

## Appendix 2. Examples of J.A.'s written and oral spelling of words pre- and post-therapy.

Target	Responses		
	Pre-therapy		Post-therapy
	Written	Oral	Written
answer	ANACKEL	ANSWER	+
wolf	WOLD	+	+
effort	EGGERT	EFERT	+
pretty	PREETY	PREETY	+
island	ILACD	ILAND	+
yacht	YAUT	YALT	+
debt	DEPT	DEPT	dk
colonel	COLNELL	COLNER	COLNEN
friction	dk	FRICKEN	+
break	BBREAT	BRAK	BRAKE
middle	MINDLE	MIDLE	+
blood	BLEED	BLOD	+
check	CHEGH	+	+
bowl	BOOT	BOUL	BOL
mortgage	MOJCOGE	MORTGAE	+
sure	STOP	SHORE	SERL
plant	PACH	+	+
marsh	MIMST	+	+
lose	IONR	LO ...	+
wedding	WELLING	+	+
miracle	MHLACHE	MIRA ...	MIRACEL
hospital	HOSPILAL	+	+
session	SECHON	SESHON	SECONE
gravity	GRANTHEY	+	GRAVITE
attitude	ATHHTIC	ATTITUDE	+
treason	TRASSON	TRESON	+
satire	SATISE	SATARE	+
clue	GHEU	+	+
length	LENGH	LENYTH	TENTH
tobacco	TREACO	TOBBACCO	+
feather	FEASHER	+	+
valour	VALLOR	+	VALLOR

N.B.: A disambiguating sentence context was provided for all homophone items.

## Case Study

### Effects of verbal plus gestural matrix training on sentence production in a patient with primary progressive aphasia

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(Received 3 March 1994; accepted 3 January 1995)

#### Abstract

This research examined the effectiveness of verbal plus gestural treatment on the acquisition and generalization of present, past and future verb tenses in NP + V + NP sentence production in a primary progressive aphasic subject. Using a single-subject multiple-baseline design across behaviours as well as a matrix training procedure, treatment and generalization effects both within and across language matrices were examined. The relation between gestural and verbal responding was also examined *post-hoc* using a modified reversal design component. Results indicated improved production of sentences utilizing trained verb tenses and generalization to untrained verbs within tense. Paired gestural plus verbal responding resulted in higher levels of correct oral sentence production than verbal training alone. Findings are discussed in the context of brain mechanisms underlying gestural and verbal language production.

#### Introduction

Primary progressive aphasia (PPA) has been described in the literature as far back as 1892 using various labels such as 'aphasia dementia', 'pure word deafness evolving towards sensory aphasia' and 'slowly progressive aphasia' (Poeck and Luzzatti 1988, Mesulam 1982). During recent years the existence and nosological status of PPA have been amply discussed in the literature. Duffy (1987) defined the disorder as a language deficit 'of insidious onset, gradual progression, and prolonged course, in the absence of generalized cognitive impairments (at least for a substantial period of time), due to a degenerative condition, predominantly and presumably involving the left perisylvian region of the brain' (p. 349). Weintraub *et al.* (1990) added to the definition a minimum 2-year history of progressive language decline with relative preservation of other mental functions, and independence of daily living activities.

Controversy and questions have been raised about the 'purity' of the specific language deterioration. Certain authors have argued that the aphasia may merely represent the most prominent deficit in an otherwise diffuse process or generalized

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dementia such as seen in Alzheimer's or Pick's disease. In a majority of the PPA cases reported in the literature, the authors (Mesulam 1982, Chawluk *et al.* 1986, Heath *et al.* 1983, Kirshner *et al.* 1984, Tyrrell *et al.* 1990, Snowden *et al.* 1992) have ruled out pathological evidence of Alzheimer's disease, although a post-mortem diagnosis of Pick's disease has been made in some cases (Holland *et al.* 1985, Wechsler *et al.* 1982).

Duffy and Petersen (1992) reviewed the literature on PPA from 1977 to 1990 and found the following demographic information: (a) age of onset ranges from 40 to 75 years, with a mean of 59.3 years; (b) an approximate 2:1 ratio of males to females has been noted; (c) the mean duration of isolated symptoms is 5.3 years, with a range from 1 to 15 years; and (d) the longer the duration of isolated symptoms, the less chance there is for a broadening to cognitive impairment.

The language disturbances, while not uniform in their initial presentation or progression, are closely associated with those of aphasic patients who present with a focal single-event aetiology (cerebrovascular accident - CVA). In some PPA patients the characteristic language disorder is non-fluency characterized by agrammatism; in others fluent patterns have been noted, and in still others both fluent and non-fluent characteristics have been reported.

Those with non-fluent language patterns appear to be strikingly similar to those of acquired agrammatism. Agrammatic language patterns have been well documented in the literature (Goodglass and Kaplan 1983) and are characterized by speech that is slow and laboured. More specifically, morphological markers of inflectional and derivational processes are simplified or left out; there is retention of, or over-reliance on, content words (especially nouns) while functor words (e.g. articles, prepositions, pronouns, auxiliary verbs) are frequently omitted, and phrase length is reduced resulting in 'telegraphic-type' speech patterns. Syntactic complexity is reduced, evinced by a breakdown in the construction and coordination of constituent phrases. Verb production is impoverished and there is an over-reliance on simple verb usage. That is, verbs requiring simple argument structure arrangements are more frequently produced in contrast to verbs requiring more complex argument structure arrangements (Thompson *et al.* 1993). In most cases auditory comprehension is relatively spared.

In other PPA patients the speech patterns are typically fluent with Wernicke-type verbal output. Although produced without apparent effort, speech is contaminated by phonological, morphological, and semantic paraphasias; by circumlocution; and by a tendency to 'splice together' grammatically incompatible syntactic structures (Butterworth 1985).

Of all the PPA cases reported in the literature only 26% have reported concomitant anatomical/physiological findings. Kirshner *et al.* (1987) documented the existence of isolated left hemisphere degeneration in two cases who had aphasia without spread of cognitive impairment. Snowden *et al.* (1992) found a different distribution of atrophy depending on the neuropsychological syndrome. Their non-fluent PPA subjects had marked atrophy on the left side, with grossly enlarged lateral ventricles and atrophied left subcortical structures, while their fluent PPA subjects had symmetrical atrophy in both the left and right hemispheres. Results of neuroimaging have shown equivocal patterns, but have lent support to the presumed functional relation between left hemisphere pathology and language disruption.

The reported literature (mostly case studies) on PPA has focused on initial descriptions of the clinical neurological and neuropsychological findings, treating PPA

more as a clinical curiosity than as a disease entity. Only three studies (Northern *et al.* 1990, Craenhalts *et al.* 1990, and Holland *et al.* 1985) have addressed treatment and management aspects of PPA. Absent in all three studies was specific information concerning treatment efficacy and detailed inspection of the decline of language behaviours. Instead the authors discussed the type and course of the treatment plan in an anecdotal/case study manner. Language degradation, despite treatment, was reported in all three studies, and failure on tasks that had been previously successful was found to cause anxiety and distress to the subjects. Also noted was the fact that, in spite of the progressive language deterioration, other areas of functioning remained intact. Only one study (Northern *et al.* 1990) discussed the use of an alternative method of communication when 'traditional' verbal methods of treatment failed. A pictorial communication chart/book was utilized as the alternative method; however, the success or failure of this alternative communication strategy was never discussed.

An alternative communication treatment strategy that has not been attempted with PPA subjects is verbal plus gestural training. Several authors (Kearns *et al.* 1982, Hoodin and Thompson 1983, Rosenbeck 1985, Rao and Horner 1978, Raymer and Thompson 1991) have demonstrated the effects of this paired treatment approach in aphasic and apraxic subjects. Usually gestures are introduced as a compensatory communicative method for aphasic patients when exhaustive speech rehabilitation has failed. Luria (1970) referred to the pairing of gestures with verbal as a method of 'intersystemic reorganization' (p. 382). In essence, intersystemic reorganization is accomplished by introducing an unprecedented form of behaviour into the act of speaking, thereby reorganizing the neural system that supports speech (Rosenbeck 1985). In the present study gestures were included to provide a means for facilitating verbal language production for the subject. Thus, in addition to providing for possible reorganization, *ergo* facilitation of the verbal system, the use of gestures also provided the opportunity to examine the relation between gestural and verbal language decline.

### Purpose of the study

The present study was designed to examine the effects of a verbal plus gestural matrix treatment procedure on the acquisition and generalization of present, past, and future verb tenses in simple noun phrase (NP) + verb(V) + NP sentence production in a woman with a 2½-year history of non-fluent progressive language decline. A matrix training procedure was utilized as a method of systematically training and measuring generalization effects. Generalization was examined both within and across language matrices. The relation between gestural and verbal productions of both trained and untrained NP + V + NP sentences across verb tenses also was evaluated. Specific experimental questions included:

1. Will production of NP + V + NP sentences using present, past, and future tense verbs be improved utilizing a gesture plus verbal treatment approach?
2. Will generalization to untrained sentences using trained verb tenses occur and/or will generalization across verb tenses result from this training?
3. Is there a functional relation between gestural and verbal sentence productions?
4. Will both verbal and gestural sentence production be maintained over time, or will both decline at the same rate?

## Methods

### Subject

The subject was a 62-year-old right-handed, monolingual Standard American English-speaking female with a 2-year college education. Her language difficulties began 2½ years prior to the study when she first noticed that there was 'something wrong with my tongue'. Longer and more difficult words were particularly troublesome. In addition, reading and spelling were reportedly slower and more difficult. She was referred for neurological and neuropsychological examinations which revealed no deficits with memory tasks or abstract thinking (see Table 1). A non-fluent aphasia, however, was indicated. Electroencephalogram (EEG), magnetic resonance imaging (MRI) single-proton emission computed tomography (SPECT), and computed tomography (CT) scans were performed, all with negative results.<sup>1</sup> Results of the neuropsychological evaluation showed normal intellectual abilities, intact memory functioning, and intact time orientation. In general, an absence of cognitive deficits was noted. Apraxia, finger agnosia, right/left confusion, and visual construction abilities were within normal limits.

Hearing was screened and found to be within normal limits bilaterally with the exception of a 40 dB loss in the right ear at 4000 Hz. Vision also was reported to be within normal limits.

The results of language testing are summarized in Tables 2–4. These data revealed a mild disruption in overall language processes, word and sentence comprehension, oral and written naming, and oral reading. Table 2 depicts data concerned with overall language and cognitive functioning. The *Porch Index of Communicative Abilities* (PICA; Porch 1981) revealed an overall percentile score of 95. Subtest scores ranged from the 89th percentile, on the verbal subtests, to the 99th percentile. The *Western Aphasia Battery* (WAB; Kertesz 1982) yielded an Aphasia Quotient of 93.6 and a Cognitive Quotient of 95.6, with subtest scores ranging from 78% to 100% correct. On the *Arizona Battery of Communication Disorders of Dementia* (ABCD; Bayles and Tomeda 1991) her performance was 87% correct. Subtest scores ranged from 72% to 100% correct, with comprehension of three stage commands and yes/no questions involving comparative sentences being the most difficult.

Sentence comprehension abilities were assessed using the Caplan Auditory Sentence Comprehension Battery (unpublished), the Philadelphia Comprehension Battery for Aphasia (PCBA; Saffran, unpublished), and the *Auditory Comprehension Test for Sentences* (ACTS; Shewan 1980). Performance on all these measures indicated a mild sentence comprehension deficit with most difficulty noted on non-canonical, reversible sentences (see Table 3).

Testing of lexical/semantic processing (see Table 4), which assessed the subject's ability to comprehend and produce single words across modalities, revealed the following results: the *Peabody Picture Vocabulary Test-Revised* (PPVT-R; Dunn and Dunn 1981) yielded a percentile rank of 81; performance on a battery of lexical/semantic processing tasks, consisting of seven lexical tasks (i.e. oral/written naming, oral reading, writing to dictation, repetition, and auditory and

<sup>1</sup>Although all the neurological results (i.e. MRI, EEG, CT and SPECT) were reported as normal, a second neurologist who later reviewed the MRI and SPECT scans noted left sylvian fissure atrophy and decreased profusion in the left perisylvian area, respectively.

**Table 1. Subject information and neurological neuropsychological test results**

<i>Subject information</i>	
Female	
62 years old	
Right-handed	
Monolingual (English–Standard American Dialect)	
Vision and hearing within normal limits for age	
2½-year history of language difficulties	
Absence of major medical/psychiatric problems	
<i>Neurological/neuropsychological test results</i>	
Normal EEG, SPECT, MRI, and CT scans	
Absence of cognitive deficits	
Intact memory functioning ( <i>Wechsler Memory Scale</i> MQ 140+)	
Normal intellectual abilities ( <i>Wechsler Adult Intelligence Scale-Revised</i> PIQ 121)	
Praxis and gnosis essentially normal	
<i>Boston Naming Test</i> (98% correct)	

**Table 2. Summary of language test results**

Test	Score
<i>Porch Index of Communicative Abilities (PICA)</i>	
Overall percentile	95
(Subtest scores–percentile)	
Writing	94
Copying	99
Reading	98
Pantomime	99
Verbal	89
Auditory	99
Visual	99
Gestural	97
Graphic	94
<i>Western Aphasia Battery (WAB)</i>	
Aphasia quotient	93.6
Cognitive quotient	95.6
Spontaneous speech	19
Comprehension	10
Repetition	7.8
Naming	10
Reading and writing	19.2
Praxis	10
Construction	9.6
<i>Arizona Battery of Communication Disorders of Dementia (ABCD)</i>	
Percentage correct	87

**Table 3. Summary of sentence comprehension test results**

Test	Percentage correct
Caplan Auditory Sentence Comprehension Battery	92
Philadelphia Comprehension Battery for Aphasia (PCBA)	
Lexical comprehension	97
Sentence comprehension	93
Reversible sentences	87
Lexical sentences	100
<i>Auditory Comprehension Test for Sentences (ACTS)</i>	100

**Table 4. Summary of lexical /semantic test results**

Test	Score
<i>Peabody Picture Vocabulary Test-Revised (PPVT-R)</i>	
Percentile rank	81
	Percentage correct
Lexical semantic processing tasks	
Oral naming	92
Written naming	100
Oral reading	98
Writing to dictation	98
Repetition	100
Auditory and reading verification	100
<i>Test of Adult/Adolescent Word Finding (TAWF)</i>	98
(Subtest scores—percentage correct)	
Picture naming (nouns)	95
Sentence completion	100
Descriptive naming	100
Naming verbs	100
Category naming	100

reading verification) each utilizing 60 items with an equal number of high-frequency and low-frequency words in the English language (Francis and Kucera 1982), ranged from 92% to 100% accuracy; and results of the *Test of Adult/Adolescent Word Finding* (TAWF; German 1990) were 98% correct.

In general, language testing revealed a high level of overall performance, although mild impairments in both language expression and comprehension were noted. Even more marked impairment in language production, however, was noted in an analysis of spontaneous language.<sup>2</sup> Spontaneous utterances were characterized by non-fluency, with a hesitant, broken, telegraphic style of delivery. Sentences were characterized by lack of free and bound morphological markers, and function words

<sup>2</sup>This pattern (i.e. high overall performance on formal language testing with clear deficits in spontaneous language abilities) provides support for the lack of sensitivity of formal assessment instruments to detect certain aspects of expressive language. Therefore non-standardized measures, designed to target specific linguistic behaviours, provide more appropriate information for evaluating treatment results.

**Table 5. Summary of pre-treatment linguistic analysis (Cinderella story)**

	Samples			Normal subjects $\bar{X}$ (SD) [range]
	1	2	3	
Total words produced	193	280	288	324 (114.55) [160–472]
Mean length of utterance	6.06	6.11	6.50	13.87 (2.14) [11.43–17.48]
Percentage of grammatical sentences	0.38	0.32	0.26	0.88 (0.09) [0.74–0.96]
Percentage of simple sentences	0.59	0.81	0.74	0.45 (0.17) [0.15–0.67]
Percentage of complex sentences	0.41	0.19	0.29	0.55 (0.17) [0.33–0.85]
Percentage of conjoined sentences	0.19	0.19	0.29	0.53 (0.09) [0.43–0.67]
Mean no. of embedded clauses (per sentence)	0.40	0.17	0.26	0.98 (0.24) [0.67–1.33]
Noun:verb ratio	0.98	1.80	1.35	1.19
Open:closed class ratio	1.12	1.06	1.06	0.92
Verb morphology index (VMI)	2.42	2.53	2.23	2.62 (0.07) [2.37–3.00]
Percentage of correct VMI	0.83	0.72	0.70	0.99 (0.06) [0.98–1.00]

(auxiliaries and prepositions) were omitted. Word-finding difficulty, marked by both phonological and semantic errors, was noted in spontaneous speech. Reading and writing mirrored spoken language. Serial speech and repetition were impaired, with sound-based errors. In addition, an awareness of her disability led to frustration and distress.

Narrative language samples were collected on three separate occasions prior to the introduction of treatment, and analysed to more precisely describe specific linguistic behaviours. These samples were collected by having the subject retell the story of 'Cinderella' using procedures described by Saffran *et al.* (1989). A picture book of the story, from which the printed words were deleted, was provided for the subject to assist her in remembering the story. After the book was removed the subject was instructed to retell the story in her own words. An example of the subject's narrative sample is provided.

Cinderella (uh) he was a she was a prince. A mother (uh) mean Cinderella. They have a really pretty dress. Don't have a dress for Cinderella. I guess she's trying crying. She don't go to the ball because no dress. And (uh) the fairy (uh) appear. Fairy said (uh) I'll you go to the ball and a beautiful, a gorgeous dress (uh uh) carriage (uh uh) houses horses. You have to leave the ball before and because after midnight you carriage will be a pumpkin and (uh) same dress. So she went to the ball. The prince (uh) in love with Cinderella. So Cinderella night time before midnight. He saw the clock and says I have to run because (uh) rags rags and pumpkins not carriages. He left one glass slipper.

Utilizing a coding system developed by Saffron *et al.* (1989), and revised by Thompson *et al.* (1994), pre-treatment narrative samples were linguistically analysed for specific lexical and syntactic features. These data were then compared to the mean of a six-subject control group (see Table 5). As can be seen, our subject produced primarily short utterances (mean length of utterance (MLU) ranged between 6.06 and 6.50) containing few grammatical sentences (32%). This was in comparison to the normals, whose MLU averaged 13.87 with 88% of their sentences being grammatical. In addition our subject produced sentences that were primarily grammatically simple

**Table 6. Summary of types of linguistic errors**

<i>Functional category errors</i>	
Failure to control for gender and number (third person pronouns)	
Missing prepositions	
Mis-selection of pronouns	
Tense and agreement errors on the matrix verb	
Missing determiners	
Mis-selection of wh-items	
Negation errors	
<i>General syntactic errors</i>	
Missing subjects	
Ill-formed genitive NPs	
Missing and ill-formed verbs	
Word-order errors	
Coordinate structure errors	
Embedded clause errors	

(range 59% to 81%) as compared to 45% produced by the normal subjects. An average of 30% of our subject's sentence production contained complex sentences (i.e. sentences containing moved sentence constituents or embedded clauses) compared with 55% of the normals' sentence production. The mean number of embeddings (range 0.17 to 0.40) produced by our subject was low compared to normal subjects' mean embedding of 0.98. Our subject also used more open-class than closed-class words; within the open-class category she produced more nouns than verbs. Consistent errors in verb morphology (i.e. tense and agreement) were noted as revealed by the percentage correct verb morphology index (VMI) which ranged from 0.70 to 0.83.

Further analysis of errors in the closed class (see Table 6) included failure to control for gender and number in third-person pronouns and mis-selection of prepositions. In addition, missing determiners, the inappropriate use of determiners with proper names, mis-selection of wh-items, and errors involving negation were found. Due to the involvement and consistency of tense and agreement errors concerning the matrix verb, present progressive, past, and future verb tenses were targeted for treatment.

In summary, our subject presented with a non-fluent language impairment consistent with agrammatism concordant with non-fluent primary progressive aphasia in the absence of signs of generalized cognitive decline.

#### *Experimental stimuli*

A matrix training procedure was utilized as a method of systematically training and measuring generalization effects. The desired end-result of matrix training is 'recombinative generalization', which has been defined by Goldstein (1983) as 'the differential responding to novel combinations of stimulus components that have been included previously in other stimulus contexts' (p. 281). By training selected rule-driven combinations, generalization to untrained combinations can be examined (Goldstein 1985); the concept being that generalization is an indication of treatment efficacy.

One hundred and eight 4 × 5 inch black-and-white line drawings were used to elicit either the present, past, or future verb tense in a NP + V + NP sentence structure.

Subject and object NPs and V structures were placed in three different matrices organized by verb tense. This array of NP + V + NP combinations, depicted in Figure 1, allowed for 36 possible combinations per verb tense (see also Appendix A). Of these, three sentences were utilized for treatment while the remaining 33 sentences were utilized for testing generalization. Only transitive verbs (pour, push, kick, kiss) were selected for inclusion in this study. In addition, all nouns and verbs were easily depicted by an Amer-Ind (Skelly 1979) gesture.

#### **Design**

A single-subject multiple-baseline design across behaviours (McReynolds and Kearns 1983) was utilized in this study. During baseline an experimental probe was administered in which all 108 items were randomly presented to assess pre-treatment production abilities. Following baseline, each treatment session began with administration of the experimental probe. Treatment was then applied to one verb tense in the context of NP + V + NP sentences, keeping untrained sentences utilizing that verb tense and the other verb tense in baseline conditions to assess generalization. That is, three sentences were trained while the remaining six sentences for that particular verb tense, as well as the 18 possible sentence combinations across the other three verbs, served to assess generalization. Treatment continued for each verb tense until a criterion of 80% was reached on the experimental probe task over three consecutive treatment sessions.

#### *Gestural pre-training*

Prior to implementation of the matrix procedure, all gestures depicting the stimuli utilized in the matrices (four verbs, 24 nouns, and three tense markers) were trained. A notebook containing pictures of all of the gestures was provided. All items were presented one at a time to the subject with the name and the model of the gesture. The subject was instructed to produce each gesture along with the therapist, and then independently. Feedback as to the completeness and correctness of each gesture was provided. The notebook was given to the subject for practice at home. Prior to the beginning of the matrix training procedure the subject was required to produce all gestures upon command with 100% accuracy over two trials. Reference to the notebook was not allowed during the trials, the probe sessions, or during the actual training procedure. All gestures were selected from the Amer-Ind Gestural Code Based on Universal American Indian Hand Talk (Skelly 1979).

#### *Baseline*

The subject's ability to orally and gesturally produce the target verb tense within the NP + V + NP sentence structure was measured over four consecutive sessions prior to initiation of treatment. All sessions were videotaped for reliability purposes.

At the beginning of each session a 3-minute videotape provided the subject with a model of the expected responses. The tape consisted of the experimenter eliciting oral and gestural NP + V + NP sentence constructions containing the three verb tenses of interest. Six stimulus sentences were utilized that were similar, but not identical, to the experimental stimuli.

All 108 picture stimuli were then randomly presented to the subject. The sentence

	Subject NP	Verb	Object NP
Future Tense	The man T The teacher The dancer	T will kiss	the woman T the baby the soldier
	The donkey G The dog The horse	G will kick	the pig G the cat the cow
	The boy G The dentist The thief	G will push	the girl G the doctor the policeman
	The cook G The nurse The sailor	G will pour	the soda G the wine the coffee
Past Tense	The man T The teacher The dancer	T kissed	the woman T the baby the soldier
	The donkey G The dog The horse	G kicked	the pig G the cat the cow
	The boy G The dentist The thief	G pushed	the girl G the doctor the policeman
	The cook G The nurse The sailor	G poured	the soda G the wine the coffee
Present Tense	The man G The teacher The dancer	G is kissing	the woman G the baby the soldier
	The donkey G The dog The horse	G is kicking	the pig G the cat the cow
	The boy G The dentist The thief	G is pushing	the girl G the doctor the policeman
	The cook G The nurse The sailor	G is pouring	the soda G the wine the coffee

T = trained      G = within matrix generalization

Figure 1. Experimental language matrices: NP, V, NP sentence constitute vocabulary utilized across future, past, and present progressive verb tenses.

Subject NP	Verb	Object NP
The man T The teacher The dancer	T will kiss	the woman T the baby the soldier
The donkey G The dog The horse	G will kick	the pig G the cat the cow
The boy G The dentist The thief	G will push	the girl G the doctor the policeman
The cook G The nurse The sailor	G will pour	the soda G the wine the coffee

Figure 2. Future tense language matrix for NP + V + NP sentence structures.

used for eliciting the appropriate verb tense reflected the verb tense being elicited. For example, if the present progressive verb tense was being elicited a picture was presented to the subject with the instructions 'This is a (NP1) and this is a (NP2). Gesture and say what *is happening* in this picture'; for the elicitation of the past tense 'This is a (NP1) and this is a (NP2). Gesture and say what *happened* in this picture'; and for the elicitation of the future tense 'This is a (NP1) and this is a (NP2). Gesture and say what *will happen* in this picture'.

Specific feedback was not provided during the baseline procedure. However, intermittent remarks of encouragement were given. The first response to occur within 10 seconds was scored according to a two-point multidimensional scale, shown in Appendix B. The scale was sensitive to the nature of both verbal and gestural responses.

*Treatment*

The verb *kiss* was randomly selected as the verb to be trained. The future tense was targeted for treatment first due to performance on the baseline probes. That is, a stable baseline for future tense was obtained whereas variable production of sentences using past and present progressive verb tenses was noted prior to treatment.

Sentence combinations containing the verb *kiss* for the future tense were selected for training using the matrix component. Three sentences consisting of subject NPs and object NPs, arranged horizontally in the matrix, combined with the verb *will kiss* were targeted for training (see Figure 2). The remaining six sentences, as well as the 18 possible sentence combinations across the other three verbs served to assess generalization for that particular verb tense in NP + V + NP sentences. That is, for the future tense, the verb *kiss* was trained in the following sentence context: 'The man *will kiss* the woman; The teacher *will kiss* the baby; and The dancer *will kiss* the soldier'. Generalization to the other cell combinations within the submatrix (i.e. 'The man *will kiss* the baby, The man *will kiss* the soldier, The teacher *will kiss* the woman, The teacher *will kiss* the soldier, The dancer *will kiss* the woman, and

The dancer *will kiss* the baby") was tested, as was generalization across the entire future tense matrix. The *a-priori* assumption was that if the subject learned the linguistic rule underlying future verb tense production, then correct production of both trained and untrained sentences utilizing the trained verb tense would occur.

A verbal plus gestural treatment sequence designed by Raymer and Thompson (1991), as seen in Appendix C, was implemented. Training on these specific NP + V + NP verb tense combinations continued until performance reached an 80% accuracy level over three consecutive training sets within a session. Feedback concerning the completeness and correctness of the response was provided throughout the training procedure.

### Probes

All trained stimuli and half of the untrained stimuli were probed at the beginning of each treatment session. Probe stimuli were randomized and counterbalanced across sessions. All probe stimuli were elicited and scored consistent with the procedures established for the baseline administration. Responses to these probes served as the dependent variable throughout the study.

### Reliability

All probe sessions were videotaped and scored for reliability purposes by an independent judge. Overall, point-to-point agreement, calculated on responses obtained from two baseline sessions and every third probe session, was 92%. As a measure of reliability on the independent variable, the steps of the training protocol were scored (+ or -) by an independent judge. A 97% inter-judge agreement was calculated based upon two randomly selected videotaped training sessions.

### Results

Figure 3 depicts the percentage of grammatically correct sentences for both the trained and untrained future, past, and present progressive verb tenses during baseline and treatment phases of the study. As can be seen, a 0% accuracy level was noted during baseline on verbal production of sentences containing verbs in the future tense. Gestural responding was at a high level, as was expected following gestural pre-training. As can be seen, stable baselines for past and present progressive verb tenses were not obtained. Inspection of these baselines suggested that the pre-trained gestures may have facilitated verbal responding during this phase, as the acquisition curves for gestural and verbal responding paralleled one another. After three treatment sessions applied to future tense sentences an 80% accuracy level was achieved and maintained for both verbal and gestural responses to trained and untrained stimuli. During this treatment both the verbal and gestural responding for the past and present progressive verb tenses remained at a high level. Therefore, as a measure of control, a reversal component (indicated by the arrow in the figure) was introduced into the design, during which the gestural response was discontinued during probe sessions. That is, only verbal responses were required during the probe task. As can be seen, a concomitant drop in verbal production was noted on past tense sentence productions. Subsequently, treatment on the past tense began, following which criterion again was reached within three training sessions. Throughout this study, high

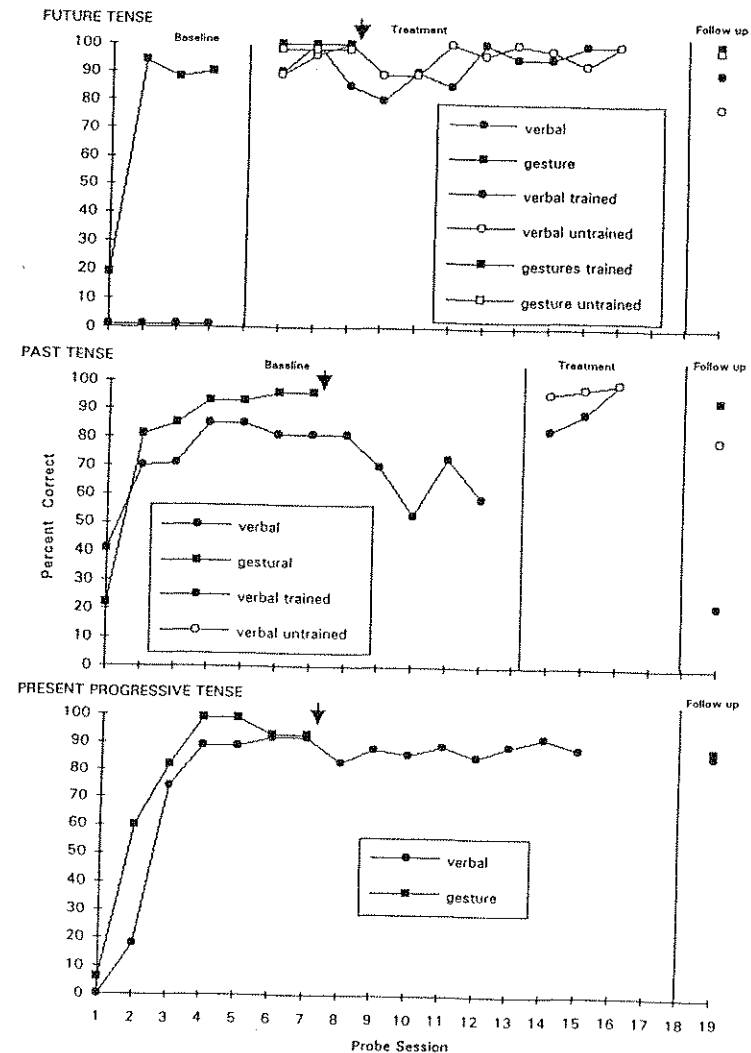


Figure 3. Percentage correct production of verbal and gestural NP + V + NP sentences for both trained and untrained future, past, and present progressive verb tenses during baseline and treatment phrases of the study. Arrow indicates session in which gestural responding was discontinued during probe tasks.



responding affected the verbal behaviour. Further, the reversal design component implemented showed a concomitant decline in verbal performance when the subject was no longer allowed to pair verbal and gestural responses (although this was not consistently noted across all behaviours), and gestural responding was maintained over time while verbal responding declined.

These findings are of theoretical interest in terms of the question of the relation between gestural and verbal behaviour, or between motor and verbal aspects of communication. That is, is language dependent upon the motor system as evinced by the close association of the apraxias with the aphasias (Kimura 1989), or is language a purely symbolic system that is located predominantly in the left hemisphere?

Interestingly, Poizner *et al.* (1987) and Klima *et al.* (1988), in their research with congenitally deaf aphasic subjects, have found that sign language breaks down along linguistic lines, independent of disorders of movement and gesture. Recognizing sign languages, such as ASL, as full-fledged linguistic systems, they found that deaf aphasic subjects have fluent and non-fluent language patterns similar to those of hearing aphasic subjects. More specifically, fluent/paragrammatic sign aphasias resulted in paraphasias and neologisms, word-retrieval difficulties, and significant comprehension deficits in the presence of grammatical output and normal prosody, while non-fluent/agrammatic sign aphasias were characterized by agrammatic output, effortful and slow signing, a predominant use of open-class signs, and impaired morphology and syntax.

Continuing with this line of research, Corina *et al.* (1992) presented evidence for the dissociation of sign language from disorders of non-linguistic gestures. In other words, gesture and sign have been found to differ in the type of movements and in their logical and behavioural relation to speech. This separability could point to separate neuroanatomical pathways that mediate sign and gesture. Is it possible, then, that verbal aphasics have access to a gestural system as an alternative method when their verbal system is inaccessible? Or are the two systems so linked that both will decline over time? The finding of this study, indicating reliance upon and maintenance of the gestural responding, provides some evidence which would support separate pathways.

In addition to looking at the relation between gestural and verbal behaviour, specific linguistic behaviours were analysed, revealing that although the mean length of utterance, noun-verb ratios, open-closed ratios, and verb group elaboration score remained consistent over time, the proportion of grammatical sentences decreased over time. The percentage of simple and conjoined sentences increased as the proportion of complex sentences decreased. These data suggest that treatment was effective in maintaining specific linguistic behaviours despite the degenerative language decline ensuing from primary progressive aphasia. Longitudinal in-depth linguistic analysis of primary progressive aphasic subjects' language could provide important information concerning the organization and representation of grammatical knowledge. For example, the progressive decline of linguistic behaviours affords researchers the opportunity to observe whether linguistic behaviours are lost in the same manner in which they are acquired. If they are not, what structures are lost and how do these structures affect an individual's overall language behaviour? Are these structures organized in modulus as proposed by Schwartz *et al.* (1979), Yamada (1990), and Pinker (1989)? Is the entire language system a distinct and separate system with principles of organization not shared with other cognitive systems such as perception or reasoning (Chomsky 1968, 1975), or is language grafted on top of cognition, as

postulated by Piaget (1952)? The progressive language decline seen in PPA has the potential to contribute to the overall understanding of the neuropathologies of language and communication, and the management of aphasia in general, by shedding light on the behavioural manifestations of language processing and production breakdown.

In summary, the results of this study suggest that verbal plus gestural pairing may be important in dealing with verbal language decline. However, agrammatic primary progressive aphasia is a rare disorder and it is expected that, as with agrammatic aphasia secondary to vascular lesion, heterogeneity among so-labelled agrammatic PPA patients is likely. Future studies with PPA subjects who demonstrate agrammatic language behaviours might utilize this gesture plus verbal treatment approach for training selected language responses, while closely examining generalization within and across theoretically related language responses. In addition, close inspection of the language decline observed in primary progressive aphasia provides an opportunity and a mechanism for studying how language may be interrelated to other cognitive systems, thus revealing important information about the organization and representation of language.

#### Acknowledgement

This research was supported by the NIH National Institutes on Deafness and Other Communication Disorders (NIDCD) grant DC01948.

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## Appendix A:

### Future tense sentences

- |                                       |  |
|---------------------------------------|--|
| 1. The man will kiss the woman.       | 30. The boy will push the policeman.     |
| 2. The man will kiss the baby.        | 31. The dentist will push the girl.      |
| 3. The man will kiss the soldier.     | 32. The dentist will push the doctor.    |
| 4. The teacher will kiss the women.   | 33. The dentist will push the policeman. |
| 5. The teacher will kiss the baby.    | 34. The thief will push the girl.        |
| 6. The teacher will kiss the soldier. | 35. The thief will push the doctor.      |
| 7. The dancer will kiss the women.    | 36. The thief will push the policeman.   |
| 8. The dancer will kiss the baby.     |  |
| 9. The dancer will kiss the soldier.  |  |

### Past tense sentences

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| 10. The cook will pour the soda.     | 37. The man kissed the woman.       |
| 11. The cook will pour the wine.     | 38. The man kissed the baby.        |
| 12. The cook will pour the coffee.   | 39. The man kissed the soldier.     |
| 13. The nurse will pour the soda.    | 40. The teacher kissed the woman.   |
| 14. The nurse will pour the wine.    | 41. The teacher kissed the baby.    |
| 15. The nurse will pour the coffee.  | 42. The teacher kissed the soldier. |
| 16. The sailor will pour the soda.   | 43. The dancer kissed the woman.    |
| 17. The sailor will pour the wine.   | 44. The dancer kissed the baby.     |
| 18. The sailor will pour the coffee. | 45. The dancer kissed the soldier.  |
| 19. The donkey will kick the pig.    | 46. The cook poured the soda.       |
| 20. The donkey will kick the cat.    | 47. The cook poured the wine.       |
| 21. The donkey will kick the cow.    | 48. The cook poured the coffee.     |
| 22. The dog will kick the pig.       | 49. The nurse poured the soda.      |
| 23. The dog will kick the cat.       | 50. The nurse poured the wine.      |
| 24. The dog will kick the cow.       | 51. The nurse poured the coffee.    |
| 25. The horse will kick the pig.     | 52. The sailor poured the soda.     |
| 26. The horse will kick the cat.     | 53. The sailor poured the wine.     |
| 27. The horse will kick the cow.     | 54. The sailor poured the coffee.   |
| 28. The boy will push the girl.      | 55. The donkey kicked the pig.      |
| 29. The boy will push the doctor.    | 56. The donkey kicked the cat.      |

57. The donkey kicked the cow.
58. The dog kicked the pig.
59. The dog kicked the cat.
60. The dog kicked the cow.
61. The horse kicked the pig.
62. The horse kicked the cat.
63. The horse kicked the cow.
64. The boy pushed the girl.
65. The boy pushed the doctor.
66. The boy pushed the policeman.
67. The dentist pushed the girl.
68. The dentist pushed the doctor.
69. The dentist pushed the policeman.
70. The thief pushed the girl.
71. The thief pushed the doctor.
72. The thief pushed the policeman.

#### *Present progressive sentences*

73. The man is kissing the woman.
74. The man is kissing the baby.
75. The man is kissing the soldier.
76. The teacher is kissing the woman.
77. The teacher is kissing the baby.
78. The teacher is kissing the soldier.
79. The dancer is kissing the woman.
80. The dancer is kissing the baby.
81. The dancer is kissing the soldier.
82. The cook is pouring the soda.
83. The cook is pouring the wine.
84. The cook is pouring the coffee.
85. The nurse is pouring the soda.
86. The nurse is pouring the wine.
87. The nurse is pouring the coffee.
88. The sailor is pouring the soda.
89. The sailor is pouring the wine.
90. The sailor is pouring the coffee.
91. The donkey is kicking the pig.
92. The donkey is kicking the cat.
93. The donkey is kicking the cow.
94. The dog is kicking the pig.
95. The dog is kicking the cat.
96. The dog is kicking the cow.
97. The horse is kicking the pig.
98. The horse is kicking the cat.
99. The horse is kicking the cow.
100. The boy is pushing the girl.
101. The boy is pushing the doctor.
102. The boy is pushing the policeman.
103. The dentist is pushing the girl.
104. The dentist is pushing the doctor.
105. The dentist is pushing the policeman.
106. The thief is pushing the girl.
107. The thief is pushing the doctor.
108. The thief is pushing the policeman.

#### **Appendix B: Scoring protocol**

Verbal responses	Score
Grammatically correct sentence includes all appropriate lexical items	2
Appropriate verbal tense with incomplete noun phrase	1
Main verb correct but morphological tense marker incorrect	0
Gestural responses	Score
Gestures complete a 'grammatically' correct sentence which includes all appropriate lexical items	2
Appropriate verb tense gesture with an incomplete 'noun' gesture	1
'Main verb' gesture correct with 'tense' gesture incorrect	0

#### **Appendix C: verbal plus gestural treatment sequence**

1. With the target picture placed in front of the subject, the following instructions were given: 'I am going to gesture and say that is *happening* (present tense training) (*happened* for past tense training, *will happen* for future tense training) in this picture.' A model of the verbal and gestural target was provided for the subject.
2. Following this verbal plus gestural model, the subject was instructed 'Okay this time you try. Gesture and say what is happening in this picture.' A 7-second response time was allowed. Feedback was provided regarding what part or parts of the response was correct or incorrect. One trial was given.
3. The gesture was then elicited in isolation. The instruction 'Let's practise just the gestural; part of the response.' The gestural model was provided for the subject. Three identical models were provided.
4. Following the gestural model, the subject was instructed 'This time you try. Gesture what is happening in this picture.' A 7-second response time was given. Verbal feedback was provided concerning the completeness and correctness of the response. A maximum of five trials was given.
5. The verbal response in isolation was then elicited utilizing the same procedures outlined in steps 3 and 4 with the exception that 'Verbal/Say' was substituted for 'Gesture'.
6. The verbal and gestural response was again modelled together for the subject to produce simultaneously. The following instructions were provided: 'I am going to put the gestural and the verbal parts together. Watch closely. I am going to gesture and say what is happening in this picture.' Three identical model were provided.
7. The verbal plus gestural response was elicited without a model. The instruction 'Okay now you try. Gesture and say what is happening in this picture.' A maximum of five trials was given.