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Verb production in agrammatic aphasia: The influence of semantic class and argument structure properties on generalisation

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Abstract

Background—Some individuals with agrammatic aphasia have difficulty producing verbs when naming and generating sentences (Miceli, Silveri, Villa, & Caramazza, 1984; Saffran, Schwartz, & Marin, 1980; Zingeser & Berndt, 1990). And when verbs are produced there is an over-reliance on verbs requiring simple argument structure arrangements (Thompson, Lange, Schneider, & Shapiro, 1997; Thompson, Shapiro, Schneider, & Tait, 1994). Verbs, as argument-taking elements, show especially complex semantic and argument structure properties. This study investigated the role these properties have on verb production in individuals with agrammatic aphasia.

Aim—This treatment study examined the extent to which semantic class and argument structure properties of verbs influenced the ability of seven individuals with agrammatic Broca's aphasia to retrieve verbs and then use them in correct sentence production. Verbs from two semantic classes and two argument structure categories were trained using either a semantic or an argument structure verb retrieval treatment. Specifically, acquisition and generalisation to trained and untrained verbs within and across semantic and argument structure categories was examined. In addition, the influence of verb production on each participant's sentence production was also examined.

Methods & Procedures—Utilising a single-subject crossover design in combination with a multiple baseline design across subjects and behaviours, seven individuals with agrammatic aphasia were trained to retrieve verbs with specific argument structures from two semantic classes under two treatment conditions—semantic verb retrieval treatment and verb argument structure retrieval treatment. Treatment was provided on two-place and three-place motion or change of state verbs, counterbalanced across subjects and behaviours. A total of 102 verbs, depicted in black and white drawings, were utilised in the study, divided equally into motion and change of state verbs (semantic classes) and one-place, two-place, and three-place verbs (argument structure arrangements). Verbs were controlled for syllable length, picturability, phonological complexity, and frequency. These same stimulus items were used to elicit the sentence production probe.

Outcomes & Results—Both treatments revealed significant effects in facilitating acquisition of verb retrieval in all participants. Minimal within and across verb category generalisation occurred. However, it was found that as retrieval of verbs improved, grammatical sentence production improved. This occurred without direct treatment on sentence production.

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Conclusions—The results of this study lend support for treatment focused on verb production with individuals with agrammatic aphasia and support the use of linguistic-based treatment strategies.

Some individuals with agrammatic aphasia have difficulty producing verbs when naming and generating sentences (Miceli et al., l984; Saffran et al., 1980; Zingeser & Berndt, 1990). In some instances they have been found to omit verbs entirely (Kohn, Lorch, & Pearson, 1989), and when verbs are produced, there appears to be an over-reliance on verbs requiring simple argument structure arrangements (Kim & Thompson, 2000; Kiss, 2000; Thompson et al., 1997; Thompson et al., 1994; Thompson, Shapiro, Li, & Schendel, 1993).

Verbs, as argument-taking elements, show especially complex semantic and syntactic properties. They have been found to fall into semantic classes such as *manner of motion* and *change of state* verbs and these dimensions of meaning figure into the determination of a verb's status (Gentner, 1982; Hale & Keyser, 1986, 1987; Levin, 1993; Levin & Rappaport Hovav, 1992). According to Levin (1993), verbs of motion are those describing movement from one place or position to another (i.e., pick, rake, give), a particular way of moving (i.e., shuffle, walk, skip), or movement in a particular direction (i.e., pull, push). Change of state verbs are those verbs describing a change from one form to another (i.e., melt, fill, break), a change in size or shape (i.e., grow, curl, bend), or a change made by the rearrangement or alteration of the material integrity of some entity (i.e., destroy, build, decorate).

In addition to relevant semantic information, verbs also fall into categories concerned with their syntactic behaviour. While verbs with similar meaning show some tendency towards displaying the same syntactic behaviour, including expression of their argument structure, there is not a one-to-one mapping of verb meaning to syntactic behaviour (Levin & Rappaport Hovav, 1995). Verbs commonly are subcategorised with respect to their argument structure properties. For example, the verb *sleep* is an intransitive (one-place) verb with only one external argument (e.g., The boy sleeps.). The verb *hit* is a transitive verb (two-place) which allows a direct object noun phrase (NP) and has two arguments (e.g., The boy hit the ball.). The verb *send* requires a direct object NP, and allows a prepositional phrase (PP), thus it has three possible argument structure arrangements (three-place verb) (e.g., Tom sent the letter.; Tom sent the letter to Vickie.; Tom sent Vickie the letter.). As shown, verbs differ in terms of the number of possible arguments and the number of different argument structure arrangements with which they can occur.

Interestingly, Gentner (1982), examining the meaning component of verbs in child language acquisition, found that change of state verbs were more difficult for children to acquire than motion verbs. And when children misinterpreted change of state verbs as motion verbs, they mapped the wrong argument onto the object position of the sentence. This finding supports the notion that the meaning of a verb is linked to its argument structure properties. According to thematic theory (Jackendoff, 1972), each argument of a verb bears a particular thematic role, so that when the verb *chase* is learned, it is also learned that one has to chase something or someone (e.g., The boy chased the dog.). Each of these argument structures is assigned a specific thematic role in the sentence (i.e., *boy* is assigned the role of agent; *dog* is assigned the role of theme). The point here is that when a verb is selected to convey a specific meaning/message, this choice influences the selection of the sentence constituents because part of the verb's lexical representation is its argument structure.

Both semantic concepts, such as manner of motion and change of state, and the argument structure properties of verbs appear to influence both verb comprehension and production in individuals with aphasia. A recent study by Kemmerer (2000), investigating knowledge of grammatically relevant (argument structure) and grammatically irrelevant (specific perceptual and conceptual) features of verbs, showed that some individuals with aphasia evinced a selective deficit involving grammatically relevant aspects of verbs, whereas others showed a selective deficit involving grammatically irrelevant aspects of verb meaning. Kiss (2000), Kim and Thompson (2000), and Thompson et al. (1997) also found that some individuals with agrammatic aphasia had more difficulty producing complex verbs (i.e., those requiring more argument structures) than verbs with simple argument structure arrangements. Further, Kegl (1995) and Thompson (2000) found that individuals with agrammatic aphasia in comparison to individuals with anomic aphasia showed difficulty producing syntactically complex intransitive verbs that do not directly map their d-structure arguments onto s-structure (i.e., unaccusative verbs) versus those with a more direct mapping of argument structure to s-structure (i.e., unergativeses), suggesting that argument structure properties of verbs influenced their production.[1]

Models of lexical access suggest that when lexical items are selected for production, the lexical search involves automatic activation of items that are semantically related to the target (Collins & Loftus, 1975). In addition, in the case of verb selection, associated grammatical information (i.e., subcategorical information and associated argument structure) is activated (Bock & Levelt, 1994). Models of sentence production (Bock & Levelt, 1994; Garrett, 1975, 1980, 1988; Levelt, 1993) pose that these activation processes occur at the “functional level” of representation, resulting in lemma selection. This selected information then is fed forward to a “positional level” where the phonological representation of words and syntactic form of sentences are designated. Kim and Thompson (2000) speculated that verb production deficits, as seen in individuals with agrammatic aphasia, can be attributed to deficits at the functional level of representation.

In the sentence production literature there is evidence that verb production is an important factor in facilitating grammatical sentence production. Berndt, Mitchum, Haendiges, and Sandson (1997b) found that individuals with both fluent and nonfluent aphasia and verb production deficits demonstrated concomitant sentence production difficulties. When the individuals were provided with a verb, their sentence production abilities were enhanced. Similarly, Marshall, Pring, and Chiat (1998) presented a case of an individual with agrammatic aphasia who had intact verb semantics and verb argument structure information, but was unable to produce verbs or well formed sentences. When a verb was provided for her, sentence production abilities improved.

This study investigated the role of semantic class and argument structure properties of verbs on verb production in individuals with agrammatic aphasia. Verbs from two semantic classes (i.e., motion or change of state) and two argument structure categories (i.e., two-place and three-place) were selected for training using either a semantic verb retrieval treatment or argument structure verb retrieval treatment. The effectiveness of each treatment on the person’s improved production of trained verbs was examined and generalisation to untrained verbs within and across semantic and argument structure categories was examined. The influence of verb production on each individual’s sentence production in constrained and narrative tasks was also investigated. Finally, the effects of treatment on each participant’s general language performance, as measured by standardised and non-standardised aphasia tests, were examined.

[1]For an excellent review of syntax linguistic theory, the reader is referred to Shapiro, L. P. (1997). Tutorial: An introduction to syntax. *Journal of Speech, Language, and Hearing Research, 40,* 254–272.

METHODS

Participants

Seven participants who evinced Broca's aphasia secondary to a single left hemisphere thromboembolic cerebral vascular accident (CVA) were selected for this study. The participants were right-handed (with the exception of Participant 5), monolingual English-speaking, and high-school graduates. Six of the participants had some college training and one participant had an advanced degree. All were neurologically stable and between 39 and 132 months post-onset of neurological infarction. All participants passed a vision screening with corrected vision of at least 20/50 in the better eye, and intact bilateral peripheral hearing was verified by an audiological screening at 40 db HL administered at frequencies of 500, 1000, and 2000 Hz. On narrative language samples, all showed reduced production of two-place and three-place verbs, as well as reduced or incorrect production of verb argument structures associated with these verb types as compared to normal participants. They were not enrolled in concurrent speech-language treatment during the course of the study.

Language testing

All participants were administered a battery of tests to establish suitability for inclusion in the study. The results are shown in Table 1. All participants presented with varying degrees of naming and repetition difficulties based on results of the *Western Aphasia Battery* (WAB, Kertesz, 1982). Utilising the *Philadelphia Comprehension Battery for Aphasia* (PCBA, Saffran, Schwartz, Linebarger, Martin, & Bochetto, 1991), participants' lexical comprehension was found to be superior to overall sentence comprehension and semantically reversible sentences were more difficult for them than non-reversible sentences. Verb comprehension and usage was tested using the *Northwestern Verb Production Battery* (Thompson et al., 1997), which assesses comprehension, naming, and constrained sentence production utilising specific types of verbs. Comprehension of verbs was superior to verb naming for all participants. On the constrained sentence production subtest, as verbs increased in complexity (i.e., the number of required argument structures increased) grammatical sentence production decreased for all but one participant.

Narrative language samples were collected, by asking participants to tell the Cinderella story, both pre- and post treatment, to analyse participants' usage of verb types and percentage of correct usage, as well as specific lexical and morpho-syntactic aspects of production. Samples were analysed using the Systematic Analysis of Language Transcripts (SALT, Miller & Chapman, 1993) software program and linguistically analysed using a coding system developed by Thompson et al. (1994). The results of these analyses were compared to the mean of an age-matched control group with normally developed language, matched for age, gender, and educational level ($n = 6$) (see Table 2). In general, participants produced more simple sentences than complex sentences (with less than 50% of the utterances grammatical), with the exception of Participant 7 who produced 69% grammatical sentences. More nouns than verbs were produced (with the exception of Participant 7), and simple verbs (i.e., those with fewer number of argument structures) were produced more frequently than complex verbs. The results from the formal and informal language measures, as well as the neuroanatomical findings, confirmed the diagnosis of Broca's aphasia with agrammatic language characteristics for each participant in the study. These features included: effortful and slowed rate of speech; dysprosody; reduced phrase length; restriction of output to simple syntactic forms; omission or substitution of grammatical morphemes, both bound and/or free standing; an over-reliance of content words while function words are omitted; and an over-reliance on simple verb usage.

Materials

A total of 102 verbs were utilised in this study: 40 three-place verbs (20 motion; 20 change of state), and 40 two-place verbs (20 motion; 20 change of state) were selected as the target stimuli. Of each group of 40 stimuli, half (i.e., 10 motion; 10 change of state verbs) were selected as the training stimuli, balanced for syllable length and frequency with the untrained stimuli. The remaining motion or change of state verbs served to assess generalisation within semantic class and syntactic type. In addition, 22 one-place verbs (11 motion; 11 change of state) were utilised to assess generalisation across semantic class and syntactic type (see Appendix A).

Verbs were controlled for syllable length, picturability, phonological complexity, and frequency (Francis & Kucera, 1982). Verbs that were longer than three syllables in length were not included in the study. Only verbs that contained three or fewer consonant blends within the word were included. To establish the reliability of the semantic categories of the verb types, five independent judges were asked to review a list of 270 verbs (varying in semantic class and syntactic type) to categorise the verbs as motion, change of state, or other. Only verbs unanimously identified as either motion or change of state were included in the study.

All verbs were depicted by black and white line drawings (see Appendix B for examples of the experimental picture stimuli). Data were collected from five age-matched individuals with normal language skills to assess the likelihood that the pictures elicited both the verbs in question and the target sentences associated with each verb. Any picture and its associated sentence that was misidentified by two or more of the judges was either re-drawn (and replaced) or eliminated from the experimental stimuli.

An additional set of experimental stimuli was used for the sentence production probe. This set was identical to the first with the addition of red arrows pointing to specific people, places, and objects in the pictures denoting argument structures.

Each participant's ability to comprehend the experimental stimulus items (all verbs utilised in the study) was assessed prior to inclusion in the study. In addition, all training and generalisation stimuli were presented to the participants to determine their ability to produce the correct nouns used in the sentence production task. On both tasks, 100% accuracy was required prior to participation in the study.

Experimental design

A single subject crossover design (Barlow & Hayes, 1979) in combination with a multiple baseline across subjects and behaviours design (Connell & Thompson, 1986; McReynolds & Kearns, 1983) was used to evaluate the effects of two treatments (semantic and argument structure) and to examine generalisation across verb type and semantic class. The multiple baseline across behaviours component was included to treat a second verb category only if the predicted generalisation patterns did not occur. A single subject experimental design was selected because it provided a means for closely examining generalisation. The design involved five phases: (1) baseline; (2) application of the first treatment condition; (3) application of the second treatment condition; (4) application of treatment on a second verb category (if necessary); and (5) maintenance. Participants were trained to produce verb categories presented in counterbalanced order using selected training items. A total of 12 sessions per treatment condition were provided for a total of 24 treatment sessions (see Table 3 for an example of the treatment design). If a second verb category was treated, criteria for treatment was 90% correct naming of that trained verb category over three consecutive sessions or a total of ten sessions.

Baseline procedures

In the baseline phase, each participant's ability to name the set of 102 verbs was examined. For the verb naming task, each picture was randomly placed in front of the participant with the instruction "In one word, tell me what is happening in this picture." Participants were given up to 20 seconds to respond. They were discouraged from providing more information. Responses were scored correct if the participant produced the appropriate verb in relation to the picture. These scores served as the dependent variable and were utilised to assess acquisition and generalisation effects.

For the sentence production task, all 102 picture stimuli were again randomly presented to each participant. Prior to the initiation of this task, the following instructions were given, "Now, I am going to show you the pictures again. Each picture will be marked with arrows pointing to people, places, or objects. In a complete sentence, I want you to tell me what is happening in each picture. Make sure you use all the people, places, and objects marked by the arrows." Participants were periodically informed throughout administration of the sentence production probe to use the people and objects indicated by the arrows when making their sentences. Responses were scored for both correctness of the verb and grammaticality (i.e., use of the correct verb with its respective argument structures). The sentence production probe was administered twice during the baseline phase and once every sixth treatment session for each participant. Feedback regarding the accuracy of the participants' responses was not provided during the baseline or probe phases; however, intermittent remarks of encouragement were given.

Treatment

Following the baseline phase, one of two treatments (semantic verb retrieval treatment or argument structure verb retrieval treatment) was applied to one category of verbs (two-place motion verbs, two-place change of state verbs, three-place motion verbs, or three-place change of state verbs), while untrained verbs from the same category and all other verb types were examined for generalisation effects. Semantic verb retrieval treatment focused on the meaning of the verb with respect to its semantic class, while argument structure verb retrieval treatment focused on the number of argument structures inherent to that verb and their thematic role assignment. Both treatments consisted of three steps: (1) presentation of the individual training item to the participant; (2) presentation of a definition of the concept being trained (i.e., the meaning of motion or change of state for the semantic treatment, or argument structure and thematic role information for the argument structure treatment); and (3) the participant naming the target item. During the semantic verb retrieval treatment, when motion verbs were trained, general definitions of the motions targeted in the study were given followed by specific definitions for each training stimuli. For example, during the general definition ofmotion verbs, sample items were placed in front of the participant with the instructions, "The items you are going to see all describe a motion. This motion can be shown by movement in a particular direction, movement from one place to another, or a particular way of moving. For example, this picture shows *pass.* It shows movement in a particular direction. This picture shows *pick*. It shows movement from one place to another. And this picture shows *shuffle*. It shows a particular way of moving." Each training item then was presented to the participant, e.g., "This picture shows jump. It shows a sudden movement off the ground using the legs. The movement shown is movement from one place to another."[2] Following the presentation of each training item, the participant was instructed to again "Tell me what is happening in the picture." If the correct response was given, the examiner moved onto the next training stimulus. If an incorrect response was given, the examiner modelled the word for the subject to repeat. "The word is_____. You say it."

During argument structure verb retrieval treatment, when two-place verbs were trained, a general definition of the argument structure assignments targeted in the study was given followed by specific definitions for each training stimuli. For example, during the general definition of two-place verbs, a sample item was placed in front of the participant with the instructions, "The items you are going to see all show *someone doing something to someone* (*or something*). That is, someone is doing the action and someone (something) is receiving the action. For example, this picture shows *mould*. It shows 'the artist is moulding the clay'. The artist is the person doing the moulding; the clay is the thing being moulded." Each training item then was presented to the participant, e.g., "This picture shows *jump*. It shows '*the girl is jumping the rope*'. The girl is the person doing the jumping; the rope is the thing being jumped."[3] Following presentation of each training item, the participant was again instructed to "Tell me what is happening in the picture." If the correct response was given, the examiner moved onto the next training stimulus. If an incorrect response was given, the examiner modelled the word for the subject to repeat. "The word is_____. You say it."

Treatment probes

Each session began by assessing verb production using the items from the target set (trained and untrained) and half of the baseline probe items. In this manner, target items were tested every treatment session; one full generalisation probe (i.e., all 102 experimental items) was obtained every two treatment sessions. For example, if two-place motion verbs were being trained, the 10 trained and 10 untrained items from this set were probed daily as were half of the remaining 102 items. The sentence production probe was administered at the end of each treatment phase. Responses to the sentence production probes served as a measure of generalisation from verb retrieval to sentence production. The elicitation and scoring procedure for both the verb naming and sentence production probes followed the protocol as outlined during the baseline phase.

Following completion of treatment, a 3-week follow-up probe was administered to determine if acquired responses were maintained over time.

Data analysis

During treatment, the data were graphed and visually inspected for treatment effects and generalisation. Treatment was considered to be effective when there was a 90% correct response rate over three consecutive treatment sessions. Generalisation was considered to have occurred when behaviours increased at least 30% above baseline performance.

Post-treatment testing

Following the completion of treatment, the *Verb Production Battery* and the *WAB* were re-administered to assess generalisation to general language functions across all language modalities. In addition, narrative language samples were collected for each participant during the follow-up phase of the study, utilising the same procedures as during the baseline

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[2]When change of state verbs were trained, the following definition was given: "The items you are going to see all show a type of change. This change can be shown by changing from one form to another, by changing size or shape, or by altering or rearranging something. For example, this picture shows *melting.* It shows a change form one form to another. This picture shows *sprouting.* It shows a change in size and shape. And this picture shows *building.* It shows a change by altering or rearranging." Each training item was then presented to the participant; "This picture shows *breaking.* It shows separating into pieces. The change shown is changing from one form to another."

[3]When three-place verbs were trained the following definition was given: "The items you are going to see all show *someone doing something with something to someone (or someplace).* That is, someone is doing the action, someone (something) is receiving the action, and something is effecting the action. For example, this picture shows *bring.* It shows 'the girl is bringing the flowers to the lady'. The girl is the person doing the bringing; the flowers are the thing being brought; and the lady is the person who the flowers are brought to." Each training item was then presented to the participant; "This picture shows *fill.* It shows '*the girl is filling the pitcher with water*'. The girl is the person doing the filling; the water is the thing doing the filling; and the pitcher is the thing being filled."

phase. These data were compared using dependent *t*-test both pre- and post-treatment for each participant.

Reliability

Reliability on the dependent variable—As a measure of inter-observer reliability for the dependent variable, the examiner and an independent judge scored responses from one baseline session and every fourth treatment session. Reliability judgements were made on a total of 42 out of 221 probe sessions administered during baseline and experimental sessions. To improve scoring accuracy, any disagreements concerning scoring were discussed. A high percentage of inter-judge agreement across all participants, with an overall range of 82% to 100% and an overall mean of 94% for all scored responses, was obtained.

Reliability on the independent variable—Inter-judge reliability on the independent variable was based on videotaped transcripts of treatment sessions taken once during each treatment phase for each participant. Four videotaped recordings were randomly selected and scored by the examiner and an independent observer on the following parameters: (1) adherence to the steps for presenting the general definitions of motion or change of state; (2) adherence to the training steps for each item; and (3) accuracy of response contingent feedback. These data indicated a high percentage of inter-judge agreement (100%) across all parameters for both treatment conditions.

Reliability on the coding of the narrative language samples—All narrative language samples were coded by the examiner (the primary coder); one fourth of these samples were checked for reliability by a second coder. Point-to-point inter-rater reliability was calculated separately for sentence/nonsentence determination, sentence type, verb code, and verb argument codes. Reliability ranged from 83% to 100% (X = 90%) for sentence/nonsentence determination, from 72% to 100% (X = 85%) for sentence type codes, from 61% to 92% (X = 77%) for verb codes, and from 76% to 91% (X = 84%) for verb argument codes. Overall inter-rater reliability ranged from 61% to 100% (X= 87%).

RESULTS

Semantic versus argument structure treatment

The acquisition of verb production by Participants 1–7 under the two treatment conditions is shown is Figures 1–7, respectively. The black squares in the top two graphs of each figure show that, for all participants, rapid acquisition of trained verbs occurred following stable baseline performance. Statistical analysis[4] comparing the final data point from the baseline phase and from the final probe of the first treatment phase for each behaviour, confirmed this improvement, $t(11)= -13.324$, $p = .001$. Statistical analysis comparing the effects of the two treatments, again using the last baseline data point and the final data point from the first treatment phase for each behaviour (six semantic verb retrieval treatment sessions and six argument structure treatment sessions), showed no significant differences, $t(11) = -.606$; $p = .607$.

Three weeks following the completion of the study, a follow-up was done with the participants to assess whether the behaviours acquired during treatment maintained over time. The data collected during this time are depicted in Figures 2–7 and show that retrieval

[4]Only data from Participants 2–7 were entered into the statistical analyses. Unfortunately, Participant 1 suffered a second stroke prior to completion of the study, therefore pre- and post-treatment data were not included.

of most of the trained and untrained verb categories was maintained at levels superior to that noted during baseline.

Generalisation data

Three types of generalisation were of interest. First, generalisation within and across verb categories was examined. Generalisation within category was considered to have occurred when untrained verbs of the same semantic or syntactic category increased at least 30% above baseline levels. Generalisation within semantic category was checked by examining production of untrained verbs of the trained semantic class (e.g., change of state to change of state), regardless of argument structure. Similarly, generalisation within argument structure category was checked by inspecting production of untrained verbs of the trained argument structure type (e.g., three-place to three-place), regardless of semantic class. Second, we examined generalisation to sentence production, and finally, generalisation to other language production tasks (i.e., standardised testing and narrative language sampling) was examined.

Within verb category generalization—Generalisation by Participants 1–7 to untrained verbs of the same semantic or syntactic verb class is shown by the white squares in the top graph of Figures 1–7 and in the bottom graph of all figures. Only Participant 4 showed any within-verb category generalisation. For the remaining participants, untrained verbs of the category trained remained at baseline levels throughout treatment. Participant 4 showed generalisation within argument structure category—from trained three-place verbs (change of state) to untrained three-place verbs (both change of state and motion verbs).

Across verb category generalisation—Generalisation to other verb categories was determined by examining each participant's production of untrained verbs, differing from trained verbs in either semantic class or argument structure type. These data are presented in the middle and bottom graphs of Figures 1–7. As can be seen, results indicated negligible across-verb category generalisation, with the exception of Participants 3 and 4 who showed a generalisation effect to one verb category during the second treatment condition. Participant 3 showed generalisation from three-place change of state verbs to one-place change of state and motion verbs. Participant 4 showed generalisation from three-place change of state verbs to two-place motion verbs. In addition, for Participant 4, production of three-place motion verbs increased 28%, and one-place motion verbs increased 26% from baseline to the second treatment condition. This increase, while not constituting the a priori generalisation level set in the study, does show an increased shift in the level, slope, and trend of these behaviours.

Generalisation to constrained sentence production—Generalisation was further investigated by examining each participant's ability to use the included verbs in the constrained sentence production task. Figure 8 shows the percent correct sentence production for each participant across all phases of the study. These data indicate that all participants improved in sentence production from pre- to post-treatment, an effect that was confirmed by statistical analysis, $t(6) = -5.137$; $p = .002$. This improvement was steady and consistent across all treatment phases regardless of type or order of treatment. In addition, for all participants (with the exception of Participant 1 who did not complete the study) this improvement was maintained during follow-up testing. There was no statistically significant difference between performance on the final sentence production probe and the follow-up probe, $t(5) = .315$; $p = .765$ (comparing baseline performance to follow-up performance). Further statistical analysis was undertaken to see if there was a difference in sentence production for the trained as compared to the untrained verbs. A significant difference was revealed, $t(6) = 2.694$; $p = .036$, indicating that although an overall improvement in sentence production was seen, trained verbs were produced correctly in sentences more often than were untrained verbs.

Generalisation to post-treatment narrative language samples—Narrative language samples were collected and analysed post-treatment utilising the same procedure as was used pre-treatment. Results of these post-treatment analyses are presented in Table 4. Increases (though not statistically significant) in percentage of grammatical sentences, percentage of correctly used obligatory one-place, obligatory two-place, and optional three-place verbs, and percentage of correct theme and goal argument structure usage were seen during post-treatment narrative language samples as compared to pre-treatment samples.

Post-treatment testing

Following completion of treatment, participants were again assessed using the *WAB* and the *Northwestern Verb Production Battery*. Table 5 reports the statistical analyses of these data using dependent *t*-tests to compare pre- versus post-treatment scores. Performance on the *WAB* showed statistically significant changes in the aphasia quotient and in repetition and naming subtests. Pre- to post-treatment performance on the *Northwestern Verb Production Battery* also showed significant improvements, with increases in the percent of sentences produced correctly on the constrained sentence production subtest and increases in the percent of correct sentences with obligatory two-place and obligatory three-place verbs. Improved performance on comprehension and confrontational naming subtests was also noted, although it was not statistically significant.

DISCUSSION

Results of this study indicate that both semantic and argument structure treatments were effective in facilitating retrieval of verbs from particular semantic and argument structure categories. As treatment was applied to a specific verb category, retrieval of trained items improved, regardless of the treatment approach. The order of the treatment condition was not found to be a factor. That is, verb retrieval improved similarly regardless of which treatment was applied first and continued to increase during the second treatment condition. One possible explanation for this finding is that while the two treatment conditions in this study were designed to be theoretically distinct in targeting either the semantic class of the verb or its argument structure properties, they were similar in that both required that participants name target items following the examiner's verbal model. Perhaps the other variables associated with each of the treatments were not sufficient to maximise access to the semantic or argument structure properties of verbs.

The general paucity of generalisation within and between verb categories further suggests that the treatment variables thought to maximise knowledge about either the semantic or argument structure properties of verbs likely did not do this. Only two participants (Participants 3 and 4) showed generalisation within or across verb categories. What is interesting is that both of these participants received treatment on three-place change of state verbs—verbs that were considered to be the most difficult in the study in terms of argument structure properties. Perhaps the generalisation noted in these participants occurred because of the complexity of structures trained, rather than because of particular treatment variables applied. As noted by Thompson et al. (1997), treatment focused on complex forms appears to facilitate generalisation to less complex forms. In the case of the verbs targeted here, one- and two-place verbs are in a hierarchical relation to three-place verbs; therefore, training three-place verbs may have heightened retrieval of simpler verb forms. Of course, Participants 5 and 6 also received treatment on three-place verbs and did not show generalisation to less complex verbs. Thus, this explanation does not completely explain the generalisation patterns noted.

What is difficult to explain is the lack of major generalisation effects within and across verb categories for the majority of the participants in the study. Consider first the lack of generalisation of verbs to similar semantic classes (i.e., motion, change of state). According to models of lexical selection (Bock & Levelt, 1994; Dell, 1986; Levelt, 1993), when a specific lexical item is activated at the functional level, not only is the target item activated but so are all semantically related items. This notion has been supported in the semantic priming literature (Collins & Loftus, 1975; Marslen-Wilson, 1987; Neely, 1977), where lexical decision latencies have consistently been found to be shorter for a target word when it is preceded by a semantically related word than when it is preceded by a semantically unrelated word, and in the literature reporting word substitution errors in both normal and aphasic individuals (Garrett, 1975). Therefore, it follows that repeated exposure to items of a particular class should heighten connections among items within the category, and generalisation should be forthcoming. However, using a word interference paradigm, Schriefers, Meyer, and Levelt (1990), Roelofs (1992), and Glaser (1992) showed that when a lexical item from one semantic class was activated, this activation actually interfered with lexical items from similar semantic classes. For example, when individuals were asked to name a picture of a “dog” and told to ignore a distractor word such as “cat”, reaction times were longer than when the distractor word was “pencil”. The findings of these studies suggest that when lexical items from similar semantic classes are activated, there can be an interference effect, thereby reducing the probability of selecting semantically related lexical items. Relevant to this study, as a verb from one semantic or argument structure class was accessed, this activation could have actually interfered with accessing verbs from that same class, thus accounting for the lack of generalisation.

Another explanation for the lack of generalisation across semantic class could be that the semantically based treatment used in the study was not “strong” enough to activate the relevant semantic features/dimensions of the verb classes targeted in the study. Levin (1993) suggests that while “motion” and “change of state” verbs are large and important classes of verbs in the English language, there are many subclasses of these verbs (e.g., direction of movement, manner of movement, positive or negative changes along a scale, etc.). While this study attempted to account for some of the more obvious features of the semantic class of the chosen verbs, it did not take into account all the features of the particular semantic verb class, nor did it consider the possibility of an interaction of these semantic features. Interestingly, a recent study by Kemmerer and Tranel (2000) examined various stimulus (e.g., visual complexity, imagability, familiarity), lexical (e.g., frequency, name agreement, homophonous), and conceptual (e.g., how the action is done, who or what undergoes the action, use of an instrument) features of verbs. They found considerable variation within and across these factors in individuals with unilateral left-hemisphere brain damage, suggesting that verb retrieval is a complex task involving many factors.

The lack of generalisation across argument structure properties also needs to be considered. There is evidence in sentence production models that both semantic and argument structure properties are assigned at the functional level. In addition, it is at this level that argument structures are assigned thematic roles, and thus there is a linking of syntactic information to semantic information. That is, the selected verb influences argument structure and thematic role assignments. What was not considered in this study was the effect of semantic class on argument structure assignment. For example, the verb “drown”, which was designated as a change of state verb, could also have been considered a motion verb depending on its conceptual use. If “drown” is pictured as “The farmer is drowning the rat” the concept of motion is evoked, whereas if “drown” is pictured as “The rat drowned” the concept of change of state is evoked. Therefore the construction of a sentence is directly related to the subtle aspects of the meaning of that verb. Pinker (1989), Rappaport Hovav and Levin (1998), and Verspoor, Lee, and Sweetser (1997), suggest that some aspects of verb meaning are more grammatically relevant than other aspects. That is, the construction of a sentence is directly associated with specific aspects of meaning, and a verb's meaning must be compatible with that construction. Interestingly, Kemmerer (2000) examined the semantic features of locative verbs in three individuals with aphasia and provided evidence for a semantic subsystem such that there are grammatically relevant and irrelevant features of verb meaning. In other words, the specific meaning of a verb influences the grammatical construction to infer the semantic content of the verb. This then could explain the lack of generalisation across argument structure properties, in that there appears to be a complex interactive relationship between semantic class and argument structure properties such that one cannot be dissociated from the other.

Another aspect of generalisation, and perhaps the most interesting finding of the study, was the generalisation effect from verb retrieval to sentence production. This was interesting since no direct treatment on sentence production occurred. This finding supports others in both the sentence processing and sentence production literature. In the sentence processing literature, Shapiro, Zurif and Grimshaw (1987), Shapiro and Levine (1990), and Shapiro, Gordon, Hack, and Killackey (1993) found that when a verb is activated in the lexicon, all possible argument structure arrangements associated with that verb are also activated. We predicted that if indeed this happens, then when a verb is retrieved from the lexicon, its associated argument structure arrangements are also retrieved, and this then should facilitate grammatical sentence production. The findings of this study supported this hypothesis in that there was increased grammatical sentence production for all participants in the study as verb retrieval improved.

In the sentence production literature, (Berndt et al., 1997b; Miceli et al., 1988; Saffran, 1982; Zingeser & Berndt, 1990) verb retrieval deficits have been associated with sentence production deficits in individuals with aphasia, which implies a co-occurrence of verb retrieval and grammatical sentence production. For example, Berndt et al. (1997) examined verb production and found that verb retrieval deficits (noted across aphasia types) significantly correlated with sentence production deficits. In a follow-up study, Berndt, Haendiges, Mitchum, and Sandson (1997a) found that when verbs were provided to individuals with verb retrieval deficits, some, but not all, produced "better-formed" sentences. Marshall et al. (1998) also showed in an individual case study that providing the verb for the individual improved sentence production abilities. The findings of our study support these observations. Our participants were trained to produce verbs, and this training resulted in significant improvements in sentence production on the constrained sentence production task. In addition, we found that grammatical sentence production was significantly better for the trained verbs than for the untrained verbs. These findings provide evidence that verb retrieval deficits contribute to sentence production deficits and that improved verb retrieval results in improved sentence production—likely because argument structure information is encoded in the verb representation; improved access to verbs facilitates improved access to verb argument structure which in turn promotes grammatical sentence production.

Generalisation to standardised testing was also examined. Improvements in the aphasia quotient and the naming and repetition subtest scores on the *WAB* and on the *Northwestern Verb Production Battery* were noted. Thus it appears that improved responding on specific linguistic structures (e.g., verb retrieval) facilitates improvement in general language responses as measured by the *WAB*. It was concluded that the improvements noted on the *WAB* and the *Verb Production Battery* were a result of improved verb retrieval or naming ability since it was this behaviour that was targeted in the verb retrieval treatment. Another explanation could be that participation in a regular treatment programme facilitates overall language improvement.

With regard to generalisation to narrative language samples, increases in the proportion of grammatical sentences produced and the proportion of verb arguments produced correctly increased, although not significantly, from pre- to post-treatment. The lack of statistical significance on these variables could be due to the small number of lexical items analysed. That is, the total language corpora per subject were small and therefore limited the number of items per linguistic category available to be analysed. That improvements were apparent at all, however, is noteworthy and suggests that verb retrieval treatment had an effect on language production.

Finally, maintenance of treatment gains was observed in all participants. That is, treatment of specific verb categories facilitated the production of trained verbs and grammatical sentence production and these behaviours were maintained over time. This finding supports the fact that treatment focused on verb production with individuals with agrammatic aphasia was effective.

Conclusion

The findings of this study showed that treatment focused on verb retrieval improves production of verbs targeted in treatment, and that improved retrieval of verbs results in an increase in grammatical sentence production in individuals with agrammatic aphasia. However, the lack of generalisation within or across semantic or argument structure classes of verbs suggests that the treatment targeting semantic or argument structure features of verbs may not fully exploit salient features of verbs.

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APPENDIX A. List of experimental stimuli (verbs and target sentences)

VERB	TARGET SENTENCE
Two-place motion verbs	
dance	**The couple (they) are dancing the waltz.**
rock	**The mother is rocking the baby.**
jump	**The girl is jumping the rope.**
kick	**The boy is kicking the ball.**
rake	**The man is raking leaves.**
climb	**The boy is climbing the mountain.**
fly	**The boy is flying the kite.**
juggle	**The clown is juggling the balls.**
walk	**The boy is walking the dog.**
chase	**The boy is chasing the girl.**
stir	The girl is stirring the cake mix (batter/ingredients).
run	The man is running the race.
bang/beat	The boy is beating (banging) the drum.

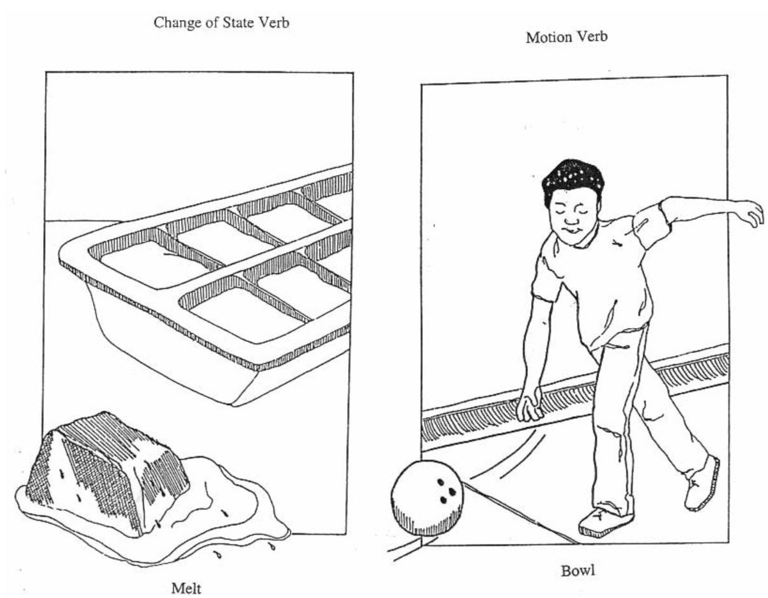
VERB	TARGET SENTENCE
track	The hunter is tracking the bear.
blow	The boy is blowing bubbles.
massage	The nurse is massaging the patient.
pound	The man is pounding the table.
screw	The boy is screwing the bench.
mow	The girl is mowing the grass (lawn).
ride	The boy is riding the bike.
Two-place change of state verbs	
shrink	**The woman is shrinking the shirt.**
build	**The man is building a doghouse.**
drown	**The farmer (man) is drowning the rat.**
marry	**The minister (priest) is marrying the man and woman (couple).**
grow	**The plant is growing new leaves.**
bend	**The man is bending the pipe.**
break	**The boy is breaking the plates.**
unravel	**The man is unraveling the scarf.**
tear	**The boy is tearing his pants.**
destroy	**The bomb is destroying the building.**
shut/close	The boy is shutting (closing) the suitcase.
ruin	The boy is ruining the snowman.
unbutton	The baby is unbuttoning his pajamas (sleeper/jumper).
unlace	The boy is unlacing the shoe.
open	The man is opening the window.
turn into	The pumpkin is turning into a carriage.
kill	The wolf is killing the rabbit.
shed	The dog is shedding his hair (coat).
erase	The girl is erasing the chalkboard.
unwrap	The child is unwrapping the present.
Three-place motion verbs	
give	**The girl is giving the present to her mother (the lady/woman).**
pull	**The boy is pulling the gum off his shoe.**
put/place	**The woman is putting (placing) the vase on the table.**
shove	**The girl is shoving the boy in the park.**
carry	**The girl is carrying the pot to the table.**
mail	**The man is mailing a letter to his mother.**
lean	**The fireman is leaning the ladder against the house.**
wipe	**he woman is wiping (drying) the dishes with a towel.**
shake	**The woman is shaking the dust from the rug.**
splash	**The boy is splashing the girl with water.**
feed	The mother is feeding the baby cereal.
stick/paste	The boy is sticking (pasting) the stamp on the letter.
measure	The man is measuring the roof with the ruler.

VERB	TARGET SENTENCE
hammer	The man is hammering (nailing) the nail in the box.
pour	The boy is pouring syrup on the ice cream.
spread	The girl is spreading peanut butter on the bread.
drag	They (the man and girl) are dragging the rock up the hill.
tuck	The mother is tucking the boy in bed.
lay/put	The mother is laying (putting) the baby in the bed (crib).
spill	The girl is spilling coke (soda) on the rug.
Three-place change of state verbs	
fill	**The girl is filling the pitcher with water.**
litter	**The man is littering the park with trash.**
load	**The farmer is loading apples into the truck.**
curl	**The woman is curling her hair with a curling iron.**
drench	**The boy is drenching the girl with water.**
stuff	**The boy is stuffing papers into his backpack.**
spray	**The boy is spraying the wall with paint.**
cover	**The father is covering his son with a blanket.**
pave	**The man is paving the road with asphalt.**
decorate	**The girl is decorating the tree with ornaments.**
block	The man is blocking the street with barricades.
smear	The boy is smearing dirt (chocolate) on the window.
return	The boy is returning the book to the library.
empty	The man is emptying the trash into the truck.
smother	The man is smothering the girl with a pillow.
inflate/pump	The man is inflating (pumping up) the tire with air.
unlock	The boy is unlocking the lock on the trunk.
unscrew	The woman is unscrewing the lid from the jar.
flood	The rain is flooding the city with water.
clear	The man is clearing snow from the street.
One-place motion verbs	
canoe	The man is canoeing.
somersault	The boy is somersaulting.
slide	The girl is sliding.
crawl	The baby is crawling.
fall	The man is falling.
kayak	The man is kayaking.
skate	The girl is skating.
swim	The girl is swimming.
tiptoe/(wade)	The girl is tiptoeing (wading).
bowl	The boy is bowling.
hop	The frog is hopping.
One-place change of state verbs	
bloom	The flower is blooming.

VERB	TARGET SENTENCE
hatch	The chicken is hatching.
blush	The girl is blushing.
disappear	The bird is disappearing.
faint	The man is fainting.
graduate	The man is graduating.
awaken	The woman is awakening (waking up).
sleep/nap	The girl is sleeping.
shiver/tremble	The man is shivering (trembling).
perspire/sweat	The man is sweating (perspiring)
wilt/die	The flower is dying (wilting).

Items in bold type indicate training items.

APPENDIX B. Examples of experimental picture stimuli



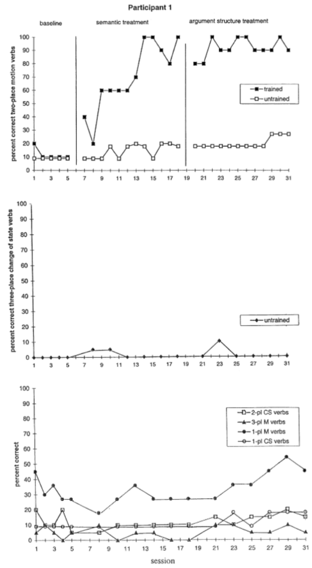


Figure 1.

Trained and untrained verb retrieval data and within and across verb category generalisation data for Participant 1. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

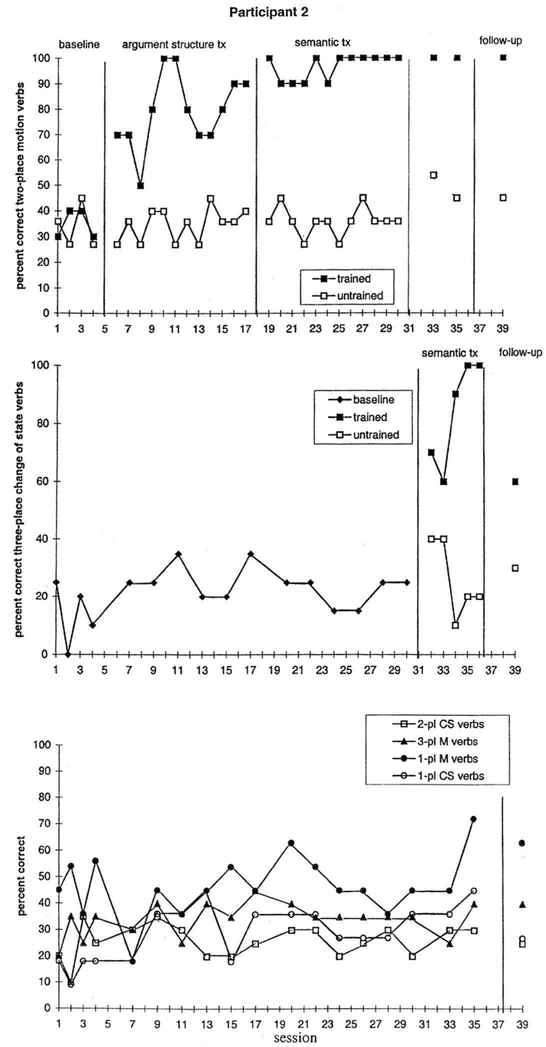


Figure 2.

Trained and untrained verb retrieval data and within and across verb category generalisation data for Participant 2. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

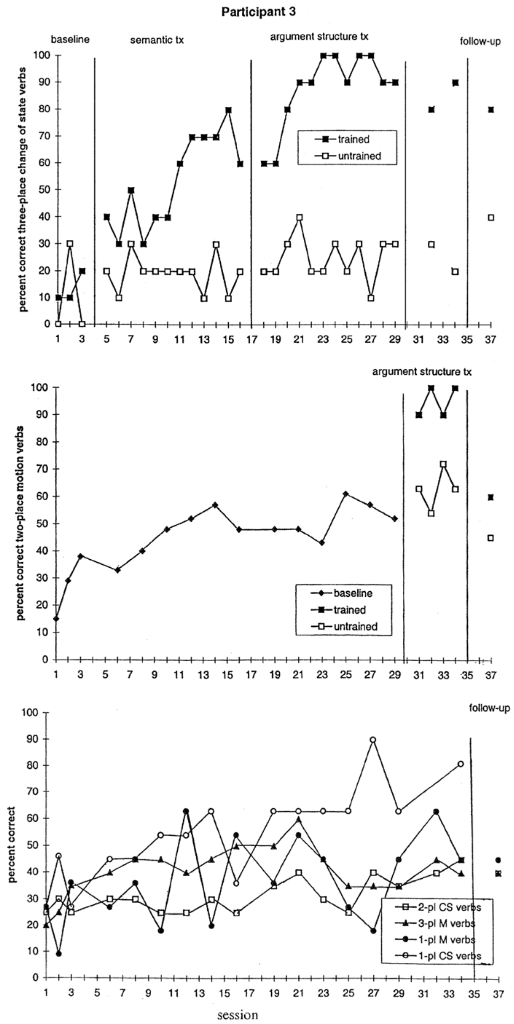


Figure 3.

Trained and untrained verb retrieval data, within and across verb category generalisation data and follow-up data for Participant 3. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

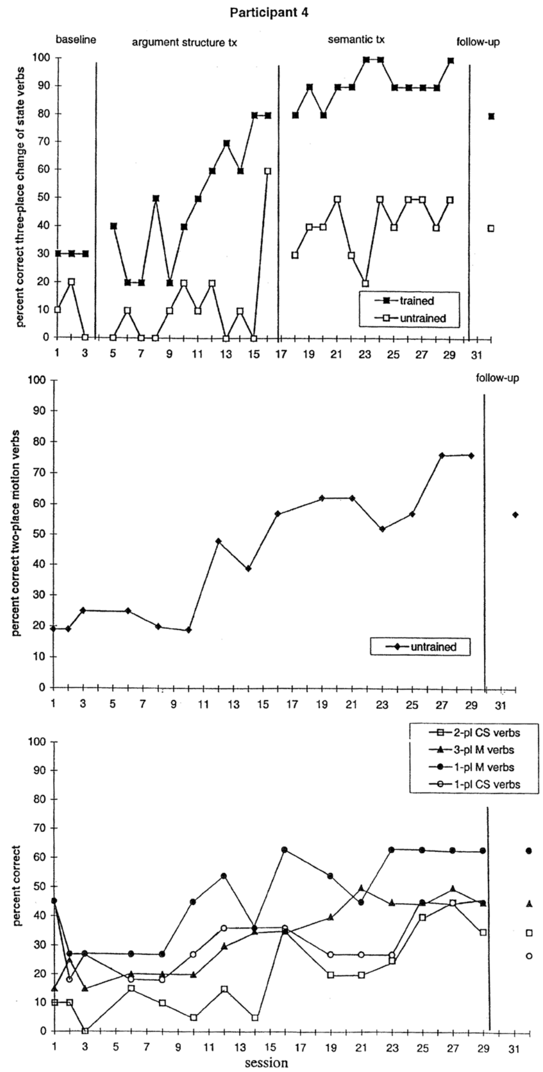


Figure 4.

Trained and untrained verb retrieval data, within and across verb category generalisation data, and follow-up data for Participant 4. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

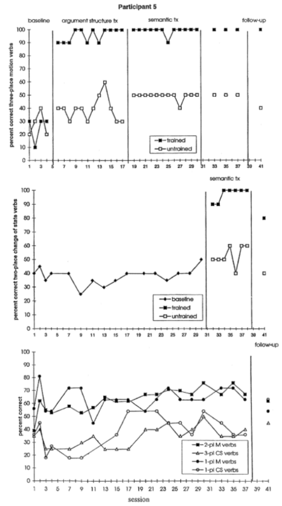


Figure 5.

Trained and untrained verb retrieval data, within and across verb category generalisation data, and follow-up data for Participant 5. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

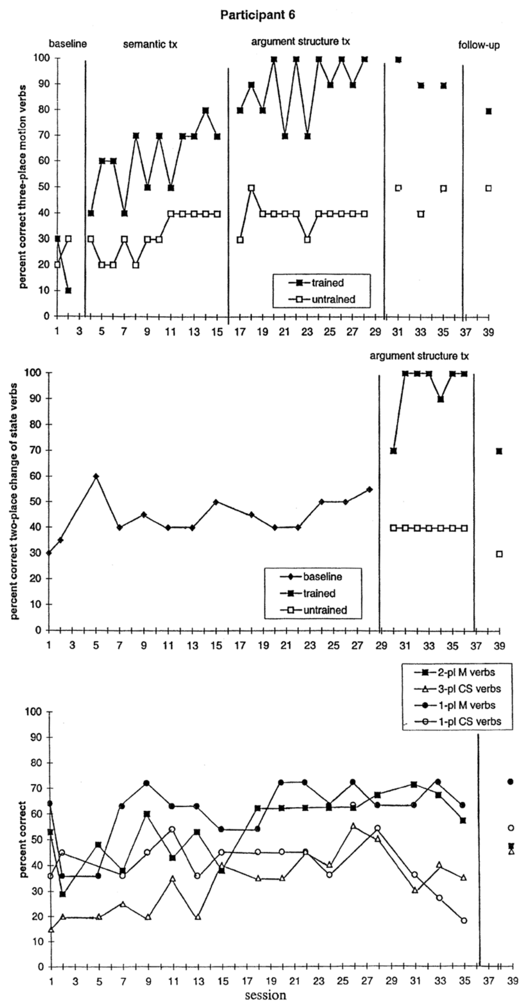


Figure 6.

Trained and untrained verb retrieval data, within and across verb category generalisation data, and follow-up data for Participant 6. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

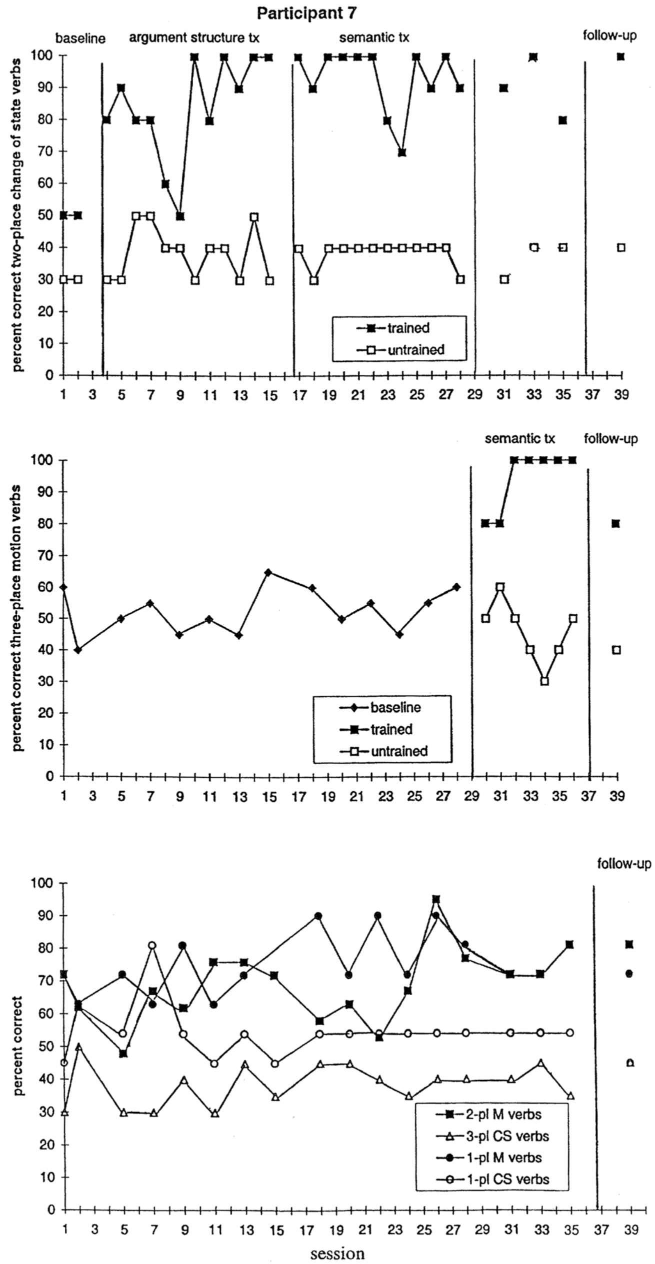


Figure 7.

Trained and untrained verb retrieval data, within and across verb category generalisation data, and follow-up data for Participant 7. 1-pl = one-place verbs; 2-pl = two-place verbs; 3-pl = three place verbs; CS = change of state verbs; M = motion verbs.

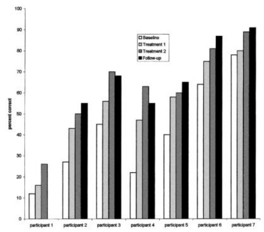


Figure 8.
Percent correct grammatical sentence production for each participant across all phases of the study.

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TABLE 1

Participants' pre-treatment language test data

Test	S1	S2	S3	S4	S5	S6	S7	Participant Mean*	Standard Deviation*
Western Aphasia Battery									
Aphasia Quotient	66.5	62.3	79.7	69.9	71.4	72.2	79.1	72.4	6.44
Fluency Score	5	4	5	4	5	5	5	5	.52
Auditory Comprehension	8.6	6.75	8.15	8.85	9.1	7.5	9.65	8.33	1.08
Repetition Score	5.2	6.4	8.8	7.0	5.6	8.4	8.2	7.4	1.27
Naming Score	6.5	7.0	7.9	7.1	8.0	7.2	8.7	7.65	.67
Philadelphia Comprehension Battery for Aphasia									
Lexical Comprehension	98	98	95	98	100	100	100	99	1.98
Sentence Comprehension	82	75	88	80	82	80	93	83	6.45
Reversible Sentences	70	63	77	77	53	63	87	70	12.44
Lexical Sentences	90	83	100	83	100	97	100	94	8.47
Actives/Subject Relatives	85	85	90	80	40	80	95	78	19.66
Passives/Object Relatives	75	80	85	75	60	30	95	71	23.11
Northwestern Verb Production Bettery Total Scores									
Comprehension	91	98	100	81	100	91	94	94	7.29
Confrontation Naming	40	83	47	40	87	73	57	65	19.41
Elicited Naming Sentence Production	30	60	85	83	85	49	100	77	18.79
Total Verb production	91	83	84	86	84	90	96	87	5.00
Agent argument production	93	87	89	57	94	90	96	86	14.35
Theme argument production	62	73	53	91	84	82	71	76	13.32
Goal argument production	36	7	50	43	50	86	13	42	28.74

* Indicates that participants' means and standard deviations are figured on Participants 2–7 only. Participant 1 did not complete the study, thus her scores were not included in the statistical analysis.

TABLE 2

Pre-treatment utterance and lexical data derived from narrative language samples

	Participants								
Utterance and lexical structures	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**Participants mean (SD)***	**Normal participants mean (SD)§**
MLU	6.80	3.39	6.89	3.86	4.94	4.51	6.98	5.10(1.52)	14.41 (2.20)
% of Grammatical Sentences	11	20	41	30	10	18	69	31(.21)	90(.08)
% of Simple Sentences	60	100	89	100	48	82	77	83(.19)	43(.08)
% of Complex Sentences	40	00	11	00	52	18	31	19(.20)	58(.17)
Noun: Verb Ratio	1.09	1.81	1.42	1.32	1.65	2.07	.90	1.53(.41)	1.21(.25)
Verb Usage by Types									
% Correct One-place Verbs (Obi)	100	67	100	100	83	00	100	76(.39)	100(.00)
% Correct Two-place Verbs (Ob2)	50	25	71	50	50	40	100	56(.26)	99(.03)
% Correct Three-place Verbs (Ob3)	00	–	–	–	–	–	–	–	100(.00)
% Correct Two-place Berbs (Op2)	68	43	71	82	47	44	100	65(.24)	97(.08)
% Correct Three-place Berbs (Op3)	100	00	100	33	50	67	–	50(.37)	98(.05)
% Correct Agent (X) arguments	70	56	81	62	81	59	100	73(.17)	99(.02)
% Correct Theme (Y) arguments	89	76	94	19	72	57	100	70(.29)	100(.01)
% Correct Goal (Z) arguments	50	100	–	–	00	50	–	50(.50)	95(.13)

*Indicates that subject's mean and standard deviation are calculated on Subjects 2–7 only for direct comparison with post-test data.

§Normal data taken from Thompson et al. (1995). MLU = mean length of utterance. Op = Optional. Ob = Obligatory.

TABLE 3

Treatment design showing the behaviours targeted and type of treatment received by each participant

Participant		Treatment 1 (type of treatment)	Treatment 2 (type of treatment)	Second Behaviour (type of treatment)
1				
	Behaviour 1	2-pl M (ST)	2-pl M (AST)	
	Behaviour 2			3-pl CS (AST)*
2		Treatment 1	Treatment 2	
	Behaviour 1	2-pl M (AST)	2-pl M (ST)	
	Behaviour 2			3-pl CS (ST)
3		Treatment 1	Treatment 2	
	Behaviour 1	3-pl CS (ST)	3-pl CS (AST)	
	Behaviour 2			2-pl M (AST)
4		Treatment 1	Treatment 2	
	Behaviour 1	3-pl CS (AST)	3-pl CS (ST)	
	Behaviour 2			2-pl M (ST)**
5		Treatment 1	Treatment 2	
	Behaviour 1	3-pl M (AST)	3-pl M (ST)	
	Behaviour 2			2-pl CS (ST)
6		Treatment 1	Treatment 2	
	Behaviour 1	3-pl M (ST)	3-pl M (AST)	
	Behaviour 2			2-pl CS (AST)
7		Treatment 1	Treatment 2	
	Behaviour 1	2-pl CS (AST)	2-pl CS (ST)	
	Behaviour 2			3-pl M (ST)

ST = Semantic Treatment; AST = Argument Structure Treatment; 2-pl = Two-place verbs; 3-pl = Three-place verbs; M = Motion verbs; CS = Change of State verbs.

* Planned but not trained due to participant's failure to complete the study.

** Planned but not trained due to generalisation to second behaviour during training of the first.

TABLE 4

Statistical analysis of pre- and post-treatment utterance and lexical data derived from the narrative language samples

	Mean (SD)			
Language variables	**Pre**	**Post**	**T score**	**Probability**
MLU	5.10(1.52)	4.94(1.06)	.370	.727
% Grammatical Sentences	31(.21)	42(.21)	−2.285	.071
% Simple Sentences	83(.19)	85(.16)	−.632	.555
% Complex Sentences	19(.20)	15(.16)	1.096	.323
Noun: Verb Ratio	1.53(.41)	1.37	− .020	.984
Verb Usage by Type				
% Correct Obligatory One-place Verbs	76(.39)	83(.17)	.353	.739
% Correct Obligatory Two-place Verbs	56(.26)	64(.50)	.137	.897
% Correct Obligatory Three-place Verbs	–	67(.58)	–	–
% Correct Optional Two-place Verbs	65(.24)	65(.29)	− .041	.969
% Correct Optional Three-place Verbs	50(.37)	66(.23)	− 1.212	.280
% Correct Agent (X) Arguments	73(.17)	77(.21)	− .762	.480
% Correct Theme (Y) Arguments	70(.29)	95(.06)	− 1.966	.106
% Correct Goal (Z) Arguments	50(.50)	100	1.732	.225

TABLE 5

Statistical analyses of pre- and post-treatment language test data

	Mean (SD)			
Language test subtest	**Pre**	**Post**	**T score**	**Probability**
Western Aphasia Battery				
Aphasia Quotient	72.4(6.44)	76.6(4.39)	− 2.762	.040*
Fluency Score	5(.52)	5(.41)	− 1.000	.363
Auditory Comprehension Score	8.33(1.08)	8.96(.49)	− 2.094	.090
Repetition Score	7.4(1.27)	7.8(1.07)	− 2.740	.041*
Naming Score	7.65(.67)	8.05(.67)	− 3.873	.012**
Northwestern Verb Production Battery				
Comprehension	95(7.29)	97(2.42)	− 1.172	.294
Confrontation Naming	65(19.41)	72(13.26)	− .850	.434
Verb Usage in Sentence Production	87(5.00)	95(4.76)	− 3.911	.011**
% Correct Obligatory One-place Verbs	89(17.04)	98(4.49)	− 1.746	.141
% Correct Obligatory Two-place Verbs	78(13.91)	98(4.49)	− 3.379	.020**
% Correct Optional Two-place Verbs	85(7.68)	80(15.19)	.862	.428
% Correct Obligatory Three-place Verbs	14(23.91)	53(23.15)	− 3.766	.013**
% Correct Optional Three-place Verbs	50(24.60)	61(31.06)	− .732	.497

*Significant at $p < .05$ level.

**Significant at $p < .02$ level.