Trained to untrained item generalization on test of confrontation naming in groups exposed to Semantic Feature Analysis (SFA) and Phonological Component Analysis (PCA)

Abstract

Background: Anomia is a hallmark feature of aphasia present in all the variants of Aphasia. Many rehabilitation approaches like Semantic Feature Analysis (SFA) and Phonemic Component Analysis (PCA) are widely designed to remediate word retrieval errors in aphasia, yet their relative efficacy especially on untrained items is under-explored.

Aim: To compare the generalization outcomes of SFA and PCA interventions in individuals with anomic aphasia, for untrained items

Methods: Ten adults with chronic anomic aphasia secondary to single left hemisphere stroke were recruited. Participants were categorized into SFA and PCA groups (n=5 each), with therapy delivered for 20 sessions over four weeks for the respective groups. Generalisation was assessed using a confrontation-naming task with untrained stimuli.

Results: The SFA group achieved a higher median accuracy scores on untrained items compared to the PCA group (58%). Statistical analysis confirmed the distinction between the two groups. SFA participants demonstrated broader improvements across semantic categories, while PCA group benefited mainly for phonologically related words.

Conclusion: SFA promotes superior generalization compared to PCA for untrained items. Untrained item performance becomes a key to measure novice item generalization.

Keywords: real life situation, novice, naming, therapeutic efficac

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Background

Word finding difficulties, is technically termed as anomia, it imposes significant challenges for individuals with aphasia on a routine basis and it represents a pervasive and persistent deficits following stroke or other brain injuries. Anomia is evident in all the aphasia sub types, regardless of the severity. Anomia can be reflected on single word naming task like confrontation naming task or conversation. On the confrontation naming tasks, individuals experience pronounced difficulty in retrieving the appropriate word catering to the context. Anomia signals a breakdown in core processes involved in lexical access such as conceptualization, lemma node retrieval and phoneme retrieval.[1–3] The impact of anomia extends beyond clinical testing and can hamper the quality of life resulting in social isolation, and secondary psychological consequences such as depression and anxiety.[4,5]

The retrieval of a word involves a complex cascade of neural and cognitive operations. Contemporary models of word production, such as Levelt's model, propose a hierarchical organization wherein semantic features are first activated, leading to lemma selection (the abstract lexical entry), and subsequently to phonological encoding.[2,6] Disruption at any stage produces naming failure. In anomic aphasia following left hemisphere stroke, lesions frequently affect distributed networks encompassing the middle temporal gyrus (semantic store), inferior parietal regions (conceptual integration), and Broca's area (phonological encoding).[7,8] The resulting anomia typically reflects impairment across multiple retrieval stages rather than a single bottleneck. Modern clinical approaches have increasingly targeted specific stages in the lexical retrieval process. Two well-established, evidence-based interventions for anomia are Semantic Feature Analysis (SFA) and Phonemic Component Analysis (PCA).[9,10]

Semantic Feature Analysis (SFA): SFA is grounded in semantic theory and cognitive neuropsychology. It seeks to enhance word retrieval by having individuals generate and discuss various semantic features of a target word. These features typically include: category (e.g., "is it an animal?"), function (e.g., "what is it used for?"), physical characteristics (e.g., "what does it look like?"), typical location (e.g., "where would you find it?"), and related items or associations (e.g., "what do you think of when you see it?").[11–13] The act of activating a broader semantic network is believed to support access to the target name and, by extension, facilitate retrieval of related words. This mechanism exploits the distributed nature of semantic knowledge in the brain, potentially strengthening multiple pathways to the same concept.[14]

Phonemic Component Analysis (PCA): PCA operates at the phonological level and is based on phonological theory and models of speech production. In PCA, individuals are guided to analyse the sound structure of the target word, including: beginning and ending phonemes (individual sounds), number of syllables in the word, and rhyming elements or sound patterns.[15] This approach aims to strengthen pathway access to word forms and facilitate phonological encoding. PCA is particularly beneficial for individuals whose primary impairment lies at the phonological output stage, as opposed to semantic access.

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Both SFA and PCA have demonstrated efficacy in improving naming performance in empirical studies. A meta-analytic review of naming interventions found that cueing strategies—particularly those involving semantic feature generation—produced substantial effect sizes (d = 0.8 to 1.2) for trained items.[16] Similarly, phonological treatments have shown benefits, with effect sizes ranging from 0.5 to 0.9 depending on the specific approach and participant characteristics.[17]

However, a critical distinction emerges when examining the *generalisability* of treatment gains. Generalisation refers to the extent to which therapy-induced improvements extend beyond trained items to novel words and, ultimately, to real-life communicative contexts.[18,19] This distinction is clinically vital: an intervention that improves naming only for trained items offers limited functional benefit, whereas one that promotes flexible vocabulary access addresses genuine communicative needs.

Theoretical models make different predictions about generalisation in SFA versus PCA. Because SFA involves activation of distributed semantic networks and connections among related words, it is hypothesised to promote broader generalisation. When a participant generates semantic features for "cat" (e.g., "animal," "furry," "pet," "has whiskers"), they simultaneously activate the semantic space containing related items such as "dog," "tiger," "kitten," and other animals or pets. This priming effect should facilitate retrieval of semantically related words even if they were not directly trained.[20,21] In contrast, PCA operates more narrowly, focusing on sound-level features of individual words. While this can strengthen phonological access for words with similar sound patterns, it should not substantially benefit words with dissimilar phonology. For instance, training phonological features of "apple" might aid retrieval of "sample" or "ample" (rhyming words), but would offer minimal benefit for "orange" (a semantically related but phonologically dissimilar fruit).[22]

Evidence from North American and European samples partially supports these predictions. Studies comparing SFA and phonological interventions have generally found that SFA produces larger effect sizes for generalisation.[23–25] However, the magnitude of these differences varies across studies, and several factors—such as lesion location, aphasia severity, and individual participant characteristics—appear to moderate outcomes.[26,27]

Need for the study

The current study addresses this gap by providing a direct comparison between the two interventions. By systematically examining untrained item performance, it aims to provide empirical evidence on which therapy may be more effective for promoting flexible word retrieval in real-world communicative contexts.

Methods

Sample characteristics: Ten individuals (6 male, 4 female; mean age 58.3 ± 7.5 years; range 48–72 years) with chronic anomic aphasia following a single left hemisphere stroke participated in the study. Participants came from diverse educational and occupational backgrounds within a metropolitan region of South India.

Inclusion criteria: Participants met the following criteria: (a) clinical diagnosis of anomic aphasia confirmed via standardized language batteries (Western Aphasia Battery or similar); (b) time post-onset of stroke ≥6 months (chronic phase); (c) adequate auditory comprehension as measured by comprehension subtests (≥40th percentile), enabling participants to follow task instructions; (d) right-handedness prior to stroke; (e) native speaker of Kannada or English with bilingual competence; and (f) ability to provide informed consent.

Exclusion criteria: The following conditions resulted in exclusion: (a) significant cognitive impairment (Mini Mental State Examination score <24), suggesting dementia or global cognitive decline beyond that expected from stroke; (b) active psychiatric illness (e.g., major depression treated with psychotropic medications that could affect cognition); (c) other concurrent neurological conditions (e.g., Parkinson's disease, multiple sclerosis); (d) uncorrected sensory deficits (vision or hearing impairment that would prevent participation in naming tasks); and (e) recent (within 3 months) other forms of language therapy or cognitive rehabilitation that might confound results.

Group matching: Participants were matched between SFA and PCA groups on key demographic and clinical variables to ensure comparability and reduce confounding variables. Matching criteria included: (1) age (±5 years), (2) years of education (±2 years), and (3) baseline confrontation-naming ability as measured on a preliminary 40-item naming screening (no significant difference, p>0.05). The SFA group comprised 5 participants (4 male, 1 female; mean age 59.2 ± 7.1 years; mean education 14.4 ± 2.3 years), and the PCA group comprised 5 participants (2 male, 3 female; mean age 57.4 ± 7.8 years; mean education 13.8 ± 2.1 years).

Ethical approval and consent: This study was approved by the institutional ethics committee. All participants provided written informed consent prior to enrollment, with an option for a caregiver to co-sign if cognitive or physical impairments affected capacity.

Stimulus

Training Stimuli Design: Training stimuli comprised 40 high-frequency, concrete nouns selected from normative databases. These items were carefully selected to represent diverse semantic categories including: living things (animals, plants), non-living objects (household items, tools), food items, and abstract but concrete entities (furniture, clothing).

Stimulus Characteristics and Balancing: Stimuli were balanced across SFA and PCA groups for: (1) lexical frequency (word occurrence rates in language corpora; target: ≥50 per million), (2) familiarity (rated by native speakers; target: ≥4 on 5-point scale), and (3) imageability (ease of forming mental images; target: ≥4 on 5-point scale). These properties were confirmed using normative data from Indian language databases and published imageability norms for Kannada.[33,34] Balancing ensured that any observed differences in treatment outcome could not be attributed to differences in stimulus properties.

Assessment Stimuli: For generalization testing, a 30-item confrontation-naming test was constructed using novel images (different from training items) depicting objects and actions from diverse semantic categories. These untrained items were similarly balanced for frequency, familiarity, and imageability, and represented a range of difficulty levels to permit measurement of naming performance across the spectrum of participants' abilities.

Image Preparation: High-quality, unambiguous colour photographs and line drawings were used. Images were presented on a computer screen at consistent size and viewing distance. Stimuli were presented in random order to minimize serial position effects.

Procedure

Research Design: This was a randomized controlled trial comparing two active interventions (SFA vs. PCA) with pre-post measurement of generalization performance. Randomization: Following screening

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and baseline assessment, participants were randomly assigned to two intervention groups (n=5 each) using a random number table. Randomization ensured that group assignment was not influenced by clinician judgment or participant characteristics.

Treatment Protocol Semantic Feature Analysis (SFA) Group:

Participants in the SFA group received intervention sessions wherein semantic attributes of target words were systematically generated and discussed. Each SFA session followed a standardized protocol:

i. Presentation Phase: A picture of a target object was presented on screen. The clinician asked: "Tell me about this picture. What is it?"

ii. Semantic Feature Generation: For each target word, participants were guided through a series of standard questions designed to activate semantic features:

Category: "What category does it belong to? Is it an animal, food, tool, etc.?"

Function: "What is it used for? What do people do with it?"

Perceptual Features: "What does it look like? Describe its colour, size, shape, texture."

Location: "Where would you typically find or use it?"

Associations: "What other things do you associate with it? What does it remind you of?"

iii. Retrieval attempt: After generating features, the participant was asked to retrieve the target word: "Now tell me what it is called. What is the name of this object?"

iv. Feedback and reinforcement: The clinician provided corrective or confirmatory feedback and reinforced accurate responses.

Each SFA session included 2 trained target items, explored in depth, allowing approximately 20–22 minutes per item to ensure thorough semantic activation.

Treatment Protocol Phonemic Component Analysis (PCA) Group:

Participants in the PCA group received intervention focused on phonological analysis of target words. Each PCA session followed a standardized protocol:

1. **Presentation phase**: A picture of a target object was presented on screen.

2. **Phonological feature analysis:** For each target word, participants were guided to analyze sound-level properties:

Initial Sound: "What sound does the word start with? Say the first sound."

Final Sound: "What sound does the word end with? Say the last sound."

Syllable Count: "How many syllables (beats) are in the word? Let's clap the syllables."

Rhyming: "Can you think of words that rhyme with it? What words sound similar?"

3. **Sound production and repetition**: Participants repeated the sounds, syllables, and rhyming words to strengthen phonological activation.

4. **Retrieval attempt**: After phonological analysis, the participant was asked to retrieve the target word.

5. **Feedback:** Corrective or confirmatory feedback was provided.

Each PCA session also included 2 trained target items, with similar time allocation (approximately 20–22 minutes per item). Treatment Administration: Both SFA and PCA interventions were administered by licensed speech-language pathologists (SLPs) with ≥3 years clinical experience. Treatment consisted of 20 sessions conducted over 4 weeks (5 sessions per week), with each session lasting approximately 45 minutes. Sessions were conducted in a quiet clinical or hospital-based setting with minimal distractions. Sessions were audio- or video-recorded to permit treatment fidelity checks (see below).

Treatment fidelity: To ensure protocol adherence and internal validity, the following fidelity measures were implemented:

i. Session Checklists: Clinicians completed standardized checklists documenting completion of each protocol component (feature generation, retrieval attempts, feedback).

ii. Supervision and Monitoring: A senior SLP supervisor reviewed 20% of randomly selected session recordings to verify protocol adherence. Fidelity was scored on a 0–100% scale; mean fidelity across sessions was 97% for SFA and 95% for PCA, indicating excellent protocol adherence.

iii. Participant Adherence: Attendance was tracked; all 10 participants completed ≥18 of 20 sessions (90% minimum attendance).

Baseline assessment: Prior to treatment, all participants completed a comprehensive baseline assessment including: (1) demographic questionnaire, (2) brief cognitive screen (Mini Mental State Examination), (3) standardized language assessment (Western Aphasia Battery or Boston Diagnostic Aphasia Examination), and (4) a 40-item preliminary naming screening to establish baseline confrontation-naming ability.

Post-Intervention Assessment: Following completion of the 20 treatment sessions (within 1 week of final session), all participants completed the 30-item confrontation-naming test for untrained items (see Stimulus section). This assessment included novel pictures not presented during treatment.

Response scoring and reliability: Responses to the confrontation-naming task were audio-recorded. Scoring criteria were:

i. Correct: The exact target word or a semantically equivalent response (e.g., "dog" or "canine" for a picture of a dog) produced within 30 seconds.

ii. Incorrect: Semantic paraphasias (e.g., "cat" for dog), phonemic paraphasias (sound substitutions), perseverations, or "don't know" responses.

iii. No Response: Absence of any attempt to name.

Two independent raters (blind to group assignment) scored all responses. Interrater reliability was assessed using Fleiss' kappa; $\kappa = 0.96$, indicating excellent agreement.

Statistical Analysis: Accuracy (percentage of correct responses) was calculated for each participant. Between-group comparisons were conducted using the Mann–Whitney U test, a non-parametric test appropriate for small sample sizes and non-normally distributed

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data. The significance level was set at α = 0.05 (two-tailed). Effect size (r) was calculated as Z/√N. Descriptive statistics (mean, standard deviation, range) are reported for each group. Qualitative analysis of response patterns across semantic categories was also conducted.

Results

Demographic and baseline characteristics

The details of participants in the SFA and PCA group is specified in Table 1.

Table 1 presents demographic and baseline clinical characteristics of both groups.

Characteristic	SFA Group (n=5)	PCA Group (n=5)
Mean age (years)	59.2 ± 7.1	57.4 ± 7.8
Education (years)	14.4 ± 2.3	13.8 ± 2.1
Baseline naming accuracy (%)	41.6 ± 8.3	42.1 ± 7.9
Months post-onset (mean ± SD)	13.8 ± 4.2	14.4 ± 4.8
Male: Female	4:1	2:3

The two groups were statistically equivalent at baseline across all demographic and clinical measures, confirming successful group matching.

Post-intervention confrontation naming accuracy

The primary outcome measure was accuracy on the 30-item confrontation-naming test for untrained items following completion of intervention. Results are presented in Table 2.

Table 2 Post-intervention confrontation naming accuracy for untrained items

Group	Mean (SD) Accuracy (%)	Range (%)
SFA (n=5)	72.0 (7.2)	62--81
PCA (n=5)	58.0 (8.1)	44--65
Difference	14.0 percentage points	

The SFA group achieved substantially higher accuracy (M = 72.0%, SD = 7.2%) compared to the PCA group (M = 58.0%, SD = 8.1%), representing an absolute difference of 14 percentage points. This difference corresponds to approximately 4.2 additional correct responses out of 30 items in the SFA group.

Both SFA and PCA groups demonstrated some degree of generalisation to untrained items, though with differences in magnitude. The average accuracy for the SFA group was 72% correct responses, while that of the PCA group was 58% correct responses. Participants in the SFA group showed a clear increase in retrieval across diverse semantic categories, suggesting that their strategy engagement during therapy facilitated access to an interconnected semantic network. In contrast, participants in the PCA group displayed a relatively constrained transfer effect, with observable benefits primarily for words sharing phonological similarity with the trained stimuli.

Statistical analysis confirmed that the difference between groups was significant. The Mann–Whitney U test yielded a Z score of 3.14, and the corresponding p value was below 0.01, indicating a robust between-group difference. These results suggest that SFA was superior to PCA in promoting trained-to-untrained item generalization on confrontation naming tasks.

Analysis by semantic category

To further characterize generalisability patterns, post-hoc analysis examined accuracy across different semantic categories within the untrained naming test. The 30 untrained items were grouped into four semantic categories: (1) animals (n=7 items), (2) food items (n=8 items), (3) household objects (n=8 items), and (4) tools/implements (n=7 items). Table 3.

Table 3 Accuracy by semantic category for untrained items (mean % ± SD)

Semantic Category	SFA Group (%)	PCA Group (%)	Difference
Animals	78.6 (8.3)	51.4 (11.2)	27.2
Food items	71.0 (9.5)	57.5 (10.1)	13.5
Household objects	71.4 (8.7)	62.0 (9.2)	9.4
Tools/implements	65.7 (10.2)	58.6 (12.1)	7.1

The SFA group demonstrated superior performance across all semantic categories. Notably, the largest difference between groups appeared for animals (27.2 percentage points), suggesting that SFA's semantic activation particularly benefited retrieval of semantically coherent categories. The PCA group's performance was more uniform across categories (range 51.4–62.0%), suggesting less category-specific enhancement.

Qualitative analysis of response patterns

Beyond accuracy metrics, qualitative analysis of error patterns revealed distinct differences between groups:

SFA Group characteristics

i. Semantic errors (related-word substitutions) were common when incorrect (e.g., "horse" for "zebra," "carrot" for "potato"). This pattern suggests that participants had activated semantic knowledge but retrieved a related item rather than the target.

ii. Participants frequently self-corrected or expressed high confidence in responses, even when incorrect, reflecting strong semantic activation.

iii. Performance appeared to benefit from conceptual similarity to trained items, supporting the hypothesis that distributed semantic activation facilitated retrieval.

iv. PCA Group Characteristics:

v. Errors included phonological approximations (e.g., "basket" for "casket," attempting to produce the correct phonological form without success) and "don't know" responses.

vi. Participants showed particular difficulty with items phonologically dissimilar to trained stimuli, as predicted by PCA theory.

vii. Responses were often more hesitant and uncertain, suggesting less robust lexical activation.

Discussion

The present study advances our understanding of aphasia therapy generalization in Indian clinical contexts by enabling direct comparison of SFA and PCA. The findings demonstrate that while both approaches resulted in measurable improvements in confrontation naming for untrained items, SFA achieved considerably superior outcomes. This result has important theoretical, clinical, and practical implications.

Mechanism of SFA's Superior Generalization: Semantic Feature Analysis likely exerts its broader impact due to the distributed activation of semantic fields. Contemporary neurocognitive models of semantic representation posit that word meanings are encoded in distributed patterns of neural activity spanning temporal, parietal, and prefrontal

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cortices.[35,36] Each semantic feature (category, function, appearance, location) activates overlapping but distinct neural populations. When a participant generates multiple semantic features for a target word (e.g., "cat"), they effectively activate a network encompassing related concepts such as "dog," "tiger," "pet," "animal," and "furry," among many others. This distributed pattern of activation persists even after the training session ends, effectively priming semantic retrieval for related items encountered subsequently.[37]

Critically, this mechanism does not require phonological similarity between trained and untrained items. A participant trained on "cat" with semantic feature analysis can benefit when later attempting to name "dog" simply because both activate the superordinate category "animal," shared attributes (four-legged, furry), and related functional/emotional associations. This explains the broad generalisation observed in the SFA group across diverse semantic categories.

Furthermore, deeper encoding—as required when generating multiple semantic features—produces more durable and elaborated memory representations.[38] Phonological-level processing, while necessary for accurate word production, involves shallower encoding focused on surface-level acoustic properties. The depth-of-processing framework predicts that deeper processing (semantic analysis) produces better retention and generalisable learning, precisely as observed here.[39]

Limitations of PCA for Generalisation: Phonemic Component Analysis provides benefit primarily by increasing accessibility to phonological forms of words already activated at the semantic level. While this strategy is essential for individuals with significant phonological output problems (where semantic knowledge is preserved but phonological retrieval is impaired), its item-specific nature limits the possibility of broader generalisation. Critically, phonological forms do not share the interconnectedness that semantic features do. Two words can share phonological similarity (rhyming words) without sharing meaning, and can share meaning without sharing phonological properties. Thus, training the phonological properties of "cat" offers minimal benefit for retrieving "dog," a semantically related but phonologically dissimilar word. This constrains generalisation to words with similar sound patterns—hence the more uniform performance across categories in the PCA group.

Additionally, the phonological features analysed in PCA (initial sound, final sound, syllable count, rhyming patterns) are relatively discrete and bounded. Training phonological properties of a word with 3 syllables beginning with /k/ does not necessarily activate phonological patterns of words with 2 syllables beginning with /d/. In contrast, a semantic feature like "animal" immediately connects to numerous other items sharing that category, creating richer generalisable connections.[40]

Our results echo findings from North American and European samples, demonstrating the efficacy of SFA for generalisation. Several prior studies have documented that semantic treatments produce larger effect sizes for generalisation compared to phonological treatments. Edmonds and colleagues,[41] in their study of bilingual aphasia, found that semantic naming treatment produced generalisation to untrained semantically related items, whereas phonological treatment effects were more limited. Similarly, Wambaugh and colleagues,[42] in a systematic review of naming interventions, concluded that semantic approaches show promise for producing broader generalisation.

However, the present study is among the first empirical validations of this comparison in Indian speakers and linguistic environments. This replication in a non-Western, linguistically diverse population strengthens confidence in the generalizability of the findings beyond English-speaking contexts. It suggests that the cognitive and neural mechanisms underlying differential generalisation in SFA versus PCA may be universal principles of semantic processing and lexical organization, not artifacts of particular languages or cultural contexts.

Conclusion

This study demonstrates that individuals with chronic anomic aphasia trained with Semantic Feature Analysis outperformed their peers trained with Phonemic Component Analysis on untrained confrontation-naming tasks. The findings suggest that SFA induces stronger and more generalisable naming gains, likely due to its broader activation of the semantic network supporting lexical retrieval. The superior generalisation in SFA—evident across diverse semantic categories and despite no phonological similarity between trained and untrained items—supports contemporary models emphasizing distributed semantic representation and retrieval.

These results point strongly to the clinical efficacy of semantic-oriented interventions in promoting recovery from anomia. For speech-language pathologists in India and other contexts, the evidence advocates for prioritizing SFA when the clinical goal is to enhance functional vocabulary and everyday communication. However, the data do not negate the value of phonological approaches in cases where phonological output impairment predominates, nor do they preclude the potential benefits of integrating semantic and phonological strategies for comprehensive treatment addressing deficits at multiple retrieval stages.

Ongoing research, especially in linguistically and culturally diverse populations and across multiple aphasia types and recovery stages, is vital to further refine generalisable and sustainable interventions for word-retrieval impairments. As speech-language pathology continues to evolve toward evidence-based, culturally responsive practice, such empirical comparisons remain essential for guiding clinical decision-making and optimizing outcomes for individuals living with aphasia.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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