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A Linguistic-Specific Approach to Treatment of Sentence Production Deficits in Aphasia

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Over the years, a number of researchers have undertaken research concerned with treatment of sentence-level deficits in aphasic individuals (e.g., Byng, 1988; Doyle, Goldstein, & Bourgeois, 1987; Helm-Estabrooks, Fitzpatrick, & Barresi, 1981; Helm-Estabrooks & Ramsberger, 1986; Jones, 1986; Kearns & Salmon, 1984; LeDorze, Jacobs, & Coderre, 1991; Loverso, Prescott, & Selinger, 1987, 1992; Mitchum, 1992; Naeser, 1975; Saffran, Schwartz, Fink, Meyers, & Martin, 1992; Thompson & McReynolds, 1986; Wambaugh & Thompson, 1989; and others). Findings derived from these investigations have shown that aphasic subjects can rather easily be retrained to produce certain sentences noted to be difficult for them. Unfortunately, limited generalization to untrained sentence types results from this training. For example, training such selected sentences as imperative transitives, wh-interrogatives, and passives does not yield observed, generalization across sentences. With few exceptions (namely, Byng, 1988; Jones, 1986; Loverso et al., 1992; and Saffran et al., 1992), most of this work has focused treatment only on the surface realization of sentences, with little attention given to underlying representational and processing antecedents that might have resulted in the sentence production deficits noted.

Inasmuch as surface realizations result from an underlying linguistic representation (i.e., D[eep]-structure) (Chomsky, 1981, 1986), we postulate that treatment focused on this underlying form, in which the linguistic and psycholinguistic underpinnings of sentences targeted for treatment are controlled, may result in successful generalization across sentence structures sharing similar linguistic properties. That is, treatment designed to train access to linguistic or grammatical rules, processes, and representations used for more than single sentence types may potentially lead not only to improved production of trained sentences but also to generaliza-

tion across linguistically related responses presumed to be influenced or subserved by similar linguistic rules and principles.

This paper presents our preliminary findings concerned with examining the effects of a *linguistic-specific* treatment on complex sentence productions—sentences in which noun phrases (NPs) have been moved out of their canonical positions. Using this treatment approach we have begun to study generalized sentence production within and across linguistically related sentences in Broca's aphasic subjects with agrammatism. We discuss here the results of two initial studies focused on wh-interrogative and object cleft sentence productions—sentences relying on wh-movement, one major type of movement subsumed under the rule *move-alpha*. The linguistic and psycholinguistic underpinnings of these sentence structures were considered in designing our treatment approach, which addressed verb predicate argument structure, thematic role assignment in the D-structure representation of targeted sentences, movement of NP sentence constituents, and trace formulation (see Shapiro & Thompson, 1994, where the authors discuss these linguistic constructs in more detail). Because we recognize that linguistic theories generally are not designed as processing/production models, the production treatment that we derive is several steps removed from the linguistic theories themselves; nevertheless, we use the representational constructs derived from linguistic theory to teach subjects to make contact with the linguistic representations involved in the sentences that we target.

In the first study, wh-interrogatives requiring wh-movement of a direct object NP to the *specifier* position of COMP phrase and using verbs with similar lexical properties and predicate argument structures were selected (*what* and *who*). We also explored the role of sentence complexity, with complexity defined in terms of the number of phrasal nodes in the D-structure representation of sentences. That is, we trained sentences with four phrasal nodes (NP-V-NP-PP) and assessed generalization to sentences derived from three (NP-V-NP). This experimental question was based on evidence from studies of acquisition of English as a second language (ESL) (Eckman, Bell, & Nelson, 1988) and of treatment of phonological disorders (Gierut, 1990); these studies indicated greater generalization when treatment began with more complex items rather than less complex ones.

The second study examined two separate sentence types that, though they take very different surface forms, have similar underlying linguistic representations and rely on wh-movement: wh-interrogative questions and object cleft sentences. In this second experiment another sentence type relying on NP-movement (passive sentences) was studied for generalization. Here we made a rather fine-grained prediction: Given that wh-interrogatives and relative clause sentences derive from a particular aspect of the move-alpha (wh-movement) rule that involves movement of a direct object from an argument position to a nonargument specifier posi-

tion of a COMP phrase, we conjectured that generalization might occur between these two sentences. At the same time, we reasoned that our treatment would not influence passive sentences, which rely on a different aspect of move-alpha (NP-movement). As has been recently shown by Shapiro, McNamara, Zurif, Lanzoni, and Cermak (1992), wh- and NP-movement-derived sentences yield distinct sentence production patterns, perhaps because producing sentences derived from wh-movement may impose a greater processing load than producing some sentences derived from NP-movement—the former but not the latter requires linking a trace to its antecedent across clausal boundaries. Indeed, object relative sentences have been shown to be more difficult for aphasic subjects to comprehend than passive sentences (Caplan, Baker, & Dehaut, 1985).

The experimental questions of interest concerned (a) the acquisition effects of treatment, (b) the generalization patterns occurring from more to less complex sentence structures, (c) the generalization patterns occurring from one wh-interrogative form to another, and (d) the generalization patterns occurring from wh-interrogatives to object cleft sentences and vice versa.

METHOD

Subjects

The study investigated five aphasic adults who exhibited deficit patterns consistent with a diagnosis of nonfluent aphasia with agrammatism. Two subjects (one male and one female) participated in the first study, and three subjects (one male and two females) participated in the second. Although of differing etiologies, all subjects were between 13 and 40 months post onset of aphasia symptoms at the time of the study. Both subjects in the first study had suffered a single left cerebrovascular accident (CVA), whereas in the second study, one subject had sustained a left CVA, one had suffered a gunshot wound, and a third carried a diagnosis of primary progressive aphasia of the nonfluent type (Duffy & Petersen, in press) with no evidence of infarction noted on SPECT scan. All subjects were native English speakers, were premorbidly right-handed, and had completed high school.

Testing of the subjects' language behavior using the *Western Aphasia Battery* (WAB) (Kertesz, 1982) revealed performance patterns consistent with nonfluent (Broca's) aphasia. Aphasia Quotients (AQs) of 56 and 62, respectively, were derived for the subjects in Study 1, whereas higher-level subjects were selected for the second study, with AQs ranging from 75 to 93. Additional testing concerned with lexical-semantic processing, reading comprehension, auditory sentence comprehension, and sentence

production was undertaken using a series of published and unpublished tests. Results indicated that all subjects sustained mild to moderate disruptions of lexical-semantic processing but had relatively intact reading comprehension and oral reading, at least for simple sentences.

Study 1 tested auditory sentence comprehension and production using wh-interrogatives, active and passive nonreversible sentences, and active and passive reversible sentences; the results indicated somewhat compromised comprehension of wh-interrogatives and reversible sentences. Comprehension of passive sentences was the most difficult for both subjects. Additionally, both subjects were completely unable to produce grammatically correct wh-interrogative or passive sentences. Subjects in the second study were administered the *Philadelphia Comprehension Battery for Aphasia* (Saffran & Schwartz, unpublished), which, among other things, tests comprehension of active, passive, and object relative sentences. All subjects evidenced good comprehension of active sentences, and a reversibility effect was noted for all subjects (i.e., near-perfect performance was noted on semantically nonreversible sentences and poorer performance was noted on semantically reversible ones). However, comprehension difficulty was apparent for all subjects on both passive and object relative sentences. Interestingly, object relative sentences were more difficult than passives across subjects—a finding consistent with linguistic predictions, in that object relatives are more computationally complex than passive sentences.

Experimental Stimuli

Study 1. Ninety sentences were prepared to elicit *what* and *who* question productions (45 items for each) and printed in large upper-and lowercase letters on cards. Each set of 45 items was further divided into three sets of 15. The first and most complex set consisted of sentences with the D-structure form of NP-V-NP-PP (e.g., "The man is giving money to the boy"); Set 2 consisted of sentences using transitive verbs taking a direct object with the D-structure form of NP-V-NP (e.g., "The man is fixing the car"), and Set 3 consisted of sentences using the copula with the D-structure form of NP-V(copula)-NP (e.g., "A dictionary is a book"). Using the linguistic principles and rules described by Shapiro and Thompson (1994) for deriving the surface form of these sentences from their underlying linguistic representation, the following target *what* questions could be formulated, respectively: $What_i$ is the man $giving_{ti}$ to the boy? $What_i$ is the man $fixing_{ti}$? $What_i$ is a $dictionary_{ti}$? For treatment purposes, the words of each sentence were individually displayed on 3-1/2-×-5-in. cards, as were *who, what,* and a question-mark.

Study 2. Twenty-five target sentences (e.g., "The girl hit the boy") were prepared to represent the D-structure of three separate sentence types—

wh-interrogatives, object cleft, and passive sentences—and an additional 25 foil sentences representing the reversed action were prepared (e.g., "The boy hit the girl"). Pictures also were prepared to coincide with both target and foil sentences. All sentences were printed in large upper-and lowercase letters on cards. Using the linguistic principles and rules described by Shapiro & Thompson (1994) for deriving the surface form of wh-interrogative, object cleft, and passive sentences from their underlying linguistic representation, the following sentences could be formulated: "Who did the girl hit?" (wh-interrogative); "It was the boy who the girl hit" (object cleft); or "The boy was hit by the girl" (passive). For treatment purposes, individual sentence elements of the target sentences again were displayed on 3-1/2-in. × 5-in. cards, together with other elements required to produce the S-structure sentence forms (e.g., *who, did, it, was*).

Design

Combined single-subject experimental designs were used in both studies to examine the effects of treatment. These designs were selected for a number of reasons concerned with experimental control, examination of variability and other issues that have been discussed elsewhere (Kearns, 1986; McReynolds & Thompson, 1986). An additional, compelling reason for selecting this experimental strategy was to examine explicitly the covariance among and between linguistically related structures. Single-subject experiments allow design components to be arranged such that this covariance can be systematically examined through measurement of generalization while experimental control is maintained (Connell & Thompson, 1986). We believe that carefully designed research in which the lexical and syntactic properties of sentences selected for treatment are manipulated and controlled may lead not only to improved production of certain sentences but also to generalization across sentences relying on the same processes. Therefore, by examining generalization within and among theoretically related behaviors using single-subject design strategies, we may—in addition to discovering effective interventions strategies—derive important data relative to the formal characterization of mental structures and operations that subserve language. That is, we may be able to use the evidence gathered from carefully controlled experiments evaluating the effects of treatment to further develop sentence-processing and sentence production models (for a complete discussion of this use of single-subject designs, see Thompson, 1992).

Single-subject multiple baseline designs across behaviors and subjects were used in the present studies. Treatment was applied to one sentence type at a time, and untrained sentence types were tested continuously. If generalization did not occur across sentences, treatment was applied to

them. In cases in which generalization did occur, experimental control was demonstrated across subjects, with treatment being applied to each subject following baselines of increasing length. In the first study, the two interrogative types (*what* and *who*) provided the multiple baseline across behaviors. Production of both wh-constructions was examined using all experimental stimuli during the baseline phase, followed by application of treatment to the most complex form (Set 1 sentences) of either *what* or *who* interrogatives, counterbalanced across subjects. Treatment then was extended to the other interrogative if generalization across interrogatives did not occur. In the second study, three sentence types provided the behaviors of interest: wh-interrogatives, object cleft, and passive sentences. During baseline, production of all sentence types was tested, followed by application of treatment to either wh-interrogatives or object cleft sentences, counterbalanced across subjects. Passive sentences were held in baseline throughout the study to examine the relation between wh-and NP-movement-derived sentences.

Baseline and Treatment Probes

Baseline testing was accomplished using the following procedures. These probe procedures also were applied prior to each treatment session to measure the effects of treatment.

Study 1. Production of *what* and *who* questions was assessed using the 90 experimental stimuli. A randomly selected written stimulus sentence was presented for the subject to read, repeat, or both (e.g., "The man is reading a book"). Next, with the full sentence in view, the examiner said, "You want to know *the thing* that the man is reading, so you ask . . .?" The word *thing* was emphasized, rising inflection was used, and a question mark was placed above the sentence. For *who* question elicitation, for example, using the stimulus sentence "The father is protecting his son," the examiner said, "You want to know *the person* the father is protecting, so you ask . . .," again emphasizing the word *person*, using rising inflection and placing a question mark on the table above the stimulus sentence. A 10-sec. response time was provided following each stimulus presentation. Response contingent feedback was not provided. Each response was scored for both lexical and grammatical accuracy. All sessions were videotaped for reliability purposes.

Study 2. Production of the three sentences types (wh-interrogatives, object cleft, and passives) was assessed using the 25 experimental stimuli. Each stimulus was randomly presented three times each during each baseline session—once to elicit production of a wh-question, once to stimulate production of an object cleft sentence, and once for production of a pas-

sive sentence. To elicit each sentence type a modeling paradigm was used. Two written sentence stimuli (one target sentence and one foil) were presented together with corresponding pictures, and the subject was instructed to read/repeat both sentences (e.g., "The girl hit the boy," and "The boy hit the girl"). The examiner then instructed: "Here are two pictures. One shows a girl [pointing to the girls] and the other shows a boy [pointing to each boy]." The examiner asked the following questions to elicit each of the three response types:

> *Wh-Interrogatives:* "In this picture [pointing to the foil], if you wanted to know the person the girl hit, you would ask the question 'Who did the girl hit?' In this picture [pointing to the target], if you wanted to know the person the boy hit you would ask . . ."
>
> *Object Cleft Sentences:* "In this picture [pointing to the foil], it was the girl who the boy hit. But in this picture [pointing to the boy in the target] . . ."
>
> *Passivization:* "In this picture [pointing to the foil], the girl was hit by the boy, but in this one [pointing to the boy in the target picture] . . ."

Treatment

Subjects were trained to recognize the verb, its argument structures, and their thematic role assignments using the D-structure representation of target sentences. Instructions concerned with movement of D-structure sentence constituents to derive target surface forms were then provided. Treatment protocols for wh-interrogative sentences and object cleft sentences are presented in Tables 1 and 2, respectively.

Reliability

An independent observer coded responses for reliability on a randomly selected 30% of videotaped baseline and treatment probe sessions, and point-to-point agreement was calculated. In addition, randomly selected treatment sessions were coded for reliability on the independent variable. Overall reliability was greater than 90% across the two studies for both the dependent and independent variables.

RESULTS

Study 1

Results of Study 1 are displayed in Tables 3 and 4, for Subjects 1 and 2, respectively. Examination of these data indicated some differences in the

Table 1. Treatment Protocol: Wh-Interrogatives

Step 1: E presents d-structure sentence printed in upper- and lowercase letters on large card (3 in. x 18 in.) with instructions to read/repeat it (e.g., *"The man is sending flowers"*). E presents instructions for S to produce a question response as in baseline. A 5-sec response interval is provided.

Step 2: E presents d-structure sentence elements on individual cards. "What," "Who," and "?" cards also are presented (e.g., *"The man is sending flowers" "What" "Who" "?"*). E instructs S to produce a question response as in baseline. A 5-sec response interval is provided.

Step 3: E identifies the verb, the subject NP, and the object NP of the sentence. E then explains (a) that the object NP is either "the thing" (for *what* questions) or "the person" (for *who* question) receiving the action of the verb and (b) that it is replaced by *What* or *Who,* respectively. E replaces the object NP with the appropriate wh-morpheme, by selecting either the "What" or "Who" card, and places the "?" card at the end, forming an echo question (e.g., *"The man is sending What ?"*). The echo question is read/repeated by S.

Step 4: E demonstrates subject/auxiliary verb inversion by physically moving the subject NP cards and the auxiliary verb card (e.g., *"Is the man sending What ?"*).

Step 5: E demonstrates movement of the wh-morpheme to the sentence initial position. The correct question is read/repeated by S (e.g., *"What is the man sending ?"*).

Step 6: Sentence element cards are rearranged in their d-structure order. "What," "Who," and "?" cards are presented. Steps 3, 4, and 5 are repeated with S replacing/selecting/moving cards. E provides assistance at each step if needed. Once formed, the correct question is read/repeated by S.

Note: E = examiner; S = subject; NP = noun phrase.

generalization patterns observed across subjects. During baseline, neither subject produced correct wh-interrogative sentences of any type—most responses were produced with rising inflection; wh-morphemes were infrequently produced; and no attempts at movement were demonstrated. When treatment was applied to the most complex *what* interrogative constructions (NP-V-NP-PP) for Subject 1, acquisition of target question responses was noted (see Table 3). Additionally, throughout this training, generalization to less complex *what* interrogative constructions was noted (both to NP-V-NP structures and to NP-V (Copula)-NP structures). Interestingly, correct production of the less complex structures actually preceded that of the trained structures (see probe sessions 16–20 on Table 3). However, during this treatment period, generalization to untrained *who* constructions was not seen. Therefore, treatment was extended to *who* questions (NP-V-NP-PP), resulting in acquisition patterns of *who* interrogative productions similar to those noted for *what*. In addition, general-

Table 2. Treatment Protocol: Object Cleft Sentences

Step 1: E presents d-structure sentences (target and foil) printed in upper and lower case letters on large card (3 in. x 18 in.) with instructions to read/repeat as in baseline testing (e.g., *"The girl hit the boy," "The boy hit the girl"*). E presents stimulus for S to produce a question response as in baseline. A 5-sec response interval is provided.

Step 2: E presents d-structure sentence elements (of target sentence only) on individual cards. "It," "Was," and "Who" cards also are presented (e.g., *"The girl hit the boy" "It" "Was" "Who"*). E instructs S to produce an object cleft sentence as in baseline (using a foil sentence that is removed before the subject responds). A 5-sec response interval is provided.

Step 3: E identifies the verb, subject NP, and object NP in the sentence and explains that (a) the object NP is the object of the sentence (e.g., *"This is the person who the girl hit"*) and that (b) the "Who" card is placed next to the person who was hit (e.g., *"The girl hit the boy" "Who"*)

Step 4: E explains that "to make the new sentence, the object NP and "Who" cards are moved to the beginning of the sentence" (e.g., *"The boy Who the girl hit"*). E demonstrates movement and reads the newly formed utterance.

Step 5: E instructs that to make the sentence grammatically correct, the elements "It was" are added in the sentence initial position. The correct sentence is read/repeated by S (e.g., *"It was the boy who the girl hit"*).

Step 6: Sentence element cards are rearranged in their d-structure order. "It," "Was," and "Who" cards are presented. Steps 3, 4, and 5 are repeated with S replacing/selecting/moving cards. E provides assistance at each step if needed. Once formed, the correct question is read/repeated by S.

Note: E = examiner; S = subject; NP = noun phrase.

ization patterns to the less complex, untrained *who* interrogative constructions again emerged.

Treatment effects similar to those noted for Subject 1 also were seen for Subject 2, as shown in Table 4. Following baseline, when treatment was applied to the most complex *who* interrogative constructions (NP-V-NP-PP), correct wh-movement was noted on some responses by session 14, and by session 24 most *who* questions were produced not only with perfect syntax but also with accurate production of word labels. Additionally, during this training, production was generalized not only to less complex *who* sentences but also across interrogatives to all *what* forms. That is, for this subject, training only a small subset ($N = 15$) of *who* interrogative productions resulted in correct production of a large portion of the total 90 target sentences. This generalization included that to less complex forms, which again preceded acquisition of the most complex forms (see probe sessions 14–18 for *who* structures and sessions 20–24 for *what* structures).

Table 3. Number of Grammatically Correct *What* and *Who* Interrogative Sentence Productions Across Sentence Complexity Levels During Baseline and Treatment Phases of Study 1 (Subject 1 Data)

Probe sessions	*1*	*2*	*4*	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*	*24*	*26*	*28*	*30*	*32*	*34*	*36*	*38*	*40*	*42*	*44*	*46*	*48*	*50*
What Interrogative Sentence Productions																										
	Baseline		***Treatment***													***Maintenance***										
NP-V-NP-PP (trained)	0(3)	0(0)	0(1)	0(3)	0(1)	0(3)	0(1)	0(1)	0(1)	1(12)	3(12)	5(10)	4(11)	9(6)	10(5)	4(9)	7(8)	3(12)	2(13)	2(13)	2(8)	3(10)	7(8)	9(6)	10(4)	10(4)
			Generalization Probes																							
NP-V-NP	0(0)	0(0)	0(0)			0(0)			12(3)			9(6)			14(1)			12(2)			9(6)			7(5)		
NP-V(Cop)-NP	0(2)	0(1)			0(1)			0(0)			11(4)			12(3)			8(6)			12(3)			11(3)			
Who Interrogative Sentence Productions																										
	Baseline															***Treatment***										
NP-V-NP-PP (trained)	0(3)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(1)	2(1)	3(8)	6(9)	8(6)	6(3)	10(3)
																Generalization Probes										
NP-V-NP	0(0)	0(0)	0(0)			0(0)			0(0)			1(0)			0(0)			0(1)			2(3)			8(6)		
NP-V(Cop)-NP	0(0)	0(0)			0(0)			0(0)			0(0)			0(0)			0(0)			0(3)			2(4)			5(8)

Note: NP = noun phrase, V = verb, Cop = copula, PP = prepositional phrase. Numbers in parentheses refer to the number of grammatically, but not lexically, correct sentences produced per probe.

Table 4. Number of Grammatically Correct *Who* and *What* Interrogative Sentence Productions Across Sentence Complexity Levels During Baseline and Treatment Phases of Study 1 (Subject 2 Data)

Probe sessions	*1*	*2*	*3*	*4*	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*	*24*	*26*	*28*	*30*	*32*	*34*	*36*
									Who Interrogative Sentence Productions											
	Baseline				*Treatment*															
NP-V-NP-PP (trained)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(1)	2(5)	4(8)	4(7)	7(6)	4(8)	13(2)	12(2)	10(5)	11(4)	11(3)	10(3)	
					Generalization Probes															
NP-V-NP	0(1)	0(0)	0(0)			1(0)			11(3)			12(3)			11(2)			13(0)		
NP-V(Cop)-NP	0(0)	0(0)		0(1)			0(1)			8(5)				11(2)			8(4)			7(5)
					What Interrogative Sentence Productions															
					Generalization Probes															
NP-V-NP-PP	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)	0(1)	0(1)	2(8)	2(5)	6(3)	10(4)	3(5)	8(3)	9(4)	
NP-V-NP	0(3)	0(1)	0(0)			0(0)			1(0)			13(0)			10(1)			14(0)		
NP-V(Cop)-NP	0(0)	0(1)		0(0)	0(0)			0(3)			0(7)			5(8)			8(6)			9(2)

Note: NP = noun phrase, V = verb, Cop = copula, PP = prepositional phrase. Numbers in parentheses refer to the number of grammatically, but not lexically, correct sentences produced per probe.

Study 2

Results of Study 2, summarized in Table 5, again revealed somewhat different findings across subjects, with Subjects 2 and 3 showing greater generalization than Subject 1. Although successful acquisition of targeted sentences was seen when Subject 1 was trained to produce each sentence type, no generalization was noted across forms, from who-interrogative to object cleft sentences. For Subjects 2 and 3, however, acquisition and generalization across forms were noted (i.e., from object cleft sentences to who-interrogatives and vice versa). Interestingly, this is the direction in which generalization was predicted based on the underlying linguistic representation of the sentences under study (i.e., both wh-interrogatives and object cleft sentences require wh-movement). The predicted clear distinction between wh-movement structures and NP-movement structures (passives), however, was noted only for Subject 2. That is, Subject 1 evinced some change in passive sentence production during who-interrogative training, although an inconsistent trend was noted across probe sessions. This covariance was not expected. Because Subject 3 produced passive sentences at a high level prior to treatment, examination of the relation between wh- and NP-movement structures was not possible in her case. However, for subject 2, treatment of object clefts clearly influenced who-interrogatives, but not passive sentences—a predicted finding, in that passives require NP-movement but not wh-movement.

DISCUSSION

The data derived from these two sentence production studies indicated that for all subjects under study, the linguistically based treatment facilitated acquisition of trained sentences. In addition, for both subjects in the first experiment, generalization to less complex sentences was noted when treatment was applied to the most complex forms of the same type, and for three of the five subjects studied across the two experiments, generalization to untrained sentence types was evident.

That generalization was enhanced with treatment *first* being applied to the most complex forms of sentences is in keeping with findings reported by Eckman et al. (1988) and Gierut (1990) concerned with generalization from more to less complex language forms in teaching English as a second language (ESL) and phonologically disordered children. The present findings with aphasic subjects support this treatment approach and stand in contrast to the aphasia treatment literature recommending that treatment programs begin with elicitation of the easiest responses of a particular type and advance to more difficult ones.

Table 5. Percent Grammatically Correct Productions of *Who* Interrogative, Object Cleft, and Passive Sentences During Baseline and Treatment Phases of Study 2 Across Subjects

Probe sessions	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
Subject 1																						
	Baseline		*Treatment*										*Maintenance*									
Who interrogative (trained)	0	12	20	88	88	100	92	88	100	88	88	88	88	88	100	88	88	92	100	100	96	100
			Generalization Probes										*Treatment*									
Object Clefts (trained)	12	0		0		0		0		0		0	0	8	12	0	8	40	72	28	72	
			Generalization Probes																			
Passives	12	12	20		24		20		20		44		40		56		20		12		12	
Subject 2																						
	Baseline									*Treatment*												
Object Cleft (trained)	8	12	8	0	8	0	16	16	24	28	32	48	56	56	48	68	68	56	76	68	68	76
				Generalization Probes																		
Who interrogatives	0	0	0	4		4		0		8		8		16		56		48		56		76
Passives	16	20	16		8		4		4		8		8		12		12		8		8	
Subject 3																						
	Baseline					*Treatment*																
Who interrogatives (trained)	0	18	0	8	4	32	56	76	68	76	88	92	88	92	100							
						Generalization Probes																
Object Cleft	0	0	0	0	0	4		4		48		68		56								
Passives	44	84	76	64	64		88		92		64		76		64							

The generalization noted *across* sentence types (from *who* to *what* questions in the first experiment, and from *who*-questions to object clefts and vice versa in the second) also is a novel finding. We suggest that this generalization was observed because the sentences selected for treatment and for generalization involved similar underlying forms and because they relied on similar linguistic processes for deriving surface representations. Further, the generalization patterns noted suggest that disrupted production of some complex sentences seen in aphasia may result, in part, from disrupted grammatical or linguistic processes and representations involved in the translation of D-structure representation to surface realizations, including the assignment of thematic roles of verbs to argument positions, empty category representation, and coindexing of the trace to its proper antecedent. That generalization occurred to sentences relying on wh-movement in both experiments—and did not occur from wh-movement structures to NP-movement structures (at all for Subject 2 or as strongly for Subject 1)—is of theoretical interest in terms of language representation and processes involved in sentence production. Because the generalization patterns noted were in keeping with those predicted from formal linguistic theory, these data provide some experimental verification of the relation between the sentence structures studied. That is, the covariance noted between trained and generalized structures suggests that the various structures are governed by the same linguistic principles. Further, these findings support the arguments advanced by Grodzinsky (1990) in favor of the "breakdown compatibility" of Government-Binding (GB) theory. In the present experiments we have shown that, at least for some subjects, the processes expected to influence certain sentence productions based on our working theoretical model did in fact influence them as predicted.

Our enthusiasm for this approach, however, must be tempered by the apparent discrepant findings noted *across* subjects in both experiments. For one subject in each experiment, generalization was not seen beyond that reported in earlier studies in which linguistically based treatments were not provided. These results are difficult to explain. Because not all subjects conformed to hypotheses based on linguistic theory, it could be suggested that our use of GB theory to explain the nature of sentence production deficits in agrammatic individuals is not entirely appropriate. However, we feel that this conclusion is premature, especially in light of the interesting generalization patterns noted for some of our subjects. Indeed, a number of variables need to be considered when examining discrepant results across subjects, including the nature of the subjects' language disruptions as well as other subject variables, both neurological (e.g., site of lesion, etiology) and psychosocial (e.g., motivation, depression, adjustment to disability).

In fact, some differences in language behavior across subjects in the present studies have been noted that are beyond the scope of discussion

here (see Thompson, Shapiro, & Roberts, 1993, for a more complete profile of one subject who participated in our first experiment). Important neurological differences (i.e., etiological disparity) across the subjects in Study 2 also may have influenced our findings. Recall that, in that study, Subject 1's language disruption stemmed from a gunshot wound; therefore, his lesion was *more diffuse* than those of the other subjects. However, the extent to which this variable influenced responses cannot be gleaned from the present study. It is equally likely that other unknown variables may have influenced this subject's response patterns and that etiology alone may not adequately explain the discrepant finding. In terms of etiology, it is most interesting to note that Subject 3 (who carried a diagnosis of primary progressive aphasia) demonstrated linguistically predicted generalization patterns, suggesting a lawfulness, even in progressive language decline, that may be described along linguistic lines.

The data derived from these initial experiments are encouraging and support our continued endeavors in this direction. Replication of the present findings across additional subjects is needed, and many questions remain to be answered. However, we believe that further research using theory-driven, linguistic-specific approaches to treatment in which neurolinguistic models of language representation and processing are considered holds promise for developing effective treatments and for furthering understanding of aphasic sentence production deficits.

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REFERENCES

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

Caplan, D., Baker, C., & Dehaut, F. (1985). Syntactic determinants of sentence comprehension in aphasia. *Cognition, 21,* 117–175.

Chomsky, N. (1981). *Lectures on government and binding.* Dordrecht: Foris.

Chomsky, N. (1986). *Knowledge of language: Its nature, origin, and use.* New York: Praeger.

Connell, P. J., & Thompson, C. K. (1986). Flexibility of single-subject designs. Part III: Using flexibility to design or modify experiments. *Journal of Speech and Hearing Disorders, 51,* 214–225.

Doyle, P. J., Goldstein, H., & Bourgeois, M. (1987). Experimental analysis of syntax training in Broca's aphasia: A generalization and social validation study. *Journal of Speech and Hearing Disorders, 52,* 143–155.

Duffy, J. R., & Petersen, R. C. (in press). Primary progressive aphasia. *Aphasiology.*

Eckman, F. R., Bell, L., & Nelson, D. (1988). On the generalization of relative clause instruction in the acquisition of English as a second language. *Applied Linguistics, 9,* 1–20.

Gierut, J. (1990). Differential learning of phonological oppositions. *Journal of Speech and Hearing Research, 33,* 540–549.

Grodzinsky, Y. (1990). *Theoretical perspectives on language deficits.* Cambridge, MA: MIT Press.

Helm-Estabrooks, N., Fitzpatrick, P. M., & Barresi, B. (1981). Response of an agrammatic patient to a syntax stimulation program for aphasia. *Journal of Speech and Hearing Disorders, 46,* 442–427.

Helm-Estabrooks, N., & Ramsberger, G. (1986). Treatment of agrammatism in long-term Broca's aphasia. *British Journal of Disorders of Communication, 21,* 39–45.

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

Kearns, K. P. (1986). Flexibility of single-subject designs. Part II: Design selection and arrangement of experimental phases. *Journal of Speech and Hearing Disorders, 51,* 204–213.

Kearns, K. P., & Salmon, S. (1984). An experimental analysis of auxiliary and copula verb generalization in aphasia. *Journal of Speech and Hearing Disorders, 49,* 152–163.

Kertesz, A. (1982). *The Western Aphasia Battery.* New York: Grune & Stratton.

LeDorze, G., Jacobs, A., & Coderre, C. (1991). Aphasia rehabilitation with a case of agrammatism: A partial replication. *Aphasiology, 5,* 63–85.

Loverso, F., Prescott, T., & Selinger, M. (1987). Cueing verbs: A treatment strategy for aphasia adults. CVT. *Journal of Rehabilitation Research and Development, 15,* 47–60.

Loverso, F., Prescott, T., & Salinger, M. (1992). Microcomputer treatment applications in aphasiology. *Aphasiology, 6,* 155–163.

McReynolds, L. V., & Thompson, C. K. (1986). Flexibility of single-subject designs. Part I: Review of the basics of single-subject designs. *Journal of Speech and Hearing Disorders, 51,* 194–203.

Mitchum, C. E. (1992). Treatment generalization and the application of cognitive neuropsychological models in aphasia therapy. In: NIDCD Monograph, *Aphasia treatment: Current approaches and research opportunities.* Bethesda, MD: National Institutes of Health/National Institute on Deafness and Other Communication Disorders.

Naeser, M. (1975). A structured approach teaching aphasics basic sentence types. *British Journal of Disorders of Communication, 10,* 70–76.

Saffran, E. M., Schwartz, M. F., Fink, R., Meyers, J., & Martin, N. (1992). Mapping therapy: An approach to remediating agrammatic sentence comprehension and production. In: NIDCD Monograph, *Aphasia treatment: Current approaches and research opportunities.* Bethesda, MD: National Institutes of Health/National Institute on Deafness and Other Communication Disorders.

Shapiro, L. P., & Thompson, C. K. (1994). The use of linguistic theory as a framework for treatment studies in aphasia. In M. L. Lemme (Ed.), *Clinical Aphasiology* (Vol. 22, pp. 291–305). Austin, TX: PRO-ED.

Shapiro, L. P., McNamara, P., Zurif, E., Lanzoni, S., & Cermak, L. (1992). Processing complexity and sentence memory: Evidence from amnesia. *Brain and Language, 42,* 431–453.

Thompson, C. K. (1992). A neurolinguistic approach to sentence production treatment and generalization research in aphasia. In: NIDCD Monograph, *Aphasia treatment: Current approaches and research opportunities.* Bethesda, MD: National

Institutes of Health/National Institute on Deafness and Other Communication Disorders.

Thompson, C. K., & McReynolds, L. V. (1986). Wh-interrogative production in agrammatic aphasia: An experimental analysis of auditory-visual stimulation and direct-production treatment. *Journal of Speech and Hearing Research, 29,* 193–206.

Thompson, C. K., Shapiro, L. P., & Roberts, M. (1993). Treatment of sentence production deficits in aphasia: A linguistic-specific approach to wh-interrogative training and generalization. *Aphasiology, 7,* 111–133.

Wambaugh, J., & Thompson, C. K. (1989). Training and generalization of agrammatic aphasic adults' wh-interrogative productions. *Journal of Speech and Hearing Disorders, 54,* 509–525.