Assessing the Efficacy of Implicit Training for Verb Tense Deficits in Aphasia: A Proof-of-Concept Single Subject Experimental Design

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Introduction

Aphasia is a language disorder resulting from acquired brain damage, most commonly due to a cerebrovascular accident (CVA), which can impair both language production and comprehension (NIDCD, 2025). Clinically, aphasia is often categorized as either fluent (e.g., Wernicke's aphasia) or non-fluent (e.g., Broca's aphasia), based on the characteristics of spontaneous speech (Le et al., 2025). Even within these broad categories, the severity of impairment can vary widely from relatively mild deficits, where individuals can produce short but complete sentences, to severe cases in which speech is limited to one or two words or even a single syllable (Fedorenko et al., 2022). Agrammatic aphasia is a subtype of aphasia marked by reduced sentence complexity and the frequent omission or substitution of grammatical morphemes and function words (Goodglass & Menn, 1985; Faroqi-Shah & Thompson, 2007). Whereas typical speech includes a mix of content words (e.g., nouns, verbs) and function words (e.g., articles, prepositions, plural markers, tense endings), agrammatic speech is often devoid of accurate—or any—functional elements, resulting in short, noun-dominated utterances (Fedorenko et al., 2022). For example, a person with agrammatic aphasia may say, "She speak," instead of "She is speaking" (O'Connor et al., 2005). These productions are syntactically simple and typically lack grammatically informative morphemes and verbs, contributing to a telegraphic and effortful speech style (Wagenaar et al., 1975).

Patterns of Verb Tense Inflection Impairments

Verb inflections are among the most consistently impaired grammatical features in English speakers with agrammatic aphasia. These markers, which attach to a verb stem (e.g., -ed in walked), serve to convey tense, agreement, and aspect in English and many other languages. Despite their communicative importance, 50-70% of errors in agrammatic speech involve incorrect or missing verb inflections (Faroqi-Shah & Thompson, 2007). Within this broader category, tense marking appears particularly susceptible (Faroqi-Shah & Thompson, 2007). Verb tense establishes a time context, informing the communication partner about the relationship between the Speech Time (the time where the exchange is taking place) and the Reference Time (what time the speaker is discussing/referencing) (Smith, 2007).

Common patterns in agrammatic verb productions include the omission of tense-bearing affixes, inaccurate substitutions, and the overuse of non-finite forms such as -ing (e.g., laughing, crying). For example, a person with agrammatic aphasia might produce a sentence like, "Yesterday Mary walk to work," where the past-tense marking is omitted despite a clear temporal adverb explicitly describing the reference time. Notably, these types of errors have been observed across a range of production contexts, including spontaneous speech, writing, picture description, and sentence completion tasks (Faroqi-Shah & Thompson, 2007). Thus, these persistent and systematic errors have led researchers to consider the underlying cognitive and linguistic mechanisms that may account for verb tense deficits in agrammatic aphasia.

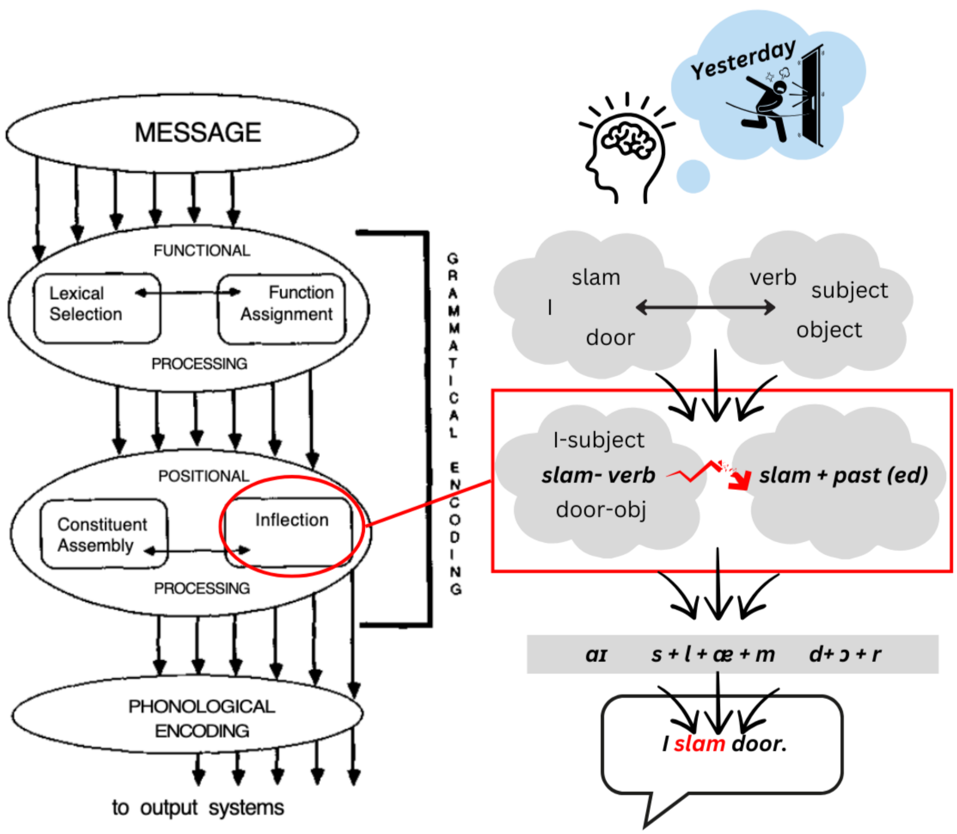
Theoretical Explanations for Verb Tense Deficits

While verbs are generally more difficult to retrieve than nouns (Abel et al., 2015), this pattern alone does not fully account for the selective verb inflection impairments observed in agrammatic aphasia. Comparisons with anomic aphasia—primarily characterized by lexical retrieval deficits—show that although both groups exhibit similar difficulties in verb naming, individuals with agrammatic aphasia are disproportionately impaired in verb inflection (Bastiaanse & Jonkers, 1998). Importantly, agrammatic speakers often produce the correct verb stem but fail to apply appropriate grammatical morphology. This dissociation suggests that verb tense deficits are not primarily driven by lexical access limitations, but instead reflect impairments in grammatical processing mechanisms.

This process of cognitively assigning words syntactic roles and grammatical features during sentence production is referred to as grammatical encoding (Slevc, 2023). This encoding process can be contextualized within Garrett's (1975) overview model of language production (Figure 1), which proposes three primary levels of sentence production: (1) the message level, where communicative intent is formulated; (2) the functional level, where words are selected and assigned semantic roles (lemmas); and (3) the positional level, where surface structure is realized, including word order, phonology, and grammatical morphemes (Bock & Levelt, 1994; Valinejad et al., 2022). The final two levels—functional and positional—are thought to support grammatical encoding. More specifically, verb inflection is presumed to occur at the positional level, meaning it is not tied to meaning selection per se, but rather to the final stages of sentence assembly. A breakdown at this level could explain why agrammatic speakers often produce correct verb stems but omit tense morphology, for they access the lemma but fail to fully encode its syntactic features.

Figure 1

An Overview of the Language Production Process (Adapted)



Several theories have been proposed to explain verb tense deficits beyond general grammatical encoding impairments. Broadly, these accounts can be categorized into syntactic and semantic perspectives (Faroqi-Shah & Friedman, 2015). Syntactic accounts propose a hierarchical organization among functional grammatical categories, such as agreement, mood, aspect, and tense. One prominent example, the Tree Pruning Hypothesis (TPH), posits that tense is located higher in this hierarchy. Consequently, damage to a given node, such as tense, is assumed to result in impairment of that node and all higher nodes, while leaving lower nodes, such as subject-verb agreement, relatively preserved (Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2004).

Alternatively, semantic accounts extend to include the meaning of an event embedded in verb tense. In other words, the grammatical elements are engaging with the semantic element of a verb, e.g. the temporal component being referenced by the verb tense's morphological form. The Diacritical Encoding and Retrieval Hypothesis (DER; Faroqi-Shah & Thompson, 2007) and the Impaired Interpretable Feature Hypothesis (Nanousi et al., 2006), are examples which both claim the issue is primarily morphosemantic, meaning it is not the grammatical elements themselves that are problematic but in the proper linking of such elements to their proper time concept (Valinejad et al., 2022). While the Impaired Interpretable Feature Hypothesis says that tense has meaningful features that are more difficult for PWA to process because they struggle to produce the corresponding word forms (Valinejad et al., 2022), DER describes this issue further as a struggle to 'translate' the tense in a message into tense markers like +PAST and/or finding and using the correct verb forms that match that tense (Faroqi-Shah & Thompson, 2007).

Evidence across languages has yielded inconsistent support for syntactic accounts. Studies in Korean, Dutch, German, Greek, and English have not consistently aligned with the hierarchical predictions of syntactic models (Faroqi-Shah & Friedman, 2015; Valinejad et al., 2022; reference Lee et al., 2008, for individual studies). Thompson et al. (2006) more directly tested the Tree Pruning Hypothesis by examining whether treatment targeting higher-level nodes, such as complementizers, would generalize to lower-level elements like tense and agreement. Contrary to hierarchical predictions, generalization occurred between tense and agreement morphology but not between complementizers and inflectional elements. These findings challenge strictly syntactic explanations of verb tense deficits.

Conversely, evidence supporting semantic accounts has emerged from studies directly comparing morphosyntactic and morphosemantic factors. For example, Faroqi-Shah (2008) compared morphosemantic and morphosyntactic treatment approaches, while Faroqi-Shah and

Dickey (2009) manipulated morphosemantic and morphosyntactic demands in individuals with agrammatic aphasia. Across studies, individuals with agrammatic aphasia demonstrated greater difficulty mapping tense morphology to temporal reference compared to evaluating syntactic agreement in both production (Faroqi-Shah & Thompson, 2007) and comprehension contexts (Faroqi-Shah & Dickey, 2009). These findings suggest that verb tense may indeed be particularly demanding because it requires both grammatical processing and time-related semantic interpretation.

Current Treatment Options and Limitations

These competing theoretical accounts have informed the development of current intervention approaches targeting verb tense deficits in aphasia. Although limited in number, most treatments are grounded in Garrett's (1975) psycholinguistic framework, while others more explicitly target syntactic or semantic mechanisms of verb processing. A third group consists of broader aphasia interventions that have been adapted to address verb deficits within sentence production. Taken together, current approaches can be broadly differentiated by the level of linguistic representation they target, ranging from sentence-level processing to lexical and morphosyntactic encoding. A brief overview of key approaches is provided below (see Figure 2; as reviewed in Valinejad et al., 2022).

The Computerized Iconographic Communication System (C-VIC) focuses on strengthening the link between functional and positional sentence production levels. Using a computer-based interface, participants construct sentences by selecting icons and images, providing structured practice with sentence building.

ACTION is another treatment program that trains verbs in various forms and sentence positions. It follows a structured, four-step progression through lexical, syntactic, morphosyntactic, and sentence construction levels, specifically focusing on verb tense inflection. For example, the client would (1) name the action "cry," (2) generate the infinitive "to cry," (3) produce a finite/tensed verb "cried," and (4) create a sentence: "The baby cried."

Constraint Induced Language Therapy (CILT) promotes spoken language through interactive, structured communication games. Players exchange cards using explicit verbal requests while visual barriers prevent reliance on nonverbal cues. The therapy emphasizes intensive practice, shaping, and gradually increasing linguistic complexity (Meinzer et al., 2012). Although designed for general language deficits, CILT can be adapted to address tense morphology by incorporating tense-focused prompts and feedback (Valinejad et al., 2022).

Building on the connection between syntax and semantics, Thompson et al. (2006) developed a treatment targeting functional grammatical categories like tense. This approach focuses on improving the assignment of thematic roles through activities such as thematic role training, sentence anagrams, and reading tasks.

Two additional treatments specifically address verb inflection at different processing levels. Morphophonological treatment emphasizes verb inflection at the single-word level with a focus on oral production. This method involves action naming, auditory discrimination, lexical decision tasks, verb form generation, oral and written transformations, and repetition of all inflectional variants (Faroqi-Shah, 2008). While this approach targets morphological processing directly, it has shown limited effectiveness in promoting functional language improvements (Valinejad et al., 2022). Comparatively, morphosemantic treatment focuses on comprehension rather than production, helping individuals associate tense with correct verb forms through input-based tasks. Activities include anomaly judgment (e.g., detecting errors like “Yesterday he will dig a hole”), sentence-picture matching, sentence completion, and anagram-based sentence construction (Faroqi-Shah, 2008; Valinejad et al., 2022). Notably, this approach has demonstrated large effect sizes across multiple studies (Dashti et al., 2018; Faroqi-Shah, 2008a, 2008b, 2013), suggesting strong efficacy in improving tense-related performance.

Among these current options, what components constitute a successful verb tense treatment for PWA? Valinejad et al. (2022) identified two key factors associated with positive patient outcomes across relevant interventions. First, therapy at the sentence level is critical. Compared to other approaches, the morphophonology treatment–which focused solely on single-word production–was the only method that did not address complete sentences and showed the least effectiveness in improving verb tense inflection, as well as in generalizing to sentence production and narrative speech (Valinejad et al., 2022). Thus, using sentence-level stimuli appears to be a notable variable in treatment transfer.

Second, generalization to untrained structures is crucial for maximizing therapy efficiency. Broadly, generalization has been defined by Stokes and Baer (1977) as "the occurrence of relevant behavior under different, non-training conditions without the scheduling of the same events in those conditions as has been scheduled in training conditions." In other words, it is the extension of treatment effects to adjacent, yet not directly treated, items or areas, notably an active, intentional process rather than a passive, naturally occurring one. There are two types of measurable generalization relevant to the context of single-subject experiments as well as any aphasia speech and language treatment: response generalization and stimulus generalization (Mayer et al., 2024; Thompson, 2006). Response generalization refers to when only stimuli within the linguistic level of what was trained/in conditions similar to treatment improve; whereas, stimulus generalization occurs when treated stimuli improvements can extend across untrained conditions (Mayer et al., 2024). For example, if one verb is trained in the past tense (e.g. "peeled") and the person with aphasia is successful in producing that past tense verb post-treatment, then an example of successful response generalization would be if the past tense for verb stems that the participant was never directly trained with also improved (e.g., "crossed"). Stimulus generalization is also possible and could be demonstrated in the improvement of the next level of language (e.g. from the word to the discourse level). Morphosemantic treatment has demonstrated both types of these generalizations, for participants demonstrated significant generalization to untrained verbs as well as to narrative samples post-treatment (Faroqi-Shah, 2013; Faroqi-Shah, 2008)

However, some treatments either fail to target generalization or do not achieve it successfully (Valinejad et al., 2022; see Figure 2). Collectively, these findings suggest that relatively few existing treatments fully meet these criteria, highlighting the need for approaches that better support both sentence-level processing and generalization.

Figure 2

Current Approaches to Verb Tense Treatment: Effectiveness Summary; CILT = Constraint Induced Language Therapy

	Verb Tense Inflection	Generalization to Sentence Production	Generalization to Speech
C-VIC	⊕	⊕	⊘
ACTION	⊕	⊕	⊕
Thematic Information	⊕	⊘	⊘
CILT (morphosyntax)	⊕	⊖	⊖
Morphosemantic	⊕	⊕	⊕
Morphophonology	⊖	⊖	⊖

⊕ EFFECT
⊖ NO EFFECT
⊘ NOT EXAMINED

Note. Adapted from Valinejad et al. (2022)'s Figure 3. This figure summarizes treatment effects for verb tense inflection, showing the measures that improved for each treatment type in verb tense use and in generalization to sentence production and narrative speech.

Implicit and Explicit Learning in Aphasia

The majority of sentence production interventions for aphasia rely on explicit instruction (Rainey et al., 2026). This approach uses conscious learning strategies where individuals are directly taught linguistic rules, forms, and structures, often requiring metalinguistic awareness and effortful practice (Schuchard & Thompson, 2014). While explicit treatments can be effective, they often place high demands on working memory and cognitive resources, which may limit their success for individuals with agrammatic aphasia (Schuchard et al., 2017; Murray et al., 2004). In contrast, implicit learning occurs outside of conscious awareness and can support language acquisition through passive exposure (Schuchard et al., 2017). Engaging a PWA's unconscious or more automatic learning processes could potentially reduce usage of already limited cognitive resources to recall explicitly taught verb form rules (Cho-Reyes et al., 2016; Lee

& Man, 2017; Lee et al., 2024; Van Boxtel et al., 2025; Rainey et al., 2026). However, to date, there are no implicit treatment methods specifically targeting verb inflection deficits.

But can people with aphasia (PWA) learn implicitly? Some research suggests they can, as individuals with agrammatic aphasia have demonstrated implicit learning of sequential patterns in serial reaction time tasks (Goschke et al., 2001; Schuchard & Thompson, 2014). Notably, Schuchard and Thompson (2014) found that individuals with aphasia demonstrated significant learning under implicit, but not explicit, conditions, suggesting preserved implicit learning abilities in agrammatic aphasia. However, clinical outcomes remain mixed. For example, Schuchard et al. (2017) exposed nine participants with agrammatic aphasia to 800 passive sentences paired with matching pictures over five cycles, yet no significant improvements in sentence comprehension were observed, possibly because participants were not required to actively produce the target structures.

Recently, Lee and colleagues (Lee et al., 2024) have tested and developed an implicit priming-based intervention approach for persons with aphasia, which includes active participant responses via structural priming to address this limitation. Structural priming provides one such mechanism. Structural priming refers to the tendency to produce a particular sentence structure after recent exposure to it (Bock, 1986; Bock & Loebell, 1990). Notably, this effect occurs without reliance on explicit memory or conscious awareness of the prior exposure (Bock et al., 2007), classifying it as implicit learning (Rainey et al., 2026). Decades of research have demonstrated robust structural priming effects in neurologically healthy individuals across a range of ages and syntactic complexities (Mahowald et al., 2016; Messenger, 2022; Rowland et al., 2012). More recently, structural priming effects have also been observed in individuals with aphasia, suggesting that this implicit learning mechanism may remain at least partially intact despite language impairments. For example, people with aphasia (PWA) were more likely to produce complex sentences, such as passives, immediately after hearing or reading passive prime sentences compared to active primes (e.g., Hartsuiker & Kolk, 1998; Man et al., 2019; Saffran & Martin, 1997; Yan et al., 2018). Additionally, individuals with more severe grammatical impairments often showed greater benefits from structural priming (Cho-Reyes et al., 2016). What is learned through structural priming has also shown persistence across time and intervening utterances, implying that priming provides opportunities for PWA to learn how messages are linked to specific grammatical structures through experience (Rainey et al., 2026).

The recently developed Syntax Treatment for Aphasia Recovery (STAR) applies structural priming principles within a treatment protocol. This approach requires participants to repeat target words and sentences, incorporating active engagement alongside implicit learning. Studies using STAR have demonstrated significant improvements in PWA's sentence production, particularly transitive, dative, or locative constructions (Lee et al., 2024; Van Boxtel et al., 2025; Rainey et al., 2026). In this approach, people with aphasia listen to or read prime sentences containing target structures (e.g., passive, transitive, dative, or locative constructions). Afterwards, PWAs are more likely to produce these structures in their own speech and improve their speech content across production tasks (Lee et al., 2025).

To date, however, STAR treatment has only been used for treating sentence structures, not morphological inflections, let alone tense, and as mentioned, verb-tense-specific treatments have yet to include an implicit learning method. Thus, the present study seeks to address this gap by examining whether implicit sentence/syntactic priming can improve access to and use of verb tense in individuals with agrammatic aphasia. Specifically, this research investigates whether implicit training focused on regular past tense verb forms leads to measurable improvements in verb inflection accuracy, and whether these improvements generalize to untrained verb forms and tenses.

Research Questions And Hypotheses

The primary aim of this study is to extend implicit sentence priming methods to the treatment of verb inflection impairments in aphasia. This study further examines generalization effects associated with this novel intervention and compares its effectiveness with morphosemantic treatment, one of the most robust explicit intervention approaches (Valinejad et al., 2022), in terms of overall treatment outcomes. Thus, the following research questions are addressed in the context of priming sentences with past tense verbs:

1. Is implicit sentence priming effective for targeting verb inflection deficits in individuals with agrammatic aphasia, as measured by the change in trained verb tense for trained verbs?
2. Does implicit training in regular past tense verbs generalize to a) untrained verb tenses (present and future) of trained verbs and b) past tense of untrained verbs (irregular and regular past)?
3. Is implicit training more effective than morphosemantic as measured by effect size (or percent change) for trained verb tense?

Based on prior findings outlined above, it is hypothesized that implicit sentence priming will improve verb inflection accuracy (RQ1). Because training occurs within a sentence context, which has been shown to support generalization (de Aguiar et al., 2016; Valinejad et al., 2022), it is further predicted that treatment targeting regular past tense verbs will generalize to untrained forms.

More specifically, generalization to untrained regular past tense verbs is expected to be strongest, as previous studies have demonstrated more consistent generalization to untrained regular morphology compared to irregular forms (Faroqi-Shah, 2013; Valinejad et al., 2025; Rashmi et al., 2025 [narrative review]). Although modest generalization to irregular verbs has been observed following regular verb training (Faroqi-Shah, 2013; Valinejad et al., 2025), the current study trains only regular verbs. Prior findings indicate that training irregular verbs tends to yield broader transfer to both irregular and regular forms, whereas training regular verbs may result in more limited generalization to irregular verbs. Therefore, generalization to untrained irregular verbs is expected to be limited.

Regarding generalization to untrained tenses (e.g., present and future), some studies have reported improvements across tense forms (Faroqi-Shah, 2013; Faroqi-Shah, 2008). However, these studies typically trained all three simple tenses (present, past, and future) or both present and past in the case of Dashti et al. (2023), which examined morphosemantic treatment outcomes in Persian rather than English. In contrast, studies that focused on past tense production (e.g., Faroqi-Shah, 2021) did not report cross-tense generalization when participants were assessed on untrained present and future tenses. Because the present study targets past tense only, improvement in untrained tenses, such as present and future, is not anticipated, despite shared verb stems. Therefore, generalization related to research question 2a is not hypothesized.

Methods

Overall Design

This study used a single case experimental design (SCED) to examine the effects of implicit tense-priming treatment on verb tense inflection in two participants with aphasia. The study consisted of three phases (ABA): baseline assessment, treatment, and post-treatment assessment. In SCED, the multiple baselines phase serves as the within-participant experimental control, allowing for documentation of the absence of spontaneous improvement and ensuring that any observed gains can be attributed to the treatment rather than repeated exposure to baseline measures. Participants completed four baseline cycles, followed by 12 treatment cycles and one post-testing cycle. The end-of-treatment criteria was 80% accuracy over three consecutive treatment cycles or the 12 cycles (3.5 weeks). Treatment was administered individually via virtual video conferencing, 2 days a week in cycles lasting approximately 1-2 hours. Post-treatment testing was conducted immediately after the final treatment cycle and included re-administration of treatment and generalization probes. The total duration of study participation was approximately 6 weeks. The study is reported using the SCRIBE reporting criteria for SCED (Tate et al., 2016; see Appendix A).

Ethics and Funding

This study received ethical approval from the University of Maryland, College Park Institutional Review Board (IRB reference number 2298627-1). Prior to study initiation, informed consent was obtained verbally in accordance with procedures approved by the University of Maryland, College Park Institutional Review Board. This study was supported by the University of Maryland Hearing and Speech Sciences Department's MCM Fund for Student

Research Excellence.

Participants

Upon institutional review board approval, two participants with moderate-to-severe agrammatic Broca's aphasia (AP001 and AP002) were recruited for the study. Both participants were recruited following completion of another study in the Aphasia Research Center assessing a variety of language abilities, which had no treatment component. Participants were recruited consecutively based on meeting eligibility criteria without any randomization. Aphasia severity and classification were confirmed using the Western Aphasia Battery-Revised (WAB-R, Kertesz, 2006). Participants were at least 1 year post-stroke onset to control for spontaneous recovery effects. Eligibility criteria for the study were deficits in producing past tense verb forms, as identified through baseline assessments and defined as less than 50% accuracy (Verb Inflection Test, Faroqi-Shah, unpublished), agrammatic language profile in spontaneous speech, evidenced in the spontaneous speech section of the WAB-R (Kertesz, 2006), functional reading ability with the reading comprehension section of the WAB-R, and ability to repeat stimuli with at least 50% accuracy (repetition section of the WAB-R). Participants self-reported normal or corrected-to-normal hearing and vision. They reported no spatial neglect or visual field deficits. Lastly, both participants were native English speakers, sustained a left hemisphere stroke, and completed at least a high school education. Both participants received 2-4 months of physical, occupational, and speech therapy following their stroke, which is the standard care available to persons with aphasia in the United States/Canada. Neither of the participants was engaged in other speech-language therapy services for the duration of this study nor had been part of any other treatment research. Demographic and relevant medical history information specific to each participant is detailed below and summarized in Table 1.

AP001

AP001 is a 62-year-old white female. She is a monolingual English speaker, and prior to her stroke, she worked as a bookkeeper. She had her stroke 4 years ago while undergoing heart surgery. AP001 reported being hospitalized for 58 days following the onset of her stroke, after

Table 1

Participant diagnosis and demographic characteristics

Participant	Gender	Age	Years of Education	Previous Occupation	Months post stroke onset
AP001	F	62	13	Bookkeeper	48 months
AP002	M	42	12	Computer Scientist	120 months

which she attended rehabilitation. She has received physical therapy, occupational therapy, and speech therapy in the past. She reports she still does home therapy daily on her own. She reported difficulty producing speech, especially in terms of pronunciation. Her pre-treatment language evaluation results indicated an aphasia quotient of 77.4, and fluency, auditory-verbal comprehension, repetition, and naming/word-finding scores reflective of mild, transcortical motor aphasia (WAB-R, Kertesz, 2006). Performance on the Apraxia Battery for Adults-Second Edition indicated severe apraxia of speech (raw score = 8+), which was accommodated through procedural adaptations described under treatment procedures. AP001's results met the present study's inclusion criteria, including: 1) demonstrated halting, telegraphic sentence production within the spontaneous speech tasks (characteristic of agrammatic, non-fluent aphasia), 2) 25% accuracy for past-tense verb production within the Verb Inflection Test (Faroqi-Shah, unpublished), 3) functional reading ability with 80% accuracy, and 4) relatively preserved repetition (81% accuracy).

AP002

AP002 is a 42-year-old white male. He is also a monolingual English speaker, and previously worked in computer science. He had his stroke 10 years ago, after which he received rehabilitation as well as physical therapy, occupational therapy, and speech therapy services. He reported difficulty with speaking, understanding, reading, and writing. His pre-treatment language evaluation demonstrated an overall aphasia quotient of 70.2, and fluency, auditory-verbal comprehension, repetition, and naming/word-finding scores congruent with moderate Broca's aphasia (WAB-R, Kertesz, 2006). Performance on the Apraxia Battery for Adults–Second Edition indicated mild apraxia of speech (raw score = 4). AP002 demonstrated the following inclusion criteria for the present study: 1) demonstrated halting, telegraphic sentence production within the spontaneous speech tasks (characteristic of agrammatic, non-fluent aphasia), 2) impaired past tense verb morphology as indexed by 22% accuracy score for the Verb Inflection Test (Faroqi-Shah, unpublished), 3) deemed functional reading ability (80% accuracy), and 4) reasonably intact repetition capabilities for the demands of the current study (67% accuracy).

Language and Speech Assessments

The baseline assessment battery included: (1) the Western Aphasia Battery-Revised (WAB-R, Kertesz, 2006), (2) the narrative language samples from the AphasiaBank protocol (MacWhinney et al., 2011), and (3) the Verb Inflection Test (Faroqi-Shah, unpublished).

Inclusion criteria for participant selection mirrored those used by Faroqi-Shah (2013) for morphosemantic treatment. Specifically, participants met the 1) aphasia type, 2) sentence production, 3) past tense verb production, and 4) reading ability criteria listed in Table 2.

Stimuli

All stimuli were adapted from or modeled after the three-image picture sets used by Faroqi-Shah (2013), which depict an action unfolding across time (future, present, past). This is illustrated in Figure 3. Participants were oriented to the nature of the sequences without indirect exposure to the tense constructions of interest: "Here are three pictures of an action. The first picture shows the action about to happen, the second picture shows the action happening now, and the third picture shows that the action is complete." The intended tense was elicited by means of a green outline around its corresponding picture in the sequence and a provided verb stem printed below the sequence.

A total of 40 action verbs were selected (Appendix B). Of these, 20 regular verbs were assigned to the training set (Research Question 1). The present and future tense forms of these same 20 verbs were used to assess Research Question 2A (generalization to untrained tenses of

Table 2

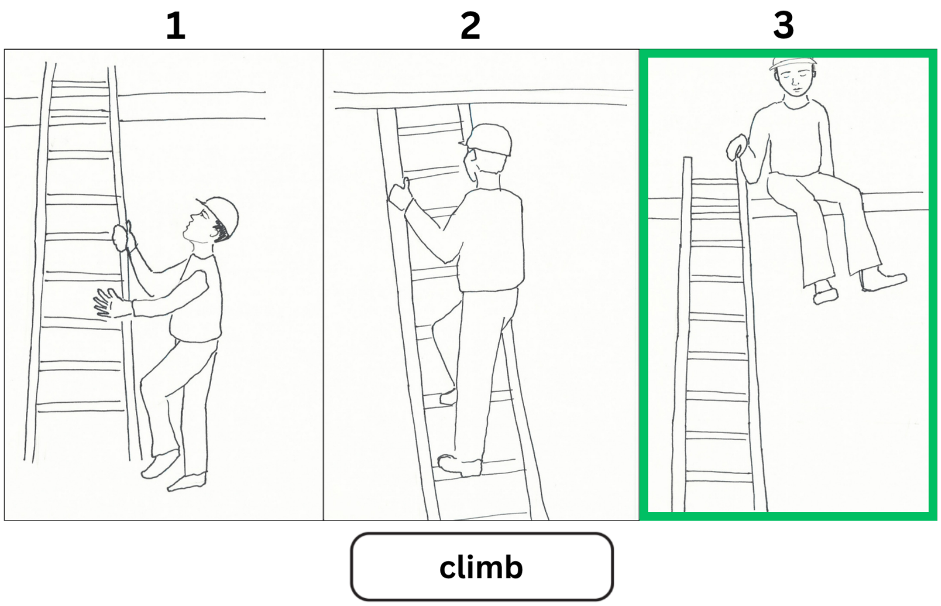
Participants' Aphasia and Language Evaluation Results

Test	AP001	AP002
Aphasia Type	Mild Transcortical Motor (Broca's subtype)	Moderate Broca's
Sentence Production Fluency	4/10	4/10
Verb Inflection Test (past tense < 60–70%)	Past tense: 25% All tenses: 36%	Past tense: 22% All tenses: 44%
Apraxia Battery for Adults-Second Edition (ABA-2) (severity documented; no minimum required)	Severe Apraxia	Mild Apraxia
WAB-R Sentence Reading Subtest (minimum = 70)	80%	80%
Repetition	81%	67%

trained verbs). The remaining 20 verbs were used to assess Research Question 2B (generalization to untrained verbs). Among these, 10 were regular, and 10 were irregular, and all were assessed in the past tense. Baseline included all 40 verbs varied to access the tenses relevant to the research questions: trained verbs in the past tense (N = 20; RQ1), trained verbs in present and future tense (N = 40; RQ2A), and untrained verbs (regular and irregular) in past tense (N = 20; RQ2B). The post-treatment assessment included only the generalization conditions: trained verbs in present and future tense (N = 40; RQ2A), and untrained verbs (regular and irregular) in past tense (N = 20; RQ2B). This resulted in 80 verb variations (probes) derived from the 40 verbs. During daily treatment cycles, only the 20 trained past tense verbs were assessed for daily probes (RQ1).

Figure 3

Examples of Sentence Elicitation Verb Image Sequence Across Treatment, Baseline, and Post-Treatment



Note. Image 1 depicts action initiation (future tense; "He will climb"), Image 2 shows the action in progress (present tense; "He is climbing"), and Image 3 presents the completed action (past tense; "He climbed"). The green outline indicates the target tense.

Treatment Procedures

All baseline, treatment, and post-treatment cycles were completed by the experimenter. The treatment procedure followed a modified STAR (Sentence Treatment for Aphasia Recovery) protocol (Lee et al., 2025), adapted to target verb tense inflections. The treatment protocol involved the following sequence of steps with each treatment verb (see Figure 4).

1. Oral reading and repetition of prime sentences containing regular past tense verb structures. A total of 40 prime sentences were created (see Appendix C). Primes were presented only in written form, without images. The experimenter read the sentence aloud, and participants were instructed to repeat the sentence aloud. In cycles 1 and 2, the prime and target sentences shared the same verb (e.g., The monkey peeled the ripe banana [PRIME]. / The

woman peeled the potatoes [TARGET].) to reduce cognitive demands during task familiarization. Starting in cycle 3, primes and targets no longer shared lexical content (verbs), though all continued to model the same syntactic structure. To reduce the likelihood of memorization or expectancy effects, prime-target pairings were randomly shuffled across cycles.

2. Following the two primes, a target verb picture sequence was presented, requiring the participant to describe the picture outlined in green (which was always the past tense). To minimize lexical retrieval demands and isolate inflection processing, the verb stem was provided, both verbally by the clinician and printed underneath the picture sequence, during the target prompt (e.g., "Tell me what is happening in this picture; please use the action "push"). In accordance with the implicit training framework, participants did not receive explicit instruction on verb tense rules but relied solely on exposure to the prime and the availability of the verb stem.

3. Following the production stage, the next prime sentence was shown, and the procedure was repeated for all treatment verbs.

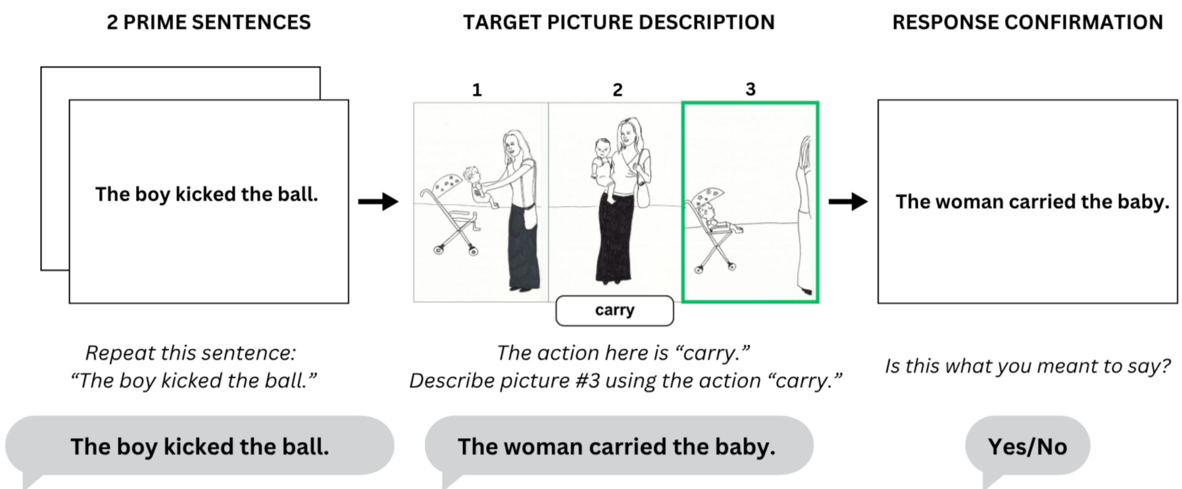
After cycling through all 20 treatment verbs in the past tense, daily probes were administered in which the same 3-picture sequences for the treatment verbs were presented in isolation (without the prime sentences), and participants were prompted to produce a sentence for the last of the three pictures. Participants took approximately 15-20 minutes to cycle through all 20 verbs, and for each day, two cycles were covered.

Procedural Adjustments

To accommodate AP001's severe verbal apraxia diagnosis and AP002's relative reading and repetition difficulties, the baseline and treatment cycles involved a response confirmation process. After participants produced their desired response, the treatment administrator transcribed their response live and posted it within the virtual meeting room chat. The participants were then asked to confirm, "Was this what you meant to say?" to accommodate any unintentional speech-motor planning issues or paraphasias. For AP002, who reported minor reading difficulties, his response was read aloud. To allow both participants the opportunity to accurately repeat the priming sentences, each sentence was read aloud by the experimenter at most twice (if needed), and participants were provided two equal opportunities to repeat the accurately inflected past-tense verb within the sentence.

Figure 4

Example of Treatment Trial with Prime Sentences and Verb Image Sequence



Outcome Measures and Scoring

During training cycles and probes, participants' responses to all target picture descriptions were transcribed verbatim and scored for accuracy. Participants sometimes repeated the prime sentence incorrectly on their first attempt. To ensure they heard and internalized the sentence, they were prompted once more (e.g., "We want you to repeat the sentence correctly; I will repeat the sentence once more"). If a participant produced multiple attempts, the accuracy of the final complete response was scored. A response was considered sentential if it included at least a subject noun and a lexical verb.

Responses were scored using both strict and lenient criteria. Under the strict criteria, a response was considered correct if the target noun(s) and verb were produced with appropriate argument structure, and the verb was correctly inflected in the past tense. Certain language production variations were permitted under this criterion to maintain focus on verb tense accuracy. Synonyms outside of the provided verb stem were accepted when the intended meaning was preserved (e.g., producing “man” for “boy”). Additionally, semantically appropriate prepositional substitutions (e.g., “for the boy” instead of “to the boy”) were accepted. Intelligible phonological errors in content words surrounding the verb (e.g., “teasher” for “teacher”) were also accepted, provided the intended meaning remained clear, and the verb tense was correctly produced. Phonemic paraphasias within the target verb itself (e.g., “jugged” for “juggled”) were accepted as long as the target verb was unambiguous. These exceptions reflect typical patterns in aphasic speech and do not directly impact the aims of the present study.

The lenient criteria were analyzed qualitatively and were dependent on individual participant progress. AP001, due to apraxia of speech, struggled with producing consonant clusters such as the /kt/ in targets like “cooked.” Thus, her responses following Baseline cycle 4 were transcribed live and confirmed by typing the transcription into the virtual meeting chat and having the participant either verbally or gesturally confirm (e.g., thumbs-up) that the sentence was what they intended to produce. For AP002, the presence of the regular past tense morphology (-ed) was considered correct under the lenient criteria, regardless of whether there was an ungrammatical auxiliary addition such as “is cooked” or “is hugged.” The rationale was that throughout AP002’s baseline cycles, they failed to produce the target verb ending at all; however, following treatment, they began to produce the inflection alongside an unnecessary auxiliary (“is”).

Data Analysis

Percent accuracy scores were calculated for each participant across three study phases (baseline, treatment, and post-training) for both treatment and generalization probes. Two primary statistical approaches were used to evaluate treatment effects. For the first research question, which examined changes in trained verb tense performance, statistical significance was assessed using the Tau-U statistic (Tarlow, 2016). Tau-U values were obtained using the Baseline

Corrected Tau Calculator (http://www.ktarlow.com/stats/tau). For the second research question, which examined generalization to untrained verb forms and tenses, McNemar's change test was used due to the binary nature of the data and the absence of multiple data points in the post-treatment testing phase. McNemar's test was conducted using GraphPad QuickCalcs (https://www.graphpad.com/quickcalcs/mcnemar1/; accessed April 2026).

Effect sizes were calculated to quantify the magnitude of treatment-related change for all three research questions. Effect sizes were defined as the standardized mean difference (SMD), which is comparable to Cohen's d for group designs (Levin et al., 2012), and were calculated for each participant (Busk & Serlin, 1992). Each effect size was computed as the difference between average baseline and post-treatment scores, divided by the standard deviation of baseline scores. This standardized mean difference (SMD) estimates the improvement relative to baseline variability. Effect sizes were interpreted using Beeson and Robey's (2006) adjusted clinical benchmarks for aphasia-specific work (e.g., 6.0 = small, 12.0 = medium, 18.0 = large) to contextualize the clinical significance of observed changes. Comparisons of effect sizes across the present study and Faroqi-Shah's (2008, 2013) morphosemantic treatment inform the final research question: whether implicit training in regular past tense verbs yields greater improvement than morphosemantic training.

Reliability

Inter-rater reliability was established for 10% of all dependent measures, including scoring of baseline, treatment, and generalization probes. Cycles were audio- and video-recorded for reliability coding. An undergraduate research assistant, trained by the primary investigator, independently transcribed and scored all speech productions using the video recordings under the strict criteria only. The rater was blind to treatment condition and study phase. Point-to-point agreement was used to calculate inter-rater reliability across all measures, yielding an agreement rate of 92% (Cohen's Kappa = 0.8376).

Results

Adherence

Overall, treatment adherence was high, with both participants completing all 12 treatment cycles with an average duration of 40 minutes per treatment cycle for AP001 and an average duration of 53 minutes per cycle for AP002. For the treatment step of prime sentence repetition, AP001 correctly repeated 63.3% of the primes, and AP002 correctly repeated 49.6%. In terms of assessment, AP002 missed half of the first baseline cycle due to an administration error.

Response to Treatment

Each participant's performance on daily probes for trained verbs using the strict and lenient scoring criteria is illustrated in Figures 6 (AP001) and 7 (AP002), and the percent scores are given in Table 3. Following the 12-cycle treatment phase, AP001 demonstrated significant improvement for trained verbs in the trained tense under both strict (Tau U = 0.611, p = 0.006, baseline M = 26.78%, Post-treatment M = 84.21%) and lenient criteria (Tau U = 0.609, p = 0.006, baseline M = 26.78%, Post-treatment M = 89.47%). AP002 did not show significant improvement under strict criteria (Tau U = 0, p = 1.00, baseline M = 0%, Post-treatment M = 0%) but demonstrated significant improvement under lenient criteria (Tau U= 0.639, p = 0.003, baseline M = 2.6%, Post-treatment M = 50%). In other words, both participants produced the verb+ed form significantly more frequently following implicit training, as noted by the lenient scoring criteria. However, only AP001 produced significantly more grammatically accurate sentences under the strict criteria.

Generalization Items

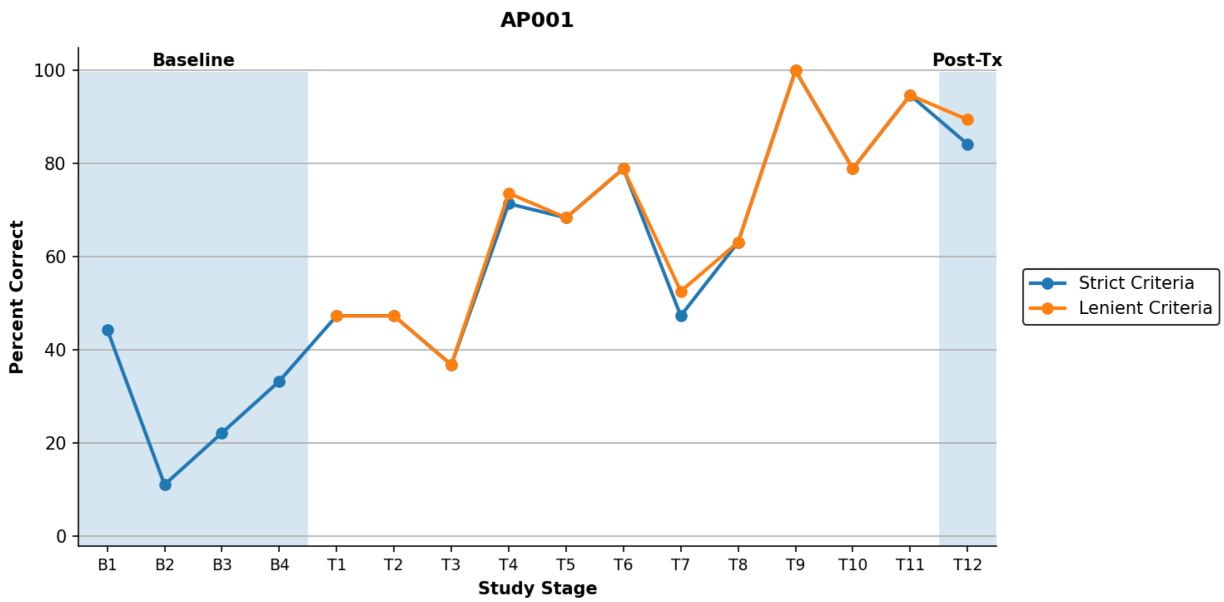
No participant showed evidence of improvement on the untreated stimuli (untrained tenses or untrained verbs) by means of McNemar significance as shown in Table 3.

Comparison to Morphosemantic

Efficacy of the current implicit priming treatment was compared to morphosemantic verb treatment (Faroqi-Shah, 2008; Faroqi-Shah, 2013) using effect sizes. For the current study,

Figure 6

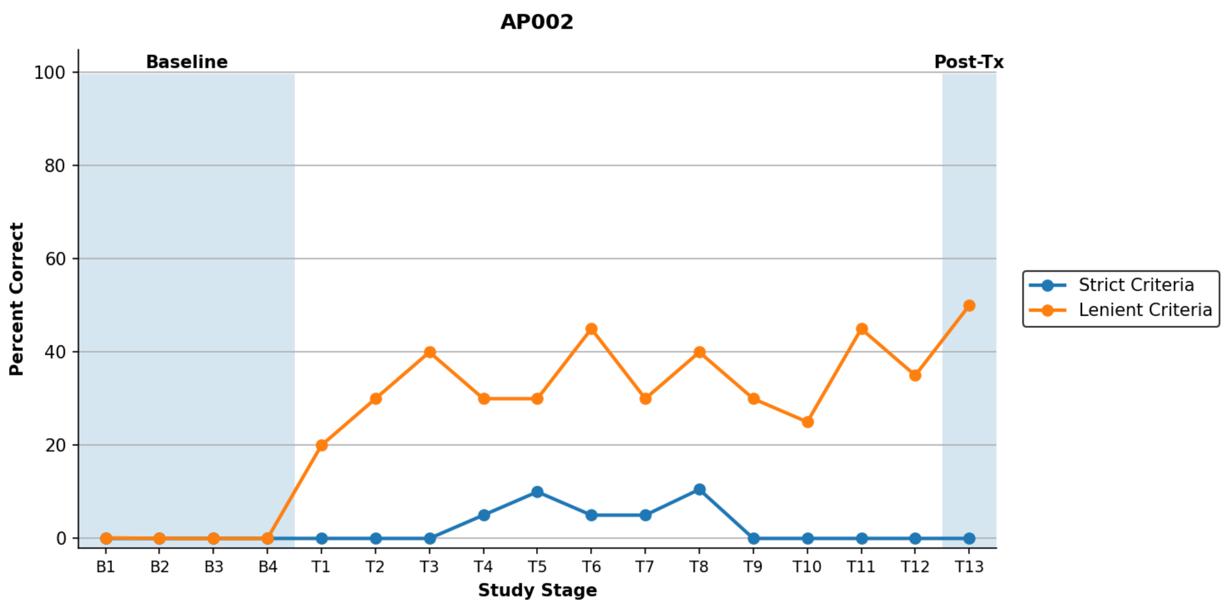
Accuracy of trained past tense verbs across the three study phases for AP001



Note. "B" indicates the baseline cycles, and "T" indicates treatment cycles.

Figure 7

Accuracy of trained past tense verbs across the three study phases for AP002



Note. "B" indicates the baseline cycles, and "T" indicates treatment cycles.

AP001 demonstrated effect sizes of 3.9 and 4.3 for strict and lenient criteria, respectively. Both values are below the small benchmark, indicating minimal treatment-related improvement despite post-treatment gains of 56.4% (strict) and 62.7% (lenient). AP002 showed highly variable outcomes across criteria. The effect size under strict criteria could not be calculated due to 0% pre- and post-treatment accuracy, whereas under lenient criteria, performance yielded an exceptionally large effect size of 287.7, corresponding to a 47.3% magnitude of improvement.

Effect sizes for level were obtained from Table 3 of Faroqi-Shah (2013) for participants P1-P3 across the Treatment set, and from Section 3.2.2 of Faroqi-Shah (2008) for participant "SK," who received morphosemantic treatment for regular verbs. Treatment verbs included all regular verbs across tenses, as specific past, present, and future tense data were not reported. Morphosemantic effect sizes were P1 = 7.8, P2 = 71.4, P3 = 193, and SK = 5.2.

Overall, aside from AP002's large effect under lenient criteria, implicit priming yielded predominantly small effect sizes, whereas morphosemantic treatment produced mostly medium-to-large effects. These findings suggest that implicit priming did not surpass morphosemantic treatment based on effect size.

Discussion

This is the first study to investigate whether implicit training focused on regular past tense verb forms leads to measurable improvements in verb inflection accuracy, and whether these improvements generalize to untrained verb forms and tenses. This work was motivated by the high prevalence of tense deficits in individuals with agrammatic aphasia (Faroqi-Shah & Thompson, 2007) and the limited use of implicit learning-based treatments (Valinejad et al., 2022), despite evidence that this population can acquire grammatical patterns outside of explicit instruction (Rainey et al., 2026; Schuchard & Thompson, 2014; Van Boxtel et al., 2025). As a proof of concept, the efficacy of implicit priming was explored for training regular past tense verbs in two participants with agrammatic aphasia.

Table 3

Summary of All Outcome Measures

	Research Question 1		Research Question 2							
	Trained Past		Trained Present		Trained Future		Untrained Regular Past		Untrained Irregular Past	
Measure	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
AP001										
Strict criteria	26.78% (10/36)	84.21% (16/19)	93.33% (70/75)	88% (8/9)	97.37% (73/75)	90% (9/10)	24.99% (7/28)	90% (9/10)	59.61% (31/52)	87.17% (8/10)
p value	0.006		0.4795		1.00		0.2482		0.4795	
Effect size	3.93		-0.67		-1.4		3.61		2.84	
Lenient criteria	26.78% (10/36)	89.47% (17/19)	93.33% (70/75)	100% (9/9)	97.37% (73/75)	100% (10/10)	24.99% (7/28)	100% (10/10)	59.61% (31/52)	100% (10/10)
p value	0.006		0.2482		N/A		0.0736		0.4795	
Effect size	4.30		1.00		1.26		4.17		4.17	
AP002										
Strict criteria	0.00%	0.00%	32.75% (19/58)	11.11%	1.45%	0%	9.82% (2/24)	0% (0/10)	0% (0/20)	0% (0/10)
p value	1.00		1.00		N/A		1.00		1.00	
Effect size	N/A		-1.36		-0.5		-0.8		-0.78	
Lenient criteria	2.70%	50%	32.75% (19/58)	22.22% (2/9)	1.44% (1/69)	0% (0/10)	20% (4/20)	50% (5/10)	2.38% (1/42)	0% (0/10)
p value	0.003		0.6171		N/A		0.2482		1.00	
Effect size	287.69		-0.069		-0.5		3.32		-0.78	

Efficacy of Implicit Priming Verb Tense Treatment (RQ1)

Within a single-case experimental design, treatment effects were first examined at the level of verb tense morphology per research question one. We hypothesized that implicit priming training would lead to increased regular past tense verb accuracy for the trained verb set. The first participant (AP001) demonstrated significant improvement in past tense production under both strict and lenient criteria. The second participant (AP002) did not improve under strict criteria but showed gains under lenient criteria. Given the differences in training outcomes across the two participants, possible reasons for these differential outcomes are discussed, including potential compensatory strategies, incomplete priming mechanisms, and overall contrasts in aphasia profiles and individual abilities.

First, AP002's reflected improvements were relatively unique and unexpected. He demonstrated increased verb morphology accuracy under the lenient criteria, as he frequently produced forms such as "is cooked" rather than the simple past "cooked." His use of the "is + verb" construction not only appeared in the trained past tense conditions but also appeared in untrained tense generalization contexts (e.g., "The old man is gambles on games" for the target "He gambles money"). This suggests he employed a common compensatory strategy in agrammatic aphasia: using auxiliaries or morphemes such as -ing or is as semi-automatic productions to initiate sentence formulation (Faroqi-Shah & Thompson, 2007; Druks and Carroll, 2005). Thus, AP002 may have indeed internalized aspects of past tense morphology while using auxiliaries to delay sentence planning.

AP002's priming of only the verb + -ed form within a contextually incorrect sentence structure may also reflect the inherent complexity of verb morphology mentioned in prior studies, which requires both activation of the morphosyntactic component (-ed) and the associated semantics of tense, in contrast to more isolated morphosyntactic principles like subject-verb agreement (Faroqi-Shah & Thompson, 2007). Repetition priming alone facilitates processing within a single item, say a word, whereas semantic priming requires activation across multiple items in the lexical-semantic network (Silkes et al., 2012). Correctly producing the target under strict criteria requires retrieving the -ed morpheme and mapping that morphological form onto its corresponding temporal reference, which is consistent with the morphosemantic accounts of tense processing (Faroqi-Shah, 2008; Valinejad et al., 2022). For AP002, priming appears to have succeeded at the form level but failed to support deeper semantic integration. However, whether this lack of connection between the verb morphology and the semantic/temporal meaning is due to insufficient repetition/internalization of the target structures or the overall insufficiency of the implicit priming protocol for resolving this disconnect still remains uncertain.

Beyond verb tense morphology, AP002 appeared to produce more complete sentences following treatment. During baseline cycles, he primarily produced fragments (e.g., "Now pours the glass now," "After the dry is uh bathroom," "Before the paint is soon"). Post-treatment, he began constructing fuller sentences with subjects, objects, and modifiers, despite ongoing grammatical errors (e.g., "Before the waitress is pour on the woman," "All done, the man is cleaned, is all shiny," "The woman is drawing in picture"). This pattern aligns with STAR's finding that implicit priming can support sentence-level improvements, such as increased production of utterances containing a subject and verb (Rainey et al., 2026).

Finally, the two participants had minor differences in aphasia profile and relevant skills. AP001 was classified as having transcortical aphasia, associated with relatively preserved repetition skills, whereas AP002 had moderate Broca's aphasia with lower repetition scores. Participants with more severe aphasia may require higher dosages of implicit priming therapy, as greater impairment may necessitate activation of multiple linguistic components (e.g., lexical retrieval and morphological encoding) simultaneously. In contrast, participants whose primary difficulty is verb inflection may benefit more directly and or quickly, as other sentence elements may remain relatively preserved. Accurate repetition is essential for engaging with and internalizing the target verb structure; participants unable to reproduce sentences accurately are less likely to spontaneously produce the target verbs.

Reading ability may have also contributed to treatment outcomes. We asked participants to confirm their responses as transcribed by the administrator to overcome misarticulations due to apraxia rather than agrammatic errors, but it also appeared to function as a form of self-monitoring. AP002 primarily noticed subject-gender inconsistencies (e.g., “The boy is skate is all done” corrected to “The girl is skate is all over”) but did not self-correct verb tense errors, whereas AP001 detected tense errors such as “cooks” instead of “cooked” and attempted correction. This may reflect subtle differences in reading ability, as verb endings are less salient than the subject, which could be a nuance not effectively captured by the multiple-choice WAB-R Reading Test used to establish eligibility (both participants scored 80%). One potential modification would be for the administrator to read the written confirmation aloud, preserving the implicit nature of the protocol while allowing participants with reading challenges to benefit from the confirmation step as a self-monitoring tool.

Overall, these findings suggest that regular past tense verb deficits characteristic of agrammatic speech may benefit from implicit priming that targets verb inflection production, extending recent sentence-level treatment approaches (Lee et al., 2025; Van Boxtel et al., 2025; Rainey et al., 2026). However, the robustness of this effect across individuals, as well as whether it reflects surface-level facilitation of verb forms versus deeper morphosyntactic learning, remains unclear.

Generalization to Untrained Tenses and Untrained Verbs (RQ2)

We were unable to find generalization in either participant for untrained verbs (regular and irregular) or untrained tenses (present and future), corresponding to Research Questions 2A and 2B. The absence of generalization to untrained tenses aligns with Faroqi-Shah (2021), who reported limited cross-tense transfer when treatment focused exclusively on past tense production. This finding is also consistent with Faroqi-Shah (2013), who trained multiple tenses using morphosemantic treatment but noted in the discussion that studies targeting a single tense often fail to demonstrate cross-tense generalization, suggesting that tense-specific training may be necessary for morphological patterns to generalize across temporal contexts. Because the present study targeted past tense only, the lack of improvement in untrained present and future forms supports this interpretation.

The absence of generalization to untrained regular verbs was unexpected, considering prior research within morphosemantic and related treatment approaches has demonstrated reliable generalization to untrained regular verbs following treatment (Faroqi-Shah, 2013; Valinejad et al., 2025; Rashmi et al., 2025). For example, morphosemantic treatment in Faroqi-Shah (2012) demonstrated consistent generalization to untrained regular morphology regardless of whether regular or irregular verbs were trained.

Similarly, no generalization was observed for untrained irregular verbs in the past tense. This finding aligns with prior literature indicating that generalization to irregular verbs is less likely when only regular verbs are trained. For example, Rashmi et al. (2025) reported that training irregular verbs can strengthen irregular verb production while also reactivating rule-based affixation processes for regular verbs, suggesting broader generalization from irregular to regular forms. However, generalization from regular verbs to irregular verbs has been reported less consistently (Faroqi-Shah, 2008; Faroqi-Shah, 2013). Because the present study trained only regular verbs, the absence of generalization to untrained irregular verbs was expected.

Notably, several baseline prompts were not administered correctly during the singular generalization cycle, and some stimulus pairs were removed due to inconsistencies, which may have reduced opportunities to demonstrate transfer of learning. Additionally, AP001 was near ceiling during baseline measures for present and future tense (e.g., 93.33% for pre-treatment trained regular present items and 97.37% accuracy for trained regular future items), which may have limited the magnitude of observable generalization.

Nevertheless, the overall lack of significant generalization across conditions most likely suggests that the implicit priming protocol may have limited effects on untrained tenses and verbs. From a broader morphosemantic perspective of verb deficits, this lack of generalization may reflect weak transfer of learned mappings between verb morphology and temporal reference representations, rather than changes to a more abstract tense-processing system.

Comparison to Morphosemantic Verb Treatment (RQ3)

To address the final research question, using effect size, the efficacy of implicit priming was compared to morphosemantic verb treatment (Faroqi-Shah, 2008; Faroqi-Shah, 2013). Morphosemantic effect sizes for regular verbs across all tenses were P1 = 7.8, P2 = 71.4, P3 = 193, and SK = 5.2. Neither of these studies established a strict vs. lenient distinction. For the current implicit training, AP001 demonstrated effect sizes of 3.9 and 4.3 for strict and lenient criteria, respectively, both with the small benchmark of 6.0 (Beeson & Robey, 2005), indicating a small treatment magnitude. AP002 showed highly variable outcomes: effect size could not be calculated under strict criteria due to 0% pre- and post-treatment accuracy, whereas the lenient criterion yielded an exceptionally large effect size of 287.7 due to the extremely minimal variability in baseline accuracy (hence a small denominator in the SMD formula). Overall, morphosemantic treatment generally produced larger and more consistent effect sizes across participants, with P2 and P3 achieving large effects. By contrast, implicit priming effects were smaller and highly participant- and measure-dependent. Considering AP002's large improvements were likely inflated by flat baseline scores and AP001's gains remained within the small effect range, these results suggest that implicit priming does not currently produce the consistency observed with morphosemantic treatment's effects.

Treatment Comparison Beyond Effect Size

Effect sizes alone do not fully account for the more nuanced differences in these treatments' structures or cognitive demands. Thus, to further interpret research question three's findings, the two treatment frameworks can be compared both in terms of load and mode of production.

First, in terms of processing demands, morphosemantic treatment involves multiple structured tasks and repeated integration of corrective feedback, which likely increases demands on executive functioning and working memory (Rainey et al., 2026). In contrast, implicit priming involves fewer task steps and no explicit feedback, and was designed to reduce such metalinguistic demands. Although the sentence repetition component of the current study still requires participants to process and reproduce syntactic structure, the continued visual availability of stimuli likely reduces working memory demands associated with sentence retention (Eom & Sung, 2016). Overall, implicit priming may impose a lower executive and metalinguistic load compared to morphosemantic training. However, it remains uncertain whether implicit priming and its reduced explicit cognitive demands are sufficient to support robust activation of semantically linked verb-tense mappings, which are explicitly reinforced in morphosemantic treatment's structured comprehension tasks.

Second, the two approaches differ in modality-specific processing requirements. Morphosemantic training avoids extended oral production, with the exception of the initial singular verb naming task (Faroqi-Shah, 2008; Faroqi-Shah, 2013), but places substantial demands on comprehension, reading, and writing abilities, which are commonly impaired in individuals with aphasia (Kjellén et al., 2017). The rationale for this modality is that morphosemantic training targets morphological and semantic processing rather than phonological output. Yet, prior research suggests these systems are closely linked, as morphological errors in repetition often co-occur with phonological errors (Miceli, Capasso, & Caramazza, 2002). In fact, Faroqi-Shah (2008) and (2012) note that participants in the morphosemantic study did not present with concomitant phonological impairments like apraxia, raising questions about generalizability to more complex, yet common, impairment profiles. Supporting this concern, Drew and Thompson (1999) reported that when participants did present with phonological impairments, two out of four did not show improvement until phonological information was incorporated into treatment, suggesting that morphological treatment alone may be insufficient for some individuals. In contrast, implicit priming consistently embeds phonological processing throughout repeated verbal output. Thus, this may partly explain why a participant in the current study with severe apraxia (AP001) benefited from this phonologically-integrated method, apart from her relatively preserved repetition and reading skills mentioned previously.

Furthermore, relative to morphosemantic, implicit priming somewhat reduces reliance on literacy skills, as the treatment administrator presents prime sentences and verb stems orally. This may improve treatment feasibility for individuals with significant reading and writing impairments. Notably, morphosemantic treatment is not strictly limited to written modality, as Rashmi et al. (2025) report that modifying morphosemantic tasks to spoken output may improve morphosyntactic production. However, such modifications have not been consistently reported with standardized effect sizes, limiting direct quantitative comparison with implicit priming outcomes. Nonetheless, the modality focus of each treatment are considerable factors in deciding optimal treatment fit.

Overall, these findings suggest that the two approaches differ not only in outcome magnitude but also in the distribution of cognitive and modality-specific demands. Thus, the clinical effectiveness of the treatment may depend on the interaction between linguistic impairment profiles and the specific processing demands of each approach. Moreover, those with aphasia who present verb deficits and reading or writing impairments may benefit more from implicit verb treatment if its effects prove to be robust. In contrast, those with relatively preserved literacy skills and cognitive tolerance for multistep task demands may be better suited for morphosemantic treatment.

Limitations and Future Directions

Due to time constraints and the exploratory nature of the study, the treatment phase consisted of only 12 treatment cycles, with participants attending therapy twice per week (four weeks of treatment). In contrast, other treatment studies were administered 4–5 days per week in 1–2 hour cycles. This difference limits across-treatment comparisons, as the implicit priming treatment was delivered at a lower dosage and frequency, and higher dosage and frequency have been shown to be necessary for individuals with more severe aphasia profiles (Brady et al., 2022).

Additionally, the small sample size (N = 2) limits the generalizability of the findings and highlights the need for replication with a larger participant pool. Unlike previous replications of the STAR treatment procedure, the current study did not examine maintenance of treatment effects or post-training changes in spontaneous speech samples (e.g., relative to WAB-R narratives collected pre-treatment). These outcomes are important for determining both the long-term effectiveness and functional communication impact of a treatment protocol.

Furthermore, individual differences in implicit and explicit memory capacity were not directly measured. Because the implicit priming treatment involved repetition of prime sentences, verbal working memory demands may have influenced performance, making it difficult to confirm the implicit nature of the treatment. Van Boxtel et al. (2025) included cognitive measures of explicit and implicit memory in their administration of the STAR treatment and found that higher implicit memory scores were associated with greater treatment effects in both controls and people with aphasia (PWA). Thus, without comparable cognitive measures, it remains unclear whether treatment outcomes were driven by implicit learning, explicit strategies, and/or working memory capacity.

Acceptability measures (e.g., perceived treatment burden, engagement, and functional communication change) were also not collected. These measures are important for evaluating treatment feasibility and patient-centered care, as these more holistic approaches to treatment have been associated with increased adherence and patient satisfaction (Mahomed-Asmail et al., 2023). Finally, treatment was administered by an undergraduate speech pathology student rather than a certified speech-language pathologist, which may have introduced variability in treatment implementation. As a result, the overall clinical value and feasibility of this treatment, particularly in terms of broader communication impact and patient-centered care, remain to be determined.

Several methodological factors should also be considered when interpreting these findings. Effect size calculations are influenced by baseline variability; extremely low baseline scores, as observed for AP002 under lenient criteria and P3 in morphosemantic treatment, may inflate effect sizes and confound interpretation. Treatment stimuli factors may have influenced outcomes. Morphological complexity in prime sentences (e.g., the inclusion of adjectives such as scary in “The girl paused the scary movie”), which was originally intended to equalize the length of future and past tense target sentences (e.g., will bake vs. baked) to prevent poorer performance in future tense conditions, may have unnecessarily increased syntactic planning demands. This could have contributed to participants’ overall prime repetition accuracy, landing below 70%.

Phonologically complex consonant clusters in primes and target verbs (e.g., consonant clusters in juggle, scribble) may have unnecessarily further challenged participants, particularly those with apraxia of speech, during both verb production tasks and prime repetition trials.

Considering these points alongside the preliminary and exploratory nature of this work, several directions for future research are proposed. First, simplifying prime sentences and selecting less phonologically complex target verbs may enhance implicit learning effects and allow for a more direct evaluation of priming effects. Future studies should also directly measure individual differences in implicit and explicit memory capacity using cognitive assessments. This would clarify the extent to which the priming treatment relies on implicit learning/memory mechanisms and allow for a more informative comparison of cognitive demands between implicit and explicit treatment approaches. To further evaluate the replicability and durability of implicit priming outcomes, future research should include larger sample sizes and more diverse participant profiles (e.g., mild, moderate, and severe aphasia). In addition, future studies should incorporate follow-up assessments to examine maintenance of treatment effects over time, as well as broader language outcome measures beyond verb inflection accuracy, including spontaneous speech performance and standardized post-treatment language assessments. Participant-reported outcome measures should also be included to better capture clinical acceptability, feasibility, and real-world impact. Finally, future studies should conduct within-study, rather than across-study, comparisons of implicit priming with established approaches such as morphosemantic treatment. These comparisons would help determine the most effective strategies for verb inflection recovery across different aphasia profiles.

Conclusion

This study provides preliminary evidence that implicit priming may support verb tense production in individuals with agrammatic aphasia, although effects were variable across participants. While one participant demonstrated robust improvement in trained past tense verbs under both criteria and the other under the lenient criterion, generalization to untrained verbs and tenses was limited for both, suggesting that gains may be largely item-specific rather than broadly generalizable. Compared to established morphosemantic treatment, implicit priming produced smaller and less consistent effect sizes; however, differences in treatment structure, cognitive demand distribution, and participant profiles complicate direct comparison. Taken together, these findings suggest that implicit priming may rely on a different learning mechanism than morphosemantic approaches, potentially emphasizing phonologically mediated repetition and form-level learning rather than strengthened mappings between verb morphology and temporal reference (i.e., morphosemantic integration). Clinically, treatment effectiveness may depend on individual differences in repetition ability, literacy skills, and cognitive capacity. More broadly, as the first investigation of implicit priming for regular past tense verb training in agrammatic aphasia, this study highlights the need for replication with larger and more diverse participant samples to establish the reliability and generalizability of these exploratory findings.

References

Abel, A. D., Maguire, M. J., Naqvi, F. M., & Kim, A. Y. (2015). Lexical Retrieval of Nouns and Verbs in a Sentence Completion Task. Journal of Psycholinguistic Research, 44(5), 545–553. https://doi.org/10.1007/s10936-014-9304-8.

Agrammatism—An overview | ScienceDirect Topics. (n.d.). Retrieved May 14, 2025, from https://www.sciencedirect.com/topics/medicine-and-dentistry/agrammatism.

Aphasia | NIDCD. (2025, April 16). https://www.nidcd.nih.gov/health/aphasia.

Basso, A., & Macis, M. (2011). Therapy Efficacy in Chronic Aphasia. Behavioural Neurology, 24(4), 313480. https://doi.org/10.3233/BEN-2011-0342.

Bastiaanse, R., & Jonkers, R. (1998). Verb retrieval in action naming and spontaneous speech in agrammatic and anomic aphasia. Aphasiology, 12, 951–969. https://doi.org/10.1080/02687039808249463.

Beeson, P. M., & Robey, R. R. (2006). Evaluating Single-Subject Treatment Research: Lessons Learned from the Aphasia Literature. Neuropsychology Review, 16(4), 161–169. https://doi.org/10.1007/s11065-006-9013-7.

Bock, K., & Levelt, W. (1994). Language Production: Grammatical Encoding. In G.M.A (Ed.), Handbook of Psycholinguistics. Academic Press.

Bonnotte, I. (2008). The Role of Semantic Features in Verb Processing. Journal of Psycholinguistic Research, 37, 199–217. https://doi.org/10.1007/s10936-007-9066-7.

Brady, M. C., Ali, M., VandenBerg, K., Williams, L. J., Williams, L. R., Abo, M., Becker, F., Bowen, A., Brandenburg, C., Breitenstein, C., Bruehl, S., Copland, D. A., Cranfill, T. B., di Pietro-Bachmann, M., Enderby, P., Fillingham, J., Galli, F. L., Gandolfi, M., Glize, B., … Wright, H. H. (2022). Dosage, Intensity, and Frequency of Language Therapy for Aphasia: A Systematic Review-Based, Individual Participant Data Network Meta-Analysis. Stroke. 2022 Mar;53(3):956-967. https://doi-org.proxy-um.researchport.umd.edu/10.1161/STROKEAHA.121.035216.

Breedin, S. D., & Martin, R. C. (1996). Patterns of Verb Impairment in Aphasia: An Analysis of Four Cases. Cognitive Neuropsychology, 13(1), 51–92. https://doi.org/10.1080/026432996382060.

Brossart, D. F., Laird, V. C., & Armstrong, T. W. (2018). Interpreting Kendall's Tau and Tau-U for single-case experimental designs. Cogent Psychology, 5(1), 1518687. https://doi.org/10.1080/23311908.2018.1518687.

Carragher, M., Sage, K., & Conroy, P. (2015). Outcomes of treatment targeting syntax production in people with Broca's-type aphasia: Evidence from psycholinguistic assessment tasks and everyday conversation. International Journal of Language & Communication Disorders, 50(3), 322–336. https://doi.org/10.1111/1460-6984.12135.

Cavanaugh, R., Quique, Y. M., Swiderski, A. M., Kallhoff, L., Terhorst, L., Wambaugh, J., Hula, W. D., & Evans, W. S. (2023). Reproducibility in Small-N Treatment Research: A Tutorial Using Examples From Aphasiology. Journal of Speech, Language, and Hearing Research, 66(6), 1908–1927. https://doi.org/10.1044/2022_JSLHR-22-00333.

Cherney, L. R. (2012). Aphasia treatment: Intensity, dose parameters, and script training. International Journal of Speech-Language Pathology, 14(5), 424–431. https://doi.org/10.3109/17549507.2012.686629.

Cho-Reyes, S., Mack, J. E., & Thompson, C. K. (2016). Grammatical encoding and learning in agrammatic aphasia: Evidence from structural priming. Journal of Memory and Language, New Approaches to Structural Priming, 91, 202–218. https://doi.org/10.1016/j.jml.2016.02.004.

Dashti, F., Asadi, M., & Yadegari, F. (2023). Morphosemantic treatment of inflection of verb tense in Persian-speaking aphasic patients with agrammatism: A single-subject study. Aphasiology, 37(2), 288–306. https://doi.org/10.1080/02687038.2021.2010272.

de Aguiar, V., Bastiaanse, R., & Miceli, G. (2016). Improving Production of Treated and Untreated Verbs in Aphasia: A Meta-Analysis. Frontiers in Human Neuroscience, 10, 468. https://doi.org/10.3389/fnhum.2016.00468.

Druks, J., & Carroll, E. (2005). The crucial role of tense for verb production. Brain and Language, 94(1), 1–18. https://doi.org/10.1016/j.bandl.2004.11.003.

Eom, B., & Sung, J. E. (2016). The Effects of Sentence Repetition–Based Working Memory Treatment on Sentence Comprehension Abilities in Individuals With Aphasia. American Journal of Speech-Language Pathology. https://doi.org/10.1044/2016_AJSLP-15-0151.

Faroqi-Shah, Y. (2008). A comparison of two theoretically driven treatments for verb inflection deficits in aphasia. Neuropsychologia, 46(13), 3088–3100. https://doi.org/10.1016/j.neuropsychologia.2008.06.018.

Faroqi-Shah, Y., & Dickey, M. W. (2009). On-line processing of tense and temporality in agrammatic aphasia. Brain and Language, 108(2), 97–111. https://doi.org/10.1016/j.bandl.2008.10.003.

Faroqi-Shah, Y., Wood, E., & Gassert, J. (2010). Verb impairment in aphasia: A priming study of body-part overlap. Aphasiology, 24(11), 1377–1388. https://doi.org/10.1080/02687030903515362.

Faroqi-Shah, Y., & Thompson, C. K. (2007). Verb inflections in agrammatic aphasia: Encoding of tense features. Journal of Memory and Language, 56(1), 129–151. https://doi.org/10.1016/j.jml.2006.09.005.

Faroqi-Shah, Y., & Graham, L. E. (2011). Treatment of semantic verb classes in aphasia: Acquisition and generalization effects. Clinical Linguistics & Phonetics, 25(5), 399–418. https://doi.org/10.3109/02699206.2010.545964.

Faroqi-Shah, Y. (2013). Selective treatment of regular versus irregular verbs in agrammatic aphasia: Efficacy data. Aphasiology, 27(6), 678–705. https://doi.org/10.1080/02687038.2012.751577.

Faroqi-Shah, Y. (2021). Training and generalization of verb tense training using irregular verbs in agrammatic aphasia. Academy of Aphasia, Virtual Conference. Preprint.

Fillingham, J. K., Sage, K., & Lambon Ralph, M. A. (2006). The treatment of anomia using errorless learning. Neuropsychological Rehabilitation, 16(2), 129–154. https://doi.org/10.1080/09602010443000254.

Kertesz, A. (2006). Western Aphasia Battery-Revised. Pearson.

Kjellén, E., Laakso, K., & Henriksson, I. (2017). Aphasia and literacy—The insider's perspective. International Journal of Language & Communication Disorders, 52(5), 573–584. https://doi.org/10.1111/1460-6984.12302.

Le, H., Lui, F., & Lui, M. Y. (2025). Aphasia. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK559315/.

Lee, J. & Man, G. (2017). Language recovery in aphasia following implicit structural priming training: A case study. Aphasiology, 31(12), 1441–1458. https://doi.org/10.1080/02687038.2017.1306638.

Lee, J., van Boxtel, W. S., Weirick, J. D., Ferreira, V., Martin, N., Bauman, E. L., Haven, L. N., Sayers, M. J., & Manning, R. G. C. (2024). Implicit structural priming as a treatment component for aphasia: Specifying essential learning conditions. Cognitive Neuropsychology, 41(5–6), 190–214. https://doi.org/10.1080/02643294.2025.2479485.

Linebarger, M. C., Schwartz, M. F., & Saffran, E. M. (1983). Sensitivity to grammatical structure in so-called agrammatic aphasics. Cognition, 13(3), 361–392. https://doi.org/10.1016/0010-0277(83)90015-X.

Lustig, C., Esser, S., & Haider, H. (2022). The interplay between unexpected events and behavior in the development of explicit knowledge in implicit sequence learning. Psychological Research, 86(7), 2225–2238. https://doi.org/10.1007/s00426-021-01630-2.

Faroqi-Shah Y & Marshall K (2025) Behavioral and neural outcomes of training manipulable verbs in aphasia: a proof-of-concept single subject experimental design. Front. Lang. Sci. 4:1560115. doi: 10.3389/flang.2025.1560115.

Mahomed-Asmail, F., Hlayisi, V.-G., Joubert, K., Metcalfe, L. A., Graham, M. A., & Swanepoel, D. W. (2023). Person-centered care: Preferences and predictors in speech-language pathology and audiology practitioners. Frontiers in Psychology, 14. https://doi.org/10.3389/fpsyg.2023.1162588.

Meinzer, M., Rodriguez, A. D., & Gonzalez Rothi, L. J. (2012). The first decade of research on constrained-induced treatment approaches for aphasia rehabilitation. Archives of Physical Medicine and Rehabilitation, 93(1 Suppl), S35–S45. https://doi.org/10.1016/j.apmr.2011.06.040.

Nanousi, V., Masterson, J., Druks, J., & Atkinson, M. (2006). Interpretable vs. uninterpretable features: Evidence from six Greek-speaking agrammatic patients. Journal of Neurolinguistics, 19(3), 209–238. https://doi.org/10.1016/j.jneuroling.2005.11.003.

Rainey, K., Brownd, H., & Lee, J. (2026). Syntax Treatment for Aphasia Recovery: Implicit Learning Through Structural Priming. Perspectives of the ASHA Special Interest Groups, 11(1), 51–67. https://doi.org/10.1044/2025_PERSP-25-00053.

Schuchard, J., Nerantzini, M., & Thompson, C. K. (2017). Implicit learning and implicit treatment outcomes in individuals with aphasia. Aphasiology, 31(1), 25–48. https://doi.org/10.1080/02687038.2016.1147526.

Silkes, J. P., Baker, C., & Love, T. (2020). The time course of priming in aphasia: An exploration of learning along a continuum of linguistic processing demands. Topics in Language Disorders, 40(1), 54–80. https://doi.org/10.1097/TLD.0000000000000205.

Slevc, L. R. (2023). Grammatical Encoding. In Language Production. Routledge.

Smith, C. S. (2007). Tense and temporal interpretation. Lingua, 117(2), 419–436. https://doi.org/10.1016/j.lingua.2004.10.005.

Tate, R. L., Perdices, M., Rosenkoetter, U., Shadish, W., Vohra, S., Barlow, D. H., Horner, R., Kazdin, A., Kratochwill, T., McDonald, S., Sampson, M., Shamseer, L., Togher, L., Albin, R., Backman, C., Douglas, J., Evans, J. J., Gast, D., Manolov, R., … Wilson, B. (2016). The Single-Case Reporting Guideline In BEhavioural Interventions (SCRIBE) 2016 Statement. Aphasiology, 30(7), 862–876. https://doi.org/10.1080/02687038.2016.1178022.

Tarlow, K. R. (2017). An Improved Rank Correlation Effect Size Statistic for Single-Case Designs: Baseline Corrected Tau. Behavior Modification, 41(4), 427–467. https://doi.org/10.1177/0145445516676750.

Thompson, C. & Shapiro, L. (2005). Treating agrammatic aphasia within a linguistic framework: Treatment of Underlying Forms. Aphasiology, 19(10–11), 1021–1036. https://doi.org/10.1080/02687030544000227.

Valinejad, V., Mehri, A., Khatoonabadi, A., Darzi, A., Barbieri, E., Shekari, E., Zare Sadeghi, A., Shati, M., Habibi, S. A. H., & Almasi-Dooghaee, M. (2025). Treatment of verb tense inflection and sentence production in Persian individuals with agrammatism. Applied Neuropsychology: Adult, 32(6), 1612–1626. https://doi.org/10.1080/23279095.2023.2297085.

Valinejad, V., Mehri, A., Khatoonabadi, A., & Shekari, E. (2022). Treatment of verb tense morphology in agrammatic aphasia: A systematic review. Journal of Neurolinguistics, 62, 101045. https://doi.org/10.1016/j.jneuroling.2021.101045.

Verneau, M., van der Kamp, J., Savelsbergh, G. J. P., & de Looze, M. P. (2014). Age and Time Effects on Implicit and Explicit Learning. Experimental Aging Research, 40(4), 477–511. https://doi.org/10.1080/0361073X.2014.926778.

Wagenaar, E., Snow, C., & Prins, R. (1975). Spontaneous speech of aphasic patients: A psycholinguistic analysis. Brain and Language, 2, 281–303. https://doi.org/10.1016/S0093-934X(75)80071-X.

Williams, J. N. (2020). The Neuroscience of Implicit Learning. Language Learning, 70(S2), 255–307. https://doi.org/10.1111/lang.12405.

Wright, H. H., & Shisler, R. J. (2005). Working Memory in Aphasia. American Journal of Speech-Language Pathology, 14(2), 107–118. https://doi.org/10.1044/1058-0360(2005/012).

Appendix A

The Single-Case Reporting Guideline in BEhavioural Interventions 2016 Statement

Item number	Topic	Item description
TITLE and ABSTRACT		
1	Title	Identify the research as a single-case experimental design in the title
2	Abstract	Summarize the research question, population, design, methods including interventions (independent variable/s) and target behavior/s and any other outcome/s (dependent variable/s), results, and conclusions
INTRODUCTION		
3	Scientific background	Describe the scientific background to identify issues under analysis, current scientific knowledge, and gaps in that knowledge base
4	Aims	State the purpose/aims of the study, research question/s, and, if applicable, hypotheses
METHOD		
DESIGN		
5	Design	Identify the design (e.g., withdrawal/reversal, multiple-baseline, alternating-treatments, changing-criterion, some combination thereof, or adaptive design) and describe the phases and phase sequence (whether determined a priori or data-driven) and, if applicable, criteria for phase change
6	Procedural changes	Describe any procedural changes that occurred during the course of the investigation after the start of the study
7	Replication	Describe any planned replication
8	Randomization	State whether randomization was used, and if so, describe the randomization method and the elements of the study that were randomized

Continued on next page

Appendix A (continued)

Item number	Topic	Item description
9	Blinding	State whether blinding/masking was used, and if so, describe who was blinded/masked
PARTICIPANT/S or UNIT/S		
10	Selection criteria	State the inclusion and exclusion criteria, if applicable, and the method of recruitment
11	Participant characteristics	For each participant, describe the demographic characteristics and clinical (or other) features relevant to the research question, such that anonymity is ensured
CONTEXT		
12	Setting	Describe characteristics of the setting and location where the study was conducted
APPROVALS		
13	Ethics	State whether ethics approval was obtained and indicate if and how informed consent and/or assent were obtained
MEASURES and MATERIALS		
14	Measures	Operationally define all target behaviors and outcome measures, describe reliability and validity, state how they were selected, and how and when they were measured
15	Equipment	Clearly describe any equipment and/or materials (e.g., technological aids, biofeedback, computer programs, intervention manuals or other material resources) used to measure target behavior/s and other outcome/s or deliver the interventions
INTERVENTIONS		
16	Intervention	Describe the intervention and control condition in each phase, including how and when they were actually administered, with as much detail as possible to facilitate attempts at replication
17	Procedural fidelity	Describe how procedural fidelity was evaluated in each phase
ANALYSIS		

Continued on next page

Appendix A (continued)

Item number	**Topic**	**Item description**
18	Analyses	Describe and justify all methods used to analyze data
RESULTS		
19	Sequence completed	For each participant, report the sequence actually completed, including the number of trials for each session for each case. For participant/s who did not complete, state when they stopped and the reasons
20	Outcomes and estimation	For each participant, report results, including raw data, for each target behavior and other outcome/s
21	Adverse events	State whether or not any adverse events occurred for any participant and the phase in which they occurred
DISCUSSION		
22	Interpretation	Summarize findings and interpret the results in the context of current evidence
23	Limitations	Discuss limitations, addressing sources of potential bias and imprecision
24	Applicability	Discuss applicability and implications of the study findings
DOCUMENTATION		
25	Protocol	If available, state where a study protocol can be accessed
26	Funding	Identify source/s of funding and other support; describe the role of funders

Appendix B

Trained and Untrained Verb Sets

Trained Verb Set	Untrained Verb Set
carry	open
cook	tie
climb	bake
dry	cross
fold	wrap
gamble	empty
hug	jump
juggle	clean
kick	wash
kneel/pour	smoke
kiss	break
paint	buy
peel	deal
play	drink
rake	hear
pull	leave
rob	ring
sew	sell
shave	shoot
skate	sing

Appendix C

Prime Sentences

Cycles 1-2	Cycle 3-12
The server skated across the floor.	The girl climbed the tall tree.
The penguin skated on thin ice.	The chef boiled the pasta water.
The boy gambled his favorite marbles.	The baby dropped its empty bottle.
The woman gambled on the fastest horse.	The student filled up her backpack.
The gang robbed every large bank.	The actress memorized all her lines.
The man robbed the convenience store.	The builder nailed the planks together.
The child folded the origami paper.	The student returned the library book.
The hostess folded the fancy napkins.	The woman sprayed her perfume.
The student carried the heavy backpack.	The teacher scribbled on the board.
The mover carried the large couch.	The housekeeper scrubbed the floor.
The snow-cone machine shaved the ice.	The dog sniffed the stranger's shoes.
The barber shaved the customer's head.	The baker tasted the cake batter.
The cat's claws raked the carpet.	The secretary typed a long email.
The farmer raked the dry soil.	The librarian whispered to be quiet.
The potter painted the vase green.	The doctor weighed the newborn baby.
The contractor painted the old fence.	The couple welcomed their wedding guests.
The chef juggled the hot pans.	The man rescued the frightened cat.
The performer juggled fire on stage.	The mother rocked the baby's crib.
The girl hugged her stuffed animal.	The team stretched their sore muscles.
The boy hugged his grandmother tightly.	The artist spilled his paint everywhere.
The boy pulled the red wagon	The boy popped the floating bubble.
The girl pulled the heavy door.	The child opened the birthday present.
The cook dried the rinsed vegetables.	The dog obeyed its owner's command.
The boy dried his soaked shoes.	The winner polished his gold medal.

Continued on next page

Appendix C (continued)

Cycles 1-2	**Cycle 3-12**
The man peeled the sticker slowly	The parent scolded the whining child.
The monkey peeled the ripe banana.	The woman unplugged the lamp.
The grandma sewed the colorful quilt.	The pastor preached a passionate sermon.
The man sewed his torn pants.	The movers loaded the entire truck.
The angry girl kicked the chair.	The nurse injected the patient's arm.
The child kicked the empty can.	The professor instructed everyone to sit.
The mother cooked a hearty dinner.	The salesman guaranteed a great deal.
The chef cooked a delicious meal.	The cashier scanned all the groceries.
The girl climbed the steep hill.	The boy scratched his bug bite.
The lemur climbed the tall tree.	The general commanded the soldier's attention.
The girl kissed the puppy's head.	The girl paused the scary movie.
The groom kissed his new wife.	The janitor mopped the dirty floor.
The family played a board game.	The detective searched for any clues.
The band played at the festival.	The captain steered the boat north.
The nurse kneeled beside the patient /The girl poured the tea carefully.	The florist arranged the fresh roses.
The knight kneeled before the king./The woman poured coffee into mugs.	The guard locked the castle gate.