Treatment of sentence production deficits in aphasia has been approached from different perspectives, depending on the etiology of the production deficit. For example, one approach has been to improve the mapping of surface structures to the underlying meaning (e.g., Schwartz, Saffran, Fink, Myers & Martin, 1994). Other interventions have directly targeted lexical-semantic processing (Marshall, Pring & Chiat, 1998), verb retrieval (e.g., Mitchum, Haendiges & Berndt), and comprehension of non-canonical sentence structures such as passive forms, wh-questions, or center-embedded clauses (Thompson, Shapiro & Roberts, 1993).

Another approach assumes that sentence production deficits in aphasia are due to impaired access to syntax not syntactic loss (Gleason, Goodglass, Green, Ackerman & Hyde, 1975; Helm-Estabrooks, Fitzpatrick, & Barrisi, 1982; Fink, Schwartz, & Myers, 1998). This assumption has been echoed in studies of normal sentence processing that indicate increased access to a particular structure following priming of that structure (Bock, 1986). Saffran and Martin (1997) used a paradigm developed by Bock to prime use of three syntactic structures. The paradigm used sentence repetition as the prime, followed by picture description to elicit the targeted structure. Results indicated an increased use of passives immediately following the primes and some increase in use of dative structures following therapy.

The present study applies the syntactic priming approach to treatment using a simple active subject-verb-object (SVO) sentence form for an individual with Broca's aphasia and severe agrammatism and sentence production deficits. We investigated whether priming of simple SVO sentences will result in improved production of syntactic structures, specifically for: verb inflections, inclusion of SVO elements, correct word order, and use of well-formed sentences.

METHODS

Participant

The participant, DD, was a 59 year-old right handed male who was 5 years post-onset of an infarct in the distribution of the left middle cerebral artery, affecting the inferiolateral frontal perisylvian gyri. Results of neuropsychological and language tests are shown in Table 1.As illustrated DD's profile was consistent with a moderate-severe Broca's aphasia with severe agrammatism.

Experimental Stimuli

Experimental stimuli were chosen from 180 pictures from the *Everyday Life Activities Photo Series* (Stark, 1992) depicting an agent-action-theme relationship (e.g., <girl> <kicking> <ball>). From these 180 pictures, we selected 40 to form two sets of 20 items each, one set for Treatment 1, the second set for Treatment Replication. For each set, 10 sentences were designated for Treatment and 10 for response generalization All sentences were matched for syntactic structure (reversible or irreversible). Verbs in each sentence were also matched for transitivity, argument structure and existence of a corresponding noun root.

Experimental Design

A single subject multiple baseline design was used to examine the effects of the priming treatment on successful production of SVO sentence structures. Treatment was applied first to Treatment 1 sentences, followed by Treatment Replication with the second set of sentences. Dependent measures were DD's production of the following: verb inflections, inclusion of SVO elements, correct word order, and use of well-formed sentences. Treatment and generalization items were continuously measured during the baseline sessions. Probes, identical to those conducted during baseline, were also administered continuously during treatment, prior to each treatment session. Treatment was conducted two times per week for 10 sessions. A follow-up probe was administered 5 months after the termination of treatment.

Treatment

The treatment paradigm was similar to that used by Bock (1986) and Saffran and Martin (1997) in their syntactic priming studies. DD was given 3 priming trials followed by a picture description trial. All priming trials involved transitive or intransitive sentences with verbs inflected for present progressive. (is ______ing) For each priming trial, a picture targeting an SVO sentence structure was presented with a spoken and written model (e.g., "The __________ is/are ________ing a/the __________."). In this canonical sentence structure, the subject assumed the thematic role of agent, whereas the object consistently assumed the role of theme/patient. When DD was unable to produce the target, repetition was used to facilitate correct production of the target sentence.

Scoring and analysis of data.

All baseline and probe sentences were recorded, transcribed and scored based on the criteria from the QPA (Berndt et al, 2000) for the four dependent measures. All responses were scored by two independent judges. Inter-rater reliability was ≥92%. Treatment effect sizes were calculated for changes between baseline and treatment, maintenance, and follow-up measures.

RESULTS

Results indicated that the treatment improved DD's syntax and sentence production abilities for SVO sentences. Treatment effect sizes (ES) were calculated to assess the changes between baseline and treatment, maintenance and follow-up. (cf. Robey, Schultz, Crawford, & Sinner, 1999) Table 2 shows treatment effect sizes for Treatment 1 and Treatment Replication. Overall, after Treatment Replication the four dependent measures showed treatment effect sizes (ES) that were in the moderate to high ranges. Figures 1-4 display the percentage correct for each dependent measure during baseline, treatment, maintenance, and follow-up.

Treatment 1

Improvement from baseline to the end of Treatment 1 was indicated by the following effect sizes: verb inflection ES = 1.2; inclusion of SVO structures, ES = 2.6, correct order, ES = 1.0. These effect sizes indicated slight to moderate increases. Effect size could not be calculated for use of well-formed sentences, but percentage correct improved from 0% to an average 22% during treatment. These treatment effects were also observed during maintenance and follow-up:

verb inflection, ES = 4.6; inclusion of SVO, ES = 3.0, correct order, ES = 0.6 (percentage improvement for use of well-formed sentences was 20%).

<u>Treatment Replication</u>

Syntax and sentence production during Treatment Replication showed stronger treatment effects than Treatment 1, as evidenced by the following ES from baseline to the end of Treatment Replication: verb inflection, ES = 4.3; inclusion of SVO, ES = 4.7, correct order, ES = 2.9; well-formed, ES = 4.7. These effect sizes were all moderate to high. Follow-up data, 5 months after the conclusion of treatment, were: verb inflection ES = 4.7; inclusion of SVO, ES = 4.3, correct order, ES = 4.8; use of well-formed sentences, ES = 9.

<u>Generalization</u>

As shown in the graphs, Figures1-4, similar patterns of performance were seen for generalization during Treatment 1 and Treatment Replication.

DISCUSSION

Our participant, DD, demonstrated positive treatment effects following syntactic priming treatment, particularly during Treatment Replication. Improvement was noted for all four dependent measures.

These results support the use of syntactic priming as an effective treatment to improve syntax in an individual with severe agrammatism. Our findings are similar to those of Fink et al (1998) whose participant was also severely agrammatic and responded well to this type of priming treatment. Fink et al (1998) attributed the deficit in producing a grammatical sentence to two co-occurring impairments: reduced working memory and slowed access to the syntactic frame. They hypothesized that the priming treatment reduced the mental resources needed to retrieve the syntactic frame. This account is plausible for our participant whose word span is limited to about two items.

In future studies, we plan to utilize this priming approach with functional sentences reflecting DD's interests and daily activities to promote more generalized responding, Since we observed more robust improvement during the maintenance phase of Treatment 1 and also during Treatment Replication, suggesting that duration had an impact on improvement, we also plan to extend treatment beyond 10 sessions.

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Table 1.
Pretreatment test results for participant DD.

Test	Results
Western Aphasia Battery (Results reported as Aphasia Quotients)	Aphasia Quotient = 57.4 Spontaneous speech = 11 Comprehension = 7.5 Repetition = 4.8 Naming = 5.4
Object and Action Naming Test	Object = 48/81 =59% Action = 29/50=58%
Discourse Comprehension Test	Overall Main Idea & Details = 28/40 = 70%
Grammaticality Judgment Test (PCB)	45/60 items = 78%
Sentence Comprehension Test (PCB)	90/120 items = 75%
Quantitative Production Analysis (QPA)	# Sentence Utterances = 16/58 = .28 Well-Formed Sentences = 11/58 =.19 % Open Class Words = .78 % Closed Class Words = .22

<u>Table 2</u>
Percent Correct on Dependent Measures and Treatment Effect Sizes

Treatment 1

Measure (out of 10)	Baseline	Post-Treatment 1	Effect Size	Maintenance	Effect Size (from baseline)	Follow-UP	Effect Size (from baseline)
Well-Formed	0.0	22.0	NA*	34.0	NA*	20.0	NA*
Subject-Verb-Object	40.0	66.0	2.6	63.8	2.4	70.0	3.0
Inflected Verb	13.3	20.0	1.2	44.3	5.4	40.0	4.6
Correct Order	26.7	48.0	1.0	61.3	1.7	40.0	0.6

Treatment Replication

Measure (out of 10)	Baseline	Post-Treatment 2	Effect Size	No Maintenance		Follow-up	Effect Size (from baseline)
Well-Formed	2.0	22.0	4.7			40.0	9.0
Subject-Verb-Object	34.0	73.3	4.7			70.0	4.3
Inflected Verb	20.0	65.0	4.3			70.0	4.7
Correct Order	44.0	72.0	2.9			90.0	4.8

*Effect size could not be calculated because there was no variation in the baseline.

Interpretation of effect size
0-2 = small effect
2-4 = moderate effect
4 and above = large effect

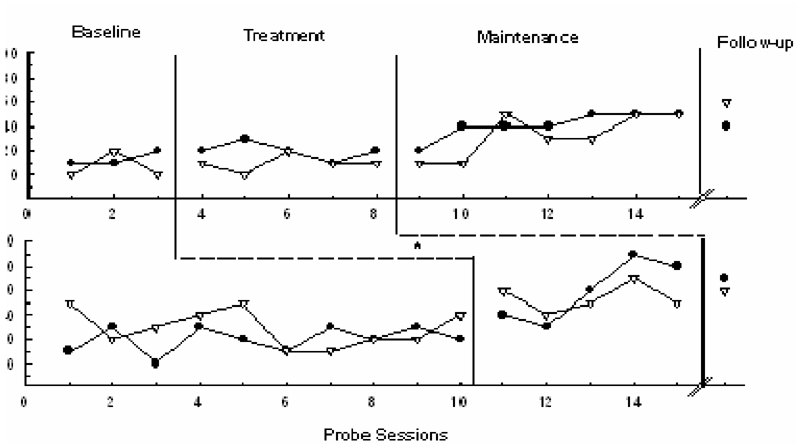
Figures 1-4. Percent correct on each dependent measure during baseline, treatment, maintenance, and follow-up

* = Extended probing

● Set 1: Treatment

Set 2: Treatment Replication

▽ Generalization



1. Production of verb inflections in probes during Treatment and Treatment Replication.

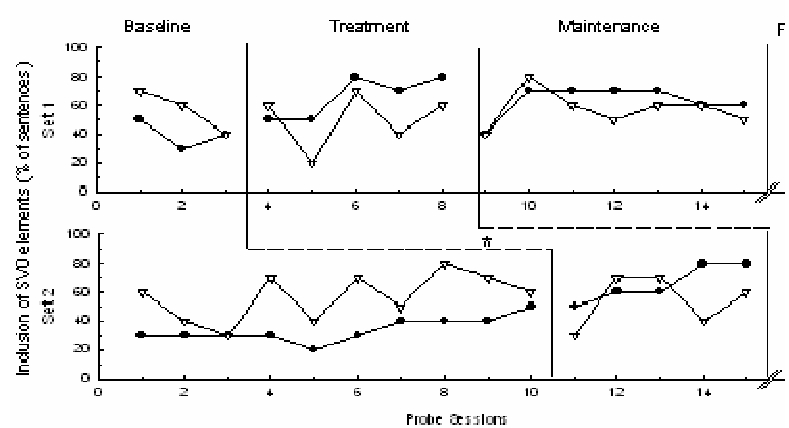
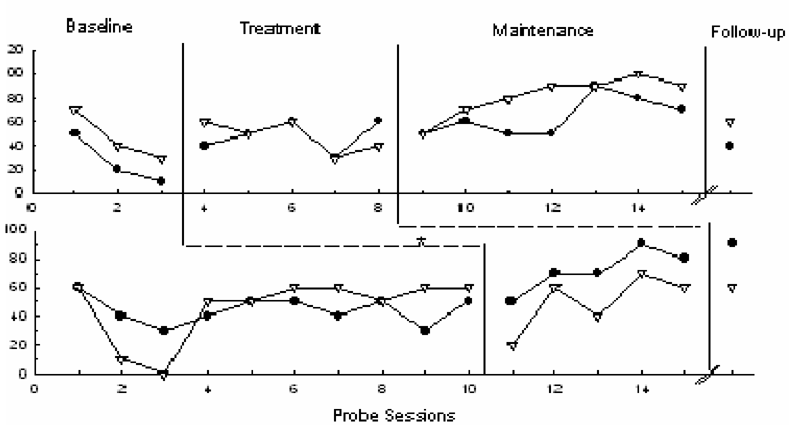


Figure 2. Inclusion of SVO elelments in probes during Treatment and Treatment Replication.



3. Production of correct word order in probes during Treatment and Treatment Replication.

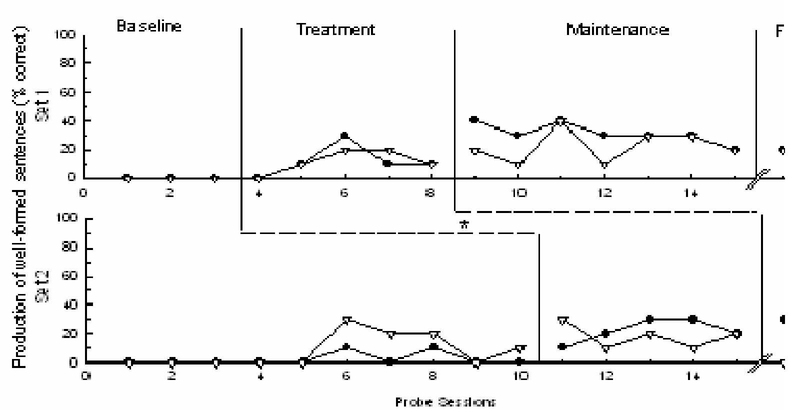


Figure 4. Production of well-formed sentences in probes during Treatment and Treatment Replicat