evaluate the primary and secondary outcome measures of the study, a series of standardized language and cognitive assessments were administered before and after the treatment intervention.

Primary outcome measures: verb naming measures

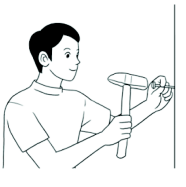
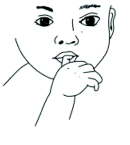
To evaluate the primary treatment outcomes of Verb-SFA, individualized probe sets were constructed using the Korean Item Selection Naming Test (ISNT; Choi et al., 2023) prior to treatment. The ISNT consisted of a list of 127 verbs accompanied by picture stimuli. Participants were asked to name each verb, and all probe set items were selected from the verbs they named incorrectly. Based on the ISNT results, individualized probe sets were constructed to include (1) 15 treated verbs, (2) 15 semantically related verbs to the treated verbs, and (3) 15 untreated control verbs. All probe items were selected from the ISNT stimulus set and semantic feature database developed by Choi et al. (2023), which was validated for semantic feature agreement in Korean. However, psycholinguistic variables such as word frequency and word length were not systematically controlled across probe items in the present study.

Semantically related verbs were chosen based on their overlap in semantic features with the treated verbs, such as agent, theme or object, manner or instrument, and location. For example, when the treated verb "climb" (Korean: "oluta") was selected, the semantically related verb "fall" (Korean: "ttelecita") was chosen based on their shared semantic feature of vertical movement. These two verbs are considered semantically related in terms of directional action. Such decisions were guided by the feature classification system proposed by Choi et al. (2023) and cross-referenced with Korean verb semantics.

By contrast, control verbs were selected from incorrectly named verbs that shared no semantic overlap with either the treated verb or its semantically related counterpart. For instance, "carry" (Korean: "naluta") was assigned as the control verb for climb (Korean: "oluta"), as it did not share any semantic features with either climb or fall. All probe items were paired with picture stimuli from the ISNT (Choi et al., 2023). A multiple-baseline design (Connell & Thompson, 1986) was employed to systematically assess treatment effects, specifically targeting improvements in treated verbs over time. The treatment consisted of three phases: baseline, treatment, and post-treatment assessments.

Before the treatment began, all participants underwent three consecutive probe sessions to establish their baseline accuracy in naming. The same 45 target verbs (15 treated, 15 semantically related, and 15 control verbs) were administered across all three baseline probe sessions and presented in randomized order to minimize potential learning effects. The same 45-item naming probe was administered at the beginning of every other treatment session (i.e., five out of ten sessions), allowing for monitoring of progress throughout the treatment phase. Following the completion of treatment, three post-treatment probe sessions were conducted to evaluate retention and generalization of treatment effects. All responses were audio- and video-recorded for subsequent detailed analysis. Examples of the probe set items are provided in Table 2.

Table 2. Examples of the probe set items.

Set	Treated verbs	Semantically related verbs	Untreated control verbs
1	 Climb (Korean: 'oluta')	 Fall (Korean: 'ttelecita')	 Carry (Korean: 'naluta')
2	 Hit (Korean: 'chita')	 Hammer (Korean: 'pakta')	 Scoop (Korean: 'phwuta')
3	 Mix (Korean: 'sekkta')	 Stir (Korean: 'cesta')	 Wash (Korean: 'ppalta')

Verb-SFA treatment protocol

The Verb-SFA treatment protocol was based on a previous study by Choi and Sung (2026). The treatment protocol consisted of the six steps as follows:

1. Step 1 (Picture Naming): Participants were presented with an image depicting a target action and asked to name the verb. Immediate feedback was provided regardless of the accuracy of their response.
2. Step 2 (Feature Description): Participants were presented with 15 semantic features for each treated verb, selected from the validated Korean Semantic Feature Database (Choi et al., 2023). These included 11 semantically related features and 4 unrelated distractors. The features were categorized into Agent, Object/Purpose, Method (instrument or body part), Physical Attributes, and Location. Participants identified and categorized each feature, encouraging semantic elaboration and activation of relevant verb-related knowledge. If they had difficulty understanding or classifying a feature, the clinician provided clarification.
3. Step 3 (Association): Participants were prompted to relate the target verb to personal experiences or familiar contexts (e.g., "Have you ever done this action?" or "Have you seen someone perform this action before?"). This step was designed to promote deeper semantic encoding and facilitate retrieval by encouraging personal relevance and contextual grounding of the verb meaning. When participants struggled to recall relevant experiences, the clinician offered prompts to stimulate contextual connections.
4. Step 4 (Feature Verification): Participants were shown the same 15 features and asked to verify whether each one applied to the target verb by answering Yes/No. The features were randomly presented to facilitate semantic decision-making. After completing this step, a summary page displaying all features was presented. Incorrect responses were reviewed and corrected during this summary review, with guidance from the clinician to reinforce accurate semantic associations.
5. Step 5 (Naming Reattempt): The target verb was presented again, and participants attempted to name it a second time. If they continued to have difficulty, previously reviewed semantic features were briefly reiterated to facilitate retrieval.
6. Step 6 (Sentence Production): Participants were asked to generate a grammatically correct sentence using the target verb. If they struggled, the clinician provided semantic cues related to the categories used in Step 2 (e.g., "Where does this action take place?"). If necessary, a model sentence was provided.

The same scoring criteria were applied consistently across all six steps of the treatment protocol. Participants received one point for correctly naming a

target verb, including responses with minor phonological errors, dialectal variations, or tense modifications. Responses were scored as incorrect (0 points) if they were unintelligible, contained multiple phonemic errors, or were left unanswered.

The Verb-SFA treatment was conducted remotely using Zoom (https://zoom.us/), an online platform for real-time videoconferencing, and was supported by PsychoPy3 (Peirce, 2007) on Pavlovia (https://pavlovia.org/) to ensure structured presentation of treatment materials. Each session lasted approximately 60 min. Participants completed a total of ten treatment sessions over a period of two to four weeks. Specifically, Participants 1 and 3 completed three sessions per week over four weeks, while Participant 2 completed five sessions per week over two weeks.

Secondary outcome measures

Untreated verb measures

1. Action Naming Test: To evaluate verb retrieval, the action naming test (ANT; Sung et al., 2014) was used. This test included 40 animated stimuli depicting various actions, categorized into one-place unergative verbs (7 items), one-place unaccusative verbs (6 items), two-place verbs (14 items), and three-place verbs (13 items). Each correct response was assigned 1 point, while incorrect responses received a score of 0, with a total possible score of 40.
2. Action Fluency Test: In the action fluency test (AFT), participants produced as many verbs as possible in one minute, following a similar scoring procedure. In this test, participants were instructed to generate as many action verbs as possible within one minute. Each correctly produced verb was awarded 1 point. Repetitions, nouns, and non-verbal responses were excluded from scoring. Errors such as naming the same verb in a different tense (e.g., "eat" and "ate") or using the same verb with a different subject were considered redundant and not scored.

Untreated noun measures

1. K-BNT: To assess noun retrieval abilities, the K-BNT (Kim & Na, 1997) was administered. Participants were shown standardized picture stimuli and asked to name each image. A 30-item version of the test was used, with odd-numbered items presented during the pre-treatment assessment and even-numbered items during the post-treatment assessment.
2. Verbal Fluency Test: Two types of verbal fluency tasks (VFT) were conducted: noun VFT (animals, supermarket items) and verb VFT. The Controlled Oral Word Association Test (COWAT; Kang et al., 2000) was used to measure the noun VFT. Participants were required to generate words within each

category for 60 s, with repeated responses or unrelated words excluded from scoring.

Sentences and discourse level tests

1. Sentence Comprehension Test: The Sentence Comprehension Test (SCT; Sung et al., 2021) was administered to assess syntactic processing abilities. This test consisted of 36 items and included six canonical and six non-canonical sentence structures across three syntactic categories: passive sentences, active sentences with two-place arguments, and active sentences with three-place arguments. Participants' responses were scored based on accuracy, with a maximum possible score of 36.
2. Discourse Production Tasks and Picture Descriptions: Discourse production abilities were evaluated using single picture descriptions and discourse tasks, which are widely used in analyzing spontaneous speech (MacWhinney et al., 2011). Three picture description tasks were included: the "Beach" picture from the Paradise-Korean version of the Western Aphasia Battery-Revised (PK-WAB-R; Kim & Na, 2012), the "Han River" picture (Patent no. D2022-0004KR) developed by Jeong et al. (2023), and the "Cat Rescue" picture (Nicholas & Brookshire, 1993) from AphasiaBank. In addition, a storytelling task was included using the Korean folktale "Heungbu-Nolbu (흥부놀부)" (Choi et al., 2022), which is culturally relevant for Korean speakers. Discourse samples were analyzed using the criteria outlined by Sung et al. (2016), which included the number of utterances, noun tokens, noun types, noun Type-to-Token Ratio (TTR), nouns per utterance, verb tokens, verb types, verb-TTR, verbs per utterance, and the Noun-to-Verb Ratio (NVR).

Cognitive assessment measures

1. General cognitive test: The Korean-Mini Mental State Examination (K-MMSE, Kang, 2006) was used to assess general cognitive abilities. This widely used screening tool evaluates orientation, attention, memory, visuospatial abilities, and language, with a total possible score of 30.
2. Verbal learning test: To measure verbal memory, the Seoul Verbal Learning Test (SVLT; Kang & Na, 2003) was administered. The SVLT includes an immediate recall task (SVLT_IMM), where participants were presented with a 12-word list and asked to recall as many words as possible immediately following each presentation. This process was repeated three times, with a total possible score of 36. The delayed recall task (SVLT_D) was conducted 20 min later, during which participants attempted to recall words from the same list, with a maximum possible score of 12.

3. Working memory test: Working memory capacity was assessed using the Digit Span Test (DST; Kang et al., 2012), a subtest from the Seoul Neuropsychological Screening Battery 2nd Edition (SNSB-II). This test included two subcomponents: the Digit Forward (DF) task, in which participants repeated number sequences in the same order as presented to assess attention span, and the Digit Backward (DB) task, in which participants repeated numbers in reverse order to measure working memory. The total working memory score was calculated as the sum of the DF and DB scores.

A summary of the pre- and post-treatment assessment measures is provided in Table 3, and a diagram outlining the overall study procedures is presented in Figure 1.

Table 3. Summary of pre-and post-assessment measures and effects.

Pre-and post-treatment assessment lists		Assessment effects
Korean version-Boston Naming Test (K-BNT)		Near-transfer effects on untreated nouns
"Animal" and "Supermarket items" verbal fluency tasks (VFT)		
Action Naming Test (ANT)		Near-transfer effects on untreated verbs
"Action" VFT		
Sentence Comprehension Test (SCT)		Far-transfer effects on syntactic processing abilities
Discourse production tasks & picture descriptions		Far-transfer effects on discourse production abilities
Item Selection Naming Tests (ISNT)	Treated verbs	Treatment effects on treated verbs
	Untreated semantically related verbs	Near-transfer effects on semantically related verbs
	Untreated control verbs	Near-transfer effects on control verbs

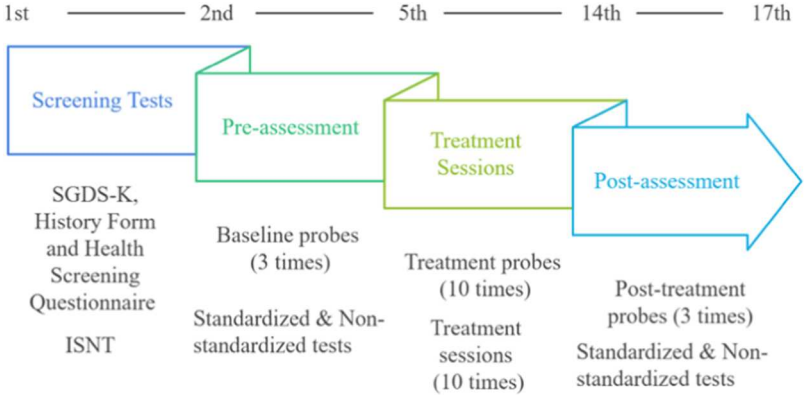


Figure 1. Diagram of study procedures. Note: SGDS-K=Korean Version of the Short Form Geriatric Depression Scale (SGDS-K; Jung et al., 1997); ISNT=Item Selection Naming Tests (ISNT; Choi et al., 2023); Sessions 1–3 indicate baseline probes, Sessions 4–13 indicate the treatment phase, including treatment sessions and intermittent treatment probes, and Sessions 14–17 indicate post-treatment assessments and probes.

Statistical analysis

Statistical analyses were conducted using R Studio (version 4.4.2), with statistical significance set at $p < .05$. Analyses were selected based on the type of dependent variable.

For binary outcome variables, such as item-level accuracy in the probe set naming task, Action Naming Test (ANT), Korean-Boston Naming Test (K-BNT), and Sentence Comprehension Test (SCT), generalized linear mixed-effects models (GLMMs) with a binomial distribution and logit link were used. In the analysis of probe set naming accuracy, fixed effects included probe session (pre-treatment, during treatment, post-treatment) and item set (treated, semantically related, control), with random intercepts for participants and items, and random slopes for probe session. The interaction between probe session and item set was tested to evaluate differential effects across item types. For the other binary tasks (ANT, K-BNT, SCT), timepoint (pre vs. post) was entered as a fixed effect, with random intercepts for participants and items.

For count variables, such as the number of correct responses in verb and noun fluency tasks, and count-based discourse measures (e.g., number of utterances, noun/verb tokens, and types), Poisson GLMMs with a log link were applied. Models included timepoint as a fixed effect and participant as a random intercept.

For continuous or ratio variables, such as type-token ratios and noun-to-verb ratios in discourse production, linear mixed-effects models (LMMs) were used. Each model included timepoint as a fixed effect and participant as a random intercept. We applied sum coding (–1, 1) for contrast coding, which centers the model intercept at the grand mean and allows each predictor to reflect half the difference between conditions, enabling more balanced interpretation of effects (Brehm & Alday, 2022). Model convergence and singularity were inspected during all mixed-effects analyses, and no major convergence issues were observed. For Poisson models, overdispersion diagnostics were additionally examined to assess model fit.

Results

Primary outcome measures: Item Selection Naming Test (ISNT) performance

1. Treatment effects on treated verbs

To examine treatment effects on the treated verbs, we conducted a generalized mixed-effects model. The analysis revealed a significant main effect of the post-treatment session, indicating that naming accuracy for treated verbs improved following the Verb-SFA treatment ($\beta = 0.999$, $SE = 0.204$, $p < 0.001$). Additionally,

a significant main effect was observed for accuracy for treated verbs (β = 1.526, SE = 0.279, $p < 0.001$), demonstrating that treated verbs had higher overall accuracy compared to the grand mean accuracy across all items. The significant interaction between probe sessions and treated verbs (β = 2.235, SE = 0.447, $p < 0.001$) showed that naming accuracy for treated verbs significantly improved over time, suggesting the effectiveness of Verb-SFA treatment.

2. Near-Transfer effects on untreated verbs (Semantically related / Control)

To identify near-transfer effects, we examined naming performance for semantically related verbs and control verbs. The analysis showed a significant main effect (β = 1.029, SE = 0.207, $p < .001$), indicating that semantically related verbs were named with higher accuracy than the grand mean across all items. However, the interaction between probe sessions and semantically related verbs was not statistically significant (β = 0.471, SE = 0.342, $p = 0.169$), suggesting that although semantically related verbs were named more accurately overall, their accuracy did not show significant improvement over time.

For control verbs, the analysis showed a significant main effect (β = −2.165, SE = 0.431, $p < 0.001$), indicating that control verbs had lower overall accuracy than the grand mean across all items. The interaction between probe sessions and control verbs was not significant (β = −0.295, SE = 0.322, $p = 0.360$), suggesting that performance on control verbs remained stable and did not improve as a result of treatment. Table 4 presents mean accuracy values across the pre-treatment, treatment, and post-treatment probe phases for each participant, whereas Figure 2 illustrates session-by-session changes in naming performance across all probe sessions.

Secondary outcome measures

1. Untreated verb tests (ANT, AFT)

To evaluate the near-transfer effects of the Verb-SFA treatment on broader verb retrieval abilities, analyses were conducted on the ANT and the AFT. For the

Table 4. Mean accuracy of probe set naming tests across sessions for each participant.

	Pre-treatment probes Mean (SE)			Treatment probes Mean (SE)			Post-treatment probes Mean (SE)		
P	Treated	SR	Control	Treated	SR	Control	Treated	SR	Control
P1	0.33 (0.33)	4.00 (0.58)	2.33 (0.33)	6.90 (1.32)	9.50 (0.72)	6.80 (1.11)	13.67 (0.33)	12.67 (0.33)	13.00 (0.00)
P2	4.00 (0.58)	3.33 (0.33)	1.33 (0.33)	9.00 (1.2)	6.40 (0.99)	3.60 (0.45)	14.33 (0.67)	11.67 (0.88)	5.33 (0.33)
P3	3.00 (0.58)	2.67 (0.67)	1.33 (0.33)	8.20 (1.34)	4.20 (0.66)	3.70 (0.63)	13.00 (1.00)	9.00 (0.58)	7.33 (0.88)

Note: *P* = Participant; SE = Standard Error; SR = Semantically Related Verbs.

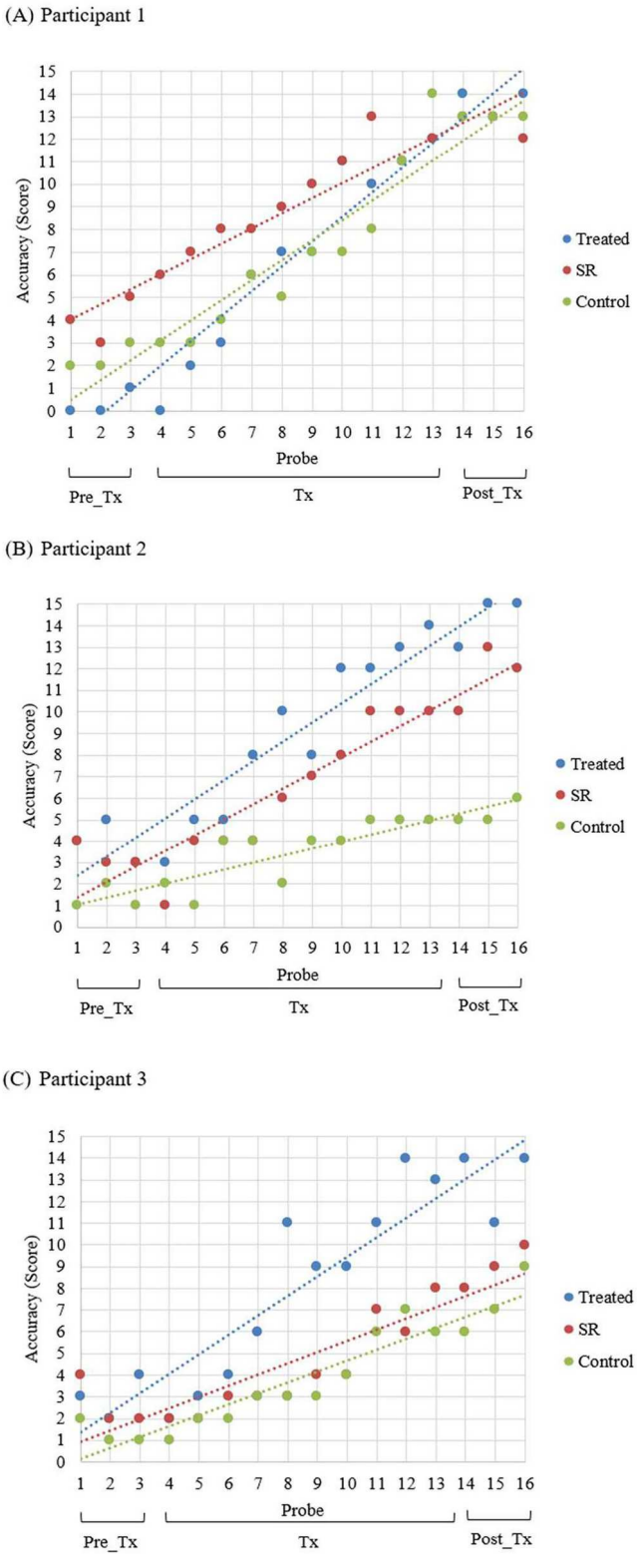


Figure 2. Accuracy in the probe set naming task across probe sessions for each participant: (A) Participant 1, (B) Participant 2, (C) Participant 3. The figure illustrates session-by-session changes in naming accuracy across all probe sessions.

ANT, a significant intercept effect was observed (β = 2.449, SE = 0.772, $p = 0.002$), indicating that overall task performance was relatively high. However, the effect of timepoint (pre- vs. post-treatment) was not statistically significant (β = 0.330, SE = 0.208, $p = 0.112$), suggesting that accuracy in action naming did not significantly improve after treatment. However, no significant effect of timepoint was observed (β = −0.100, SE = 0.129, $p = 0.438$), suggesting that performance in AFT did not improve over time. The results for the untreated verb tests are visualized in Figure 3.

2. Untreated noun tests (K-BNT, VFT)

To assess whether the Verb-SFA treatment influenced noun retrieval, results from the K-BNT and VFT (animal and supermarket) were analyzed. For the K-BNT, the mixed-effects model revealed a significant interaction between timepoint and item accuracy (β = 1.410, SE = 0.379, $p < 0.001$), suggesting that the Verb-

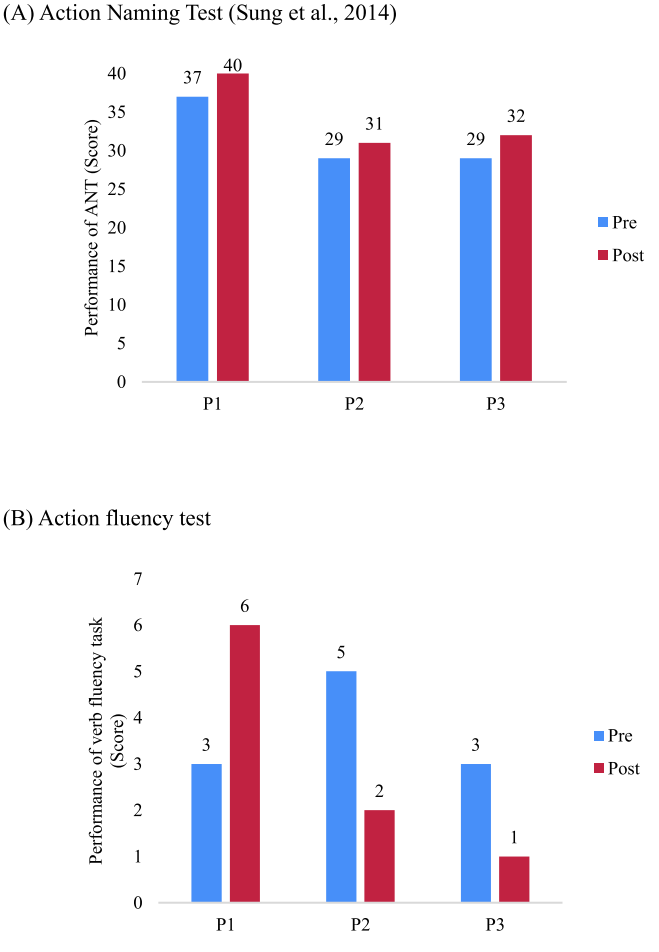


Figure 3. Performance of untreated verb tests for each participant.

SFA treatment positively influenced noun retrieval abilities. However, the animal VFT (β = −0.105, SE = 0.105, $p = 0.319$) and supermarket VFT (β = −0.063, SE = 0.102, $p = 0.538$) showed no significant differences pre- and post-treatment, indicating that the noun generation abilities did not improve after verb-SFA treatment. The results are summarized in Table 5 and visualized in Figure 4.

3. Sentence Comprehension Test (SCT)

To examine whether the Verb-SFA treatment facilitated improvements in sentence comprehension, GMMs were applied to the SCT results (Figure 5). The model revealed a significant interaction between timepoint and item-level accuracy (β = 0.453, SE = 0.214, $p = 0.035$), indicating that the Verb-SFA treatment had a positive impact on sentence comprehension.

4. Discourse production tasks

No significant improvements were observed in any discourse-level measures following Verb-SFA treatment. Specifically, the number of verb types (β = −0.03, SE = 0.038, $p = 0.495$) and verb tokens (β = −0.04, SE = 0.035, $p = 0.29$) showed no statistically significant changes Similarly, noun-related measures remained unchanged, with non-significant effects for noun tokens (β = –0.03, SE = 0.03, $p = .260$) and noun types (β = –0.03, SE = 0.04, $p = .350$).

Regarding utterance-level outcomes, no significant differences were found in the number of utterances (β = –0.05, SE = 0.05, $p = .270$), as well as in the ratios of nouns per utterance (β = –0.086, SE = 0.096, $p = .375$) and verbs per utterance (β = –0.028, SE = 0.053, $p = .612$). Also, the Noun-TTR (β = 0.011, SE = 0.025, $p = 0.670$) and the Verb-TTR (β = 0.004, SE = 0.019, $p = 0.817$) showed no significant increases. The NVR Token (β = −0.029, SE = 0.049, $p = 0.562$) and NVR type (β = −0.024, SE = 0.043, $p = 0.571$) remained unchanged post-treatment.

5. Cognitive assessment measures

Descriptive pre- and post-treatment cognitive assessment scores are presented in Table 6. Across participants, K-MMSE scores remained relatively stable following treatment. SVLT performance showed modest variability across participants, with Participant 2 demonstrating improvement in verbal

Table 5. Pre- and post-treatment performance on untreated noun tests by the participant.

	K-BNT (/60)		VFT (animal)		VFT (supermarket)	
P	Pre	Post	Pre	Post	Pre	Post
P1	26	29	7	8	10	10
P2	24	30	5	6	4	5
P3	14	24	7	5	3	0

Note: *P* = Participant; K-BNT = Korean version-Boston Naming Test (Kim & Na, 1997); VFT = Verbal Fluency Tasks.

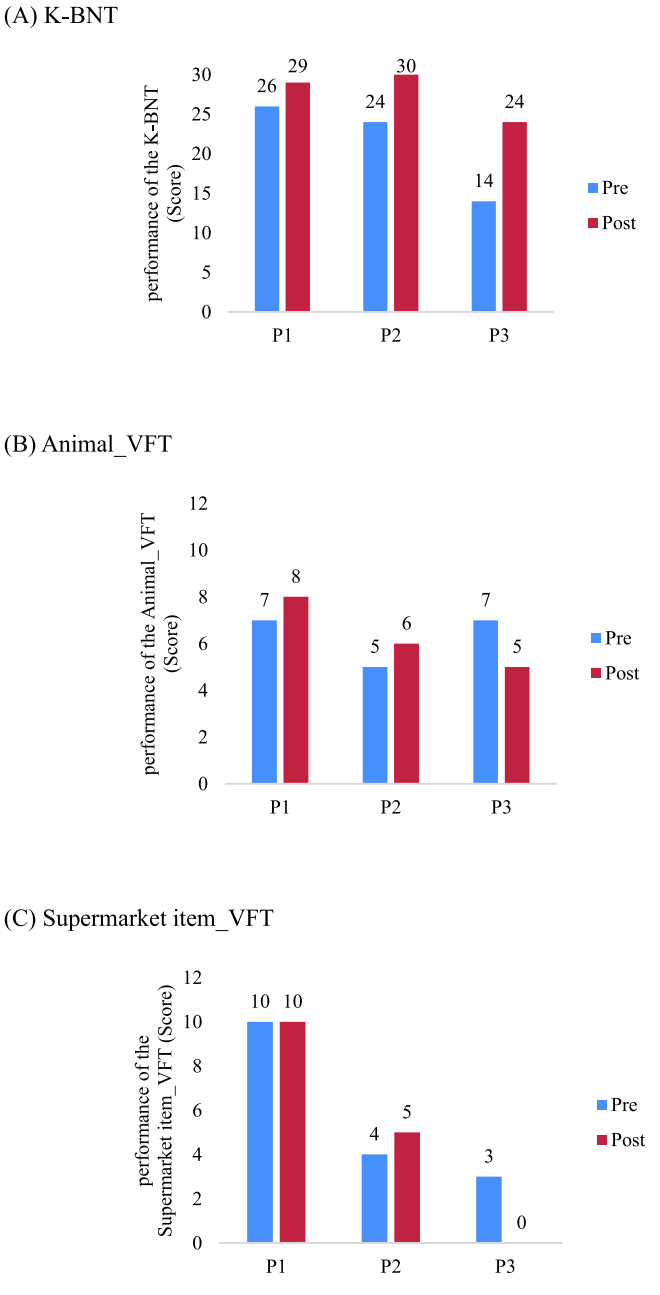


Figure 4. Performance of untreated noun tests for each participant; (A) K-BNT, (B) VFT (animal), (C) VFT (supermarket).

learning performance, whereas Participants 1 and 3 showed relatively stable or slightly reduced scores. Working memory performance, measured using the Digit Span Test (DST), showed slight improvement in Participants 1 and 3, while Participant 2 remained stable.

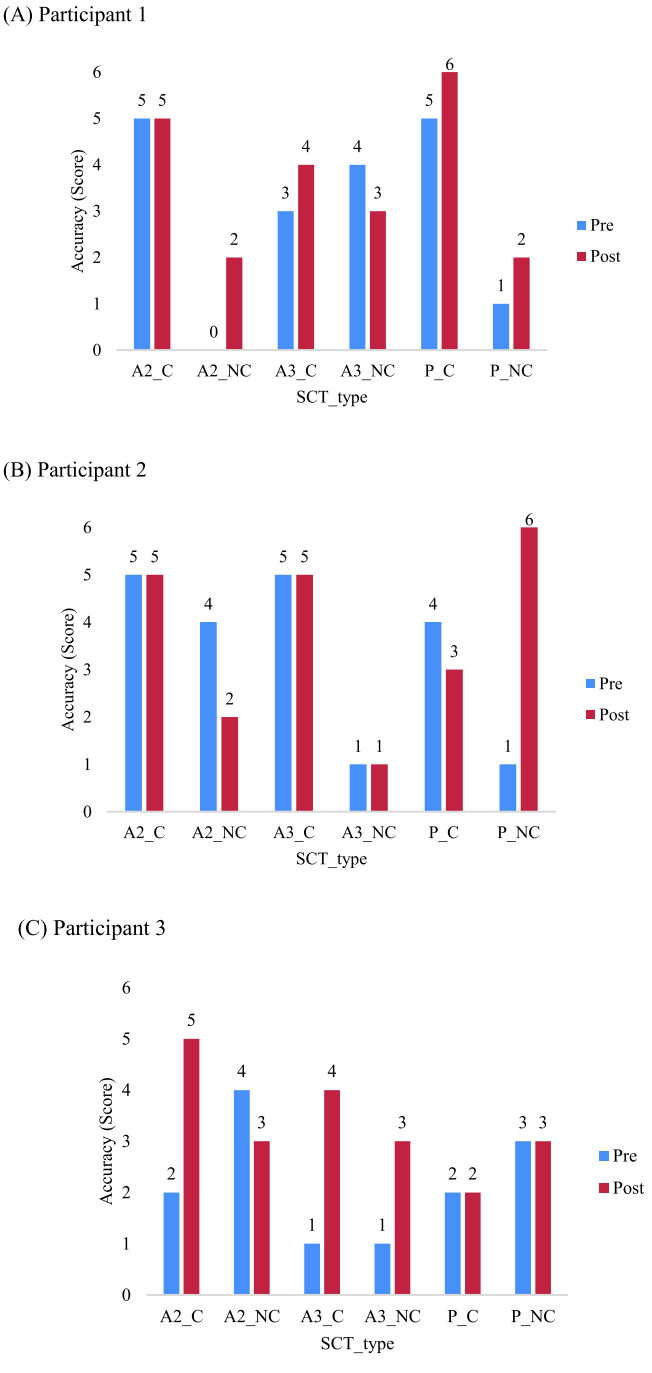


Figure 5. Performance of SCT for each participant: (A) Participant 1, (B) Participant 2, (C) Participant 3. Note: SCT=Sentence Comprehension Test (Sung et al., 2021); A2_C = Active sentences with two-place arguments (Canonical); A2_NC = Active sentences with two-place arguments (Non-canonical); A3_C = Active sentences with three-place arguments (Canonical); A3_NC = Active sentences with three-place arguments (Non-canonical); *P*_C = Passive sentences (Canonical); *P*_NC = Passive sentences (Non-canonical).

Table 6. Pre- and post-treatment performance on cognitive assessment measures by the participant.

	K-MMSE (/30)		SVLT(Sum IM & D)		DST(Sum)	
P	Pre	Post	Pre	Post	Pre	Post
P1	27	28	27	23	10	11
P2	24	24	9	13	11	11
P3	23	22	4	4	6	10

Note: K-MMSE = Korean-Mini Mental State Examination (Kang, 2006); SVLT = Seoul Verbal Learning Test (Kang & Na, 2003); DST = Digit Span Test (Kang et al., 2012).

Discussion

Verb-SFA is an evidence-based lexical retrieval treatment that has demonstrated effectiveness in improving verb naming and facilitating generalization to untrained items and higher-level language processing in individuals with language impairments (Choi & Sung, 2026; Flanagan et al., 2016; Mo et al., 2015). Because verbs carry substantial grammatical and semantic information – encoding tense, aspect, honorifics, and mood – verb-centered intervention is particularly meaningful in Korean, a verb-final and agglutinative language where sentence comprehension and production are highly dependent on accurate verb retrieval (Choi, 2020; Sohn, 1999). The efficacy of Verb-SFA has been previously validated in aphasia and early dementia populations, suggesting its potential to strengthen both lexical and syntactic processing through semantic activation. Building upon this evidence, the present study investigated the efficacy of Verb-SFA in individuals with mild AD, focusing on treatment effects for verb naming, near-transfer effects on untreated lexical items, and far-transfer effects on sentence comprehension and discourse production.

First, participants demonstrated significant improvements in the naming accuracy of treated verbs, underscoring the effectiveness of Verb-SFA in enhancing lexical retrieval. The observed interaction between treatment sessions and treated items suggests that repeated activation of semantic features reinforced access to verb representations over time. These findings are consistent with previous reports in AD and post-stroke aphasia populations (Choi & Sung, 2026; Flanagan et al., 2016; Kang et al., 2015; Mo et al., 2015). Importantly, the results further highlight the relevance of verb-centered intervention in verb-final languages such as Korean, where verbs encode tense, aspect, honorifics, and mood and play a crucial role in sentence formulation and comprehension (Choi, 2020; Sohn, 1999). Improvements in verb naming therefore not only enhance lexical retrieval but may also indirectly support sentence-level processing, given the morphosyntactic weight verbs carry in Korean.

Second, near-transfer effects were observed for semantically related verbs, indicating that the treatment indirectly facilitated the retrieval of untreated items that shared overlapping semantic features. However, these improvements were not statistically significant over time, emphasizing the role of inherent

semantic connections rather than direct treatment effects (Li & Kiran, 2023). The limited improvements in control verbs further suggest that Verb-SFA treatment primarily strengthens pre-existing semantic relationships rather than generating broader lexical generalizations. Individual differences among participants suggest that cognitive factors, such as working memory and baseline lexical abilities, may influence the extent of near-transfer effects (Martin & Fedio, 1983). Participants with relatively stronger baseline language performance appeared to demonstrate more consistent improvement patterns and broader transfer effects across tasks, whereas participants with lower baseline lexical and sentence-level abilities showed more restricted generalization. For example, Participant 1, who exhibited stable cognitive reserves and the highest pre- and post-treatment K-MMSE scores (27), showed consistent improvements across all verb categories. In contrast, Participant 3, with lower cognitive scores (K-MMSE: 23) and memory challenges (SVLT_D: 0), showed gains only in treated verbs. The study also found significant near-transfer effects in noun retrieval, particularly in the Korean-Boston Naming Test (K-BNT). These results align with previous research suggesting that SFA can enhance word retrieval beyond the targeted lexical category (Boyle & Coelho, 1995; Kiran & Iakupova, 2011). However, fluency-based tasks, such as noun and action fluency tests, did not show significant improvements, indicating that while structured retrieval processes benefited from the treatment, spontaneous lexical generation remained largely unaffected. Participant 2, who showed marked improvements in K-BNT (24→30) and noun fluency tasks, demonstrated that improved semantic activation could generalize beyond verbs. However, Participant 3, despite substantial K-BNT gains (14→24), exhibited declines in fluency tasks, suggesting that working memory limitations may have restricted broader generalization to spontaneous lexical retrieval.

Third, far-transfer effects were evident in sentence comprehension, as participants demonstrated significant post-treatment improvements on the Sentence Comprehension Test (SCT). These findings support previous research suggesting that semantic activation strategies can positively influence syntactic and higher-order linguistic processing (Kiran & Thompson, 2003; Sandberg et al., 2020). Participant 1, who demonstrated stable cognitive performance (K-MMSE: 27) and working memory improvement (10→11), maintained consistent accuracy across sentence types but exhibited no notable post-treatment gains, likely due to ceiling effects. Participant 2, who already had relatively higher baseline scores, showed modest gains of 2 points, suggesting that his improvement may reflect consolidation of existing comprehension skills. By contrast, Participant 3 exhibited the largest increase (13→20), indicating that Verb-SFA may provide substantial benefits even for individuals with lower baseline performance. Given that sentence comprehension in Korean relies heavily on accurate processing of sentence-final verbs, these improvements suggest that strengthening semantic representations of verbs may indirectly support

syntactic and sentence-level processing (Kiran & Thompson, 2003; Sandberg et al., 2020). Because Korean is a verb-final language, sentence comprehension often requires listeners to maintain and integrate lexical and syntactic information until the sentence-final verb is processed. These processing demands may place increased burdens on working memory and executive control, particularly in individuals with AD. The SCT findings further suggest that treatment-related improvements may have differed according to sentence type. Relatively greater gains were observed in more canonical sentence structures, whereas performance in non-canonical or syntactically more demanding sentence types remained comparatively limited in some participants. In particular, sentence structures involving passive constructions or three-place arguments may have imposed greater processing and working memory demands on individuals with AD. These findings suggest that sentence complexity, sentence typicality, and working memory capacity may all influence sentence-level treatment responsiveness in Korean-speaking individuals with AD.

The results of discourse production tasks revealed no significant improvement in noun and verb production, utterance count, or measures of linguistic diversity following the Verb-SFA treatment. These findings contrast with previous studies that reported gains in utterance production and lexical diversity after semantic feature-based interventions (Choi & Sung, 2026; Li & Kiran, 2023). While prior research suggests that Verb-SFA can facilitate verb use within structured tasks, its impact on spontaneous discourse production may vary depending on participants' linguistic and cognitive profiles. In this study, measures such as the number of noun and verb tokens, noun-type token ratio (TTR), and noun-verb ratio (NVR) did not show significant post-treatment increases, suggesting that Verb-SFA alone was insufficient to enhance discourse-level lexical retrieval. Unlike structured tasks, discourse requires the integration of lexical, syntactic, pragmatic, and executive functions, which may explain the limited generalization observed in this domain. These results align with prior findings that semantic feature strategies do not always extend to connected speech, particularly in participants with weaker baseline sentence production abilities (Wambaugh & Ferguson, 2007).

Despite its contributions, this study has several limitations. The small sample size limits the generalizability of the findings, and future research should include larger, controlled trials to further validate the effectiveness of Verb-SFA treatment in AD populations. Additionally, the study focused on short-term outcomes, leaving the long-term maintenance of treatment effects unexamined. Longitudinal studies are needed to assess the durability of language improvements over extended periods (Maltais et al., 2018). Another limitation is the lack of formal participant and caregiver satisfaction assessments. Although participants subjectively reported improvements in communication confidence, structured surveys and qualitative interviews would provide a more comprehensive evaluation of treatment acceptability and functional impact.

In conclusion, Verb-SFA was shown to improve verb naming and sentence comprehension in Korean-speaking individuals with mild AD, with limited but promising transfer effects to related lexical categories. Generalization to fluency and discourse production remained constrained, underscoring the need for complementary interventions targeting spontaneous language use. These findings highlight both the universal challenges of verb retrieval deficits in AD (White-Devine et al., 1996) and the particular importance of verb-centered interventions in Korean, a verb-final and morphologically rich language (Choi, 2020; Sohn, 1999). Future studies should pursue larger controlled trials, longitudinal follow-ups, and comparative investigations of verb- and noun-based SFA to clarify their differential efficacy and potential for cross-category generalization.

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References

Appell, J., Kertesz, A., & Fisman, M. (1982). A study of language functioning in Alzheimer patients. *Brain and Language*, *17*(1), 73–91. https://doi.org/10.1016/0093-934X(82)90006-2

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological Bulletin*, *128*(4), 612. https://doi.org/10.1037/0033-2909.128.4.612

Bayles, K. A., & Trosset, M. W. (1992). Confrontation naming in Alzheimer's patients: Relation to disease severity. *Psychology & Aging*, *7*(2), 197–203. https://doi.org/10.1037/0882-7974.7.2.197

Bowles, N. L., Obler, L. K., & Albert, M. L. (1987). Naming errors in healthy aging and dementia of the Alzheimer type. *Cortex*, *23*, 519–524. https://doi.org/10.1016/S0010-9452(87)80012-6

Boyle, M., & Coelho, C. A. (1995). Application of semantic feature analysis. *American Journal of Speech-Language Pathology*, *4*(4), 94–98. https://doi.org/10.1044/1058-0360.0404.94

Brehm, L., & Alday, P. M. (2022). Contrast coding choices in a decade of mixed models. *Journal of Memory and Language*, *125*, 104334. https://doi.org/10.1016/j.jml.2022.104334

Chertkow, H., & Bub, D. (1990). Semantic memory loss in dementia of Alzheimer's type: What do various measures measure? *Brain*, *113*(2), 397–417. https://doi.org/10.1093/brain/113.2.397

Choi, S. (2020). Development of clause chaining in Korean. *Frontiers in Psychology*, *11*, 256. https://doi.org/10.3389/fpsyg.2020.00256

Choi, S., Kim, J. E., & Sung, J. E. (2023). Developing the Korean version of a semantic feature database for semantic feature analysis treatment. *Communication Sciences & Disorders*, *28*(3), 505–521. https://doi.org/10.12963/csd.23963

Choi, S., & Sung, J. E. (2026). 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?. *American Journal of Speech-Language Pathology*, (35), 284–305.

Choi, Y., Han, J., Park, J., Lee, S., Choi, J., Sung, J. E., & Choi, S. (2022). Illustration design to derive storytelling for the elderly in South Korea: (traditional folklore of heungbu and nolbu). *Archives of Design Research*, *35*(2), 155–165. https://doi.org/10.15187/adr.2022.05.35.2.155

Christensen, K. J., Multhaup, K. S., Nordstrom, S., & Voss, K. (1991). A cognitive battery for dementia: Development and measurement characteristics. *Psychological Assessment*, *3*(2), 168–174. https://doi.org/10.1037/1040-3590.3.2.168

Connell, P. J., & Thompson, C. K. (1986). Flexibility of single-subject experimental designs. Part III: Using flexibility to design or modify experiments. *Journal of Speech and Hearing Disorders*, *51*(3), 214–225. https://doi.org/10.1044/jshd.5103.214

Efstratiadou, E. A., Papathanasiou, I., Holland, R., Archonti, A., & Hilari, K. (2018). A systematic review of semantic feature analysis therapy studies for aphasia. *Journal of Speech, Language, and Hearing Research*, *61*(5), 1261–1278. https://doi.org/10.1044/2018_JSLHR-L-16-0330

Flanagan, K. J., Copland, D. A., van Hees, S., Byrne, G. J., & Angwin, A. J. (2016). Semantic feature training for the treatment of anomia in Alzheimer disease: A preliminary investigation. *Cognitive & Behavioral Neurology*, *29*(1), 32–43. https://doi.org/10.1097/WNN.0000000000000088

Hodges, J. R., Salmon, D. P., & Butters, N. (1992). Semantic memory impairment in Alzheimer's disease: Failure of access or degraded knowledge? *Neuropsychologia*, *30*(4), 301–314. https://doi.org/10.1016/0028-3932(92)90104-T

Jelcic, N., Cagnin, A., Meneghello, F., Turolla, A., Ermani, M., & Dam, M. (2012). Effects of lexical–semantic treatment on memory in early Alzheimer disease: An observer-blinded randomized controlled trial. *Neurorehabilitation and Neural Repair*, *26*(8), 949–956. https://doi.org/10.1177/1545968312440146

Jeong, I., Han, J., Choi, J., Choi, Y., Choi, S., & Sung, J. E. (2023). Improving picture description tasks for Korean seniors. *Journal of Digital Contents Society*, *24*, 2767–2775. https://doi.org/10.9728/dcs.2023.24.11.2767

Jokel, R., & Anderson, N. D. (2012). Quest for the best: Effects of errorless and active encoding on word re-learning in semantic dementia. *Neuropsychological Rehabilitation*, *22*(2), 187–214. https://doi.org/10.1080/09602011.2011.639626

Jung, I., Kwak, D., Joe, S., & Lee, H. (1997). A study of standardization of Korean form of geriatric depression scale(KGDS). *Journal of Korean Geriatric Psychiatry*, *1*(1), 61–72.

Kang, J. Y., Sung, J. E., & Lee, S. E. (2015). Effects of computerized language intervention on abilities of time-person-place orientation and naming for individuals with dementia of

the Alzheimer's type. *Communication Sciences and Disorders*, *20*(2), 237–254. https://doi.org/10.12963/csd.15225

Kang, Y. (2006). A normative study of the Korean-mini mental state examination(K-MMSE) in the elderly. *Korean Journal of Psychology: General*, *25*(2), 1–12.

Kang, Y., Chin, J., Na, D. L., Lee, J., & Park, J. S. (2000). A normative study of the Korean version of controlled oral word association test (COWAT) in the elderly. *Korean Journal of Clinical Psychology: General*, *19*(2), 385–392.

Kang, Y., Jahng, S., & Na, D. L. (2012). *Seoul neuropsychological screening battery. 2nd ed. (SNSB-II)*. Human Brain Research & Consulting Co.

Kang, Y., & Na, D. L. (2003). *Seoul verbal learning test (SVLT)*. Human Brain Research and Consulting Co.

Kim, H., & Na, D. L. (1997). *Korean version-Boston naming test*. Hakjisa.

Kim, H., & Na, D. L. (2012). *Paradise· Korean version of the western aphasia battery revised (PK-WAB-R)*. Paradise Welfare Foundation.

Kim, M., & Thompson, C. K. (2000). Patterns of comprehension and production of nouns and verbs in agrammatism: Implications for lexical organization. *Brain and Language*, *74*(1), 1–25. https://doi.org/10.1006/brln.2000.2315

Kiran, S., & Iakupova, R. (2011). Understanding the relationship between language proficiency, language impairment, and rehabilitation: Evidence from a case study. *Clinical Linguistics & Phonetics*, *25*(6-7), 565–583. https://doi.org/10.3109/02699206.2011.566664

Kiran, S., Sandberg, C., Gray, T., Ascenso, E., & Kester, E. (2013). Rehabilitation in bilingual aphasia: Evidence for within-and between-language generalization. *American Journal of Speech-Language Pathology*, *22*(2), 298–309. https://doi.org/10.1044/1058-0360(2013/12-0085)

Kiran, S., & Thompson, C. K. (2003). The role semantic complexity in treatment of naming deficits: Training semantic categories in fluent aphasia by controlling exemplar typicality. *Journal of Speech, Language, and Hearing Research*, *46*(4), 773–787. https://doi.org/10.1044/1092-4388(2003/061)

Li, R., Chen, S., & Kiran, S. (2022). The active ingredients of semantic-based intervention in Mandarin-English bilinguals with aphasia. Presentation at the Clinical Aphasiology Conference 2022, Wrightsville Beach, NC.

Li, R., & Kiran, S. (2023). Treatment-induced recovery patterns between nouns and verbs in Mandarin–English bilingual adults with aphasia. *American Journal of Speech-Language Pathology*, *32*(5), 2128–2145. https://doi.org/10.1044/2023_AJSLP-22-00236

MacWhinney, B., Fromm, D., Forbes, M., & Holland, A. (2011). Aphasiabank: Methods for studying discourse. *Aphasiology*, *25*(11), 1286–1307. https://doi.org/10.1080/02687038.2011.589893

Maltais, M., Rolland, Y., Haÿ, P., Armaingaud, D., Vellas, B., & De Souto Barreto, P. (2018). Six-month observational follow-up on activities of daily living in people with dementia living in nursing homes after a 6-month group based on either exercise or social activities. *Aging Clinical and Experimental Research*, *31*(3), 361–366. https://doi.org/10.1007/s40520-018-0984-z

Marshall, J., Pring, T., & Chiat, S. (1998). Verb retrieval and sentence production in aphasia. *Brain and Language*, *63*(2), 159–183. https://doi.org/10.1006/brln.1998.1949

Martin, A., & Fedio, P. (1983). A study of semantic memory in Alzheimer's disease. *Brain and Language*, *19*(3), 303–311.

Massaro, M., & Tompkins, C. A. (1994). Feature analysis for treatment of communication disorders in traumatically brain-injured patients: An efficacy study. *Clinical Aphasiology*, *22*, 245–256.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspices of department of health and human services task force on Alzheimer's disease. *Neurology*, *34*(7), 939–944. https://doi.org/10.1212/WNL.34.7.939

Mo, K. O., Sung, J. E., & Jeong, J. H. (2015). The effects of semantic feature analysis treatment on naming performance in Korean individuals with early dementia of the Alzheimer's type: Using a familiarity of nouns scale. *Communication Sciences & Disorders*, *20*(1), 34–47. https://doi.org/10.12963/csd.14215

Mohs, R. C., Kim, Y., Johns, C. A., Dunn, D. D., & Davis, K. L. (1986). Assessing changes in Alzheimer's disease: Memory and language. In L. W. Poon, T. Crook, K. L. Davis, C. Eisdorfer, B. J. Gurland, A. W. Kaszniak, & L. W. Thompson (Eds.), *Handbook for clinical memory assessment of older adults* (pp. 149–155). American Psychological Association.

Morris, J. C. (1993). The clinical dementia rating (CDR): current version and scoring rules. *Neurology*, *43*, 2412–2414. https://doi.org/10.1212/WNL.43.11.2412-a

Nicholas, L. E., & Brookshire, R. H. (1993). A system for quantifying the informativeness and efficiency of the connected speech of adults with aphasia. *Journal of Speech and Hearing Research*, *36*, 338–350. https://doi.org/10.1044/jshr.3602.338

Nussbaum, R. L., & Ellis, C. E. (2003). Alzheimer's disease and Parkinson's disease. *The New England Journal of Medicine*, *348*(14), 1356–1364. https://doi.org/10.1056/NEJM2003ra020003

Parks, R. W., & Haxby, J. V. (1993). Positron Emission Tomography in Neuropsychology of Alzheimer's disease and other dementias, 459.

Peirce, J. W. (2007). Psychopy—psychophysics software in Python. *Journal of Neuroscience Methods*, *162*, 8–13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Peñaloza, C., Dekhtyar, M., Scimeca, M., Carpenter, E., Mukadam, N., & Kiran, S. (2020). Predicting treatment outcomes for bilinguals with aphasia using computational modeling: Study protocol for the PROCoM randomised controlled trial. *BMJ Open*, *10*(11), e040495. https://doi.org/10.1136/bmjopen-2020-040495

Reisberg, B., Ferris, S. H., de Leon, M. J., & Crook, T. (1982). The global deterioration scale for assessment of primary degenerative dementia. *The American Journal of Psychiatry*, *139*(9), 1136–1139. https://doi.org/10.1176/ajp.139.9.1136

Sandberg, C., Gray, T., & Kiran, S. (2020). Development of a free online interactive naming therapy for bilingual aphasia. *American Journal of Speech-Language Pathology*, *29*(1), 20–29. https://doi.org/10.1044/2019_AJSLP-19-0035

Sohn, H. M. (1999). *The Korean language*. Cambridge University Press.

Sung, J. E., Ahn, H., Choi, S., & Lee, K. (2021). Age and education effects on a novel syntactic assessment battery for elderly adults. *Frontiers in Psychology*, *21*, 639866. https://doi.org/10.3389/fpsyg.2021.639866

Sung, J. E., DeDe, G., & Lee, S. E. (2016). Cross-linguistic differences in a picture-description task between Korean- and English-speaking individuals with aphasia. *American Journal of Speech-Language Pathology*, *25*(4S), S813–S822. https://doi.org/10.1044/2016_AJSLP-15-0140

Sung, J. E., Kwag, E., Choi, S., Tak, H., & Kim, J. (2014). Effects of verb-argument cues on verb production in persons with aphasia using a verb-final language. *Frontiers in Psychology*, *5*(Conference Abstract: Academy of Aphasia – 52nd Annual Meeting). https://doi.org/10.3389/conf.fpsyg.2014.64.00095

Thompson, C. K. (2003). Unaccusative verb production in agrammatic aphasia: The argument structure complexity hypothesis. *Journal of Neurolinguistics*, *16*(2-3), 151–167. https://doi.org/10.1016/S0911-6044(02)00014-3

Wambaugh, J. L., & Ferguson, M. (2007). Application of semantic feature analysis to retrieval of action names in aphasia. *Journal of Rehabilitation Research & Development*, *44*(3), 381–394. https://doi.org/10.1682/JRRD.2006.05.0038

Weng, W., Liang, J., Xue, J., Zhu, T., Jiang, Y., Wang, J., & Chen, S. (2019). The transfer effects of cognitive training on working memory among Chinese older adults with mild cognitive impairment: A randomized controlled trial. *Frontiers in Aging Neuroscience*, *11*, 212. https://doi.org/10.3389/fnagi.2019.00212

White-Devine, T., Grossman, M., Robinson, K. M., Onishi, K., & Biassou, N. (1996). Verb confrontation naming and word-picture matching in Alzheimer's disease. *Neuropsychology*, *10*(4), 495–503. https://doi.org/10.1037/0894-4105.10.4.495

Ylvisaker, M., & Szekeres, S. (1985). *Cognitive-language intervention with brain injured adolescents and adults*. Paper presented at the Annual Convention of the Illinois Speech-Language-Hearing Association, Chicago, IL, United States.