Generalisation and maintenance across word classes: comparing the efficacy of two anomia treatments in improving verb naming

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ABSTRACT

Background: Many language treatments have been developed to remediate anomia, a debilitating and pervasive symptom of aphasia. The two major types of anomia treatments, semantic and phonological, have been shown to improve spoken production of trained words. However, generalisation to untrained words has been considerably variable and few studies have examined the improvement of untrained words from a different word class despite the presence of unbalanced noun-verb impairments in the majority of people with aphasia.

Aim: This retrospective study investigated within and between treatment group effects of two anomia treatments (Semantic Feature Analysis, SFA, and Phonomotor Treatment, PMT) on naming of untrained verbs.

Methods & Procedures: The data for this study were retrospectively analysed from a randomised controlled trial with 57 persons with aphasia randomised to one of two treatment groups. Each participant received 56–60 hours of intensively delivered treatment over 6 weeks, with testing before, immediately after, and three months after treatment termination.

Outcomes & Results: There was no significant between-group difference on confrontation naming of untrained verbs immediately post-treatment or three months following treatment termination (maintenance). Significant within-group findings were evident immediately post-treatment for the individuals in the SFA group and at maintenance for the PMT group.

Conclusions: Our results show that neither SFA nor PMT was superior at inducing generalisation effects across word class (i.e. from nouns to verbs). These findings were consistent with the between-group results from the larger randomised controlled trial from which these data are analysed (Kendall, Oelke, Allen, Torrence, & Nadeau, 2018) in that there was no between-group difference in generalization to untrained words that do not share semantic or phonological sequence features. However, the within-treatment group results in

the maintenance phase add to evidence from prior studies that Phonomotor Treatment is more likely to facilitate generalisation. Although generalisation to untrained stimuli was minimally maintained after SFA treatment, there was further improvement to untrained exemplars over time following Phonomotor Treatment.

KEYWORDS: Aphasia, anomia treatments, generalisation, verbs

Introduction

Aphasia is an acquired disorder of language typically following a stroke to the left cerebral hemisphere. One pervasive and debilitating aspect of aphasia is anomia, or impaired word retrieval, which results from damage to semantic, lexical-semantic, and/or phonologic processes. Extant research has demonstrated improvements in word retrieval on trained items (i.e. acquisition) in individuals with aphasia following anomia treatment (Nickels, 2002; Robey, 1994). On the other hand, generalisation of treatment effects to untrained words and linguistic contexts is usually minimal and typically limited to words that are semantically related to those in the training corpus (Kiran & Thompson, 2003; Wisenburn & Mahoney, 2009). One seldom investigated aspect of linguistic generalisation is generalisation across word class; that is, do aphasia treatments aimed at improving production of nouns impact production of verbs?

Noun and verb production impairments in persons with aphasia

Nouns and verbs are differentially impaired in people with aphasia (PWA; e.g. Caramazza & Hillis, 1991; Miceli, Silveri, Nocentini, & Caramazza, 1988; Saffran, Berndt, & Schwartz, 1989; Thompson, Lange, Schneider, & Shapiro, 1997; Zingeser & Berndt, 1990), with greater difficulty frequently observed in verb production relative to nouns (Kim & Thompson, 2000; Luzzatti, Aggujaro, & Crepaldi, 2006; Luzzatti et al., 2002; Mätzig, Druks, Masterson, & Vigliocco, 2009). A literature review of data from 280 PWA across 38 studies (Mätzig et al., 2009) demonstrated differential noun-verb naming impairments in 85% of the PWA, with 87% of those individuals demonstrating greater impairment with verb than noun production. This discrepancy could be due, in part, to the differences in imageability between nouns and verbs; verbs have been rated as less imageable than nouns (Bird, Howard, & Franklin, 2000; Druks, 2002) and, therefore, more difficult to retrieve (Luzzatti et al., 2006). In addition, verbs might be harder to retrieve because of noun-verb differences at the morphological and syntactic level; verbs have comparatively greater morphological complexity (Vigliocco et al., 2006) and play an essential role in determining argument structure and type as well as assigning thematic roles in sentences (Druks, 2002; Grimshaw, 2000).

In spite of these differences between nouns and verbs, they are heavily associated and interactive in lexical networks. For example, behavioural semantic priming studies have shown that multiple words and meanings, including nouns and verbs, are simultaneously activated with a given sentence or context (McKoon & Ratcliff, 1992; Swinney, 1979; Swinney, Onifer, Prather, & Hirshkowitz, 1979). In addition, studies have shown that nouns and verbs that capture the elements of a given situation, or *event*, are co-activated if both are involved in the same event (McRae, Spivey-Knowlton, & Tanenhaus, 1998; Nagy & Gentner, 1990). Verbs not only activate nouns with thematic roles (i.e. verb agents and patients) in an event, but also, the nouns of related instruments, as well as features of related agents/patients (Ferretti, McRae, & Hatherell, 2001). For instance, in the event described by *The elephant ate the food on the table*, the verb, *ate*, will prime the related nouns *elephant*, *food*, and *table*.

Furthermore, nouns that co-occur with each other within an event (e.g. agents, patients, instruments, and locations) can prime each other (Hare, Jones, Thomson, Kelly, & McRae, 2009). For instance, the agent, *elephant*, will prime the patient, *food*, and the location, *table*. In addition, nouns can prime their related verbs (e.g. *elephant* and *food* will prime *eat*; McRae, Hare, Elman, & Ferretti, 2005). Note that this priming occurs even if the words are not typically closely associated (e.g. *elephant* and *table*); their relationship within the event is adequate to create widespread priming within the distributed lexical network (McKoon & Ratcliff, 1992). Indeed, the strong connections between nouns and verbs are central to many verb-based treatments for anomia, which involve clients generating event-related language involving both nouns and verbs (Edmonds, Nadeau, & Kiran, 2009; Marshall & Cairns, 2005; Raymer & Kohen, 2006; Wambaugh & Ferguson, 2007; Webster, Morris, & Franklin, 2005). Research on treatment outcomes with these approaches has shown that these event-related networks can be used to promote generalisation across word class (Edmonds, 2016; Edmonds, Mammino, & Ojeda, 2014; Webster & Whitworth, 2012).

Current study

Given the previous research demonstrating coactivation of nouns and verbs, we were interested in exploring whether treatment of nouns can lead to improvement of verb naming in PWA. We approached this question in a retrospective analysis from a randomised controlled trial in which two anomia treatments that have noun production as an element of their protocols were delivered to 57 PWA (Kendall, Oelke, Allen, Torrence, & Nadeau, 2018). The two anomia treatments delivered were Semantic Feature Analysis (SFA), which was modified, as described below, to focus on improving lexical-semantic processing through linking of semantic features, and Phonomotor Treatment (PMT), which focuses on phonological processes.

SFA targets lexical retrieval through systematic stimulation of the semantic system by having participants provide semantic features (i.e. group, description, function, context and personal association) to describe target words (Boyle & Coelho, 1995). The SFA treatment used in the present study was modified to omit phonological cues so as to emphasize lexical-semantic processes; therefore, the only phonologically-related practice of target words in SFA occurred during one opportunity to repeat the target picture on each treatment trial. The SFA protocol was motivated by an interactive activation model of lexical retrieval (Dell, 1986, 1988; Dell, Martin, Saffran, Schwartz, & Gagnon, 1997; Dell & O'Seaghdha, 1992): Coactivation of semantically related nouns and verbs should improve production of both trained items and untrained semantically related words, including both nouns and verbs, through shared semantic features. For example, the stimulus "hammer" would activate verbs "pound", "lift" and "wrist"; thus, repeated coactivation of semantically related stimuli during SFA treatment should facilitate generalisation to untrained but related lexical items.

PMT involves multi-modal (e.g. visual, auditory, tactile-kinesthetic) training of all consonants and vowels in tasks that involve phonological awareness and manipulation. Treatment starts at the level of single phonemes in isolation and progresses to 1-, 2- and 3-syllable combinations in primarily nonword contexts and some real words in isolation. This treatment approach is motivated by a connectionist model of phonology (Nadeau, 2001, 2012, 2014), which posits that through the systematic training of phonemes and phoneme sequences, neural connectivity supporting phoneme sequence knowledge is enhanced. Because these sounds and sound sequences provide the basis for all words that represent semantic conceptual knowledge, PMT should improve naming of untrained words across word classes (e.g. both nouns and verbs).

In the larger randomised controlled trial by Kendall et al. (2018), participants receiving SFA treatment showed generalisation to naming untrained nouns that were semantically related to treatment stimuli but not to semantically unrelated nouns. Similarly, participants who received PMT, focusing on phonological sequences, showed generalisation to naming phonologically related untrained nouns but not to phonologically unrelated untrained nouns. The purpose of this retrospective analysis was to extend Kendall et al.'s findings to explore any effects of the SFA and PMT programs on confrontation naming of verbs. We asked if there was a significant between-group difference in confrontation naming accuracy for verbs immediately after treatment completion and three months after treatment completion.

Materials and methods

Study design

Participants in the study from which these data were taken (Kendall et al., 2018) were 60 PWA randomly assigned to one of two treatment groups (SFA or PMT). Following randomization, all participants received testing one week prior to treatment (T1), immediately post-treatment (T2), and three months after treatment completion (T3). Study-specific standardised assessments and outcome measures, as described below, were administered at all assessment periods (T1, T2, and T3).

Participants

Sixty participants were recruited through the Veterans Affairs (VA) Puget Sound Health Care System and the Northwest Aphasia Registry and Repository at the University of Washington (UW). All participants exhibited chronic aphasia (>6 months post-onset) due to left-hemisphere damage from one or more strokes, as verified by computed tomography (CT) or magnetic resonance imaging (MRI) scans.

Inclusion criteria consisted of the presence of aphasia and auditory comprehension skills sufficient for following simple directions, both as determined by the Comprehensive Aphasia Test (CAT; Howard, Swinburn, & Porter, 2004). Participants were excluded from participation if they exhibited degenerative neurological diseases, depression or other psychological/psychiatric illnesses, chronic medical illnesses, or severe hearing and/or visual impairments. Additionally, two speech-language pathologists (SLPs) evaluated speech samples from each potential participant and excluded any with severe apraxia of speech as determined by perceptual assessment of reduced speech rate, segment or intersegment prolongations, sound distortions or distorted substitutions, prosodic abnormalities in connected speech, and/or effortful groping (Duffy, 2013).

Two participants were excluded from analysis as they were unable to complete a minimum of 56 hours of therapy. Another participant who did not return for the 3-month post-treatment testing was excluded, resulting in a total of 57 participants analysed in this study. For the 57 participants included in this study, 29 had received SFA (18 males and 12 females; mean age = 63.4 years, *SD* = 12.3 years) and 28 received PMT (15 males and 13 females; mean age = 63.3 years, *SD* = 10.6 years). Mean number of years of education was 15.2 (*SD* = 2.8) for the SFA group and 14.3 (*SD* = 2.0) for the PMT group. Mean time post-onset of stroke for

SFA and PMT groups were 4.1 years (*SD* = 4.7) and 4.3 years (*SD* = 4.7), respectively. 2-sample *t*-tests showed no significant differences between the groups in age, average years of education and average time after stroke. Fifty-five participants were monolingual English speakers and two were multi-lingual; all spoke English fluently prior to their stroke. Participants received no other individual speech-language therapy during the course of the study (including through the maintenance period), but many continued participating in communication groups and stroke support groups. Table 1 summarises the demographics of each treatment group.

Table 1. Summary of participant demographics in each treatment group for n = 57 PWA.

	Treatment Approach (total *n* = 57)			
	SFA (*n* = 29)		PMT (*n* = 28)	
	M	*(SD)*	*M*	*(SD)*
Age (years)	64.0	(12.0)	63.3	(10.6)
Time post-stroke (years)	4.1	(4.3)	4.3	(4.7)
Education (years)	15.2	(2.8)	14.3	(2.0)
Sex	8 Male, 11 Female		5 Male, 13 Female	

SFA = Semantic Feature Analysis; PMT = Phonomotor Treatment

The following tests were used to describe each individual's aphasia, cognitive, and speech profile: (1) CAT for semantic memory ability (Subtest 4) and diagnosing aphasia (Subtests 7–13, 16, 24–26); (2) Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 2001); (3) Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010); (4) Raven's Coloured Progressive Matrices (RCPM; Raven, Raven, & Court, 2003) for non-verbal problem solving; and (5) digit and word pointing span subtests from the Temple Assessment of Language and Short Term Memory in Aphasia (TALSA; Martin, Minkina, Kohen, & Kalinyak-Fliszar, 2018). Standardised assessments were administered by trained SLPs. Table 2 summarises the profiles of participants in each treatment group, including their pre-treatment naming accuracy on untrained verbs, which were selected from the Object/Action Naming Battery (Druks & Masterson, 2000), as described below. 2-sample *t*-tests on BNT, CAT scores (semantic memory and auditory comprehension), SAPA, and verb naming accuracy showed no significant differences between the two treatment groups at baseline, indicating no differences in aphasia or anomia severity. Treatment groups also did not differ significantly on non-verbal reasoning ability and verbal short-term memory as indicated by scores on RCPM and the TALSA subtests respectively. See Appendices A and B for details on individual participants' demographics and profiles for SFA and PMT, respectively.

Table 2. Summary of participant cognitive-linguistic profiles in each treatment group.

	Treatment Approach (total n = 27)			
	SFA (n = 29)		PMT (n = 28)	
	M	*(SD)*	*M*	*(SD)*
Auditory comprehension: CAT comprehension of spoken language (*t*-score)	50.7	(7.1)	50.4	(6.6)
Naming nouns: BNT (out of 60)	25.8	(19.4)	21.6	(17.8)
Naming verbs (untrained from OANB; out of 25)	11.3	(7.9)	9.2	(7.8)
Semantic processing: CAT semantic memory (*t*-score)	51.0	(12.6)	55.9	(9.8)
Phonologic processing: SAPA (out of 144)	78.8	(25.3)	74.8	(24.9)
Reading comprehension: CAT comprehension of written language (*t*-score)	53.2	(6.3)	52.3	(7.2)
Writing: CAT production of written language (*t*-score)	53.1	(6.0)	52.4	(7.3)
Non-verbal reasoning: Raven's progressive matrices (out of 36)	30.3	(5.2)	29.8	(5.0)
Verbal short term memory TALSA – Digit span (pointing; out of 7)	3.1	(1.5)	2.7	(1.0)
Verbal short term memory TALSA – Word span (pointing; out of 7)	2.1	(1.1)	2.2	(0.8)

SFA = Semantic Feature Analysis; PMT = Phonomotor Treatment; CAT = Comprehensive Aphasia Test; BNT = Boston Naming Test; OANB = Object/Action Naming Battery; CAT memory = Comprehensive Aphasia Test memory composite score (Semantic Memory + Recognition Memory); SAPA = Standardized Assessment of Phonology in Aphasia; TALSA = Temple Assessment of Language and Short Term Memory in Aphasia

Randomization & treatment administration

Participants were randomly assigned in pairs to one of two treatment conditions. Aphasia severity was matched in each randomization pair using scores on CAT subtests to designate each participant as either "more impaired" (standard score below 50) or "less impaired" (standard score above 50). If severity was ambiguous (i.e. half of subtests scores above 50, half below 50), the administering SLP shared clinical judgment and scores from other standardised measures with the research team to collectively arrive at a severity rating. Subsequently, the severity ratings were run through a computer program based on Pocock's (1983, 1975) minimization randomization method to randomly assign the pair of participants to each treatment condition (for details, see Kendall et al., 2018).

Treatment was delivered by one of two certified SLPs trained on the treatment protocols. At the participants' convenience, treatment occurred in the participants' homes or the UW Aphasia Laboratory. Individuals in each condition received two hours of therapy per day, 4–5 days per week for 6–7 weeks (total of 56–60 hours of therapy). Treatment fidelity was ensured through random observations of approximately 10% of treatment time by another trained SLP. In addition, 10-minute random audio samples were evaluated by graduate students for essential therapy components. There were six key components identified for PMT (e.g. use of Socratic questioning) and nine key components for SFA (e.g. repetition of the target word three times). If the SLP who was delivering treatment delivered the key component, the evaluator gave it a score of 1; if not, it was given a score of 0. The average treatment fidelity across weeks and participants was 96.75% for PMT and 99.51% for SFA.

Treatment procedures and stimuli

Semantic feature analysis

SFA treatment consisted of picture naming and feature generation across five categories using a modified feature analysis chart (Coelho, McHugh, & Boyle, 2000); the five categories were group, description, function, context, and other/personal relevance. The SLP used a modified cueing hierarchy commonly used in semantic therapies (Linebaugh & Lehner, 1977) for incorrect responses. Once features were verbalised, either by the SLP or the participant, the SLP would write them down on the chart. Each week, participants practiced a different set of thirteen or fourteen pictures with at least one from each of the eight semantic categories; nouns were randomised in each session. See Appendix C for details on charts and the cueing hierarchy used in SFA treatment.

SFA stimuli consisted of 160 highly imageable nouns from eight semantic categories. The imageability ratings of the selected nouns were obtained from an imageability dataset (Reilly & Kean, 2007) and the SUBTLEX-US database (Brysbaert, New, & Keuleers, 2012). A total of twenty nouns for each of eight semantic categories were selected: body parts, clothing and accessories, food and beverages, household items, hobbies and recreation/sports, nature, occupation, and transportation (see Appendix D). Stimuli were concrete nouns, although some also had verb meanings (e.g. belt, snow). Of the 160 treatment words, 127 had only a noun meaning while the remaining 33 had an additional verb meaning. Importantly, of these 33, all but one ("tie") had a dominant noun meaning; the range of relative frequency of noun vs. verb meanings, which reflects whether the noun or verb meaning is dominant for each word, was 46–100% (average = 97.5%, *SD* = 7.3%) (Brysbaert et al., 2012). Five neurologically healthy individuals rated the match between each picture and the target word during stimulus development and were all in agreement. Median lexical frequency was 308 to 475 in all semantic categories.

The median word frequency value for each category was used to split stimuli equally into high- or low-frequency groups (Storkel, Armbrüster, & Hogan, 2006). A *t*-test revealed that the high- and low-frequency word groups were statistically different within semantic categories ($p < 0.001$) but not across semantic categories (low-frequency range = 111–229, *SD* = 43; high-frequency range = 845–995, *SD* = 48). SFA participants were assigned to high- or low-frequency training word lists on a case-by-case basis by the research team based on their scores on the BNT and initial probe of the untrained nouns, which did not share semantic or phonologic features with treatment stimuli, prior to treatment. If the participant's appropriate assignment was unclear from the outset, accuracy on the high frequency items and the low frequency items from the screening probe would be analysed to determine which assignment allowed for appropriate room for improvement over the course of treatment.

Phonomotor treatment

PMT involved the use of multi-modal auditory, articulatory-kinesthetic, visual, orthographic, and tactile-kinesthetic tasks. The treatment began by training individual phonemes, which consisted of sound exploration, motor descriptions, perception and production tasks, and establishing sound-letter relationships. Following exposure to all phonemes in isolation, treatment targeted sound combinations at the syllable and multi-syllable levels. Perception and production tasks included manipulation of sound combinations such as sound segmentation and blending. See Appendix E for details of the PMT protocol.

PMT stimuli consisted of individual sounds and one- to three-syllable phonotactically legal nonwords and real words with low phonotactic probability and high neighbourhood density. A web-based interface was used to calculate phonotactic probabilities for the real words and nonwords (Vitevitch & Luce, 2004). Neighbourhood density was computed by counting the number of words in the dictionary that differed from the target by a one phoneme addition, deletion, or substitution. Phonotactic probability and neighbourhood density were computed for stimuli and were categorised as high or low based on a median split (using procedures similar to those of Storkel et al., 2006). A total of 70 non-words and 39 real words were trained (see Appendix F for list of stimuli). All real word stimuli were concrete nouns, although some also had verb meanings (e.g. fire, shower). Nineteen of the 39 real words that are designated to be included in treatment have only a noun meaning while 20 of the words have an additional verb meaning. Of these 20, all except one word had a dominant noun meaning; the range of relative frequency of noun vs. verb meanings was 46–100% (average = 92.9%, *SD* = 12.9%) (Brysbaert et al., 2012).

Outcome measure

Description

The outcome measure for this study was accuracy of confrontation naming of untreated verbs. Black and white line drawings for 100 untrained verbs from the Object/Action Naming Battery (Druks & Masterson, 2000) were randomly assigned to four different lists of 25 verbs and matched for age of acquisition, word frequency, and familiarity. Semantic relatedness between the 199 trained nouns (in both PMT and SFA) and the list of 100 untrained verbs was analysed using a 5-point rating scale in a questionnaire completed by six UW undergraduates (healthy females; mean age of 24.2 years; mean education of 16.5 years; all fluent English speakers). Of the 19,900 trained noun-untrained verb pairs rated, 68 pairs (0.34%) were highly related (average of 3.7–5.0 points), 480 pairs (2.41%) were moderately related (average of 2.3–3.6 points), and the remaining 97.25% of pairs were slightly/not related (average of 1.0–2.3 points). Given the small percentage of untrained words that were moderately-highly related to trained words, all untrained words were included in analyses of changes in naming accuracy.

Administration

The outcome naming probe measure was administered two to three times over the course of one week during each of the pre-treatment (T1), immediately post-treatment (T2), and 3-months post-treatment (T3) periods. The list of 25 untrained verbs differed for each testing day to avoid practice effects. Stimuli were presented using Microsoft Office 2013 Power Point on a Dell 24-inch monitor connected to a Dell Optiplex 9020 Desktop, or a Dell Latitude 7370 laptop with 14-inch HP EliteDisplay S140u display. Responses were audio-recorded using an Audio-Technica Power Module AT8531 head-mounted microphone which was linked to a Tascam US-125M USB audio mixing interface to record verbal responses using Adobe Audition CS6 Version 5.0 software. Participants were asked to name the picture on the screen, which was presented for ten seconds, followed by a blank white screen for a brief period (2–10 seconds, depending on individual participant needs) before the next stimulus was presented. No cues were provided.

Scoring

Responses were scored and transcribed offline in broad transcription by student research assistants and graduate students in speech-language pathology, none of whom participated in other parts of the study. Although scorers were not blind to the phase of treatment (pre-, immediately post- or 3 months post-treatment) or type of treatment (PMT or SFA), different people scored different time points for each participant. The first verbal responses were scored as correct or incorrect. Correct responses included phonologically accurate target words, target words with phonological distortions that did not cross phonemic boundaries, and acceptable alternative responses, which were based on dictionary-defined synonyms and the consensus of the research team. Productions containing phonologic errors (substitutions, additions, omissions, transpositions, or mixed errors), semantically related or unrelated real words, semantic feature description, neologisms, and omissions were scored as incorrect responses.

Accuracy of confrontation naming was determined by the total number of correct productions. The scores on each of the three consecutive days at each time point were averaged to obtain the mean score prior to treatment (T1), immediately after treatment (T2), and three months post-treatment (T3). These mean accuracy scores were converted to percentage accuracy for use in the statistical analyses.

Statistical analysis

A split-plot, mixed-model analysis of variance (ANOVA) with two fixed factors and a random factor was conducted. One fixed factor was between-subjects (treatment type; SFA vs PMT), and the other fixed factor was within-subjects (time point; T1, T2, and T3). Participants were included as the random factor to account for individual variability in performance. With $N = 57$ participants, this ANOVA had 80% power at the 0.05 significance level to detect a large effect size ($f = 0.42$). Main effects of treatment type and time, as well as the interaction of treatment type with time, were determined.

Follow-up *t*-tests for significant main effects and simple effects contrasts to test group differences for each time point were conducted using Dunn-Sidak adjusted *p*-values. Effect sizes (*partial* ω^2) calculated for both fixed factors and their interaction were determined according to Cohen's (1988) standards – *partial* $\omega^2 = 0.01$ (small), *partial* $\omega^2 = 0.06$ (medium), *partial* $\omega^2 = 0.14$ (large).

Reliability of scoring was performed on 25% of the data by trained research assistants (undergraduate or post-baccalaureate students in the University of Washington department of Speech and Hearing Sciences). Cohen's kappa (Landis & Koch, 1977) was calculated and the inter-rater agreement for naming accuracy of untrained verbs was 0.98 (almost perfect agreement). The intra-rater agreement for naming accuracy of untrained verbs was 0.99 (almost perfect agreement).

Results

In the larger study (Kendall et al., 2018), between-group differences in confrontation naming of untrained nouns that were linguistically (semantically for SFA and phonologically for PMT) unrelated to the treatment stimuli were not significant ($p = 0.587$ immediately after treatment and $p = 0.797$ at three months post-treatment).

In this study, pre-treatment verb naming accuracy was 45.31% ($SD = 31.63$) for the SFA group and 36.86% ($SD = 31.21$) for the PMT group, with no significant between-group difference ($p = 0.314$; see Table 3). Immediately post-treatment verb naming accuracy was 48.90% ($SD = 31.58$) for the SFA group and 38.59% ($SD = 30.91$) for the PMT group. Three-month post-treatment verb naming accuracy was 47.77% ($SD = 29.69$) for the SFA group and 40.21% ($SD = 30.74$) for the PMT group.

Table 3. Descriptive statistics: Generalisation and maintenance in naming accuracy of untrained verbs in SFA and PMT groups.

	Treatment Approach (total *n* = 57)			
	SFA (*n* = 29)		PMT (*n* = 28)	
Percentage naming accuracy of untrained verbs	*M*	*(SD)*	*M*	*(SD)*
Pre-treatment (T1)	45.31	(31.63)	36.86	(31.21)
Immediately post-treatment (T2)	48.90	(31.58)	38.59	(30.91)
3-months post-treatment (T3)	47.77	(29.69)	40.21	(30.74)

SFA = Semantic Feature Analysis; PMT = Phonomotor Treatment

A split-plot, mixed model ANOVA on confrontation naming accuracy for untrained verbs showed no significant main effect of treatment type, $F(1,55) = 1.17$, $p = 0.284$, and a significant main effect of time $F(2,110) = 4.49$, $p = 0.013$, *partial* $\omega^2 = 0.06$, with trend contrasts showing that the changes from pre-treatment to immediately post-treatment to 3-months post-treatment had a significant linear component ($p = 0.010$). The pattern of marginal means across time points indicated that there was a significant increase in naming accuracy for untrained verbs (across both treatment groups) from pre-treatment to immediately post-treatment (Dunn-Sidak adjusted paired *t*-test $p = 0.038$), but no significant change from immediately post- to 3-months post-treatment (Dunn-Sidak adjusted paired *t*-test $p = 0.994$). Comparison of performance at T3 to T1, however, was significant (Dunn-Sidak adjusted $p = 0.030$). No significant interaction between treatment type and time was found, $F(2,110) = 0.85$, $p = 0.432$. Follow-up simple effects *t*-tests of group differences at each time point, with a Dunn-Sidak adjustment for multiple comparisons, did not show any significant between-group differences (all adjusted *p*-values > 0.05) at any time point.

Post-hoc analyses: within-group analysis

Given that pairwise comparisons across treatment groups for different time points showed significant changes in performance from T1 to T2 and T3, but not between T2 and T3, post-hoc within-group analyses on changes in percentage naming accuracy from baseline to T2 and T3 were conducted separately.

Two 1-sample *t*-tests were conducted on percentage change scores for each treatment group. With $N = 28$ or 29 participants, the *t*-tests had 80% power at the 0.05 significance level to detect a medium effect size ($d = 0.54$–0.55). Effect sizes were calculated by subtracting the mean percentage accuracy score (*M*) at pre-treatment from the mean percentage accuracy score immediately or three months post-treatment, and then dividing this by the standard deviation (SD) of pre-treatment scores. The effect sizes were interpreted according to Cohen's (1988) standards: $d = 0.2$ (small); $d = 0.5$ (medium); $d = 0.8$ (large).

One-sample *t*-tests for change scores in the SFA group (with Dunn-Sidak adjusted *p*-values) were significant for T2 compared to T1, $t(28) = 2.70$, $p = 0.012$, $d = 0.11$, but not for T3 compared to T1, $t(28) = 1.46$, $p = 0.157$ (see Figure 1). One-sample *t*-test for change scores in the PMT group (with Dunn-Sidak adjusted *p*-values) was not significant immediately post-treatment, $t(27) = 1.09$, $p = 0.287$. However, change scores at T3 compared to baseline T1, an increment of 3.35%, was significant, $t(27) = 2.47$, $p = 0.020$, $d = 0.11$.

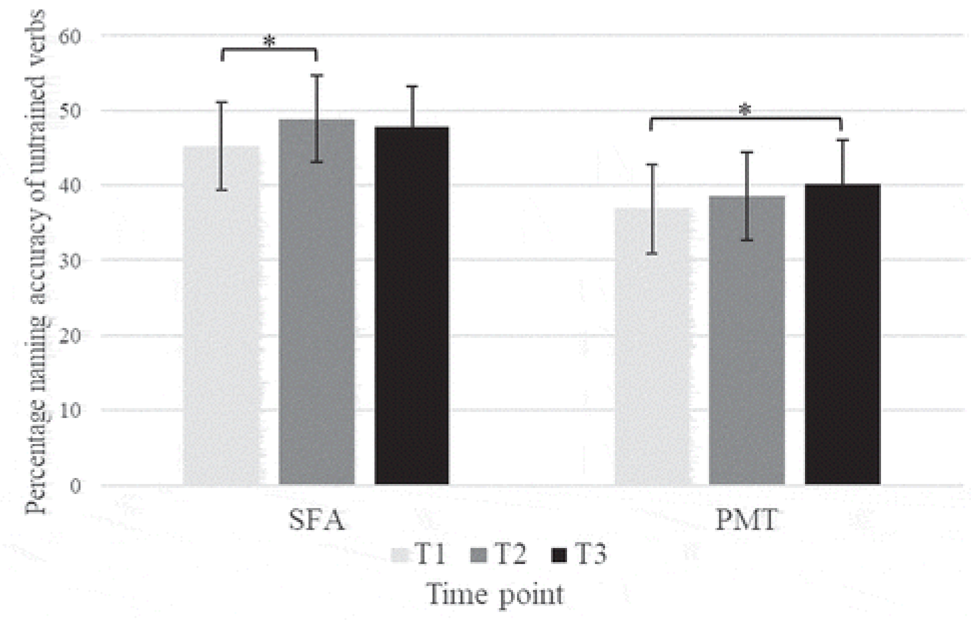

Figure 1. Between- and within-group performance on confrontation naming for SFA and PMT at T1, T2, and T3. Error bars represent standard errors.

SFA = Semantic Feature Analysis, PMT = Phonomotor Treatment; T1 = pre-treatment, T2 = immediately post-treatment, T3 = three months post-treatment, SFA = Semantic Feature Analysis, PMT = Phonomotor Treatment; T1 = pre-treatment, T2 = immediately post-treatment, T3 = three months post-treatment.

Discussion

The purpose of this retrospective study was to investigate whether two treatments (SFA and PMT) resulted in improved production of verbs immediately post-treatment and three months later. The results showed that both treatments led to small but significant generalisation to verbs, and that SFA and PMT yielded comparable amounts of generalisation. These findings are consistent with the larger trial (Kendall et al., 2018) in which both treatments were efficacious in improving naming of some untrained nouns (those that shared semantic features for SFA and those that shared phonologic features for PMT).

PMT was anticipated to show greater generalisation to verb naming than SFA, so this outcome was unexpected. The absence of the hypothesised significant between-group difference is likely to have been a result of the unexpectedly small generalisation effect that was found in the PMT group, which was not differentiated from the predicted minimal generalisation seen in the SFA group. PMT was designed on the premise that training phonological sequences of words and nonwords with high neighbourhood density and low phonotactic probability should facilitate generalisation to more common phonological sequences and a wide range of untrained words. Unfortunately, the results of the current study, as well as Kendall et al.'s (2018) larger trial, suggest that such broad generalisation did not occur. Generalisation in the larger trial was evident only for untrained words that shared phonologic properties of the trained stimuli (i.e. high neighbourhood density and low phonotactic probabilities), likely because the atypical phonological sequences that were trained did not have much overlap with more frequent phonological sequences. This limited overlap with common phonological sequences would provide little basis for shared features between sequences to activate untrained words with more frequently-occurring phonologic sequences. This same issue could be expected to affect untrained verbs in the same way; little phonological overlap with the trained sequences might have limited the spread of activation and, therefore, improvement of naming untrained items.

Although the two treatments were no different from each other in the degree to which they led to changes in naming accuracy of untrained verbs (both immediately and three months posttreatment), further examination of changes in performance within each treatment group suggests that PMT is potentially a more efficacious treatment. For the PMT group, the improvement in verb production immediately post-treatment was not significant, consistent with the larger trial's findings for untrained nouns. What is different from the larger trial, though, is that verb production continued to improve over the three-month post-treatment period, albeit changes in actual accuracy scores were small, such that verb-naming ability was significantly greater at maintenance than prior to treatment. This finding of continued growth has also been shown in earlier PMT studies with the production of untrained nouns and discourse production after treatment ends (Kendall et al., 2008; Kendall, Oelke, Brookshire, & Nadeau, 2015; Silkes, Fergadiotis, Hunting Pompon, Torrence, & Kendall, 2018). This further improvement in word production over time has been attributed to the opportunity to use and enhance the newly formed phonological sequence knowledge gained in treatment during everyday communication. As phonological networks continue to be strengthened over time, the interactive connections with semantic knowledge are strengthened as well, leading to gradual improvement of both nouns and verbs.

On the other hand, the SFA group showed changes in performance in the opposite direction from immediately post-treatment to maintenance. Although there was significant improvement in verb production immediately after treatment, this was not maintained, resulting in participants' verb-naming ability three months later being similar to their baseline performance. The positive generalisation to verbs immediately post-treatment is likely due to two factors. The first factor is likely related to event schemas and the second factor is that the SFA treatment tasks employ the repetition and production of verbs throughout each session. Participants are likely to generate and rehearse verbs as part of the "Description" or "Function" categories of a noun during SFA therapy. At three months post-treatment, this decline in verb naming skills is consistent with the SFA literature (Efstratiadou, Papathanasiou, Holland, Archonti, & Hilari, 2018), which suggests that activation of the language network is no longer adequate after treatment ceases. Furthermore, in keeping with previous SFA studies, despite findings of generalisation to improvement in discourse (Lavoie, Bier, & Macoir, 2018; Rider, Wright, Marshall, & Page, 2008), generalisation to untrained words is typically absent and even when observed, is limited to words that are semantically related to those in the training corpus (Kiran & Thompson, 2003; Wisenburn & Mahoney, 2009). Thus, absence of further improvement to other semantically unrelated untrained words is not surprising.

From a clinical perspective, these results have a few implications. First, while SFA is commonly used to treat anomia in aphasia, these results suggest that improvements in verb naming with SFA are likely to be limited and short-lived. This is consistent with prior literature that has used a SFA-like approach with verbs with poor outcomes (Wambaugh & Ferguson, 2007; Wambaugh, Mauszycki, & Wright, 2013). A clinician interested in using a lexically-based treatment approach may be most successful using SFA to train nouns and a context-based, verb-oriented treatment (e.g. Verb Network Strengthening Treatment; Edmonds et al., 2009) to train verbs.

A second clinical implication is that PMT may be a viable option for improving verb naming. While generalisation to verbs may not be evident during or immediately after a full course of PMT, these results suggest that verb naming may continue to improve even after therapy ends, yielding long-term generalisation across word classes. In this way, PMT may be a more efficacious, efficient method for remediating anomia for both nouns and verbs.

Limitations

One potential limitation of this study is that verbs were encountered in the course of both SFA and PMT. In SFA, verbs were generated as semantic features during treatment. It is possible that this was the source of the relatively stronger generalisation effects identified immediately post-treatment, as mentioned earlier. The prominent presence of verbs during treatment, however, makes it difficult to interpret the mechanism of generalisation; it is possible that improved naming of untrained verbs was due to generalisation from verbs to verbs, rather than truly being cross-class generalisation from nouns to verbs.

In both SFA and PMT, some words incorporated into treatment had both noun and verb meanings, which opens up the possibility that generalisation may have been due to verb-verb connections in the lexical network rather than cross-class connections. Generalisation as a result of stimuli having dual meanings is unlikely, however, for several reasons. First, although there were quite a number of words with verb meanings, all but two had the noun meaning as dominant, most by a very large margin (a relative frequency of noun meaning of 80% or higher). While all meanings of a word are activated when it is presented, the high dominance of noun meanings would likely result in a stronger activation and subsequent spread of activation to other lexical items connected to the noun meanings. Furthermore, PMT never focuses on meaning at all; the real words are analysed only in terms of phonological parameters, so any semantic processing that may have occurred would likely have been related to the dominant meaning; non-dominant meanings would likely have been activated only weakly and briefly. A second reason that the presence of words with verb meanings is unlikely to be responsible for the changes seen in verb naming after PMT is that the majority of PMT involved nonword sound sequences, with real words playing only a minor role, in contrast with the pervasive, regular presence of verbs in SFA; this is likely to reduce their impact. Finally, if verbs were playing a large role in PMT one might expect more immediate, stronger generalisation effects, similar to what was seen after SFA treatment. This did not occur, suggesting that the presence of words with verb meanings in the training material was not a driving force for generalisation from PMT. It is possible, though, that their presence may have encouraged gradual development and reinforcement of connections between phonology and verb semantic networks that continued to increase over time as the entire language processing network continued self-reinforcing after treatment was completed. Future studies could manipulate the presence or absence of verbs in the training protocols to further elucidate the mechanisms responsible for improved verb naming following SFA and PMT.

Another potential limitation of this study is the large individual variability of language profiles in both treatment groups. It would be informative to separate analyses for PWA with predominantly semantic versus phonological impairments, which could be determined by analysis of naming errors (Martin & Saffran, 1997; Minkina et al., 2016). The relative severity of semantic to phonological deficits in a particular individual could lead to differential impacts of semantic (SFA) versus phonological (PMT) treatment approaches. On the one hand, identifying and targeting the relatively weaker processing level may ameliorate word-retrieval difficulties more effectively; conversely, focusing on the stronger processing level may better facilitate change in the impaired networks. The consideration of the relationship between language impairment profile and treatment responsiveness can help guide clinical decisions regarding treatment choice. It is imperative for researchers in designing future anomia treatment studies to include data that reflect the relative semantic/phonological difficulties of aphasic participants.

Further insight into factors that might influence the magnitude of generalisation to different word classes could also be gained by collecting neuroimaging data and correlating lesion size and location with naming accuracy. Nouns are processed predominantly in the left temporal cortex while verb processing is more distributed, with significant involvement of the left fronto-temporal perisylvian area and subcortical structures (Aggujaro, Crepaldi, Pistarini, Taricco, & Luzzatti, 2006; Mätzig et al., 2009). More focal lesions in the left temporal lobe might limit generalisation to nouns while distributed lesions in left frontal and subcortical regions could hinder generalisation to verbs. Understanding how the size and distribution of lesions influence generalisation patterns may potentially aid in the selection of an effective treatment approach.

Conclusions

The results of this retrospective study examining the ability of two anomia treatments, SFA and PMT, to facilitate generalisation across word class provided evidence that both treatment approaches were effective. However, the effect sizes were less-than-small suggesting that extra consideration for incorporating verbs should be given when providing anomia treatment. Performance immediately and three months post-treatment relative to baseline varied for each group. SFA performance declined while PMT showed continued improvement, suggesting that PMT likely has a greater potential to promote lasting generalisation across word class.

Acknowledgments

The authors would like to acknowledge the participants and their families for their time and efforts. The last author was funded by VA RR&D Merit Review Grant #C6572R. We are very grateful to Megan Oelke Moldestad and Wesley Allen for treatment delivery, Janaki Torrence for her assistance with data analysis, Kerry Lam for her assistance in recruiting and scheduling participants, Jenny Erpenbeck for managing the data analysis team, and Dr. Yasmeen Faroqi-Shah for her intellectual contribution to this project. We acknowledge the students at the University of Washington who were involved in data analysis and the Aphasia Network (Oregon) for participant recruitment. The contents of this publication do not represent the views of the U.S. Department of Veterans Affairs or the United States government.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the U.S. Department of Veterans Affairs [VA RR&D Merit Review Grant #C6572R].

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