A Modular Treatment for Sentence Processing Impairments: Sentence Comprehension

Un traitement modulaire pour les difficultés d'intégration des phrases : la compréhension de phrase

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Abstract

A new treatment for sentence comprehension impairment was investigated in an individual with aphasia. This comprehension module of treatment followed therapy for sentence production difficulties in the same patient-D.L. (Rochon & Reichman, 2003). The treatment programme employed an object manipulation procedure and a sentence query approach (Fink, Schwartz & Myers, 1998). Treatment of complex sentence types (passive and object cleft sentences) resulted in acquisition for both treated and untreated exemplars of the sentence types trained. Treatment effects also were maintained at two follow-up sessions. There was no generalization of treatment gains to two novel sentence comprehension tasks. However, there was generalization to sentence production abilities on a constrained task of sentence production. Results are discussed with reference to the underlying operations in sentence comprehension and production.

Abrégé

Un nouveau traitement pour les problèmes de compréhension de phrases a été étudié auprès d'un individu avec aphasie. Ce module de traitement de la compréhension faisait suite à une thérapie visant la production de phrases, auprès du même patient-D.L. (Rochon & Reichman, 2003). Le traitement consistait à manipuler un objet et à utiliser des phrases interrogatives (Fink, Schwartz & Myers, 1998). Comme résultat, à la suite du traitement des phrases complexes (phrases passives et phrases avec complément d'objet), l'acquisition des types de phrases traitées et même celles de type non-traitées a été notée. Les effets du traitement étaient toujours présents même à la deuxième session de suivi. Il n'y avait pas de généralisation du gain obtenu à la suite du traitement pour les tâches impliquant la compréhension de phrases à double intentions. Cependant, il a eu généralisation pour la production de phrases lors de tâches de production forcée de phrases. Les résultats sont discutés en lien avec les opérations à la base de la production et de la compréhension de phrases.

Key words: Sentence comprehension, aphasia, treatment, mapping therapy, sentence production

Model-driven approaches to treatment of aphasia emphasize processing language in a more conscious way on the part of the participant (Byng, 1992). One such approach, designed for sentence processing impairments, is mapping therapy (e.g., Byng, 1988; Jones, 1986; Schwartz, Saffran, Fink, Myers, & Martin, 1994). Mapping therapy is designed to target the constellation of sentence production and comprehension impairments often seen in individuals with agrammatic Broca's aphasia (Schwartz et al., 1994). We present a treatment study designed for a patient with mixed (fluent/nonfluent) aphasia who demonstrated sentence processing difficulties. We adopted a "modular treatment" approach (Schwartz, Fink & Saffran, 1995). By a modular approach we mean that the individual's sentence production difficulties were treated first and separately in a previous module (Rochon & Reichman, 2003). In this study we present the treatment module designed to target our patient's sentence comprehension impairment.

Though patients with agrammatism generally have comparatively spared comprehension abilities in comparison to the severity of their verbal production

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impairment, in fact, many of these same patients have difficulty comprehending sentences when the sentences can be understood only on the basis of the syntax of the sentences. For instance, patients may be able to understand an irreversible sentence, such as (1) *The ball the man is kicking is blue*, based largely on knowledge of the words in the sentence (lexical meaning) and world knowledge (i.e., men kick balls, but balls do not kick men). However, these same patients may be unable to understand a reversible sentence, such as (2) *The man the woman is hugging is happy*, because in this case lexical knowledge and world knowledge are not sufficient for sentence comprehension to occur: assignment and interpretation of syntactic structure are necessary. The difficulty for an individual with aphasia is believed to come in mapping the thematic relations in a sentence. What makes sentence (2) reversible is the fact that both the man and the woman can be the 'doers' (i.e., the agents) or the "receivers" of the action "hugging." Knowing "who is doing what to whom" in a sentence requires understanding the thematic roles, such that one can determine who is the agent of the action and who is the theme. The thematic roles must then be correctly linked onto the syntactic positions of subject and object in the sentence to achieve meaning. Thus, in cases such as sentence (1), where sentence meaning is semantically and pragmatically constrained, patients may be able to understand a sentence even if they have a syntactic impairment. In situations where sentences are semantically and pragmatically unconstrained, and where a syntactic analysis is necessary, as in sentence (2), patients may exhibit syntactic comprehension impairments (see Caplan & Hildebrandt, 1988; Caplan, 1992).

Canonicity of thematic role assignment is another factor that determines the difficulty of a sentence for individuals with aphasia. 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.* In contrast, active sentences, like the *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, and this is especially so when sentences have noncanonical thematic role assignment (Berndt, Mitchum & Haendiges, 1996; Caplan & Hildebrandt, 1988; Caramazza & Zurif, 1976; Saffran & Schwartz, 1988).

Garrett's (1980, 1988) model of sentence production also has been used to account for sentence processing deficits in patients with aphasia. In this model there are two important levels that must be computed in order for sentence production to occur. The first is the functional level, where semantic aspects of words are computed. The second is the positional level, where syntactic and phonological aspects are computed. Thematic roles are computed at the functional level and must be "mapped" on to the syntactic slots at the positional level for a sentence to be produced. It has been proposed that patients with agrammatism can have a mapping deficit (Schwartz, Linebarger, Saffran, & Pate, 1987). In sentence production, this takes the form of an impairment in mapping relations between the thematic roles at the functional level and the surface syntax at the positional level. In comprehension, patients are thought to have an impairment in assigning thematic roles to the parsed constituents in the sentence. They are unable to correctly "map" from the positional level in Garrett's model to the functional level in order to arrive at the meaning of the sentence. It is important to note that while it is thought that production and comprehension might both employ a mapping operation, the claim is not that the processes required to produce an utterance and/or to comprehend one are identical in production and comprehension.

The asyntactic comprehension pattern described above is not found in all individuals with agrammatism, and patients with different kinds of aphasia also can show this pattern (Berndt, 1991; Caplan & Hildebrandt, 1988). Explanations for this pattern of comprehension impairment have ranged from linguistic ones (see Bradley, Garrett, & Zurif, 1980; Caplan & Futter, 1986; Caramazza & Berndt, 1985; Grodzinsky, 1986, 2000) to limitations in processing resources (Caplan & Hildebrandt, 1988) or working memory abilities (Miyake, Carpenter, & Just, 1994).

Mapping therapy studies have all aimed to train the underlying "meaning relations" in sentences. (Fink, 2001). Briefly, the approach of Schwartz and colleagues, and others, was to use a step-wise sentence query approach to treatment (Fink et al., 1998; Jones, 1986; Le Dorze, Jacob & Coderre, 1991; Marshall, Pring & Chiat, 1993; Schwartz et al., 1994). For instance, in Schwartz et al.'s (1994) approach patients were trained to identify the verb and the lexical items corresponding to the agent and the theme in a written sentence, via a series of queries. One variant of this approach blocked training by sentence structure (Fink et al., 1998; Schwartz et al., 1994, study 1), another blocked training by thematic role query (Fink et al., 1998, study 2). Byng and colleagues (Byng, 1988; Byng, Nickels & Black, 1994; Nickels, Byng & Black, 1991) focused on an approach where the verb, the agent, and the theme were identified in abstract designs (preposition therapy) or action pictures and the patient was guided to create a written sentence (with the help of anagrams) that matched the pictured event. Color and/or visual icon cues (Byng, 1988; Byng et al., 1994; Nickels et al., 1991; Schwartz et al., 1994) were often used and feedback was either direct or indirect. Mitchum and colleagues (Berndt & Mitchum, 1997; Haendiges, Berndt & Mitchum 1996; Mitchum, Haendiges, & Berndt, 1995) developed an approach in which specific sentence structures (active and passive), not individual elements of the sentence, were contrasted in a picture verification task.

For most participants, improvements have been found for trained sentence structures (usually reversible active sentences) with little evidence for improvement on sentences not trained in treatment (Mitchum, Greenwald & Berndt, 2000). In addition, when measured, generalization of

performance to untrained tasks and to production, an untrained modality, has been variable (LeDorze et al., 1991; Schwartz et al., 1994).

We present a treatment study designed for an aphasic individual, D.L., with sentence comprehension difficulty. In a previous study (Rochon & Reichman, 2003), we designed a treatment protocol to remediate D.L.'s sentence production impairment. After treatment, D.L.'s sentence production improved for reversible active and passive sentences. However, D.L.'s performance on a sentence comprehension task remained unchanged.

The present study was designed to treat D.L.'s comprehension of reversible active, passive, and object cleft sentences. We used a mapping therapy approach to highlight the underlying thematic role relationships in the sentence. An object manipulation procedure was devised (Butler-Hinz, Caplan & Waters, 1990; Caplan & Hildebrandt, 1988) for the treatment protocol, where D.L. manipulated figures to demonstrate his comprehension of the information conveyed in the sentence. We expected to demonstrate acquisition in treatment of the sentence types trained, in particular the complex sentence types (i.e., passive and object cleft sentences). We also expected generalization of performance on the trained sentence types to novel sentence comprehension tasks, and generalization to sentence production abilities.

Methods

Participant

D.L. was a 67-year-old right-handed man who suffered two consecutive left hemisphere strokes, 2 months apart, 6 years prior to this study. Computed tomography 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 center 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 8 months one year before the commencement of this study. D.L. is a native speaker of English and has a university education.

D.L. was administered a number of tests during the course of his participation in the research, including the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983). On the basis of the results of these tests, D.L. had mixed (fluent/nonfluent) aphasia characterized by a verb retrieval impairment and agrammatism. Details about his performance and profile can be found in Rochon & Reichman (2003). His deficit in sentence comprehension was especially evident on reversible sentences (see scores on Psycholinguistic Assessments of Language Processing in Aphasia [PALPA] test, Table 1) and on complex sentence types, such as passive and object cleft sentences, also presented in Table 1. Prior to this treatment module, D.L. scored 76/80 on word repetition and 33/80 on a nonword task (Kay, Lesser, & Coltheart, 1992).

This module of treatment was administered 16 months after the completion of a treatment module for sentence production, reported in Rochon and Reichman (2003). The research was carried out in the course of routine clinical treatment. A single-subject research design was not employed, however procedures were used to demonstrate experimental control, such as the use of multiple pretreatment and posttreatment measures, including tests to assess generalization and the use of a control task.

Materials and Procedures

Treatment stimuli. Three versions of nonreversible and reversible sentences (active, passive, and object cleft) were constructed from 16 action verbs and 16 nouns. Eight agentive nouns (e.g., the *rabbit* is fed by the doctor) and eight nonagentive nouns (e.g., The *letter* was mailed by the soldier) were employed. A large sentence bank of over 600 sentences was created, from which these sentences were constructed. Treatment employed an object manipulation procedure previously used by Caplan and colleagues to assess sentence comprehension in aphasic patients (Caplan & Hildebrandt, 1988) and an explicit teaching method adapted from mapping therapy (Schwartz et al., 1994; Fink et al., 1998). Sixteen character figures (5-6 inches in height, e.g., a doctor) and 16 object figures (e.g., a mailbox) were used. D.L. was required to act out a presented sentence using the figures and objects.

Sentence comprehension treatment. The treatment was conducted in three levels, each level containing two blocks. All three sentence types were balanced across each block. Throughout Level I, D.L. was asked an agent query (e.g., *Who is doing the splashing?*); in Level II he was asked a theme query (e.g., *Who was being splashed?*); and in Level III, agent and theme queries were presented in random order. The step-wise query procedure was adapted from an existing mapping therapy protocol (Fink et al., 1998). To familiarize D.L. with both the object manipulation procedure and the alternating query approach, a practice block, across all levels and sentence types, was first carried out. In the practice block, only nonreversible sentences were used. D.L. was at ceiling in his comprehension of nonreversible sentences before treatment began, and he was able to proceed through all three levels of the treatment programme without difficulty in the practice block. In Block 1 training employed reversible sentences, and in Block 2 training combined both reversible and nonreversible sentences in random order.

Treatment sessions were one hour long. Training was conducted twice weekly and included regular review for maintenance of trained items. Treatment sessions in both blocks consisted of eight sentences: sentences were presented once with both auditory input and written support (Table 2), and a second time, in a different random order with only auditory input from the examiner. Detailed procedures were developed for teaching and feedback and can be obtained from the authors. When D.L. reached criterion of

Table 1
D.L.'s Performance (percent correct) on Two Sentence Comprehension Tests Pre- and Posttreatment

Test	Sentence	Pre	Post
PALPA[1]	Active	75	100
	Passive	58	33
	Reversible	65	33
	Nonreversible	88	75
	Gapped	75	67
	Mean	72	62
SPV[2]	Active	100	95
	Active Conjoined Theme	70	80
	Dative	80	95
	Subject Object	50	45
	Truncated Passive	70	70
	Dative Passive	60	5
	Passive	30	15
	Object Subject	40	65
	Conjoined	90	50
	Object Cleft	30	45
	Mean	62	56.5

[1]Psycholinguistic Assessments of Language Processing in Aphasia (Kay et al., 1992)
[2]Sentence/Picture Verification (Rochon et al., 1994)

80% correct in two consecutive sessions, training moved onto the next block. Responses were scored for accuracy of figure manipulation. Table 2 presents an overview of the treatment protocol.

Generalization measures. In addition to acquisition in treatment, a number of measures were administered before and after treatment to assess generalization of treatment effects. We constructed a sentence comprehension test which comprised 72 active, passive, and object cleft treated and untreated sentences. The same lexical items were used in the treatment stimuli, however they were presented in different random combinations to produce different sentences. Sentences were evenly distributed across the three sentence types. The procedure was the same as in the treatment, where D.L. was required to demonstrate his comprehension by acting out the sentence action using the figures and objects used in treatment. No feedback or teaching was provided in this test administration. This test also was administered one month and 18 months after the completion of the treatment protocol to assess maintenance of treatment effects.

To assess generalization to novel sentence comprehension tasks, D.L. was tested before and after treatment on two sentence picture matching tasks. One test was the sentence/picture verification procedure (SPV) (Rochon, Waters, & Caplan, 1994); another was the sentence picture matching subtest from the PALPA test (Kay, et al.,1992). Both tests require the subject to point to a picture that matches a sentence spoken by the examiner, and both include a wide variety of sentence types. The SPV test requires the subject to choose between two pictures; the PALPA test requires the subject to choose one from among three.

To assess generalization to sentence production and connected spoken language, D.L. was administered three tasks: the active/passive elicitation procedure (APEP) (Mitchum, Haendiges & Berndt, 1993); picture description with structure modeling (PDSM) (Fink et al., 1994); and analysis of a video narrative using the quantitative production analysis (QPA) (Saffran, Berndt, & Schwartz, 1989; Rochon, Saffran, Berndt, & Schwartz, 2000; Berndt, Wayland, Rochon, Saffran, & Schwartz, 2000).

A nonword repetition task was administered as a control task to control for effects of repeated exposure or improvement due to general language stimulation. The nonword stimuli were taken from subtest nine of the PALPA test (Kay et al., 1992) and contained 80 items that were one to three syllables in length.

Results

Sentence comprehension treatment

D.L. completed training in 26 sessions. Figures 1 and 2 show the data for his performance in Levels I and II of treatment. Performance for Level III of treatment is not shown in a figure, but is described below. As can be seen in Figure 1, at Level I (agent query only), D.L. improved steadily in Block 1, once treatment of reversible sentences began: From a chance-level baseline, his performance improved from 75-100% in three treatment sessions. As can also be seen in Figure 1, when we moved onto Block 2, where nonreversible and reversible sentences were combined, his performance in baseline was high. We decided to institute treatment despite his high baseline, and D.L. achieved 100% in his first two treatment sessions.

Figure 2 shows the data for D.L.'s performance in Level II (Theme query only) of treatment.[1] In Block 1, where only reversible sentences were trained, D.L. improved to 75% correct by the third session of treatment. In Block 2, he achieved criterion in five treatment sessions. D.L.'s performance in Level III, where agent and theme query were randomly presented, showed that he achieved 100% performance in the first two sessions of treatment for reversible sentences in Block 1. In Block 2 he also achieved criterion in the first two treatment sessions: He scored 100% in the first session and 88% in the second.

Table 3 shows D.L.'s performance on our sentence comprehension test which included both treated and untreated sentences. D.L.'s performance on active sentences was at ceiling throughout. His performance on passive and object cleft sentences increased to such an extent that his performance on this test after treatment was almost perfect, at 97% overall. At follow-up both 1 month and 18 months later, his performance remained very high.

Generalization

Comprehension tasks. A number of other measures were included to assess generalization of treatment effects. Table 1 shows D.L.'s performance before and after treatment on the PALPA (Kay et al., 1992) and SPV (Rochon et al., 1994) sentence comprehension tests. The pattern of improvement was the same on both tests: There was little change in performance after therapy. In fact, D.L.'s performance declined slightly after therapy on both tests.

Production tasks. Table 4 shows D.L.'s performance before and after treatment on two sentence production tests, the APEP (Mitchum et al., 1993)[2] and the PDSM (Fink et al., 1994). On the APEP, there is improvement on active sentences after treatment, but not on passive sentences. On the PDSM, while there is little change on active sentences, there is improvement on both passive and relative (including both object cleft and embedded) sentences after treatment. On the narrative production task, D.L.'s performance on a number of lexical and structural measures remained unchanged after treatment. His performance on the nonword repetition control task also remained unchanged at 41% before treatment and 43% after treatment.

Discussion

Using an object manipulation procedure, we have presented a new intervention for sentence comprehension impairment in a patient with aphasia based on a mapping therapy approach. We attempted to improve our patient's sentence comprehension abilities of complex noncanonical sentences (i.e., passive and object cleft sentences). D.L.'s comprehension of passive and object cleft sentences did improve in treatment, and effects were maintained 1 month and 18 months later. There was no generalization to two other,

Table 2
Sentence Comprehension Treatment Protocol

Level I (Agent query)	
Example sentence: *The doctor was splashed by the dancer.*	
Materials	Action figures
	Letter size unlined paper folder (three times) with sentence typed on upper half and lower half; the sentence occuring on the lower half (hidden from view) has the correct target agent (or theme) marked by underlining
Examinier	Lays 'Dancer' and 'Doctor' figures out in front of the participant
	Says the verb is *splash.*
	Presents folded paper (typed sentences hidden from view) and writes *splash.*
	Says the sentence, *The doctor was splashed by the dancer.*
	Unfolds paper to show typed sentence and repeats, *The doctor was splashed by the dancer.*
	Asks the participant to show the action.
Participant	Acts out the sentence by manipulating the two figurines.
Examiner	Asks, who is doing the 'splashing'?
Participant	Points to the 'agent' figure and underlines agent noun in the sentence.
	Check whether answered correctly by unfolding the paper to view the underlined noun (agent)*
Level II (Theme query)	
Example sentence: *The doctor was splashed by the guard.*	
Materials	Action figures
	Letter size unlined paper folded (three times) with sentence typed on upper half and lower half; the sentence occuring on the lower half (hidden from view) has the correct target agent (or theme) marked by underlining
Examiner	Lays 'Guard' and 'Doctor' figures out in front of the participant.
	Says the verb is *splash.*
	Presents folded paper (typed sentences hidden from view) and writes *splash.*
	Says the sentence, *The doctor was splashed by the guard.*
	Unfolds paper to show typed sentence and repeats, *The doctor was splashed by the guard.*
	Asks the participant to show the action.
Participant	Acts out the sentence by manipulating the two figurines.
Examiner	Asks, who was 'splashed'?
Participant	Points to the 'theme' figure and underlines theme noun in the sentence.
	Check whether answered correctly by unfolding the paper to view the underlined noun (theme).

Note: The procedure for Level III was identical to Levels I and II, except that the queries included both agent and theme, presented in random order.
* Detailed procedures for corrective feedback were developed for when an incorrect response was provided.

Table 3
D.L.'s Performace (percent correct) on Reversible Sentences Pretreatment and Posttreatment

Sentence Type	Pre	Post	Follow-up (1 month)	Follow-up (18 months)
Active	100	100	100	100
Passive	42	92	83	79
Object cleft	17	100	92	96
Mean	53	97	92	92

Table 4
D.L.'s Performance (percent correct) on Two Sentence Production Tests Pre- and Posttreatment

Test	Sentence Type	Pre	Post
APEP[1]	Active	75	88
	Passive	81	81
	Mean	78	84.5
PDSM[2]	Active	65	65
	Passive	65	85
	Relative	0	75
	Mean	43	75

[1] Active-Passive Elicitation Procedure (Mitchum et al., 1993)
[2] Picture Description with Structure Modeling (Fink et al., 1995)

novel sentence comprehension tasks, however there was generalization to a constrained sentence production task. Our findings are in keeping with previous mapping therapy studies (Mitchum et al., 2000), which have shown improvement in comprehension with both trained and untrained exemplars of trained sentence types. The pattern of generalization to constrained production tasks, but not novel comprehension tasks, will be discussed.

D.L.'s acquisition in treatment and in our posttreatment sentence comprehension test was excellent, however he demonstrated no change in performance on two other sentence comprehension tests after treatment. It is unlikely that his performance on our posttreatment test was simply due to repeated exposure to the sentences, as the posttest included both treated and untreated exemplars of the sentence types trained. His performance indicated that he performed equally well on both treated and untreated items. One possibility is that D.L.'s performance may have been influenced by task variables. The PALPA and SPV tests are both sentence picture matching tests, whereas our treatment procedure was an object manipulation one. As well, in one stage of treatment, D.L. had the benefit of having the written sentence in front of him. After administration of our posttests, we tested D.L. further informally, by administering the PALPA and SPV tests in written format in one condition and by adapting the SPV test to the object manipulation format in another condition. We noted improvement with both these adaptations over his scores presented in Table 1. We did not present these scores as we do not know whether D.L. would have performed better on the written than the auditory versions of the sentence comprehension tests and/or the object manipulation adaptation before treatment. However, these findings underscore the importance of analyzing task demands when assessing underlying competence in aphasia (Cupples & Inglis, 1993; Inglis, 2003). For instance, D.L. may have learned a rule about mapping noncanonical thematic roles from the positional to the functional level that he was unable to apply in sentence-picture matching tasks (Inglis, 2003).

Another possibility is that D.L.'s lack of generalization to novel sentence comprehension tasks may have indicated that his improvements in treatment and on our posttest were simply a "training-to-task" phenomenon. However, his improved performance on the PDSM sentence production test argues against this likelihood. Though there was no improvement noted on passive sentences on the other sentence production test, (i.e., the APEP), his performance before therapy on passives on this test was quite high, at 81%, leaving only limited room for improvement (i.e., a potential ceiling effect). Previous findings from comprehension-based mapping therapies have not shown the sort of generalization pattern to sentence production that we obtained here. Though claims for improved production after comprehension treatment have been made in mapping therapy studies (Byng, 1988; Schwartz et al., 1994), these have been based on gains (usually variable) on narrative production tasks. In contrast, we did not find gains after treatment on a narrative production task, however, we did find evidence that the mapping operations learned in comprehension treatment for passive and object cleft sentences generalized to sentence production of these same sentence types. Another possibility is that D.L.'s previous training for sentence production (Rochon & Reichman, 2003) may also have contributed to his good performance on the PDSM after treatment in the current treatment module.

Taken together with the pattern of findings from the first module of treatment we carried out with D.L. (Rochon & Reichman, 2003), the generalization patterns observed

Figure 1.

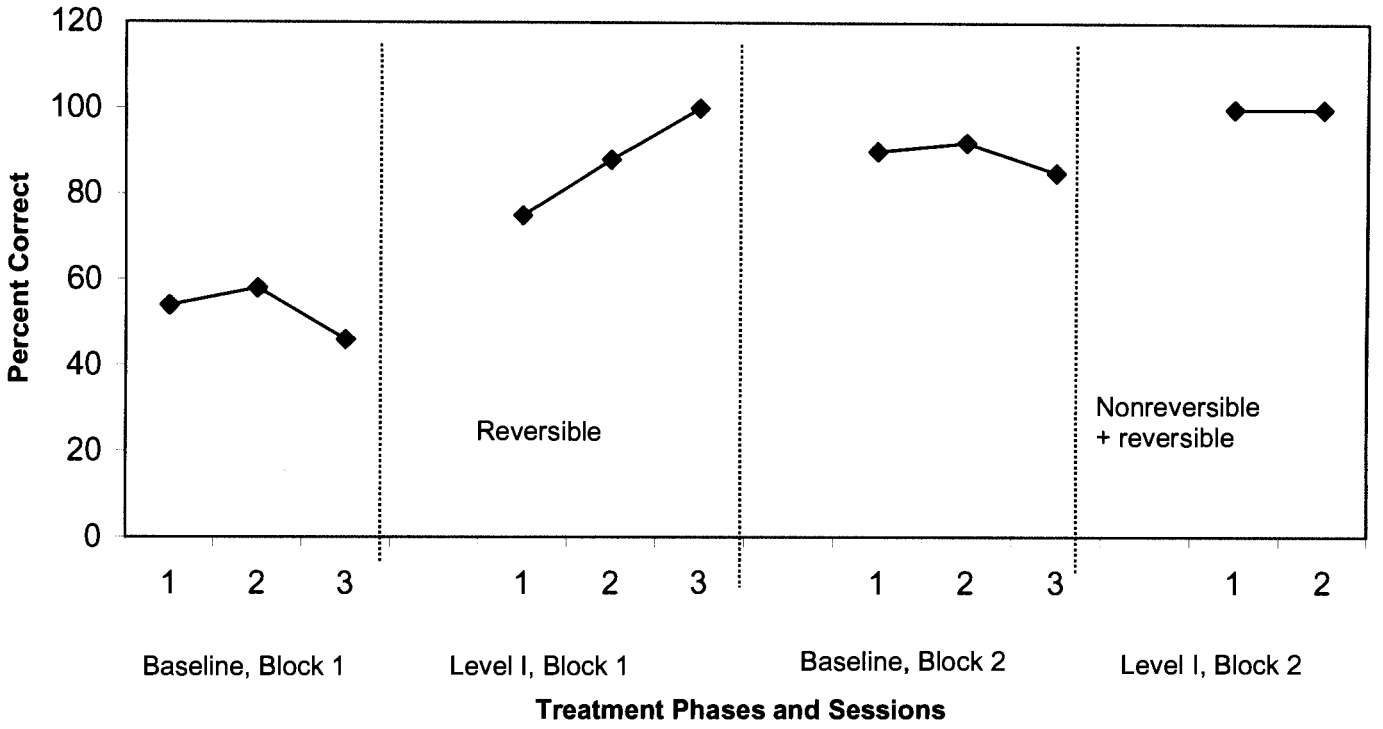

Figure 1. D.L.'s performance in Level I (agent query only) of treatment for both Block 1 (reversible sentences) and Block 2 (reversible and non-reversible sentences) for baseline and treatment sessions.

Figure 2.

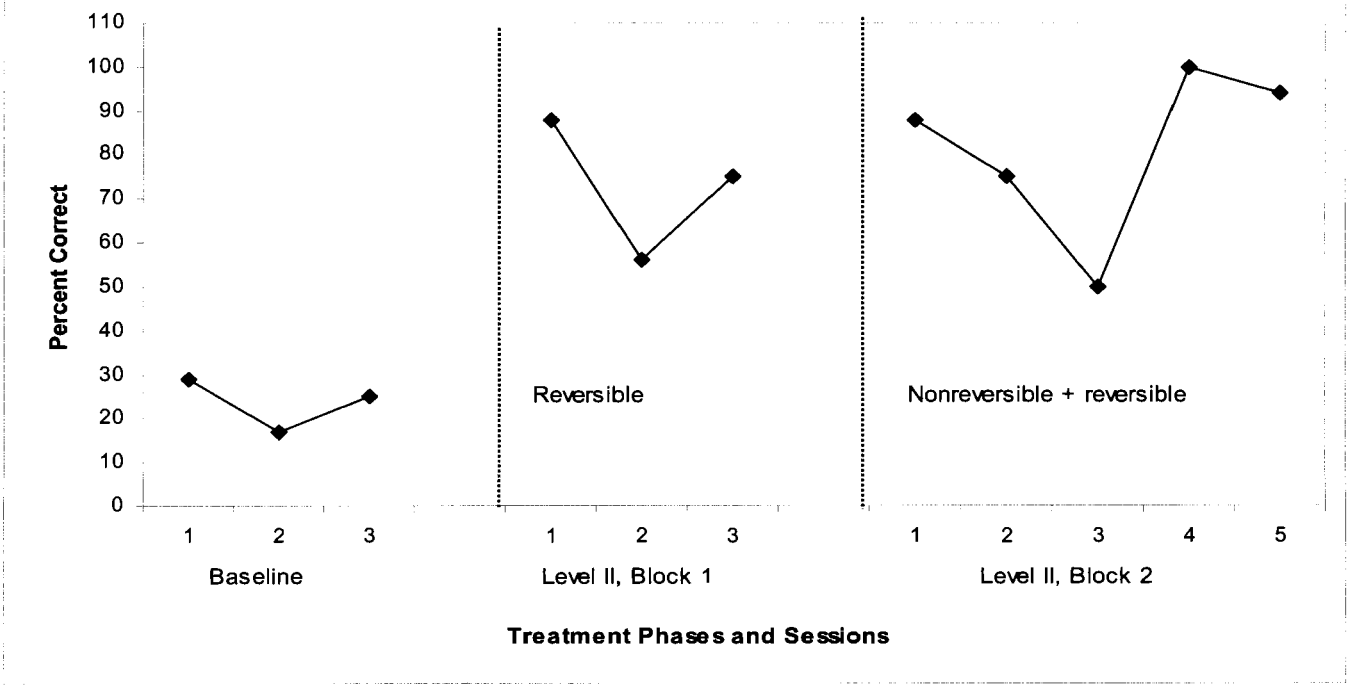

Figure 2. D.L.'s performance in Level II (theme query only) of treatment for both Block 1 (reversible sentences) and Block 2 (reversible and non-reversible sentences) for baseline and treatment sessions.

here are compelling. In the first module of treatment, where we trained production abilities, D.L.'s expressive skills improved substantially after treatment, on a number of measures. However, his comprehension abilities remained unchanged. We also found this pattern in another mapping therapy study with a small number of agrammatic patients (Rochon, Laird, Bose, & Scofield, in press). In the present study, after comprehension treatment, we found generalization to production abilities. These findings are in keeping with those of Jacobs and Thompson (2000), who found cross modal generalization for comprehension but not production training. These findings suggest that mapping operations may not be completely bidirectional. Treatment for mapping from the positional to the functional level, which is targeted in comprehension treatment, may be sufficient to generalize to successful mapping from the functional to the positional level (i.e., in production); however the reverse may not hold.

After completing the production modules of our treatment programme (Rochon & Reichman, 2003), the sentence comprehension module of the programme was in turn successful in improving D.L.'s sentence comprehension abilities. These improvements generalized to sentence production, however, no generalization was noted on novel sentence comprehension tests. While the lack of generalization to other sentence comprehension tests is surprising, it points to the importance of carefully analyzing the nature of the underlying impairment in aphasia and to the role that task demands may play in a patient's ability to respond correctly. Overall, the separate modules of our treatment programme were successful in improving D.L.'s abilities in the targeted domains. The results also help to define expectations for generalization in treatment for sentence processing disorders.

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Endnotes

1. Due to an administrative error, a fourth session of treatment was not included in Block 1 and baseline was omitted in Block 2.

2. D.L.'s scores on this test are different than those reported in Rochon & Reichman (2003): 9 months elapsed between the two administrations.

References

Berndt, R.S. (1991). Sentence processing in aphasia. In M.T. Sarno (Ed.), *Acquired aphasia* (pp. 223-270). San Diego: Academic Press.

Berndt, R.S., & Mitchum, C.C. (1997). An experimental treatment of sentence comprehension. In N. Helm-Estabrooks & A. Holland (Eds.), *Approaches to the treatment of aphasia* (pp. 91-111). San Diego, CA: Singular Publishing Group.

Berndt, R.S., Mitchum, C.C., & Haendiges, A.N. (1996). Comprehension of reversible sentences in "agrammatism": A meta-analysis. *Cognition, 58,* 289-308.

Berndt, R., Wayland, S., Rochon, E., Saffran, E., & Schwartz, M. (2000). *Quantitative production analysis: A training manual for the analysis of aphasic sentence production.* Hove, UK: Psychology Press.

Bradley, D.C., Garrett, M.F., & Zurif, E.B. (1980). Syntactic deficits in Broca's aphasia. In D. Caplan (Ed.), *Biological studies of mental processes* (pp. 269-286). Cambridge, MA: MIT Press.

Butler-Hinz, S., Caplan, D., & Waters, G. (1990). Characteristics of syntactic comprehension deficits following closed head injury versus left cerebrovascular accident. *Journal of Speech and Hearing Research, 33,* 269-280.

Byng, S. (1992). Testing the tried: Replicating sentence-processing therapy for agrammatic Broca's aphasia. *Clinics in Communication Disorders, 2,* 34-42.

Byng, S. (1988). Sentence processing deficits: theory and therapy. *Cognitive Neuropsychology, 5,* 629-676.

Byng, S., Nickels, L., & Black, M. (1994). Replicating therapy for mapping deficits in agrammatism: remapping the deficit. *Aphasiology, 8,* 315-341.

Caplan, D. (1992). *Language: Structure, processing, and disorders.* Cambridge, MA: MIT Press.

Caplan, D., & Hildebrandt, N. (1988). *Disorders of syntactic comprehension.* Cambridge, MA: MIT Press.

Caplan, D., & Futter, C. (1986). Assignment of thematic roles to nouns in sentence comprehension by an agrammatic patient. *Brain and Language, 27,* 117-134.

Caramazza, A., & Berndt, R.S. (1985). A multicomponent view of agrammatic Broca's aphasia. In M.L. Kean (Ed.), *Agrammatism* (pp. 27-64). New York: Academic Press.

Caramazza, A., & Zurif, E.B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language, 3,* 572-582.

Cupples, L., & Inglis, A.L. (1993). When task demands induce "asyntactic" comprehension: A study of sentence comprehension in aphasia. *Cognitive Neuropsychology, 10,* 201-234.

Fink, R. (2001). Mapping treatment: An approach to treating sentence level impairments in agrammatism. *Special Interest Division 2,* 11, 83-87.

Fink, R.B., Schwartz, M.F, & Myers, J.L. (1998). Investigations of the sentence-query approach to mapping therapy. *Brain and Language, 65,* 203-207.

Fink, R.B., Schwartz, M.F., Rochon, E., Myers, J.L., Socolof, G.S., Bluestone, R., & Sobel, P.R. (1994). Picture Description with Structure Modeling (PDSM): A procedure for measuring syntactic generalization. Poster presented at the Academy of Aphasia, Boston, MA.

Garrett, M.F. (1980). Levels of processing in sentence production. In B.Butterworth (Ed.), *Language production, vol. 1: Speech and Talk* (pp. 177-220). New York: Academic Press.

Garrett, M.F. (1988). Processes in language production. In F.J. Newmeyer (Ed.), *Linguistics: The Cambridge survey: III. Language: Psychological and biological aspects* (pp. 69-96). Cambridge: Cambridge University Press.

Goodglass, H., & Kaplan, E. (1983). *The assessment of aphasia and related disorders* (Second edition). Philadelphia: Lea & Febiger.

Grodzinsky, Y. (1986). Language deficits and syntactic theory. *Brain and Language, 27,* 135-159.

Grodzinsky, Y. (2000). The neurology of syntax: Language use without Broca's area. *Behavioral and Brain Sciences, 23,* 1-21.

Haendiges, A.N., Berndt, R.S., & Mitchum, C.C. (1996). Assessing the elements contributing to a "mapping" deficit: A targeted treatment study. *Brain and Language, 52,* 276-302.

Inglis, A.L. (2003). Taking expectations to task in aphasic sentence comprehension: Investigations of off-line performance. *Aphasiology, 17,* 265-289.

Jacobs, B.J., & Thompson, C.K. (2000). Cross-modal generalization effects of training noncanonical sentence comprehension and production in agrammatic aphasia. *Journal of Speech, Language, and Hearing Research, 43,* 5-20.

Jones, E.V. (1986). Building the foundations for sentence production in a non-fluent aphasic. *British Journal of Disorders of Communication, 21,* 63-82.

Kay, J., Lesser, R., & Coltheart, M. (1992). *Psycholinguistic assessments of language processing in aphasia.* London: Psychology Press.

Le Dorze, G., Jacob, A., & Coderre, L. (1991). Aphasia rehabilitation with a case of agrammatism: a partial replication. *Aphasiology, 5,* 63-85.

Marshall, J., Pring, T., & Chiat, S. (1993). Sentence processing therapy: working at the level of the event. *Aphasiology, 7*, 177-199.

Mitchum, C.C., Greenwald, M.L., & Berndt, R.S. (2000). Cognitive treatments of sentence processing disorders: What have we learned? *Neuropsychological Rehabilitation, 10*, 311-336.

Mitchum, C.C., Haendiges, A.N., & Berndt, R.S. (1993). Model-guided treatment to improve written sentence production: A case study. *Aphasiology, 7*, 71-109.

Mitchum, C.C., Haendiges, A.N., & Berndt, R.S. (1995). Treatment of thematic mapping in sentence comprehension: Implications for normal processing. *Cognitive Neuropsychology, 12*, 503-547.

Miyake, A., Carpenter, P.A., & Just, M.A. (1994). A capacity approach to syntactic comprehension disorders: Making normal adults perform like aphasic individuals. *Cognitive Neuropsychology, 11*, 671-717.

Nickels, L., Byng, S., & Black, M. (1991). Sentence processing deficits: A replication of therapy. *British Journal of Disorders of Communication, 26*, 175-199.

Rochon, E., Fink, R.B., Schwartz, M.F., Myers, J.L., Sobel, P.R., Bluestone, R., & Socolof, G.S. (1994). Stability of agrammatic production across narrative elicitation tasks. Poster presented at the Academy of Aphasia, Boston, MA.

Rochon, E., Laird, L., Bose, A., & Scofield, J. (in press). Mapping therapy for sentence production impairments in non-fluent aphasia. *Neuropsychological Rehabilitation*.

Rochon, E. & Reichman, S. (2003). A modular treatment for sentence processing impairments in aphasia: 1. Sentence production. *Journal of Speech-Language Pathology and Audiology, 27*, 202-210.

Rochon, E., Saffran, E.M., Berndt, R.S., & Schwartz, M.F. (2000). Quantitative analysis of aphasic sentence production: Further development and new data. *Brain and Language, 72*, 193-218.

Rochon, E., Waters, G.S., Caplan, D. (1994). Sentence comprehension in patients with Alzheimer's disease. *Brain and Language, 46*, 329-349.

Saffran, E.M., Berndt, R.S., & Schwartz, M.F. (1989). The quantitative analysis of agrammatic production: Procedure and data. *Brain and Language, 37*, 440-479.

Saffran, E.M., & Schwartz, M.F. (1988). Agrammatic comprehension it's not: Alternatives and implications. *Aphasiology, 2*, 389-394.

Schwartz, M.F., Fink, R.B., & Saffran, E.M. (1995). The modular treatment of agrammatism. *Neuropsychological Rehabilitation, 5*, 93-127.

Schwartz, M.F., Linebarger, M.C., Saffran, E.M., & Pate, D.S. (1987). Syntactic transparency and sentence interpretation in aphasia. *Language and Cognitive Processes, 2*, 85-113.

Schwartz, M.F., Saffran, E.M., Fink, R.B., Myers, J.L., & Martin, N. (1994). Mapping therapy: A treatment programme for agrammatism. *Aphasiology, 8*,19-54.

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