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## Improved word comprehension in Global aphasia using a modified semantic feature analysis treatment

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### ABSTRACT

Limited research has investigated treatment of single word comprehension in people with aphasia, despite numerous studies examining treatment of naming deficits. This study employed a single case experimental design to examine efficacy of a modified semantic feature analysis (SFA) therapy in improving word comprehension in an individual with Global aphasia, who presented with a semantically based comprehension impairment. Ten treatment sessions were conducted over a period of two weeks. Following therapy, the participant demonstrated improved comprehension of treatment items and generalisation to control items, measured by performance on a spoken word picture matching task. Improvements were also observed on other language assessments (e.g. subtests of WAB-R; PALPA subtest 47) and were largely maintained over a period of 12 weeks without further therapy. This study provides support for the efficacy of a modified SFA therapy in remediating single word comprehension in individuals with aphasia with a semantically based comprehension deficit.

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While numerous treatment studies have investigated remediation of naming difficulties associated with aphasia, research regarding treatment of auditory comprehension is comparatively limited (Morris, Franklin, Ellis, Turner, & Bailey, 1996; Francis, Riddoch, & Humphreys, 2001; Tessier, Weill-Chounlamountry, Michelot, & Pradat-Diehl, 2007). This is to the detriment of individuals diagnosed with aphasia, as auditory comprehension is almost always affected to some degree following the onset of aphasia (Bastiaanse, Nijboer, & Taconis, 1993; Morris et al., 1996). While it is acknowledged that in many cases comprehension deficits may improve spontaneously over time, it is important to recognise that full recovery of comprehension does not always occur, especially in more severe cases such as individuals diagnosed with Global aphasia (Alexander & Loverso, 1992; Sarno, 1998).

Thus far, only a small number of studies have explored remediation of comprehension deficits in individuals with aphasia (Behrmann & Lieberthal, 1989; Bastiaanse et al., 1993; Francis et al., 2001; Morris et al., 1996; Tessier et al., 2007; Morris & Franklin, 2012). These studies employed a cognitive neuropsychological approach which aims to utilise language processing models to identify the underlying level of language deficit and target

it directly through therapy (Behrmann & Lieberthal, 1989; Hall & Riddoch, 1997; Albert, 1998; Best & Nickels, 2000). This approach allows explanations to be posited regarding how different therapeutic approaches can influence a specific level of language impairment (Best & Nickels, 2000).

According to cognitive neuropsychological theory, auditory comprehension disorders can be classified into three main types based on the level of impairment (Bastiaanse et al., 1993; Hall & Riddoch, 1997; Francis et al., 2001). These levels can be defined as an individual's ability to: a) identify and process phonemes (auditory processing); b) recognise strings of sounds as real and familiar words (lexical-phonological processing); or c) to comprehend or access the meaning of words (semantic processing) (Bastiaanse et al., 1993; Whitworth, Webster, & Howard, 2005; Tessier et al., 2007). Impairments that impede semantic processing are typically treated using a semantically based treatment that focuses on meaning, whereas impairments that affect the preceding levels may be targeted using a phonologically based treatment that focuses on processing of sounds or phonemes.

Several studies have focused on remediation of semantically based comprehension impairments; those resulting from a breakdown in the access to, or processing within, the semantic system (Behrmann & Lieberthal, 1989; Bastiaanse et al., 1993; Francis et al., 2001; Morris & Franklin, 2012). Francis et al. (2001) employed explicit and implicit therapy approaches, utilising semantically based tasks, to target a comprehension impairment in a participant who demonstrated difficulty accessing the semantic system. Therapy was conducted over two separate phases to enable comparison between the two approaches. The first phase, implicit therapy, required the participant to read definitions and match synonyms with the target word. While results indicated improved comprehension following the implicit therapy, maintenance of these improvements was poor with a significant decline noted in the individual's performance two weeks post-treatment. Explicit therapy, however, where the participant was required to reproduce definitions from written and auditory models and produce synonyms for target words, resulted in improved comprehension that was maintained across the two weeks without therapy. The authors suggested that the difference in maintenance of improvement could be attributed to the design of explicit therapy activities, combined with the participant's strengths and weaknesses. It could also be suggested that the active participation required by the participant during the explicit therapy may have assisted with improved maintenance of results (Francis et al., 2001; Hickin, Best, Herbert, Howard, & Osborne, 2002; Leonard, Rochon, & Laird, 2008). No generalisation of improved comprehension was observed on untreated items.

Behrmann and Lieberthal (1989) conducted a single case experimental design study investigating remediation of a semantically based comprehension deficit using therapy that employed analysis of semantic features. In semantic feature analysis (SFA) approaches, the patient is encouraged to explore semantic features of the target word, such as the properties, category, location, shape, and colour that contribute to the target word's meaning (see Boyle & Coelho, 1995; Conley & Coelho, 2003; Boyle, 2004; Davis, 2005; Rider, Wright, Marshall, & Page, 2008). In their study (Behrmann & Lieberthal, 1989), the participant, a 57-year-old individual who had Global aphasia and was three months post-onset of a left middle cerebral artery infarct, demonstrated severe expressive and receptive deficits secondary to a breakdown at the level of semantic processing. Unlike SFA approaches typically discussed within naming studies, Behrmann and Lieberthal (1989) explored the semantic features of target words with a two-stage treatment; first,

teaching the general concept of a category and then teaching specific details of items within a category. Stimuli consisted of primarily spoken and written words with pictorial stimuli used for some items only.

Following therapy, results indicated improved comprehension of treated single words with some generalisation to control items; however, no follow-up assessment was included in the study to investigate maintenance of these results over time. Behrmann and Lieberthal (1989) argued that improvements observed post-treatment were the result of therapy and not spontaneous recovery, as the participant demonstrated no significant fluctuations in comprehension ability on pre-treatment assessments, which were conducted using spoken and written stimuli, over a three-week period. Although the study showed promising findings, limited information was provided regarding feedback utilised for correct or incorrect responses from the participant during the treatment, making it difficult to replicate this study.

Bastiaanse et al. (1993) described another word-level therapy approach to target comprehension impairment, the Auditory Language Comprehension Program (ALCP). According to the authors, the ALCP is a structured programme consisting of semantic, phonological and complement (combination of semantic and phonological tasks) phases, with each phase containing a number of blocks that progressively challenge the patient. The participant is required to select a picture in response to a verbal label, from a selection of four black and white pictures. During pre-treatment assessments, Bastiaanse et al. (1993) determined that their participant, a 37-year-old male who was approximately three months post-onset, presented with Wernicke's aphasia with semantic impairments being the most salient feature; therefore, only the semantic phase of the ALCP was completed.

The results of their study revealed significant improvement in the participant's comprehension of single words, with generalisation of improved comprehension to control words and sentence level tasks. One unique aspect of this study, when compared to other comprehension studies, was the improvement noted in the participant's spoken language, specifically, his naming ability. Unfortunately, no measures of maintenance were included to determine the long-term effect of therapy. Additionally, Bastiaanse et al. (1993) did not complete the pre-treatment assessments necessary to discount spontaneous recovery influencing therapy outcomes, a particularly important factor given that the participant was three months post-onset and may still have been demonstrating spontaneous recovery (Pulvermüller et al., 2001; Meinzer et al., 2004).

Finally, a more recent study (Morris & Franklin, 2012) investigated treatment of comprehension deficits in a 69-year-old male who was 14 months post-onset of stroke (participant one), and a 59-year-old male who was 16 months post-onset of stroke (participant two). On pre-treatment assessment, both participants demonstrated phonological processing difficulties and significant impairments in accessing semantic information. The initial baseline assessments were administered to eliminate spontaneous recovery as a factor for any change observed during the treatment study; however, details pertaining to the timing of these assessments are limited. Both participants received the same total number of therapy hours, although the intensity and scheduling of therapy sessions differed across the two participants. During therapy, the participants were presented with images of 100 treatment items and provided with a verbal label, either the target or a semantically related name, and were asked to either accept or reject the label based on the

image presented. Participants were provided with immediate feedback regarding the accuracy of their response.

Following therapy, participant 2 demonstrated improved comprehension on both treated and untreated items. While participant two demonstrated generalisation to untreated items in the control set, no significant improvements were observed on additional similar post-treatment assessments (i.e. picture verification task), indicating a lack of generalisation to other tasks. Improved performance on treated and untreated items within the therapy tasks was maintained on assessment four months post-treatment. In contrast, participant one showed no statistically significant improvement on any therapy tasks. Morris and Franklin (2012) suggested that this significant difference in performance could possibly be the result of differing levels of impairment between the two participants wherein one participant had an impairment that was primarily semantic in nature (i.e. implicating meaning) whereas the other had an impairment that was lexical-semantic (i.e. implicating word form).

Previous research (Behrmann & Liberthal, 1989; Bastiaanse et al., 1993; Francis et al., 2001; Morris & Franklin, 2012) has shown that appropriate therapy can lead to improvement in semantic comprehension in individuals with aphasia; however, further research is needed due to the limited number of existing studies, lack of methodological inclusions in some studies (e.g. thorough pre-treatment baseline assessments, follow-up assessment to investigate maintenance of treatment effects), along with the diversity of aphasia types targeted across treatment studies. Further studies targeting semantically based comprehension deficits in people with aphasia are needed to strengthen and extend the findings of preceding studies. A treatment approach that merits further exploration is the use of SFA to treat comprehension deficits.

Numerous naming studies have employed a SFA or modified SFA approach with significant improvements observed post-treatment for treated items and with improvements maintained following the withdrawal or completion of therapy (Boyle & Coelho, 1995; Drew & Thompson, 1999; Conley & Coelho, 2003; Boyle, 2004; Coelho, Davis, 2005; Rider et al., 2008; Rose & Douglas, 2008). In her review of SFA treatment studies conducted with aphasic individuals with anomia, Boyle (2010) notes that SFA has been used to refer to a number of treatments that deviate from the original treatment developed by Ylvisaker and colleagues (1985, as cited in Boyle, 2010). The original SFA treatment required participants to analyse a concept and generate semantic features, whereas some later studies employing the label SFA have not required features to be generated. Instead, participants have been required to employ a different method of processing semantic features such as selecting features from amongst distractors or verifying that a semantic feature is related to a concept.

Long-lasting positive results observed within naming studies employing a semantic-based therapy approach, such as SFA, have been attributed to the active role individuals are required to take during therapy tasks for semantic feature exploration and production (Hickin et al., 2002; Boyle, 2004; Leonard et al., 2008; Boyle, 2010). Results for generalisation of improved naming to control items following SFA and SFA-based treatments remain variable within the literature (Boyle & Coelho, 1995; Rider et al., 2008; Rose & Douglas, 2008; Boyle 2010). As very few participants in the treatment studies have presented with severe aphasia, Boyle (2010) has also highlighted that more studies are needed employing SFA with individuals with more severe diagnoses. Given the centrality of semantics to both language production and comprehension, the mechanism that underlies SFA in treatment of naming deficits may also produce positive effects in the treatment of comprehension impairment. Some evidence of this

was found in the study by Behrmann and Lieberthal (1989), in which positive results were demonstrated when implementing an approach involving analysis of semantic features to target comprehension deficits. A limitation of the existing literature for comprehension treatment approaches is that only a single study (Francis et al., 2001) included measures investigating maintenance of improved comprehension ability following withdrawal of therapy.

The aim of the present study, therefore, was to further investigate the use of semantically based therapy to remediate comprehension deficits at word level using a modified SFA approach in an individual with Global aphasia. We have employed the term ‘modified SFA’ to highlight the different task employed in comparison to traditional SFA studies. In the present study, participants were required to select the correct semantic feature from a choice of two, rather than generating the semantic feature themselves. The modifications to the original SFA procedure were necessary to adapt the task to target comprehension and to accommodate the lack of nonverbal output that individuals with severe aphasia may present with. To strengthen the design of the present study, in comparison to past studies investigating remediation of semantically based comprehension deficits, several factors were taken into account. The present study aimed to investigate remediation of chronic aphasia, to allow observation of treatment effects in isolation of any possible effects of spontaneous recovery. Unlike individuals with aphasia in the acute phase, such as participants in the studies by Behrmann and Lieberthal (1989) and Bastiaanse et al. (1993), individuals with chronic aphasic (greater than 12 months post-onset of stroke; Meinzer et al., 2004; Barthel et al. 2007) are unlikely to improve spontaneously as a result of neural recovery; however, they have previously demonstrated significant improvement following provision of naming therapy (Pulvermüller et al., 2001; Meinzer et al., 2005; Moss & Nicholas, 2006; Barthel et al., 2007). In addition, as previous studies have failed to provide conclusive evidence regarding maintenance of improvements following the withdrawal of therapy, this study also incorporated follow-up assessments at 12 weeks post-treatment in order to determine the longer term benefits, if any, of semantically based therapy for comprehension deficits. Finally, therapy was delivered at a relatively high intensity (10 one-hour sessions over two weeks), since several studies have found that increased intensity of treatment may enhance therapy success for individuals with chronic aphasia (Hinckley & Craig, 1998; Pulvermüller et al., 2001; Bhogal, Teasell, & Speechley, 2003; Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005; Raymer, Kohen, & Saffell, 2006; Barthel, Meinzer, Djundja, & Rockstroh, 2007; Cherney, Patterson, Raymer, Rymark, & Schooling, 2008). It was anticipated, based on previous findings from both comprehension and naming studies, that an individual with chronic Global aphasia with a semantically based comprehension deficit would demonstrate improved single word comprehension following modified SFA therapy.

## **Method**

### ***Ethical approval***

This single case treatment study was completed in accordance with ethical approval from the Human Research Ethics Committees of the relevant University and local Health Service District.

## **Participant details**

### **Case history**

The participant, MB, was a 69-year-old male who was a native English speaker. He was 1 year, 8 months post-onset of a left hemisphere ischaemic stroke when he participated in the present treatment study. Neuroimaging records were not available to indicate the exact location and extent of the lesion; however, following the stroke, MB presented with a right-sided hemiplegia and speech pathology records indicated a diagnosis of Global aphasia and severe apraxia of speech. At the time of participating in the present study, MB remained largely nonverbal, consistent with his original diagnosis. MB's handedness was assessed using Bryden's (1982) hand preference questionnaire which indicated that he was right-handed for all tasks. MB had completed 7 years of formal education and had owned his own earthmoving business up until his stroke. MB reported corrected-to-normal vision when wearing prescription glasses and wore hearing aids to correct an industrial hearing loss. As a result of his hearing loss, the participant reported difficulty hearing with background noise; therefore, all assessments and therapy sessions were completed in a quiet clinical room with only the clinician, participant and participant's wife present.

### **Language profile**

Prior to commencing treatment, a battery of assessments was administered to develop an understanding of MB's current language abilities. MB achieved an Aphasia Quotient of 14.4 on the Western Aphasia Battery Revised (WAB-R; Kertesz, 2006), with severe impairment of both auditory comprehension and verbal expression, consistent with a diagnosis of severe Global aphasia (see Table 1 for a summary of all language assessment results). MB demonstrated greater success for single word comprehension when using real objects compared to pictured objects (which consisted of black and white line drawings) on the WAB-R; however, all tasks proved difficult for the participant. MB produced very low scores on verbal expression tasks such as naming, sentence completion (e.g. *The grass is \_\_\_\_*) and responsive speech (e.g. *How many days are there in a week?*). In the naming subtest, tactile, phonological and semantic cues did not appear to assist with word retrieval.

The picture–picture version of the Pyramids and Palm Trees test (PPT; Howard and Patterson, 1992) and subtest 47 (Spoken Word–Picture Matching) of the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser & Coltheart, 1992) were also administered to provide more detailed information about the nature of MB's comprehension deficit. Results on pre-treatment standardised assessments indicated that MB was demonstrating a semantically based comprehension deficit.

### **Selection of treatment stimuli**

A spoken word–picture matching task was devised to identify appropriate items to target in the treatment programme and to monitor for changes in comprehension ability across the course of the study. Prior to commencing treatment, a total of 80 picture sets were developed for use in the spoken word–picture matching task. Each picture set consisted of four separate images: the target image and three distractors. Photographs or coloured

**Table 1.** Summary of MB's language assessment results from pre- and post-treatment.

Test	Total score possible	Pre-treatment score	Post-treatment score
Western Aphasia Battery Revised			
<i>Spontaneous Speech</i>	20	4 (20%)	4 (20%)
<i>Auditory Verbal Comprehension</i>	10	2.5 (25%)	2.85 (28.5%)
<i>Repetition</i>	10	0.4 (4%)	1 (10%)
<i>Naming and Word Finding</i>	10	0.3 (3%)	0.7 (7%)
<i>Aphasia Quotient</i>	100	14.4 (14.4%)	17.1 (17.1%)
Pyramids and Palm Trees	55	38 (69%)	28 (50.9%)
PALPA subtest 47: Spoken Word-Picture Matching			
<i>Items correct</i>	40	20 (50%)	23 (57.5%)
<i>Close semantic errors</i>		11 (27.5%)	9 (22.5%)
<i>Distant semantic errors</i>		3 (7.5%)	6 (15%)
<i>Visual errors</i>		3 (7.5%)	2 (5%)
<i>Unrelated errors</i>		3 (7.5%)	0 (0%)
Spoken Word–Picture Matching task			
<i>Items correct</i>	26	12 <sup>a</sup> (46%)	24 <sup>b</sup> (92.3%)
<i>Semantic errors</i>		8 (30.7%)	2 (7.7%)
<i>Phonological errors</i>		3 (11.5%)	0 (0%)
<i>Unrelated errors</i>		3 (11.5%)	0 (0%)

<sup>a</sup>Average number of correct responses over three pre-treatment assessments.

<sup>b</sup>Average number of correct responses over three post-treatment assessments.

illustrations of real objects (8 × 8 cm) were used as picture stimuli to try to make the treatment material more aphasia friendly, since some people with aphasia have previously shown a preference for photographic illustrations (Rose, Worrall, Hickson & Hoffman, 2012). Target images were selected using four different categories from published category norms (Van Overschelde, Rawson, & Dunlosky, 2004): food, animals, furniture and clothing. Distractors included a semantic distractor (an item from the same semantic category), a phonological distractor (an item which shared at least an initial phoneme with the target) and a familiarity distractor (an unrelated item which was a target from another set). For example, for the target word *dolphin*, the distractors were *pig* (semantic), *doll* (phonological) and *mushroom* (familiarity).

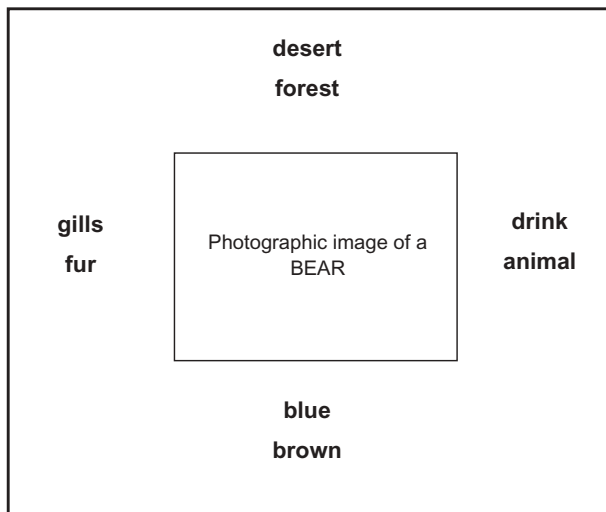
To complete the spoken word–picture matching task, the participant was asked to identify the target picture in these picture sets in response to a verbal request e.g. “Show me the \_\_\_\_\_”. Items were presented in random order and no feedback was provided to the participant regarding his choice. The spoken word–picture matching task was completed on three separate occasions over a period of a week; the targets that were incorrectly identified on two or more occasions were selected to be used within the treatment programme.

A total of 26 items were identified as problematic for the participant and were then divided into two sets labelled ‘treatment’ and ‘control’, with 13 items in each set. Items in the treatment and control groups were statistically matched (Unpaired Wilcoxon signed rank test: Category  $z = 0.000$ ,  $p = 0.540$ , Familiarity  $z = -0.722$ ,  $p = 0.242$ , Imageability  $z = -0.880$ ,  $p = 0.196$ , Kucera–Francis written frequency,  $z = -0.245$ ,  $p = 0.410$ , Syllable length,  $z = -0.144$ ,  $p = 0.500$ ), using category norms (Van Overschelde et al., 2004) and normative data for familiarity, imageability, Kucera–Francis word frequency and word length from the MRC Psycholinguistic Database (Wilson, 1988). Once the 26 items were allocated to treatment and control sets, the spoken word–picture matching was again conducted for the 26 problematic targets to ensure the participant had comparable comprehension for treatment and control sets pre-treatment. Targets and distractors were presented in random order and



configuration, on three separate but consecutive occasions over a period of one week. Fisher's Exact Test indicated no significant difference in the participant's comprehension ability of treatment versus control items across the three pre-treatment assessments (pre-treatment 1: Fisher's Exact,  $\chi^2 = 3.166$ ,  $p = 0.371$ ; pre-treatment 2: Fisher's Exact,  $\chi^2 = 0.982$ ,  $p = 1.000$ ; pre-treatment 3: Fisher's Exact,  $\chi^2 = 1.463$ ,  $p = 0.861$ ).

Following the identification and allocation of items to the treatment or control condition, modified semantic feature analysis sets were developed for each of the treatment items. Semantic feature analysis sets consisted of either a large photograph or coloured illustration of the treatment item ( $14 \times 11$  cm) in the centre of a white A4 ( $29.7 \times 21.0$  cm) page, surrounded by four pairs of printed words representing semantic features. Within each pair of semantic features, one item was consistent with the treatment target and the other was a distractor (see [Figure 1](#) for a schematic example). Semantic features were presented in pairs to allow the participant to actively engage in semantic processing, by making a conscious decision regarding which feature was correct, without having to make a verbal response. Written words were utilised to maximise the modalities the participant could access in order to select a semantic feature during therapy, given his expressive difficulties (e.g. the participant was able to point to, or attempt to verbalise, the chosen semantic feature). Semantic feature categories were identified from categories outlined in previous SFA studies (Boyle and Coelho, 1995; Coelho et al., 2000; Boyle, 2004). While the original SFA design utilises six categories, including group, use, action, properties, location and associations for each item, the semantic features explored within this study were limited to four options to minimise the cognitive load and maximise the participant's ability to participate despite his comprehension deficits. Semantic features included the group (group or category the item belonged to), the location (where the item could be found), the use (how or what the item was used for) and properties (a property iconic for the item).



**Figure 1.** Example of semantic feature analysis treatment stimulus.

## Treatment procedure

### Pre-treatment

Following the administration of standardised assessments to establish the nature of MB's language disorder, and the selection of treatment stimuli using a spoken word–picture matching task; multiple pre-treatment assessments were then conducted to determine stability of comprehension ability across treatment and control tasks (Franklin, 1997; Tate et al., 2008) and to establish the presence or absence of spontaneous recovery. The spoken word–picture matching task (consisting of all 26 treatment and control items) was administered, as previously described, on three consecutive but separate occasions, over the period of a week. Items were presented in random order for each pre-treatment assessment and no feedback was provided regarding whether the participant's response was correct. No statistical difference was observed across the three pre-treatment assessments, suggesting that the participant's comprehension was stable and that he was beyond the period of spontaneous recovery (pre-treatment 1 vs. pre-treatment 2: Fisher's Exact,  $\chi^2 = 9.632$ ,  $p = 0.342$ ; pre-treatment 1 vs. pre-treatment 3: Fisher's Exact,  $\chi^2 = 9.393$ ,  $p = 0.567$ ; pre-treatment 2 vs. pre-treatment 3: Fisher's Exact,  $\chi^2 = 10.541$ ,  $p = 0.201$ ). This strengthens the notion that any changes in comprehension ability observed post-treatment would be attributable to the treatment programme as opposed to natural recovery of function or normal variation.

### Treatment

Over the following two weeks, a total of ten therapy sessions of one hour were completed (see Appendix for treatment schedule). In each session, therapy was provided for all 13 treatment items using the modified semantic feature analysis sets. For each item, the participant was asked to indicate which semantic feature from each of the four pairs was consistent with the pictured target item (e.g. “Does a bear have fur?” or “Does a bear have gills?”; with the therapist pointing to each written semantic feature as it was spoken). The participant's response was acknowledged as either correct or incorrect and the correct response was either restated or explained (e.g. “Yes, the bear has fur” or “No, the bear has fur”).

Mid-treatment probes were conducted at the beginning of every third session to monitor for improved comprehension and/or generalisation of improvement to control items (see Appendix). For these probes, the participant completed the spoken word–picture matching task for all treatment and control items. No feedback or cues were provided during mid-treatment probes.

### Post-treatment

Following completion of the treatment phase, post-treatment assessment was conducted by administering the spoken word–picture matching task with all treatment and control items. Post-treatment assessments were conducted on three separate occasions during a period of one week to determine stability of results. Follow-up assessment was administered 12 weeks after the completion of the treatment phase to determine whether changes in comprehension ability were maintained in the long-term, following withdrawal of therapy. This follow-up assessment included the re-administration of standardised assessments (WAB-R, PPT, and PALPA subtest 47) and administration of the spoken word–picture matching task.

## Results

### Treatment items

Results from mid-treatment probes, completed at regular intervals throughout the treatment programme, indicated a progressive increase in correct responses for treatment items (see Figure 2). Comparison of correct responses from the spoken word–picture matching task at pre- ( $M = 6$ ) and post-treatment ( $M = 12$ ) indicated a significant change in comprehension of treatment words following therapy (items correct at pre-treatment vs. items correct at post-treatment: Wilcoxon signed rank test, exact,  $z = -2.705$ ,  $p = 0.003$ ; see Table 2). Error patterns were also noted to change from semantic, phonological and unrelated errors pre-treatment to solely semantic errors at post-treatment.

### Control items (generalisation)

Analysis of control items at pre ( $M = 6$ ) and post-treatment ( $M = 12.333$ ) indicated that there was also a statistically significant increase of correct responses observed for control items (items correct at pre-treatment vs. items correct at post-treatment: Wilcoxon signed rank test, exact,  $z = -2.980$ ,  $p = 0.0001$ ; see Table 2).

### Maintenance

Results from the follow-up assessment, administered 12 weeks after the completion and withdrawal of therapy, indicated that improvements observed at post-treatment assessment were maintained, with only one less correct response for treatment items and two less for control items. No statistically significant difference was observed between the final post-treatment assessment and follow-up assessment indicating comprehension ability was maintained over the 12 weeks (treatment items: Wilcoxon signed rank test, exact,  $z = -.577$ ,  $p = 0.500$ ; control items: Wilcoxon signed rank test, exact,  $z = -1.342$ ,  $p = 0.250$ ) (see Table 2).

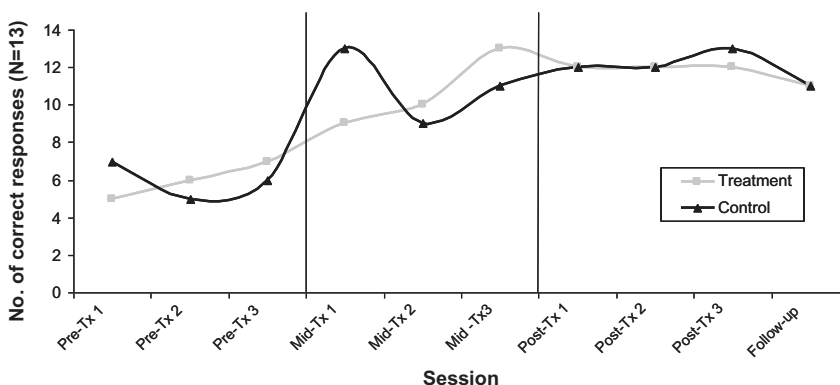


Figure 2. Accuracy of comprehension for treatment and control items across treatment schedule.

**Table 2.** Accuracy of responses across treatment schedule.

Group	Pre-treatment 1	Pre-treatment 2	Pre-treatment 3	Post-treatment 1	Post-treatment 2	Post-treatment 3	Follow-up	Correct responses at pre- vs post-treatment <sup>a</sup>	Correct responses at post-treatment 3 versus follow-up <sup>a</sup>
Treatment items (N = 13)	5	6	7	12	12	12	11	$p = .003^*$	$p = .500$
Control items (N = 13)	7	5	6	12	12	13	11	$p = .0001^*$	$p = .250$

<sup>a</sup> Wilcoxon signed rank test.

\* $p \leq 0.05$  statistically significant.

### **Post-treatment language profile**

Post-treatment results on all standardised assessment, except the PPT, indicated an improvement in scores, including an improvement in the WAB-R AQ from 14.4 to 17.1. Following treatment, the score on the spontaneous speech subtest of the WAB-R demonstrated no change, while small improvements were observed on auditory comprehension (3.5%), repetition (6%), and naming (0.4%) subtests (see Table 1).

An overall improvement of 7.5% was observed for PALPA subtest 47 (Spoken Word-Picture Matching). Error response patterns also changed from pre- to post-treatment. At pre-treatment, assessment errors included close semantic (27.5%), distant semantic (7.5%), visual (7.5%) and unrelated errors (7.5%). At post-treatment, errors consisted of close semantic (22.5%), distant semantic (15%) and visual errors (5%) only (see Table 1). The participant's performance on the PPT demonstrated a reduction in his overall score to 18.1% (see Table 1).

### **Discussion**

The present study provides some support that using a modified SFA therapy approach was effective in improving auditory comprehension of single words in a person with Global aphasia. Following therapy, the participant demonstrated improved auditory comprehension of treatment items, with generalisation to control items within the same semantic categories (i.e. food, animals, clothes, and furniture). Furthermore, follow-up assessment completed 12 weeks after the completion of therapy indicated that improved comprehension of both treatment and control items was maintained following the withdrawal of therapy. The findings of the present study provide preliminary evidence that a modified SFA treatment can be used to improve comprehension deficits in individuals with aphasia, extending the findings of previous studies that have employed this approach to treat semantically based naming deficits (see Boyle & Coelho, 1995; Coelho et al., 2000; Kiran & Thompson, 2003; Boyle, 2004; Rider et al., 2008).

As the participant demonstrated stable comprehension across multiple pre-treatment assessments, it seems likely that the improvements observed in the participant's comprehension post-treatment are attributable to the treatment programme itself and not spontaneous recovery. Additionally, post-treatment results on standardised assessments (i.e. PPT, PALPA subtest 47, WAB-R) provided further evidence to negate the possibility of

improvement being due to spontaneous recovery. For example, the participant demonstrated only a small degree of improvement on tasks not targeted in therapy such as repetition or naming. If spontaneous recovery is occurring, all aspects of language should improve together (Franklin, 1997), therefore, the disproportionate change in ability across tasks suggests that the participant was not experiencing spontaneous or natural recovery of function.

### ***Mechanism of improvement in comprehension***

The participant's improvement in auditory word comprehension following therapy may be explained using the semantic processing concept of automatic spreading activation (Collins & Loftus, 1975; Neely, 1991). According to this concept, word meanings are stored as nodes which are interconnected to other nodes based on a semantic relationship or association. As a word is accessed, activation spreads to other words which are semantically related to the retrieved word. This activation can facilitate the retrieval of related words by reducing the threshold which must be reached in order to access the related words.

A semantically based deficit occurs when these semantic representations or connections between words are damaged, reducing an individual's ability to access words either directly or through spreading activation (Boyle & Coelho, 1995; Coelho et al., 2000; Boyle, 2004). SFA therefore aims to remediate semantic deficits by strengthening semantic connections and networks (Boyle & Coelho, 1995; Coelho et al., 2000; Boyle, 2004). The findings of the present study further support results of previous naming studies that have used SFA or modified-SFA approaches, which suggest that by providing the participant with opportunities to repetitively access and activate semantic networks, it is possible that connections and networks targeted will be reorganised and strengthened. Strengthening semantic networks will in turn allow for enhanced semantic processing, through improved access to the semantic system and enriched semantic representation (Boyle & Coelho, 1995; Boyle, 2004).

In the present study, encouraging the participant to explore semantic features that were closely related to the target word may have improved the retrieval of concepts via the activated semantic network. Activating a number of semantic features related to the target provides it with spreading activation from several related nodes, thus allowing threshold to be reached and facilitating word retrieval. Nodes and connections that were previously degraded due to damage caused by the stroke may have been strengthened via the therapy task. Additionally, the repetitive nature of therapy is likely to have contributed to strengthening semantic representations over time, allowing threshold for activation to be reached more easily for target items.

### ***Generalisation and maintenance of treatment effects***

Generalisation of improved comprehension to untreated items following semantically based therapy approaches has been inconsistent across previous comprehension treatment studies. In the current study, generalisation to control items may have been due to the treatment and control items being from the same semantic categories (i.e. food, animals, clothes and furniture). Boyle (2004) suggests that an SFA approach to therapy enables

category-specific generalisation through the repetitive stimulation of a category, consequently improving the participant's ability to access words within that category. According to the concept of automatic spreading activation, by accessing a word or concept such as a category name (i.e. food, animals, clothes, and furniture), words that share a semantic connection with this word also receive activation (Collins & Loftus, 1975; Neely, 1991). In the present study, the participant was required to identify the semantic category to which the target belonged and by doing so was presumably activating the surrounding semantic network, causing activation to spread to other items within that category.

In terms of maintenance of treatment effects, previous studies suggest that better maintenance in semantically based treatment approaches can be explained by active participant involvement during treatment (e.g. producing a definition, identifying correct semantic features, deciding whether semantic information is correct or not) (Francis et al., 2001; Hickin et al., 2002; Leonard et al., 2008). Findings from the present study also highlight the possible role of participant involvement as a beneficial factor in establishing better maintenance of results. By presenting semantic features in pairs, one correct and one incorrect, the participant was required to actively engage in the treatment process. This active involvement may have led the participant to engage in semantic processing and possibly assisted in internalising the therapy process.

### ***Changes in error response patterns***

In addition to improved and maintained comprehension of treatment and control items, a qualitative change in the error response pattern demonstrated on post-treatment assessment may also support a change in the participant's central semantic ability. Prior to therapy, error responses on the spoken word–picture matching task developed for the treatment programme included semantic, phonological and unrelated errors. Following therapy, errors were purely semantic. This qualitative change may suggest that the treatment improved the participant's access to semantic information relating to the target word. As previously discussed, this change to the semantic system may have been achieved through a general strengthening of semantic representations and processes, improving the participant's ability to effectively access and select semantically related items, resulting in less phonological or unrelated errors. Given the small amount of error data available, these hypotheses are preliminary until confirmed by replication of the present results.

### ***Overall changes to language ability***

Overall results on PALPA subtest 47 (Spoken Word–Picture Matching) showed an increase in the number of correct responses, suggesting a positive change in the participant's general comprehension of single words. The smaller degree of improvement observed on PALPA subtest 47, in comparison to the spoken word–picture matching task used in the treatment programme, could be explained by the broader diversity of semantic categories on PALPA subtest 47. Reduced levels of improvement on PALPA subtest 47 may also be explained by the different number of distractors presented for each target (i.e. PALPA subtest 47 had four distractors while the spoken word–picture matching task from the treatment programme had three distractors). Findings from a study by Pierce, Jareci and Cannito (1990) concluded that increasing the number of stimuli

presented simultaneously increases the cognitive load, which in turn reduces the participant's ability to make a decision. These conclusions are based on the resource allocation model which suggests that by increasing the number of stimuli presented, the individual is required to scan, process and retain more information while engaging in semantic processing, therefore increasing cognitive demands and reducing cognitive resources available to complete the task (Pierce et al., 1990; Howland & Pierce, 2004).

Comparison between pre- and post-treatment results on PALPA subtest 47 also indicated a change in error responses. Initially, errors consisted of close semantic, distant semantic, visual and unrelated errors. Following treatment, errors consisted primarily of close semantic (53%; 9/17 errors) and distant semantic errors (35%; 6/17 errors). This pattern is consistent with that seen on the spoken word–picture matching task developed for the treatment programme and provides further evidence that the participant showed improved semantic processing post-therapy, allowing him to activate semantic networks closer to, or related to the target, as opposed to selecting or accessing semantically unrelated information (i.e. phonological, visual or unrelated distractors).

The participant's superior performance on the spoken word–picture matching task from the treatment programme, relative to his performance on PALPA subtest 47 (Spoken Word–Picture Matching) and the PPT, may be due to the visual appearance of the assessment stimuli. Black and white line drawings are used as stimuli for both PALPA subtest 47 and the PPT, while stimuli for the current study consisted of coloured photographs of real objects which may have been more representative of the target items and facilitated semantic processing and comprehension to a greater degree. The less representative line drawing stimuli featured in the PPT may provide a possible explanation for the unexpected finding seen on the PPT at post-treatment (i.e. scores on the PPT decreased in contrast to improved scores on the other language assessment tasks).

The participant's results on the WAB-R, a general language assessment, are also consistent with a change in central semantic ability post-treatment, with minor improvements observed on all subtests except for spontaneous speech (i.e. auditory comprehension, repetition, naming). While these improvements were not clinically significant, they further suggest that the participant is demonstrating improved semantic access and representation, since semantic processing is central to both auditory comprehension and verbal expression. Expressive ability was not a focus of this study since the participant presented with Global aphasia and co-occurring apraxia of speech, therefore it is not surprising that expressive ability did not show any change. Given the difficulties associated with treating language deficits in individuals with Global aphasia, due to the limited initial spontaneous recovery post stroke and slow overall progress with speech therapy (Alexander & Loverso, 1992), the results of this study are particularly promising for this population.

### ***Limitations and future directions***

The findings outlined within this study remain preliminary and require further research and replication to support the outcomes of this treatment approach. To further clarify and consolidate the results observed within the present study, it would have been beneficial to include an auditory comprehension task (i.e. spoken word picture matching task) that included items from the same category that were not used as probes, as well as items from other semantic categories.

While single case studies have been identified as a valid and appropriate means of researching the efficacy of aphasia treatments, it is recognised that variables such as an individual's aphasia diagnosis or severity, and time post-onset, can influence response to treatment (Holland et al., 1996; Franklin, 1997; Thompson, 2006). It would therefore be advantageous to trial this treatment with a wider range of individuals with comprehension deficits, who present with differing language profiles. Further single case experimental studies or case series would strengthen the findings presented here.

Additionally, only a small number of items were identified as problematic for this participant. Future studies should ideally aim to include a larger number of treatment and control items to increase the power of results observed. The small number of stimuli did, however, enable therapy to be provided in a comprehensive manner during the daily, one hour sessions. Where there are a greater number of stimuli, the length of sessions would need to be considered to ensure adequate time is available to implement the therapy properly. Although treatment intensity was not a focus of this study, it is possible that intensity contributed to the positive results observed.

## Conclusions

The current study demonstrated that use of a modified SFA therapy approach may have been beneficial in improving single word comprehension of an individual with Global aphasia, who presented with a semantically based comprehension deficit. Results indicated that significant improvements in single word comprehension were achieved for both treatment and control items. Furthermore, results appeared to be maintained for 12 weeks following the withdrawal of therapy. These findings expand on conclusions made by previous naming studies that use SFA, by indicating that this approach can also be used successfully to address semantically based comprehension deficits. While the present study provides positive evidence for the use of a modified SFA approach for individuals who present with a semantically based comprehension deficit, replication of this study is required to strengthen and expand the findings.

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## Declaration of interest

The authors declare no conflicts of interest.

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## Appendix

### *Treatment schedule*

Week 1: Pre-treatment assessment and stimuli selection
Session 1: Case history, consent forms, SWPM task with all 80 picture sets (stimuli selection)
Session 2: WAB-R, SWPM with all 80 picture sets (stimuli selection)
Session 3: PALPA subtest 47, PPT, SWPM with all 80 picture sets (stimuli selection)
Week 2: Pre-treatment assessment
Session 1: SWPM task with treatment and control items
Session 2: SWPM task with treatment and control items
Session 3: SWPM task with treatment and control items
Week 3: Treatment programme
Session 1: SFA task with treatment items
Session 2: SFA task with treatment items
Session 3: SFA task with treatment items, mid-treatment probe <sup>a</sup>
Session 4: SFA task with treatment items
Session 5: SFA task with treatment items
Week 4: Treatment programme
Session 6: SFA task with treatment items, mid-treatment probe <sup>a</sup>
Session 7: SFA task with treatment items
Session 8: SFA task with treatment items
Session 9: SFA task with treatment items, mid-treatment probe <sup>a</sup>
Session 10: SFA task with treatment items
Week 5: Post-treatment assessment
Session 1: SWPM task with treatment and control items
Session 2: SWPM task with treatment and control items
Session 3: SWPM task with treatment and control items
Week 17: Post-treatment (Follow-up assessment)
Session 1: PALPA subtest 47, PPT
Session 2: WAB-R, SWPM with all 80 picture sets

Note. SWPM = Spoken Word Picture Matching; WAB-R = Western Aphasia Battery-Revised; PALPA = Psycholinguistic Assessment of Language Processing in Aphasia; PPT = Pyramids and Palm Trees; SFA = semantic feature analysis.

<sup>a</sup>Mid-treatment probe = SWPM task with treated and control items.