Behavioral and Pharmacological Treatment of Lexical-Semantic Deficits in a Single Patient With Primary Progressive Aphasia

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In the context of a hybrid multiple-baseline design, this study demonstrated the positive effects of a behavioral + pharmacological (dextroamphetamine) treatment for lexical-semantic deficits in an individual with primary progressive aphasia (PPA). Behavioral treatment entailed application of a cuing hierarchy to predicative adjectives in order to facilitate lexical retrieval. Treatment was effective for both antonym and synonym adjectives, although extended practice was required to achieve criterion. Generalization to nontreated adjectives, verbs, and prepositions was observed, and maintenance was difficult to disambiguate from the progressive nature of the disease. It was proposed that the mechanisms of activation and inhibition were responsible for improved performance. Differential effects between behavioral and behavioral + pharmacological treatment were not observed.

The phenomenon of "slowly progressive aphasia" or "primary progressive aphasia" (PPA) first reported by Mesulam (1982) is now a well accepted diagnostic category in research (Duffy, 1992), if not in clinical practice. Reluctance to accept the syndrome clinically is well justified because of a paucity of information about its natural course, whether it develops into a dementia of the Alzheimer or Pick type, and because little is known about the heterogeneity of the behavioral and pathophysiological characteristics of subjects legitimately classified as having PPA (Kempler et al., 1988). In spite of the lack of information about the syndrome, its presence has necessitated consideration of its treatment. To date, only one study reports the effects of treating an individual with PPA (Schneider, Thompson, & Luring; in press). These authors reported improved sentence production using trained past, present, and future tense verbs with generalization to untrained verbs. It was also reported that gestural plus verbal responding resulted in higher levels of correct oral productions than verbal training alone.

The success of aphasia therapy using both group (Hagen, 1973, Wertz et al., 1981; Wertz et al., 1986) and single subject (Robey, 1994) research designs has been demonstrated using a variety of theoretical motivations as well as treatment methods and procedures. In spite of this success, the effectiveness and efficiency of treatments for all cognitive, linguistic, and communicative disabilities are in continuous need of refinement, elaboration, and documentation. The present study sought to integrate some known efficacious methods with some previously untested ones. We report the effects of treating the lexical-semantic deficits of an individual with PPA in a combined behavioral language and dextroamphetamine treatment paradigm. The rationale, methods, and efficacy for the pharmacological adjunct to the behavioral treatment is summarized in Small (1994). Briefly, the literature from both animal and human studies has shown that dextroamphetamine, in combination with systematic experience, aids recovery of function following cerebral lesions to an extent greater than no experience (treatment) or experience alone. The essence of the behavioral treatment was the use of the Linebaugh Cuing Hierarchy (Linebaugh, 1990) targeted to adjectives. The logic and demonstrated success (Linebaugh & Lehner, 1977) of the cuing hierarchy motivated this treatment technique (see Table 1 for a summary of the specific hierarchy used in this investigation). The choice of adjectives as treatment targets was motivated by the semantic scaffolding structure of this word class as proposed by Gross, Fischer, and Miller (1989). The general principles of "naming therapy" in the context of intensive stimulus-response drill were motivated by the notion of semantic activation networks as discussed by Seidenberg (1989) and others.

We sought answers to the following research questions: Is the language deficit found in this individual with primary progressive aphasia amenable to treatment with the particular behavioral/pharmacological treatment used in this study? Are any positive effects of treatment generalized to untreated behaviors within (i.e., adjectives) and between (i.e., verbs and prepositions) word classes as well as to standardized aphasia tests and to discourse-level measures? Are any positive effects of treatment and generalization maintained following treatment termination? Is there evidence that the pharmacological adjunct to the behavioral treatment augmented any positive effects of the behavioral treatment ?

Methods and Procedures

Subject. GP, a 61-year-old, right-handed, practicing attorney with no history of speech, language, or other neurologic deficits was referred by GP's family physician to the University of Pittsburgh Neurology Service. Referral followed the patient's self-referral for an unspecified communication disorder of an unknown etiology that had existed for approximately 4 months. Neurological examination of the cranial and somatic

TABLE 1 (part 1 of 2). Assessment measures for GP from initial onset of symptoms.

Formal Measure	Months Postonset	Results
Nonlinguistic-Cognitive		
Benton Facial Recognition Task (Benton, Van Allen, Hamsher, & Levin, 1978)	5	50/54 normal
CES-Depression Scale (Radloff, 1977)	5	18/60 borderline
Coloured Progressive Matrices (Raven, 1965)	8	
Overall: (Forms A, B, AB):		25/36
Grooved Peg Board (Matthews & Klove, 1964)	5	
Right hand—85 seconds (dominant)		T-score = 39
Left hand—82 seconds (nondominant)		T-score = 48
Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975)	4	28/30
Pyramids and Palm Trees Test (Howard & Franklin, 1988)	5	49/52
Recognition Memory Test (Warrington, 1984)	5	
Faces		46/50
Rey Complex Figure (Rey, 1964)	5	Complex
Copy		30/36 Mean for age = 33
Immediate recall		18/36 Mean for age = 16
Delayed recall		18/36 Mean for age = 16
Clock Drawing (Wilson, Cockburn, & Halligan, 1987)	5	spontaneously correct
Trailmaking Test (Reitan & Wolfson, 1985)	5	
A time = 67 seconds/0		errors scaled score = 4 T-score =28
B time = 178 seconds/1		error scaled score = 5 T-score= 30
Wechsler Adult Intelligence Scale–Revised (Wechsler, 1981)	5	Performance IQ: 107 Full Scale IQ: 99
Wechsler Memory Scale–Revised (Wechsler, 1987)	5	
Visual memory span		
Forward span		6/8 percentile: 55
Backward span		5/7 percentile: 59
Indexes		
Visual memory		104
General memory		97
Attention/concentration		90
Delayed recall		93
Western Aphasia Battery (WAB) (Kertesz, 1982)	5	
Apraxia		
Upper limb		15/15
Facial		15/15
Instrumental		14/15
Complex		15/15
Construction/Visuospatial/Calculation		
Drawing		28/30
Block design		9/9
Calculation		24/24
Wisconsin Card Sorting Test (Grant & Berg, 1948)	5	
# categories		6
#perseverative responses		30
# errors		24
# correct		81
Linguistic-Cognitive		
Arizona Battery for Communication Disorders of Dementia (Bayles & Tomoeda, 1991)	8	Immediate: 10 Delayed: 10
Boston Naming Test: (Correct) (Kaplan, Goodglass, Weintraub, 1983)	6	46/60
Discourse Comprehension Test (Brookshire & Nicholas, 1993)	8	
Set B		37/40
Nelson Adult Reading Test (Nelson, 1982)	4	VIQ = 102 ± 6.56
PALPA (Kay, Lesser, & Coltheart, 1992)	5	
Reading task regular words		29/30
Exception words		27/30
Nonword reading task		24/24
Written synonym judgments		
High imageability		29/30
Low imageability		29/30
Visual lexical decision & spelling		
Sound regularity:		
Regular words		15/15
Exception words		14/15
Pseudohomophones		14/15
Nonhomonophonic nonwords		15/15
Porch Index of Communicative Ability (Porch, 1981)		
Overall	8	90%ile (Aphasic)
Gestural		79
Verbal		75
Auditory		72
Visual		99
Graphic		97
Writing		98
Reading		80
Copying		89
Pantomime		82

TABLE 1 (part 2 of 2). Assessment measures for GP from initial onset of symptoms.

Formal Measure	Months Postonset	Results
Rapid Automatized Naming (Seconds) (Denckla & Rudel, 1976)	8	
Colors		54
Letters		40
Numbers		37
Objects		54
Combination		59
Reading Comprehension Battery for Aphasia (LaPointe & Horner, 1979)		
Correct	8	93/100
Recognition Memory Test (Warrington, 1984)	5	
Words		47/50
Revised Token Test (Overall) (McNeil & Prescott, 1978)	8	
Overall		94%ile (Aphasic)
Shipley Institute of Living Scale (Shipley, & Zachary, 1986)	5	
Abstraction		14/20; T-score = 64
Vocabulary		30/40; T-score = 53
Total		58; T-score = 60
Stroop Color/Word Test (Stroop, 1935)	5	
# items in 45		sec err T-sc.
Word		54 0 27
Color		40 0 27
Color/word		8 1 <20 Interference effect = -12.7/ T-score = 37
Wechsler Adult Intelligence Scale–Revised (Wechsler, 1981)	5	
Verbal IQ		95
Full Scale IQ		99
Verbal Fluency (Benton & Hamsher, 1976)	5	
F		6
A		5
S		4
		1st-3rd percentile for FAS
Animals		9
Birds		4
Makes of cars		16
Types of dogs		3
Golf courses		15
Wechsler Memory Scale–Revised (Wechsler, 1987)	5	
Digit span		
Forward span		7/8 percentile: 70
Backward span		2/7 percentile: 1
Verbal memory index		94
Western Aphasia Battery (WAB): (Kertesz, 1982)	5	
Spontaneous Speech		
Information content		10/10
Fluency, grammar, paraphasias		9/10
Auditory Comprehension		
Yes/No		60/60
Word		60/60
Sequence		80/80
Repetition		99/100
Naming		
Objects		58/60
Word fluency		8/20
Sentence completion		10/10
Responsive speech		10/10
Reading		
Sentence comprehension		40/40
Commands		18/20
		Prorated score: 96 Max score: 100
Spelled Words		5/6
Spelling		6/6
Writing		
Request		6/6
Output		32/34
Dictation		10/10 Prorated score 94 Maximum score 100
Words		10/10
Alphabet/numbers		22.5/22.5
Dictated letters/numbers		7.5/7.5
Verbal Memory		
Story retell		
Speech-Motor		
Apraxia Battery for Adults (Dabul, 1983)	8	Mild hypernasality and strained strangled voice

sensorimotor systems by a board-certified neurologist was normal. Initial neuroimaging was performed with magnetic resonance imaging (MRI) about 4 months postonset of the symptoms and was read by the neurologist and by a board-certified neuroradiologist as completely normal. Single photon emission computed tomography (SPECT), performed within the third month postonset, demonstrated decreased regional cerebral blood flow in the left temporal and parietal regions. A repeat MRI performed approximately 1 year postonset demonstrated isolated volume loss of the left temporal lobe.

A speech motor deficit was detected at the initiation of treatment, which began approximately 9 months after self-referral. The deficit was restricted to the musculature subserving speech and was consistent with involvement of the corticobulbar tract bilaterally with sparing throughout the corticospinal tract. The corticospinal tract remained uninvolved throughout the course of the study. The motor speech disorder was diagnosed as spastic dysarthria by a certified speech-language pathologist, based on the neurologic findings and on the perceptual pattern of signs. This speech motor deficit pro-

gressed rather rapidly over the course of the treatment regimen and became very severe. That rapid progression was the reason for treatment termination.

Extensive speech, language, neuropsychological, and clinical neurological evaluations were conducted from the fourth to the eighth month postonset of symptoms. A summary of these findings is presented in Table 1.

The general conclusion from the extensive battery of tests was that GP presented with a mild linguistic processing deficit that was not generalized to other domains of knowledge and processing. Among the language and communication measures administered during the initial evaluations was the Porch Index of Communicative Ability (PICA; Porch, 1981). His overall performance on the PICA was at the 90th percentile compared to subjects with aphasia, and his overall profile was consistent with the diagnosis of aphasia using discriminant analysis (Brauer, McNeil, Duffy, Keith, & Collins, 1988). Oral sentence formulation, reading, and noun sentence completion were the areas of most disparate performance compared to normal subjects. His overall performance on the Revised Token Test (RTT; McNeil and Prescott, 1978) was at the 94th percentile compared to aphasic subjects. Performance on both tests was outside of the performance range of subjects without brain damage. GP was also administered the Western Aphasia Battery (WAB; Kertesz, 1982). Performance on this measure is summarized in Table 1. His performance on the WAB was within normal levels; however, his self-reported symptoms and his signs evidenced on other measures were not revealed by this instrument.

Given the progressive nature of his impairments, the differential diagnosis of dementia was of prime concern. A variety of nonlinguistic measures and measures sensitive to dementia were administered and are summarized in Table 1. Initial performance on the Coloured Progressive Matrices (CPM; Raven, 1965) was 24 out of 36, a performance within the normal range for individuals at his age. His performance on such tests as the Test of Facial Recognition (Benton, Van Allen, Hamsher, & Levin, 1978), the Pyramids and Palm Trees Test (Howard & Franklin, 1988), the Rey Figure Tests (Rey, 1964), the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), and the Story Retelling subtest of the Arizona Battery for Communication Disorders of Dementia (Bayles & Tomoeda, 1991) were also interpreted as supportive of the diagnosis of PPA and as a lack of evidence for a more general cognitive impairment and dementia.

Treatment Design

A hybrid single-subject experimental design with components of multiple-baseline, multiple-probe, incomplete-principal, and withdrawal designs was developed in order to evaluate the differential effects of behavioral and pharmacological treatment on the subject's lexical-semantic performance. In this design, several baseline sessions were devoted to the assessment of GP's performance on several lists of potential treatment targets and to the assessment of his performance on several standardized speech and language tests and connected speech samples. Potential treatment lists were baselined or periodically probed throughout the 5-month course of the treatment.

It should be noted that nouns are conspicuously absent from the lists that were probed or treated. Although nouns were initially baselined, the specific lists that were constructed were apparently too easy for this subject as they were all above treatment criteria, and thus were not included as potential treatment candidates or as baselines from which other treatment effects could be judged. The reconstruction and baselining of additional noun lists would have delayed the initiation of treatment and was judged to be less important to the study and the judgment of the treatments effects than the timely institution of the treatment.

Treatment

At the ninth month postonset, a regimen of treatment was initiated whereby GP received individual language treatment for approximately 3 hours per week, extended over a period of approximately 5 months (31 total treatment sessions). A 3-week period of treatment withdrawal occurred between sessions 21 and 41, a time about midpoint in the treatment regimen. Each treatment session lasted approximately 2 hours, with one hour devoted to the collection of baseline, treatment probe, and standardized probe measures, and one devoted to administering the treatment. Probe data were collected for several lists of adjectives, verbs, and prepositions elicited as both antonyms and synonyms. Separate stimuli were used for all antonym and synonym lists.

Each treatment trial consisted of orally presenting GP with a series of lexical items from a relatively homogeneous list of 10 predicative adjectives[1] and asking him to vocally produce either antonyms or synonyms for the word or phrase. (See Appendix A for means and standard deviations of word length and frequency of usage for each treatment and probe list.) When failure to produce the correct antonym or synonym occurred, a cuing hierarchy based on the work of Linebaugh (1990) was used in an attempt to evoke the correct answer. An example of the hierarchy for one treatment item is presented in Table 2. Linebaugh's cuing hierarchy is based on the idea that internally generated cues result in better maintainence of skills than do external cues. The instruction for the antonym lists was to "give a word that means the opposite of...." The instruction for the synonym lists was to "give a word that means the same as...." A correct answer was always elicited at some point in the hierarchy and verbally reinforced. Each response was scored as immediately accurate or accurate with a 5-second delay. Each list was generally practiced only once per treatment session. Previously treated lists were re-treated when maintenance of the achieved performance dropped below the 90% criterion.

The general structure of the single subject design used in this study is illustrated in Figure 1. This figure also summarizes the subject's performance for treated

[1]Predicative adjectives were used because they have obvious antonyms and have representation in both the subject noun phrase and the predicate of a sentence. Levi (1978), specifies that predicate adjectives derive from an intermediate structure level of language in which differentiation of the predicate and argument of the logical structure occurs. It is hypothesized that generalization to verbs occurred because of the relationship between predicate adjectives and other sentential elements.

TABLE 2. Modified Linebaugh cuing hierarchy (example: antonym for *big*).

Description:	"This describes decreased size."
Gesture:	Clinician moves hands together.
Sentence Completion:	"An elephant is big, a mouse is...."
Written word recognition (from two foils):	"Big, narrow, small."
Sentence completion with initial phoneme:	"An adult is big, a child is s...."
Word repetition:	"Small."

adjective lists 1 and 2, untreated adjective list 3, untreated verb list 1, and untreated preposition lists 1 and 2, respectively. The shaded horizontal areas indicate the range of baseline scores for each panel. Data points outside of this range represent performance that exceeded baseline levels (either above or below). The vertical lines indicate baseline, behavioral treatment with and without dextroamphetamine, withdrawal, and maintenance phases as labeled across the top of the figure. The dotted line on each panel at 90% represents the criterion level (90% accurate for delayed responses for three consecutive treatments) for treating the next list. The thick vertical and horizontal lines on panels 1 and 2 represent treatment initiation and termination for adjective lists 1 and 2. Each number at the bottom of the figure represents two calendar days (32 baseline, 160 treatment, and 110 maintenance).

The pharmaceutical agent used in combination with the behavioral treatment was dextroamphetamine. It was administered in divided doses beginning with 2.5 mg twice per day for 4 or 5 days, escalating by 2.5 mg over the same time period to a maximum daily dosage (7.5 mg twice per day) of 15 mg. Doses were scheduled to peak during treatment periods and were taken only during the periods of treatment labeled in the figures as "Beh. + Pharm. Tx." Behavioral treatment always accompanied dextroamphetamine because previous research with dextroamphetamine alone has failed to show a positive effect for aphasia and other neurological disorders. In addition, positive effects of dextroamphetamine have been shown in animals and humans but only in conjunction with behavioral interventions (Small, 1994).

Results

Two judges, uninvolved in this investigation, who were highly knowledgeable about single-subject design and the analysis of single-subject experimental data served as judges for this study. Both judges had previously published single-subject experimental design studies and had taught graduate-level coursework on single-subject experimental design. Judges were asked to evaluate, by visual inspection, the four figures (1 through 4) to determine whether a treatment, generalization, or maintenance effect had or had not occurred for all treated and untreated lists and probe measures. Judges were asked to make their binary judgments subjectively at a 95% confidence level. Only results on which both judges agreed are reported here as a treatment, generalization, maintenance effect or as no effect. Treatment, probe, and standardized test results are summarized in Figures 1, 2, 3, and 4. Antonym and synonym lists were always treated in the same sessions. The first antonym adjective list in Figure 1 received treatment until session 59, at which time the second adjective list began receiving treatment. No other antonym list of adjectives, verbs, or prepositions received treatment. All other lists were, however, continuously baselined in order to reveal either a general performance increase (in which case performance change could *not* be attributed to either the behavioral treatment or the combined effects of the behavioral treatment plus the dextroamphetamine) or a systematic generalization of treatment to untreated stimuli (which reveals an effect that can be attributed to the intervention and not to any number of other possible explanations for improved performance).

Inspection of the data for the antonym task presented in Figure 1 reveals a pattern of performance that increased beyond baseline variability in both magnitude and slope with the institution of the behavior + pharmacology treatment. When the criterion was met, treatment applied to adjective list 2 yielded immediate improvement beyond baseline levels. It should be noted that although treatment was initiated in the behavioral + pharmacology phase for list 1, treatment was initiated for list 2 during the behavioral only treatment phase with essentially equivalent results. The positive treatment effect achieved for adjective list 2 was judged to have generalized to adjective list 3. In addition, generalization was judged to have occurred across word class to verbs and prepositions from the treatment of adjective list 1. No clear differential trend for increased generalization to untreated lists was shown for behavioral + pharmacology treatment phases compared to the behavioral treatment phases alone. The stability of preposition list 2 offers a measure of control for judging both treatment and generalization effects for the adjective lists. Maintenance was initially high (for approximately 1 month) for all treated and probe lists for which generalization was shown; however, performance declined to levels within or approaching baselines at approximately 3-1/2 months after treatment termination.

The judges' evaluations revealed, and inspection of Figure 2 (synonym task) shows, that adjective list 1 performance increased sharply beyond baseline levels during the behavioral + pharmacological treatment phase after three treatment sessions. Adjective list 1 for the synonyms never reached criterion and was treated continuously until treatment was terminated. Generalization to untreated verbs followed the response to treatment of the adjective list. Generalization to the preposition list was apparent but lagged in time relative to the initiation of treatment. Baselines for adjective lists were initiated during the withdrawal phase for list 2 and during a behavioral-only treatment phase for list 3. Generalization was judged to have been achieved for both adjective lists during the final behavioral + pharmacology treatment phase. Generalization was *not* judged to be consistently greater during behavioral + pharmacology than behavior treatment only phases. Criterion was not met prior to treatment termination, hence only adjective list 1 received treatment for the synonym task. Maintenance was poorer for the synonym than the antonym treatment, although performance levels were all above baseline levels.

Figure 3 summarizes five standardized speech and language measures that were periodically probed throughout the course of the baseline, treatment, and maintenance phases of the treatment regimen. Panel 1 plots the overall and verbal percentile scores on the PICA (Porch, 1981). Overall scores showed a decrement beyond baseline levels throughout the course of the treatment. These scores continued to decline substantively during the maintenance phase. The verbal percentile scores sagged marginally below baseline levels until treatment was terminated, at which time they also dropped substantively. Panel 2 shows overall RTT (McNeil & Prescott, 1978) percentile scores that closely parallel the decline of the PICA overall scores. Of particular importance to the diagnosis and general interpretation of this subject's impairment is the percentage of total correct for the CPM (Raven, 1965). As can be seen in Panel 3, performance was high and did not vary from baseline levels throughout the course of the treatment and across the maintenance phase. GP did not show a general decline in cognitive behaviors despite a rather systematic decline in language performance. Panel 4 displays a hierarchy of times (seconds) for correct names produced on the Rapid Automatized Naming Test (RAN; Denckla & Rudel, 1976), with a rather small but systematic decline (increase in time) across all word classes until the latter stage of the maintenance phase. At this later time, performance decreased dramatically (from about 60 seconds during baseline for the combination naming condition to about 225 seconds during the final maintenance measure). Panel 5 shows a systematic and substantive drop in

FIGURE 1. Antonym treatment (adjective lists 1 & 2) and probe data (adjective list 3, verb list 1 and preposition lists 1 & 2) for subject GP across the course of the treatment regimen.

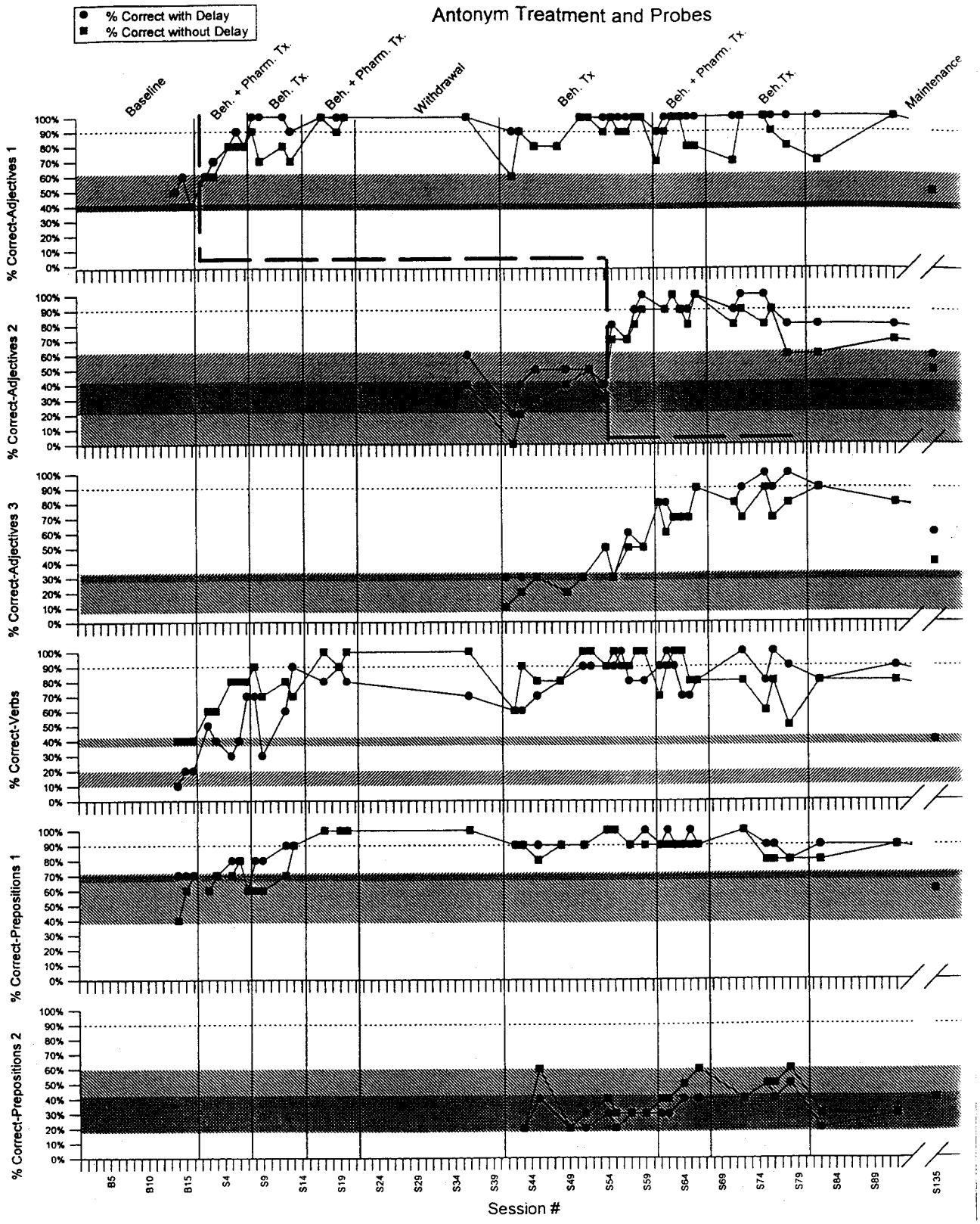


FIGURE 2. Synonym treatment (adjective list 1) and probe data (adjective lists 2&3, verb list 1, and preposition list 1) for subject GP across the course of the treatment regimen.

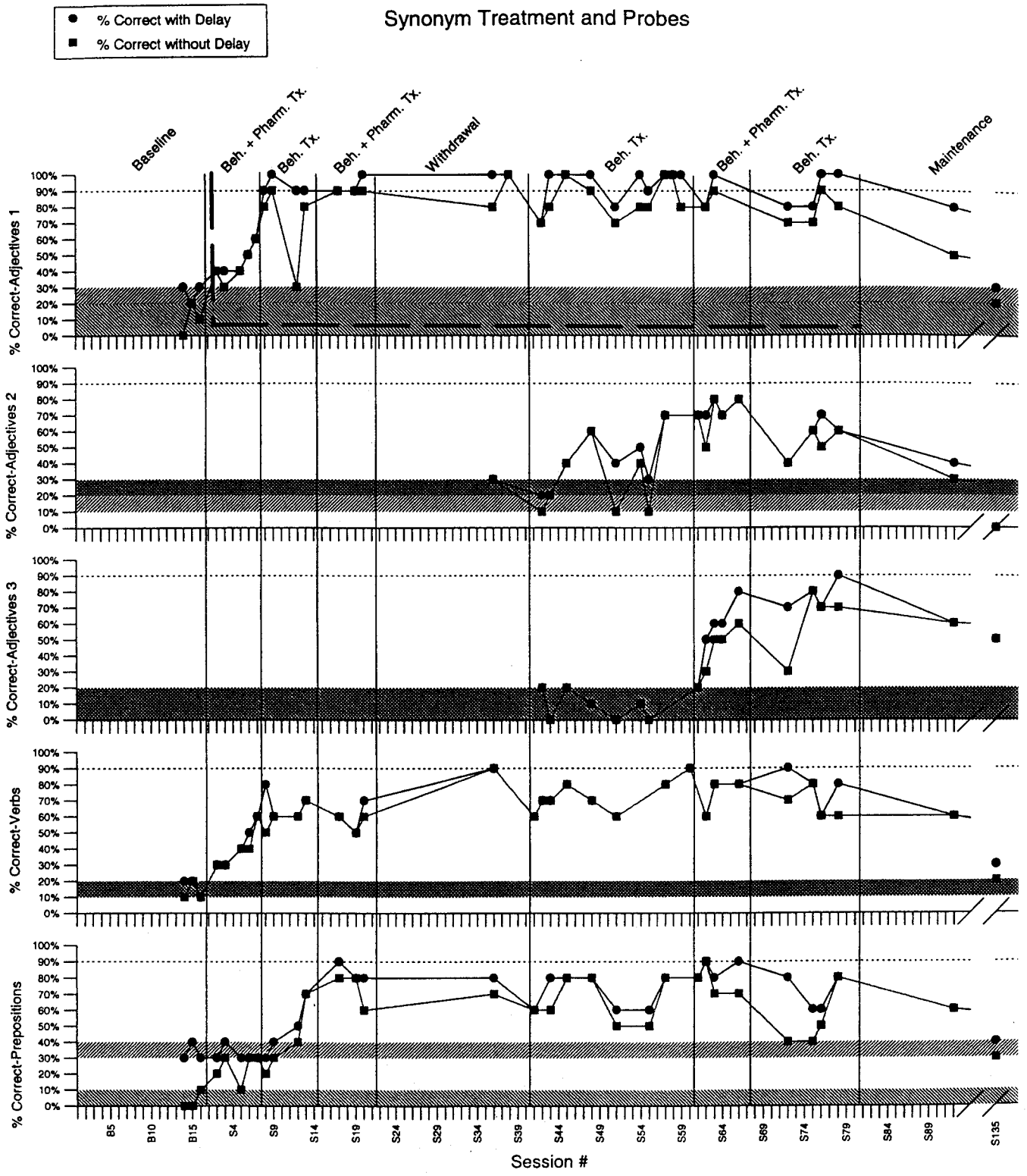


FIGURE 3. Subject GP's probed performance on the Porch Index of Communicative Ability (PICA), the Revised Token Test (RTT), the Coloured Progressive Matrix (CPM), the Rapid Automatized Naming Test (RAN), and a measure of diadochokinesis (DDK) across the course of the treatment regimen.

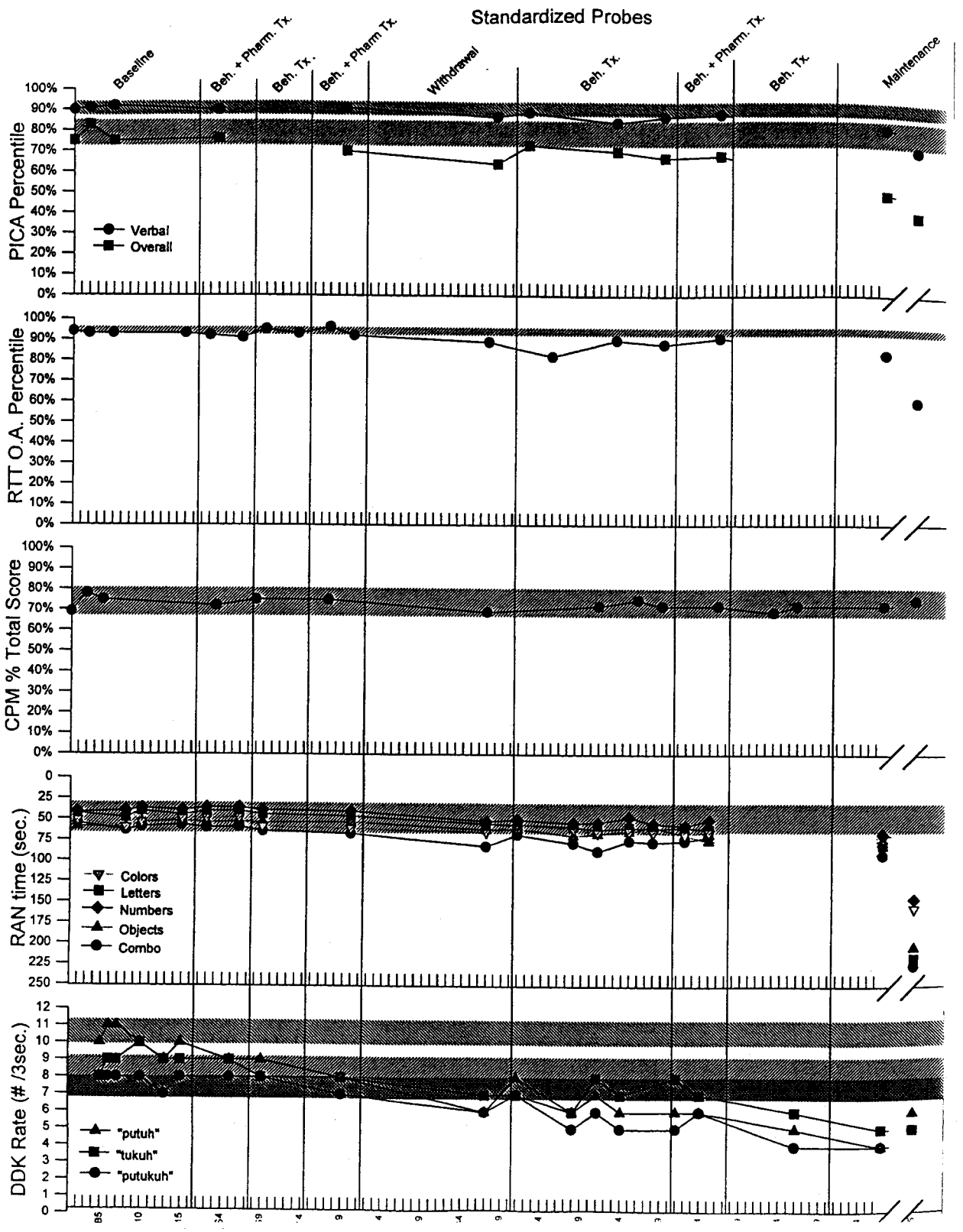
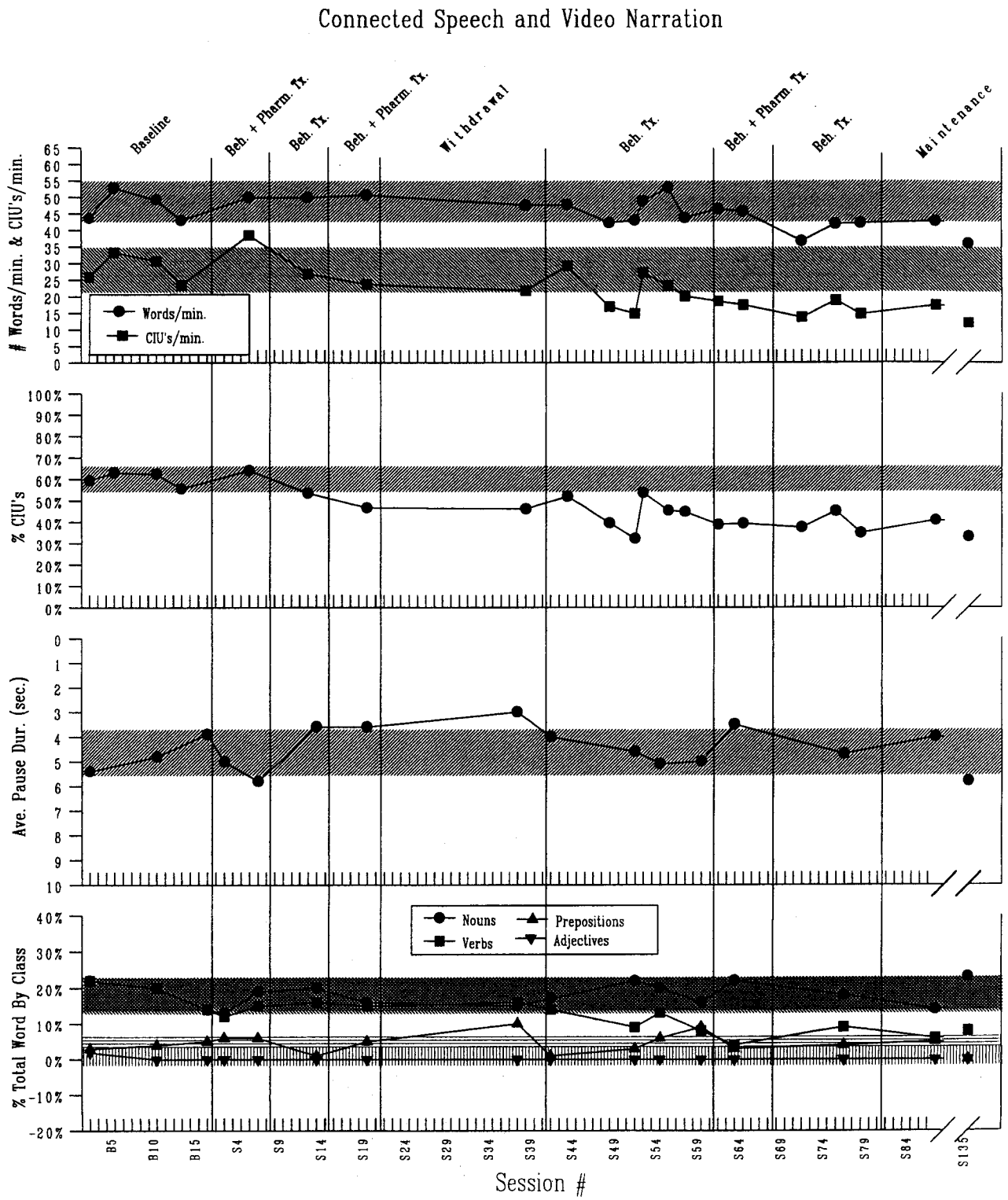


FIGURE 4. Subject GP's probed performance on a standardized narrative discourse test [panels 1 (number of words/min. and CIUs/min.) and 2 (percentage of CIUs)] and on a standardized video narration task [panels 3 (average pause duration) and 4 (number of words by class)] across the course of the treatment regimen.



diadochokinetic speech across the course of the treatment and maintenance phases of the study that exceeded dramatically the baseline levels for each task.

Figure 4 summarizes several measures of connected speech elicited from three pictured descriptions (cookie theft, cat and man in tree, farmer giving directions) and two procedural narratives (washing dishes and writing a letter) (Nicholas & Brookshire, 1993). In addition, a video narration task, consisting of an animated cartoon in which a shark pursues a smaller fish, was used as the stimulus for a connected speech sample (Dollaghan, Campbell, & Tomlin, 1990). These measures were probed throughout the course of the study. Performance showed a general decline that exceeded baseline levels across the course of the study for the number of words per minute (words/min.) and correct information units per minute (CIUs/min.), the percentage of CIUs, and percentage of total words by class used in the video narration task. Only the average pause duration (in seconds) and the percentage of nouns produced remained relatively stable and within baseline ranges across all phases of the study. The percentage of adjectives produced did not change from baseline levels; however, they occurred so infrequently that they were near the floor throughout the study.

It should be noted that GP almost never progressed through all phases of the cuing hierarchy to the point where a stimulus repetition was required. For example, in the first month of treatment, a stimulus repetition was required on 4 occasions, but in the following months it was never necessary to cue target productions. A reduction in the frequency of other cue levels was also noted during the course of treatment. Therefore, the treatment task was not one of a simple stimulus-response conditioning paradigm. The hierarchy was designed to facilitate the active retrieval of specific lexical items, with the activation and inhibition processes controlled and strategically engaged.

Discussion

The purpose of this study was to investigate the effects of pharmacological plus behavioral treatment on the lexical-semantic deficit of one individual with PPA. Results revealed a pattern of performance that increased beyond baseline variability in both magnitude and slope that coincided in time with the institution of treatment for both the pharmacological + behavioral treatment phase and the behavioral treatment alone phase for both the antonym and synonym adjective lists that received treatment. Generalization of these treatment effects occurred for other lists of adjectives, as well as across word class to verbs and prepositions.

The answer to the first question—whether the language deficit found in this individual with PPA was amenable to treatment—can be answered with a qualified yes. The qualification is necessary and dependent on the answer to the second research question and on the definition of treatment to which one adheres. If the judgment of a positive treatment effect is dependent on the presence of generalization (research question number 2), then this study could be judged as positive. If the extent of generalization requires effects that reach the discourse level, then this study might be judged as negative. In addition, a qualification is necessary, as with all single subject experimental designs, because generalization to any other individual with PPA cannot be made based on these data alone. It can be concluded, however, that it was possible to improve the lexical production abilities in this individual and that it was possible to maintain and even improve language and communication performance beyond that which would occur with the progression that is a result of the natural course of the disease. The improved performance on the treated behaviors and the generalization to similar behaviors that occurred simultaneous with other declining language and communicative behaviors argues persuasively for a rather potent treatment effect. This effect was potent in the sense that it occurred in spite of neuroanatomic and neurophysiologic changes that were ultimately responsible for the progression of the aphasic signs and symptoms. The treatment was not so robust, however, that it prevented or disguised the progression to more general or complex language or communicative behaviors (e.g., connected speech production or auditory processing). It is interesting to speculate that the relatively stable performance on naming as measured by the RAN during the course of treatment, with the large increase in naming time following the treatment, may have been buoyed by the treatment. Without additional measures or treatment trials applied to these behaviors, it is, of course, impossible to determine if this observation reflects the natural course of the disease or the interaction of the disease with the positive effects of the treatment.

The third question proved difficult to answer given the progressive nature of the disorder and the positive effects of the treatment that were realized. The judges both agreed that the treated and generalization behaviors were maintained. However, given the general pattern of initially maintained performance immediately following treatment for the treated and generalization lists as well as on the probed measures followed by a general precipitous decline in performance on the second maintenance probe for all measures, it appears that a maintenance effect was not convincingly demonstrated.

The final research question asked if there was evidence for a differential contribution to the positive treatment effects from the pharmacological and the behavioral components. There appeared to the investigators to be a greater generalization effect under the pharmacological + behavioral treatment conditions than under the behavioral treatment conditions alone. However, this differential effect was not found at the 95% confidence level on the treated or generalization lists for either the antonyms or the synonyms lists.

Other questions, though not formally posed as research questions, relate to the mechanisms to which one can attribute the observed positive therapeutic changes. There are several models of lexical retrieval (e.g., Stemberger, 1985), and several psycholinguistic factors affecting these models. These include phonological, word frequency, word length, and grammatical form or class (Linebaugh, 1990; Williams and Canter, 1987). Each of these mechanisms produces common errors that result in limited accessibility to certain lexical entries, variations of target productions (i.e., semantic paraphasia), increased response latencies, and extended interword pausing (Linebaugh, 1990). The treatment data from this investigation do not argue selectively for any of them. This study is, however, based firmly on the assumption that the deficit in aphasia in general is not one of a lost or even altered representation and that an accessing deficit, formalized best as an activation/inhibition deficit, accounts for this patient's dysnomia. The nature of the lexical deficit in this patient is not believed to be at the phonological level, but rather at the lexical-semantic activation/inhibition level. This is based on the apparent high level of performance of GP's phonological system evidenced by the lack of phonological paraphasias in his speech and on his performance on tasks that stress phonological processing (e.g., reading nonwords). At the inception of treatment, GP's errors were most frequently characterized by delayed accurate or inaccurate but semantically related responses. Unrelated responses were produced less frequently. At the termination of treatment, GP's responses to treated items were typically accurate; however, responses to untreated probe lists were primarily characterized by accurate

or accurate but delayed responses, morphological opposites (i.e., adding the prefix "un" before the target word), unrelated responses, and a large proportion of "I don't know" responses. In general, we interpret GP's error responses to be most consistent with a delay or failure of activation to reach an adequate level in intact neuronal representations.

The literature almost exclusively discusses naming performance and the treatment of dysnomia and "word finding" in relation to nouns and verbs (Le Dorze, Boulay, Gaudreau, & Brassard, 1994; Williams & Canter, 1987; Zingeser & Berndt, 1990). Discussion of lexical retrieval in relation to other grammatical classes is considerably less frequent. Williams and Canter (1987) propose that the perceptual information that occurs with nouns provides other avenues of access and may suggest a more "redundant representation" than occurs with verbs. It is our view that both the semantic organization of adjectives, as proposed by Gross, Fischer, and Miller (1989), and the specific derivational qualities of predicative adjectives (Levi, 1978), as used in this investigation, provide the motivation for their use to facilitate lexical access across word classes. We hypothesize that the mechanism responsible for the improvement on treated adjective lists and on the untreated generalization lists is the directed and efficient spread of activation. This activation was facilitated by both the cuing hierarchy and the intense practice which helped to make the task of lexical retrieval more automatic, as indicated by faster and more accurate responding.

The final interpretation of this study requires several caveats. First, some potential treatment lists were baselined during the course of treating other lists. The lack of a continuous baseline for all lists makes the interpretation of both the treated lists and the generalization lists more difficult, though not impossible. Second, differences in the effects of treatment were noted in the lists of preposition stimuli. Whereas one list of untreated prepositions did not change, another untreated list of prepositions did improve. It is hypothesized that the unchanged list may have consisted of prepositions representing more abstract concepts, or that were less operative or less visualizable than those in the other list. Without the demonstration that this list was amenable to the same treatment procedures as the other lists, the use of this list as the stable baseline from which other treatment effects were judged remains tentative. A third caveat concerns the termination of noun baselining before all treatment phases were completed. While the noun lists had consistently high accuracy rates throughout the duration of the baseline phase, early termination of these potential treatment/generalization lists weakens the experimental control and generalizability of this study. A final caveat involves the lack of a return to baseline, or even a diminution of performance during the withdrawal phase of the study. This observed maintenance of the treatment gains does not allow the withdrawal phase to serve as a control for the interpretation of either treatment or generalization effects.

Further studies might consider priming tasks as dependent measures in order to assess the contribution of the mechanism of activation for improvement in lexical-semantic retrieval. In addition, the relative effects of the treatment could be more readily established if used with an individual presenting with a more stable language impairment as opposed to the deteriorating skills that were exhibited in this subject with PPA. Finally, the experimental design, whereby behavioral treatment always accompanied the administration of the dextroamphetamine was weak relative to its ability to help differentiate the contributions of the two treatments. Future designs will need to separate the behavioral from the pharmacological effects and these from placebo effects.

Acknowledgments

The authors acknowledge the extensive suggestions by reviewers Patrick Doyle and Linda Nicholas. Appreciation is also gratefully acknowledged for the extensive help of Thomas F. Campbell, Joseph R. Duffy, and Sheila R. Pratt.

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Key Words: progressive aphasia, pharmacotherapy, adjective naming, lexical-semantic, treatment

Appendix A

Word Frequency and Word Length for All Treated and Probe Lists

List Type	List Number	Word Frequency (per 1,014,232 words) Mean	Word Frequency (per 1,014,232 words) Standard Deviation	Word Length (syllables) Mean
Antonym Adjective	1	210.8	212.6	1.1
Antonym Adjective	2	219.8	344.8	1.6
Antonym Adjective	3	106.5	180.8	1.5
Antonym Adjective	4	103.0	151.1	1.5
Antonym Verb	1	198.5	239.7	1.7
Antonym Verb	2	97.8	90.2	1.7
Antonym Verb	3	62.7	47.1	1.7
Antonym Preposition	1	1849.9	2794.7	1.8
Antonym Preposition	2	320.0	376.4	1.5
Antonym Adverb	1	256.4	323.2	2.4
Synonym Adjective	1	83.7	162.9	1.7
Synonym Adjective	2	95.4	139.6	1.6
Synonym Adjective	3	26.1	30.1	2.6
Synonym Adjective	4	33.9	48.5	2.3
Synonym Verb	1	40.5	45.0	1.4
Synonym Verb	2	83.2	176.7	1.7
Synonym Verb	3	35.1	57.1	2.1
Synonym Preposition	1	198.4	295.3	2.4
Synonym Preposition	2	66.2	96.2	3.6