A Modular Treatment for Sentence Processing Impairments in Aphasia: Sentence Production

Un traitement par modules pour les difficultés d'intégration des phrases dans un cas d'aphasie : la production des phrases

Elizabeth Rochon and Sonia Reichman

Abstract

This study investigated a treatment for sentence production impairment in an individual with aphasia. Treatment was administered in two modules: the first involved training single verb naming, the second involved training sentence production. The sentence production treatment incorporated the principles of grammatical frame therapy (Mitchum & Berndt, 1994) and mapping therapy (Schwartz, Saffran, Fink, Myers, & Martin, 1994). Despite improved performance on verb naming after treatment for single verb naming, there were no improvements on measures of sentence production or comprehension. Treatment of passive sentences in the second module led to improvements in production of passive and active sentences after therapy. In addition, passive sentence production improved on two other generalization tasks, however, performance on active sentences deteriorated after treatment. Gains also were noted on a narrative retelling task. There were no changes in sentence comprehension after training sentence production. Implications for interventions aimed at sentence processing impairments are discussed.

Abrégé

Cette étude faisait l'analyse d'une méthode de traitement de difficultés de production de phrases chez un individu atteint d'aphasie. Ce traitement est administré en deux modules: dans le premier, il s'agit d'un entraînement à nommer des verbes et dans le second, à produire des phrases. Ce traitement de la production des phrases est basé sur les principes de la « thérapie du cadre grammatical » de Mitchum & Berndt (1994) et de la thérapie de la représentation une à une proposée par Schwartz, Saffran, Fink, Myers, & Martin (1994). Malgré l'amélioration post-traitement de la performance à nommer des verbes après le premier module du traitement, aucune amélioration n'a été notée en production et en compréhension de phrases. Le traitement des phrases passives, lors du second module, a permis l'amélioration de la production de phrases actives et passives. De plus, la production de phrases passives s'est améliorée dans le cadre de deux tâches de généralisation. Cependant, la performance concernant la production de phrases actives s'est détériorée après le traitement. Des gains ont aussi été notés au niveau de la narration lors de tâches où il s'agissait de raconter à nouveau une histoire. Il n'y avait aucun changement au niveau de la compréhension des phrases après le traitement visant la production des phrases. À la fin de l'article, l'auteur discute des implications au niveau des interventions visant à traiter les difficultés d'intégration des phrases.

Key words: sentence production, aphasia, treatment, grammatical frames, mapping therapy

Elizabeth Rochon
University of Toronto
Toronto, Ontario
Sonia Reichman
Baycrest Centre for Geriatric Care and University of Toronto
Toronto, Ontario

Sentence processing impairments in patients with aphasia have been targeted with a number of cognitive treatment approaches. Some have focussed on training sentence comprehension (e.g., Berndt & Mitchum, 1997; Byng, Nickels, & Black, 1994; Jones, 1986; LeDorze, Jacob, & Coderre, 1991; Schwartz et al., 1994), others have focussed on training

sentence production (e.g., Mitchum, Greenwald, & Berndt, 1997; Mitchum, Haendiges, & Berndt, 1993; Rochon, Laird, Bose, & Scofield, under review; Weinrich, Bosser, McCall, & Bishop, 2001). We present a treatment study designed for an individual with a mixed (fluent/nonfluent) aphasia. In designing the programme, we adopted a 'modular treatment' approach (Schwartz, Fink & Saffran, 1995), in which separate interventions targeted the verb production, the sentence production and the sentence comprehension components of his sentence processing difficulties. The production modules are presented in this article, and the comprehension module is presented separately (Rochon & Reichman, in press).

Garrett's model (1980, 1988) of sentence production has been used to account for difficulties in sentence processing in patients with aphasia. In the model, there are two important levels of representation that must be computed in order for sentence production to occur. The first is the 'Functional level,' where semantic aspects of words are represented. It is here that thematic roles, which determine 'who does what to whom' in a sentence, are assigned. The second is the 'Positional level' where syntactic and phonological aspects of a sentence are assigned. It is suggested that many of the difficulties experienced by patients with agrammatic aphasia in particular can be attributed to a difficulty mapping relations between the abstract functional level and the surface syntax at the positional level (Schwartz, Linebarger, Saffran & Pate, 1987; Schwartz et al., 1994).

Linguists and psycholinguists also have elaborated theories in which semantic and syntactic aspects of verb representation are closely linked (e.g., Pinker, 1989), according a central role to the verb in sentence processing abilities. Investigations with aphasic individuals have found that the same individuals often have both verb production and sentence processing impairments (Saffran, Schwartz, & Marin, 1980). Indeed, several production treatment studies have focused on the relationship between the verb and sentence production. For the most part, it has been found that verb retrieval therapy alone has little or no effect on sentence production abilities (Mitchum & Berndt, 1994; Mitchum et al., 1993; but see Marshall, Pring, & Chiat, 1998). However, Mitchum and colleagues (Mitchum & Berndt, 1994; Mitchum et al., 1993) have shown an increased range of production of active sentences in two individuals after treatment with 'grammatical frame,' therapy. Grammatical frame therapy is designed to highlight the link between the Functional and Positional levels in Garrett's (1980; 1988) model.

Grammatical frame therapy focuses on training morphological elements associated with verb tense and aspect in sentence production. The goal of the therapy is to assist the participant to construct a 'planning frame' for the production of a given sentence. To achieve this, the therapy targets sentences in which the verb morphology contrasts future, present, and past tense action, by matching sentences to sequential pictures (e.g., the horse /will jump/is jumping/has jumped/the fence; see Mitchum & Berndt, 2001; and Mitchum, Greenwald, & Berndt, 2000, for description of the therapy approach and review of the literature). Two individuals learned to use the grammatical frames trained in therapy to improve their sentence production (Mitchum et al., 1993; Mitchum & Berndt, 1994). However, there was no generalization of treatment effects to untrained, complex structures, such as passives sentences.

In another study, Mitchum et al. (2000) successfully trained passive sentence production in a patient by training the patient to change the voice of a presented sentence into the alternative voice (i.e., passives into actives or vice versa). The treatment task required the participant to manipulate word anagrams to construct sentences. The goal of therapy was to demonstrate to the participant that while active and passive sentences require different grammatical frames, the underlying meaning can be the same. Active sentences were initially used as models and the participant had to rearrange the word anagrams to produce a passive sentence. The treatment task became progressively more difficult such that random production of active and passive anagram sentences was required. In the final step of the therapy, the participant was able to produce spoken sentences. Mitchum et al. (2000) attributed their participant's improvement in sentence production to successful linking, or mapping from the Functional to the Positional level. Weinrich et al. (2001) have shown similar results using an iconic computer-based communication system (C-VIC), in one individual.

The above studies have all targeted the production impairment in treating sentence production. Other studies have focussed on treating sentence comprehension impairments (e.g., Byng, 1988; Jones, 1986; LeDorze et al., 1991; Schwartz et al., 1994), and many have predicted gains in sentence production as well. These have been called 'mapping' therapies. The goal in all these studies has been to improve the mapping between the Positional and the Functional levels, especially in noncanonical sentences such as passive sentences. In noncanonical sentences, thematic role assignment is such that the second noun in the sentence is the 'doer' (i.e., the agent) of the action, whereas the first noun is the 'receiver' (i.e., the theme) of the action, as in a sentence such as *The boy is hugged by the girl* (see Caplan & Hildebrandt, 1988). In contrast, active sentences like *The girl is hugging the boy*, have canonical thematic role assignment, such that the first noun is the agent and the second noun is the theme. Many studies have shown that reversible sentences are more difficult to understand than nonreversible sentences for individuals with aphasia, and this is so especially when sentences have noncanonical thematic role assignment (e.g., Berndt, Mitchum & Haendiges, 1996; Caplan & Hildebrandt, 1988; Caramazza & Zurif, 1976; Saffran & Schwartz, 1988). Sentences are reversible when both actors in the sentence can be the doer or the receiver of the action (e.g., *The boy is calling the girl* is a reversible sentence, whereas *The boy is washing the car* is not.)

While mapping treatments have varied, one study (Schwartz et al., 1994) used a 'Sentence Query Approach.' Via a series of queries, participants were trained to identify the verb and the lexical items in a sentence corresponding to the agent and the theme. Most studies have found improvement in participants' sentence comprehension abilities on the sentence types trained, with little

generalization to untrained sentence types. In addition, a number of studies have provided evidence of gains in production on a narrative retelling task (e.g., Byng, 1988; Byng et al., 1994; Schwartz et al., 1994). While encouraging on the one hand, these gains in production have been difficult to evaluate with respect to the comprehension treatment the participants received: most comprehension therapies included a production component to the therapy, and unconstrained narrative tasks do not require that a particular sentence type be used.

We describe a treatment program for an individual with a verb retrieval and sentence production impairment. As in Mitchum and Berndt (1994), treatment to address these impairments was conducted in two phases: verb retrieval was trained in Phase A and production of passive sentences in Phase B. Following upon the work of Mitchum and colleagues, we did not expect that improved verb retrieval would generalize to untrained verbs in Phase A, or that improved verb retrieval would lead to improved sentence production after Phase A treatment. We predicted that our participant's sentence production abilities would be improved after treatment targeting sentence production in Phase B. We predicted generalization of treatment gains to constrained sentence production tasks, as well as to an unconstrained narrative production task after Phase B but not after Phase A. In addition, we tracked performance on a sentence comprehension task, and a control task.

Method

Participant

D.L. was a 67-year-old right-handed man who suffered two consecutive left hemisphere strokes, two months apart, six years prior to this study. CT scan results indicated lesions in the left middle cerebral artery and left posterior cerebral artery territories. The strokes resulted in aphasia and loss of right peripheral vision in both eyes. After a brief period of acute care hospitalization D.L. received speech-language treatment in an outpatient rehabilitation centre for a period of one year. Thereafter, he has attended a local aphasia centre, to pursue social and participation goals in a supported environment. He also received speech-language therapy once a week for eight months one year before the commencement of this study. D.L. was a native speaker of English and had a university education.

D.L. was administered the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1983) and a number of other tests. Based upon the results of all these tests, D.L. had mixed (fluent/nonfluent) aphasia characterized by a severe verb retrieval impairment and agrammatism. D.L. demonstrated highly accurate noun naming as seen in his score of 37/40 on a naming subtest of the Psycholinguistic Assessments of Language Processing test (PALPA; Kay, Lesser, & Coltheart, 1992). In contrast, he evidenced poor performance naming picturable actions: he achieved a score of 12/40 on a verb test constructed by the authors using the Everyday Life Activities stimuli (ELA; Stark, 1992) and 13/76 on another test constructed by the authors to test verbs with differing properties (Breedin, 1991). He scored 70/80 on a word repetition task and 48/80 on a nonword repetition task (PALPA; Kay et al., 1992). Relative strengths on assessment included written word comprehension (10/10 on BDAE), oral word reading abilities (23/30 on BDAE), and written confrontation naming (10/10 on BDAE). D.L.'s articulatory and fluency abilities were rated six and seven respectively, on a scale of seven (BDAE). We developed a treatment to address D.L.'s wish to work on 'grammar and talking.' This research was carried out in the course of routine clinical treatment. A single-participant research design was not employed; however, procedures were used to demonstrate experimental control, such as the use of multiple pre and posttreatment measures, including tests to assess generalization, and the use of a control task.

Materials and Procedures

Phase A: Verb retrieval treatment

Two sets of transitive verbs were matched in frequency (Francis & Kucera, 1982), one of which was to be the treated the other the untreated set. The mean frequency of the treated set ($n = 11$) was 108.9 and of the untreated set ($n = 13$) was 90.1.

Given D.L.'s preserved writing abilities, the written modality was selected to facilitate oral verb naming. Pictures were used to elicit the target responses. Up to three pictorial depictions of each verb were used to represent the actions used as treatment stimuli (e.g., for the verb *water*, there was picture of a boy watering a flower; a woman watering flowers in a window box; and a boy watering a vegetable garden). This was done in order to ensure that D.L. was not learning a single verbal response to a single picture. All verbs were treated in each treatment session.

In treatment, D.L. was instructed to write the verb depicting the action in the drawing he was shown. Then he was asked to say the verb. If he was unable to produce the verb in writing, he was cued (in writing) with the first letter. The written cue was always successful in aiding D.L. to produce a written verb correctly. Treatment sessions were conducted twice a week, for approximately one hour. Criterion for successful termination of treatment was 100 percent correct verb naming in a session.

Phase A: Generalization measures

In addition to tracking performance of single word verb production for treated and untreated verbs, measurement of generalization of treatment effects included an assessment pre- and posttreatment on a sentence production task, a narrative production task, a sentence comprehension task, and a nonword repetition task (used as a control task).

Production generalization tasks. We constructed a sentence production task using the treated and untreated verbs from our treatment protocol. Eight of the treated verbs and 12 of the untreated verbs were included in both active and passive forms, balanced for present, past and future tense.[1] The task was designed after Caplan and Hanna's (1998) procedure. In this task, pictures were annotated with arrows designating all items in the picture that were to be mentioned in the sentence.

The examiner provided the root form of the verb to be used in the sentence in spoken form. Stimuli were randomized and presented in a different random order before and after Phase A.

To assess connected spoken language, we analyzed a narration task pre- and posttreatment using the Quantitative Production Analysis (QPA; Rochon, Saffran, Berndt, & Schwartz, 2000; Saffran, Berndt, & Schwartz, 1989). To elicit a language sample, D.L. was asked to retell a story elicited by watching a brief video segment (Rochon et al., 1994). The narrative sample was analyzed for a number of lexical, syntactic and morphological elements, using the QPA (Berndt, Wayland, Rochon, Saffran, & Schwartz, 2000).

Comprehension generalization task. Sentence comprehension abilities were assessed using the sentence-picture matching subtest from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay et al., 1992), which includes a variety of sentence structures, including active and passive sentences. There was no overlap between the verbs in this test and the ones trained in treatment.

Control generalization task. We also included a nonword repetition task as a control task, to rule out an explanation of improvements in treatment that might be attributed simply to general language stimulation or to the passage of time.

Table 1
Phase B: Sentence Production Treatment Protocol

A. Sentence training (in response to given action picture) Example: A photograph of a nurse chasing a tall teacher is presented	
Instruction 1: What is the action?	Response or (teaching response)*
Instruction 1: Read what you wrote	Response or (correction)
Instruction 2: What is the passive of the action/verb?	Response or (teaching response)
Instruction 2: Read what you wrote	Response or (correction)
Instruction 3: The action takes place yesterday/today/tomorrow	Response or (teaching response)
Instruction 3: Read what you wrote	Response or (correction)
Instruction 4: What was *verb*ed?	Response or (teaching response)
Instruction 4: Read what you wrote	Response or (correction)
Instruction 5: By whom?	Response or (teaching response)
Instruction 5: Read the whole sentence	
B. Self evaluation	
Instruction 6: Let's listen. How was that sentence?	
If correct go on to C. If wrong, cue/teach to correct response.	
C. Sentence production (in response to given action picture, same as in A	
Instruction 7: What was done in this picture yesterday/today/tomorrow?	

*All responses were a) verbal followed by b) written response, followed by c) reading out loud the response written thus far, until the entire sentence had been formed.

Phase B: Sentence production treatment

Phase B began one month after the termination of Phase A. We employed an explicit teaching method adapted from grammatical frame therapy (Mitchum & Berndt, 1994) and mapping therapy (Schwartz et al., 1994). Our treatment was designed to highlight the importance of verb tense and aspect in constructing a grammatical frame for sentence production. In addition, we attempted to aid D.L. in mapping between the surface syntactic form and the underlying meaning of the sentence by incorporating a sentence query (Schwartz et al.).

The stimuli for the treatment were line drawings chosen from a variety of commercially available treatment sets. Two versions of 15 passive sentences were constructed using five each of the trained and untrained verbs from Phase A, as well five novel verbs to which D.L. had not been previously exposed. Each sentence was depicted in three tenses (past, present, future), yielding a stimulus set of 90 sentences. Both irreversible and reversible sentences were trained. D.L. was presented with an action picture and a blank page with three lines (for subject, verb, object) on it. He was asked to respond to the therapist's prompts. Correct passive sentence production in response to the treatment procedure was considered a successful response.

At the beginning of the treatment D.L. was provided with an explanation of passive sentence structure (aux -Verb-ed and the by-phrase) beginning with a sentence containing an irreversible verb (e.g., *peel*), then for one containing a reversible verb (e.g., *kiss*). In addition, he was introduced to the concepts of the 'doer' and the 'receiver' of the action (i.e., the thematic roles) in a sentence.

The treatment procedure contained three treatment sections (A: sentence training in response to given action picture, B: self evaluation, and C: sentence production in response to the same action picture presented in A). The treatment protocol is outlined in Table 1.

In section A, the presentation of the action picture (e.g., a picture representing a nurse chasing a teacher) was followed by the question (prompt 1.) 'What is the action?' D.L. was asked to respond verbally (chase), to follow his verbal response by writing the verb down on the middle line of his written response page and then to read the written verb out loud. Correction was provided if D.L.'s response was not correct (e.g. 'the action in this picture is..., it is spelled...', etc.). D.L. was required to provide the verbal, written and read response in all the treatment steps in section A and verbal and written correction was provided if needed. In step 2 of section A ('What is the passive of the action?') D.L. was required to say the passive form of the verb (*chased*) and add the *–ed* suffix to the verb written on the page and then read out loud what he had written thus far (*chased*). Thereafter, (step 3.) D.L. was

provided the tense prompt for the verb, 'The action takes place yesterday/today/tomorrow.') and was required to fill in the auxiliary in the correct tense, for example *is, was* or *will be* (is/was/will be chased). In step 4. D.L. was asked: 'What was *VERBed?*' (response: teacher was chased) and 'By whom?' (step 5; response: by the nurse) and finally D.L. was asked to read the entire sentence (*The teacher was chased by the nurse*). D.L. was always able to successfully read the sentence.

In section B, D.L. was asked to listen to the tape-recording of his sentence production (of the sentence he had just read) and evaluate whether the sentence he heard and wrote was correct. If needed, D.L. was cued to correct his response; if correct, he proceeded onto section C in which he was asked 'What was done in this picture yesterday (or today/tomorrow)?' D.L. then responded verbally providing a complete passive sentence (*The teacher was chased by the nurse.*).

New treatment stimuli were presented in random order across treatment sessions. Initially D.L. completed three sentences per session and in the latter stages of treatment he completed six to nine sentences in a treatment session. Treatment sessions were approximately one hour long. All treatment sessions were tape-recorded for use in D.L.'s self-evaluation. Criterion for successful termination of treatment was 100 percent correct sentence production of all sentences in a treatment session. D.L. requested homework assignments. To accommodate his wish, homework was provided only for those items that he had mastered in a treatment session.

Phase B: Generalization measures

To assess generalization of treatment effects the same sentence production test that was administered in Phase A was administered before and after Phase B. As well, we employed two constrained sentence production tasks: the Caplan and Hanna Test (1998) and the Active-Passive Elicitation Procedure (APEP; Mitchum et al., 1993). Briefly, the Caplan and Hanna Test is a 20-item test in which five exemplars of each of four sentence structures are elicited. The target sentences are: active, passive, dative, and dative-passive sentences. Stimuli are line drawings of actions and events. Pictures are annotated with arrows designating all items in the picture that are to be mentioned in a sentence. With the presentation of each picture, the experimenter also provides the root form of the verb to be used in the sentence. Details of administration and scoring can be found in Caplan and Hanna (1998). The APEP test also is a picture description task, containing 16 active and 16 passive sentences. Sentences are elicited by having the examiner provide the first two words of the sentence. To assess connected language, a video narration task was administered, as in Phase A (the video segment was a different story with each presentation). The same comprehension and control generalization tasks as were administered after Phase A were also administered after Phase B.

Table 2
Correct Sentence Production on Active and Passive Sentences Pre- and Post-Phase A

	Pre-Phase A		Post-Phase A	
Verbs	Active	Passive	Active	Passive
Treated in Phase A	3/7 (43%)	1/7 (14%)	3/8 (38%)	2/8 (25%)
Untreated in Phase A	9/11 (82%)	5/11 (45%)	5/12 (42%)	6/12 (50%)
Mean	12/18 (67%)	6/18 (33%)	8/20 (40%)	8/20 (40%)

Note. See footnote for explanation of different denominators used.

Scoring

All responses in both single-word and sentence production tasks were recorded on audiotape and/or videotape for transcription and scoring. Single word and sentence responses were scored as correct or incorrect based upon D.L.'s first attempt.

Results

Phase A. Verb retrieval treatment

Treatment effects

D.L. reached criterion on the seventh treatment session. His performance was maintained at 100% when he was retested two weeks after the completion of treatment. Figure 1 shows D.L.'s performance on both treated and untreated verbs before and after treatment. As can be seen in the figure, naming performance for treated verbs improved from 50% before treatment to 100% posttreatment. Performance for untreated verbs deteriorated from 83% pretreatment to 50% posttreatment. It is difficult to know why performance on the untreated verbs deteriorated to such an extent. This may have been due to lack of practice, relative to the treated verbs. Alternatively, there might have been variability noted in D.L.'s performance if production for this verb set had been sampled at another time.

Generalization

As expected, there was no generalization to our posttreatment sentence production task, as can be seen in Table 2. Nor was there any change on the narrative production task or the sentence comprehension test after this first phase of treatment. These results are presented in Tables 6 and 7, respectively, and discussed with Phase B results, below.

Phase B. Sentence production treatment

Treatment effects

All passive sentences were trained to 100% criterion, which D.L. reached by session 14. Table 3 shows D.L.'s performance on the posttreatment sentence production test. As can be seen in the table, there was very little improvement overall posttreatment.

Figure 1.
D.L.'s Performance on Treated and Untreated Verbs Pre- and Post-Phase A Training.

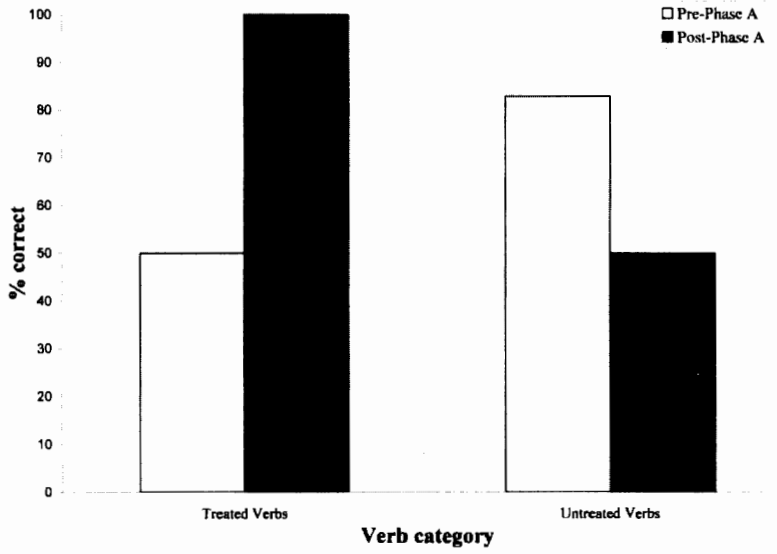

Table 3
Correct Sentence Production on Active and Passive Sentences Pre- and Post-Phase B

	Pre-Phase B		Post-Phase B	
Verbs	Active	Passive	Active	Passive
Treated in Phase A	3/8 (38%)	2/8 (25%)	7/8 (88%)	6/8 (75%)
Untreated in Phase A	5/12 (42%)	6/12 (50%)	10/12 (83%)	8/12 (67%)
Mean	8/20 (40%)	8/20 (40%)	17/20 (85%)	14/20 (70%)

Note. The same results are reported for Post-Phase A in Table 2 and Pre-Phase B in this table.

Table 4
Percent Correct Pre- and Post-Phase B on Two Sentence Production Tests

Test	Sentence Type	Pre-Phase B	Post-Phase B
Caplan and Hanna Test[1]	Active	92	76
	Passive	66.6	100*
	Dative	92.5	82.5
	Dative Passive	73.3	84.2
APEP[2]	Active	87.5	56.3*
	Passive	62.5	93.8*

*x^2, $p < .05$
1. Caplan and Hanna Test (Caplan & Hanna, 1998)
2. Active-Passive Elicitation Procedure (Mitchum et al., 1993)

Generalization

Production tasks. We included a number of other measures to assess generalization of treatment effects. Table 4 shows D.L.'s performance before and after treatment on the Caplan and Hanna (1998) test and Mitchum et al's (1993) APEP. The pattern of performance appears to be the same on both tests: D.L.'s improvement was structure-specific such that he showed significant improvement on both tests after treatment in his production of passive sentences. Production of active sentences after treatment declined (there was a significant difference on the APEP test for active sentences after treatment, however, it was in the opposite direction). Although it is difficult to know why there was greater deterioration seen for active sentences on the APEP than on the Caplan and Hanna Test, one possibility may relate to the different methods of elicitation used in these two tests. The verb is provided by the examiner in the Caplan and Hanna Test, whereas the first two words of the sentence (determiner plus noun) are provided in the APEP test. It is possible that for untrained active sentences the presentation of the verb was more beneficial than was presentation of the first two words. Production of untreated dative sentences (on the Caplan and Hanna Test), declined slightly after treatment, whereas production of untreated dative passive sentences showed a trend toward improvement after treatment (neither finding was significant).

Results of generalization on a narrative production task are shown in Table 5. As can be seen in the table, all measures either remained the same or declined after Phase A training on verb production alone. However, after Phase B training, the number of sentences, the overall proportion and the well formedness of D.L.'s sentences improved. While the median length of utterance (MedLu) and the overall number of verbs used remained relatively unchanged, the proportion of lexical to nonlexical verbs used increased substantially.

Comprehension task. D.L.'s sentence comprehension abilities remained relatively unchanged before and after both phases of production treatment. Table 6 shows the data on the PALPA sentence comprehension test. His performance on nonreversible passive, as well as reversible passive sentences, the type of sentences upon which he was trained in sentence production, remained essentially unchanged. His comprehension of reversible active and gapped sentences improved slightly.

Control task. Performance on our nonword repetition control task remained unchanged before and after both phases of treatment. D.L.'s performance on nonword repetition was at 53% before Phase A treatment, 40% after Phase A, and 50% after Phase B treatment.

Discussion

In this study we targeted sentence production difficulties by adopting a modular approach to treatment. We first attempted to improve D.L.'s single word naming abilities to determine whether improved verb production abilities would lead to improved sentence production. We found no improvement in sentence production after successful treatment for verb naming. We then targeted sentence production directly by training production of passive sentences. This led to improved sentence production on our treatment task and on a number of generalization measures. Our findings are in keeping with earlier studies (Mitchum & Berndt, 1994; Mitchum et al., 1993, 2000; Weinrich et al., 2001), which showed that improvement in sentence production abilities could be successfully trained with a grammatical frame and/or mapping therapy approach. They extend earlier findings by demonstrating the range of generalization of treatment effects. We will discuss the implications of these findings below.

Training of single verb production did not lead to improved sentence production on any of our measures. This outcome was the same as found in previous studies by Mitchum and colleagues with grammatical frame therapy (Mitchum & Berndt, 1994; Mitchum et al., 1993). In contrast, Marshall et al. (1998) found improved sentence production after verb naming therapy. The treatment task used in the Marshall et al. (1998) study was a semantically based one focused on verb meaning, and on pairing nouns and verbs. It is possible that the different nature of the treatment task led to the different pattern of results seen in our study and Marshall et al.'s (1998).

When sentence production was targeted directly in therapy, Mitchum and colleagues found improved production of active sentences with little generalization to untrained structures. We found that passive sentences could be successfully trained with a grammatical frame approach, with limited generalization to untrained active sentences. On our sentence production test, administered before and after treatment, D.L. improved after treatment on both active and passive sentences.

On two other sentence production tasks used as generalization measures, the Caplan and Hanna Test and Mitchum et al.'s (1993) APEP, D.L. showed significant improvement in his production of passive sentences after treatment. However, no generalization to active sentences was noted; in fact, his performance on active sentences deteriorated. These findings, as well as those of Mitchum et al. (1993; Mitchum & Berndt, 1994) suggest that production of particular sentence types may require explicit training (but see Ballard & Thompson, 1999). They also raise the possibility that treatment gains sometimes may occur at a cost to previously spared abilities.

Importantly, D.L.'s performance on a more naturalistic task, the video narrative, showed improved performance after sentence production treatment in Phase B. It is not likely that this effect was due to repeated exposure or practice, because his performance on most measures on this task remained stable or deteriorated after Phase A treatment. The

Table 5
D.L.'s Performance on Selected Measures on the Narrative Task Before and After Both Phases of Treatment

	Pre-Phase A	Post-Phase A/Pre-B	Post-Phase B
Number of Sentences	16	18	21
Proportion of Sentences	0.8	0.78	0.91
Percent of Well-Formed Sentences	63	55	76
Median Length of Utterance (MedLu)	7	7	6
Number of Verbs	30	22	28
Proportion Lexical/Nonlexical Verbs*	0.4	0.27	0.58

*not included as a measure in Saffran et al (1989) or Rochon et al. (2000)

Table 6
D.L.'s Performance on the PALPA Sentence Picture Matching Task Before and After Both Phases of Treatment

	Pre-Phase A	Post-Phase A/Pre-B	Post-Phase B
Total correct reversible active	50	63	75
Total correct reversible passive	25	38	25
Total correct non-reversible active	100	100	100
Total correct non-reversible passive	100	100	75
Total correct gapped sentences	63	56	75
Converse relations	100	63	63

overall number and proportion of sentences, as well as the number of well-formed sentences in the narrative increased, while the median length of utterance remained the same. In addition, while the overall number of verbs used in the narrative remained the same, the proportion of lexical to nonlexical verbs increased. Nonlexical verbs (e.g., *give, have, do*) also referred to as 'light' verbs (Jesperson, 1965, in Berndt et al., 1997), do not usually provide very specific meanings or information and are often used as substitutions for auxiliary verbs (e.g., *going to*). Berndt and Mitchum (1997) have shown that many individuals with verb naming impairments rely on empty or nonlexical verbs in their sentence production. As was seen in our participant, after sentence production treatment, his use of these verbs diminished. It is possible that, together with the improved sentential measures, this improved ability to use lexical over nonlexical verbs allowed D.L. to better communicate his intended meaning in connected speech.

We found very little change in D.L.'s sentence comprehension abilities after training on passive sentence production. While his comprehension of nonreversible sentences was high before treatment, his comprehension of reversible sentences was not. His performance on reversible active sentences improved after therapy, however his comprehension of reversible passive sentences, the sentence type on which he had been trained in production, did not improve. It is possible that he was sensitized to thematic roles in treatment, which in turn helped him to better comprehend reversible actives. However, the lack of improvement on reversible passives precludes any strong conclusions regarding the reciprocal relationship between sentence production and comprehension abilities. Though Weinrich et al. (2001, Participant EA) found improved comprehension after production training, our results are more in keeping with those of Mitchum and colleagues, who showed no cross-modality generalization in their treatment studies. Of note is a study by Jacobs and Thompson (2000) in which cross-modal generalization for comprehension but not production training was found. Our results, and those of others, suggest that the operations involved in sentence production and comprehension may be distinct (or at least not completely bidirectional), requiring treatment targeted at each modality separately (see Mitchum et al., 2000).

The findings of this study relate to the theoretical models mentioned earlier in a number of ways. First, we hypothesized that D.L. had difficulty 'mapping' thematic role information from the Functional level of Garrett's (1980, 1988) model onto the syntax at the Positional level. Focusing treatment on the different roles played by the actors in the treatment sentences, as well as showing the contrast between how these roles get expressed in different kinds of sentences should have, according to the theory, improved sentence production. We saw a clear improvement in D.L.'s production of sentences in our study, and it is reasonable to assume that the mechanism at work was improved thematic mapping from the Functional to the Positional level. Secondly, the mapping deficit hypothesis (Schwartz et al., 1987) predicts that mapping operations are reciprocal in production and comprehension. We might have expected improved sentence comprehension abilities along with improved production abilities, based upon this hypothesis. Since we did not find improved comprehension abilities, our findings suggest that further research is needed with regards to the reciprocal relationship between sentence production and comprehension processes.

Our modular treatment programme resulted in successful acquisition in treatment of complex passive sentences. Generalization to two novel tasks was found for trained sentence types (passives) but not untrained sentence types (actives), and very little change was found in sentence comprehension abilities. Marked improvement was found on a number of lexical and sentential measures in a narrative production task. To the extent that our narrative task approximated connected spoken language, the results indicate that the benefits of treatment may have extended to a more 'functional' context for our participant. Given his persisting difficulties with sentence comprehension, a subsequent module of treatment (Rochon & Reichman, in press) focused on D.L.'s sentence comprehension abilities.

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Author Note

Please address all correspondence to Elizabeth Rochon, PhD, Department of Speech-Language Pathology, Faculty of Medicine, University of Toronto, Rehabilitation Sciences Building, 500 University Ave., Room 160 Toronto, Ontario M5G 1V7; elizabeth.rochon@utoronto.ca.

Endnote

1. Due to an administrative error, not all treated and untreated verbs were included in the sentence production test. Prior to Phase A treatment, seven treated and eleven untreated verbs were included; after both Phase A and Phase B treatment eight treated and twelve untreated verbs were included.

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