

POSTER SESSION 3

1. Increase in Lesion Size on CT Scan in Chronic Aphasia Patients with Improved Naming Ability

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This research project examined any changes in the borders of the low density area (lesion size) on CT scan together with patterns of long-term recovery in aphasia, by following stroke patients out to 5 or 10 years poststroke. Studies which detail histological changes associated with stroke evolution have been limited to the first 4 to 8 weeks poststroke (Adams & Sidman, 1986; Garcia, Ho, & Caccamo, 1992; Chuaqui & Tapia, 1993; Brierly & Graham, 1984; Brierly & Brown, 1982; Garcia & Kamujyo, 1974). We have recently had the opportunity to examine the CT scans and language behavior of 12 aphasia patients at 5 to 12 years poststroke. The same patients had also been studied in our CT/MRI Scan Aphasia Research Laboratory during the first year of their stroke, in 1981 to 1988.

We examined CT scans and language behavior obtained at Time 1 (2 months to 1 year poststroke) and at Time 2 (5 years to 12 years poststroke). Twelve patients who had suffered only one left hemisphere stroke participated in the study. Etiology was nonhemorrhagic in 11 cases and a ruptured arteriovenous malformation in 1 case. There were 11 men and 1 woman who were ages 51 to 71 years at stroke. There were 9 nonfluent aphasia patients (Broca's or global aphasia) and 3 fluent aphasia patients (Wernicke's or conduction aphasia).

Methods. The purpose of this study was twofold: (1) to measure any changes in lesion size which may be present on CT scan in chronic aphasia patients between Time 1 and Time 2 and (2) to study these potential changes in relationship to long-term recovery in aphasia, as measured by picture naming, auditory comprehension, and word repetition. The Time 1 and Time 2 CT scans were analyzed using a program developed by

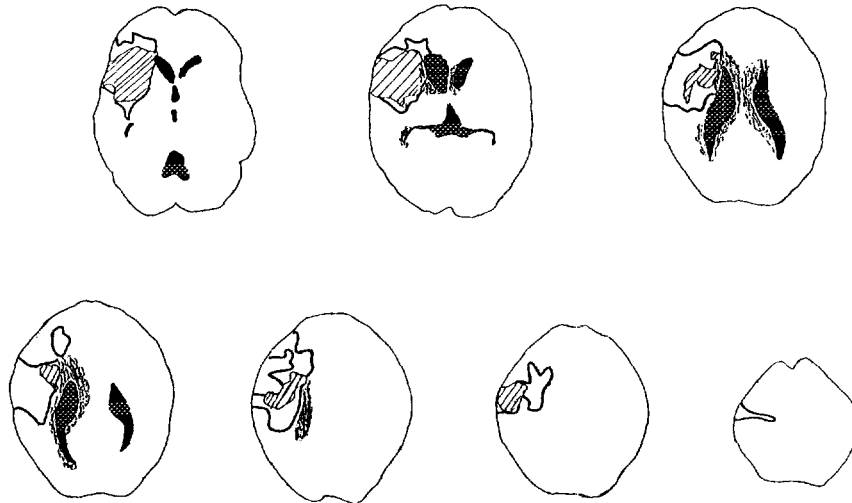


FIG. 23. CT scan diagram showing expansion of lesion in the white matter after 6 years following stroke onset in a 63-year-old male aphasic patient. At 4 MPO the lesion size was 4.6%; at 6 years postonset the lesion size was 9.6%. Thus, there was a 5% increase in lesion size over the 6-year period. There was no second CVA reported by physicians or family. The patient's Visual Confrontation Naming ability on the BDAE continued to improve: 4 MPO = 39; 14 MPO = 50; 6 year = 72 out of a maximum possible score of 114. ▨, Lesion at 4 MPO; □, Lesion at 75 MPO; ■, Ventricles at 4 MPO; ▩, Ventricles at 75 MPO.

the National Institutes of Health (Image, version 1.41). A MacTablet Summagraphics board interfaced with a Macintosh IIsx computer was used to trace both the lesion and the inner table of the skull on each slice of the CT scans. The percent lesion size was determined by dividing the size of the lesion by the size of the inner table of the skull (brain size).

Language behavior was assessed by a speech pathologist using the Boston Diagnostic Aphasia Exam (BDAE) (Goodglass & Kaplan, 1983). All patients were administered the Visual Confrontation Naming subtest, the Auditory Comprehension portion of the BDAE which includes four subtests (Word Discrimination, Body Part Identification, Commands, and Complex Ideational Material), and Single Word Repetition.

Results. A significant increase in percent lesion size on the CT scans was observed between Time 1 and Time 2 (+2.56%; SD, 1.73; $p < .0003$; $n = 12$). The increase in lesion size was obvious, even with only visual inspection of the Time 1 CT scan and the Time 2 CT scan. (See example of lesion size change on CT scan in Fig. 23). Not one patient was reported to have had a second stroke or second "episode" before this Time 2 period. None of these 12 patients had presented with increased neurologi-

cal problems following the first year of stroke. Neither the physician nor the spouse had suspected an increase in the borders of the lesion over this long time interval. The expanded lesion boundaries were located primarily in white matter, especially near the lateral ventricle.

As was reported by Fitzpatrick, Glosser, and Helm-Estabrooks (1988), these patients continued to *improve* in their ability to name pictures. There was a significant increase in naming ability from Time 1 to Time 2 (mean +23.2 words; SD, 19.8; $p < .0019$). There were no significant differences between Time 1 and Time 2 for any of the other subtests of the BDAE that were administered (i.e., Overall Auditory Comprehension z-score, Word Discrimination, Body Part Identification, Commands, Complex Ideational Material, or Single Word Repetition).

Conclusions. These results bring into question the "stability" of the CT image of an area of infarction in chronic stroke patients. The mechanisms underlying the apparent increase in expansion of the low density area (lesion size) are not understood at this time. Possible mechanisms include Wallerian degeneration and chronic hypoperfusion.

These findings suggest that the ability to name pictures is diffusely represented in the brain and that despite changes on the CT scan which suggest increasing lesion size over time, the brain can continue to reorganize and recover new abilities in naming over long periods of time poststroke.

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2. Transient Arithmetic Fact Retrieval Deficits during Cortical Stimulation

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Abstract. Studies of brain-damaged patients have revealed several functionally autonomous numerical processes, yet little is known about their anatomical correlates or the relation of numerical processing deficits to general language-processing abilities. In this single case study, cortical stimulation was used as a method of producing transient deficits of a highly circumscribed area of the cortex. No significant impairments were found in unstimulated testing of arithmetic fact retrieval, numeral processing, or general language abilities. However, stimulation of a specific electrode produced transient arithmetic fact retrieval deficits. Stimulation of the same electrode pair produced no comparable impairments of numeral comprehension, numeral production, or general language abilities. The specificity of the transient deficit is consistent with the notion that focal areas of the anterior parietal cortex are implicated in the retrieval of arithmetic facts and that arithmetic fact retrieval mechanisms are functionally distinct from numeral processing and general language mechanisms.

Introduction. In order to perform a simple calculation, several cognitive processes are required, including comprehension of the problem (e.g., 5×4), retrieval of the arithmetic fact, and production of the answer (McCloskey, 1992). Studies of brain-damaged patients have revealed that each of the processes above comprises a functionally autonomous component within the numerical processing system (Warrington, 1982). However, much less is known about the anatomical correlates of these processes (Kahn & Whitaker, 1991). Clearer lesion/deficit correlations may emerge if both the functional deficit is characterized within a motivated theoretical model and better techniques are employed to localize the anatomical correlates of the deficit.

We present a case study of a patient with electrode grids surgically implanted on the surface of the cortex. Cortical stimulation was used as a method of producing transient impairments of focal areas of the cortex. In contrast to the highly accurate performance before stimulation, the patient experienced transient impairments in retrieving arithmetic facts while cortical stimulation was applied to a specific region of the parietal lobe.

Case study. Patient P.H. is a 16-year-old left-handed male who started to experience seizures in 1986 at age 9. At that time, a tumor was discovered in the left parasagittal parietal lobe, and he underwent surgery to excise the tumor. In 1993, the subject was reevaluated when seizures reappeared. MRI revealed a mass effect consistent with recurrence of the tumor.

General language abilities were found to be within normal limits. The WISC-R revealed a verbal IQ of 103 and a performance IQ of 91, for a full-scale score of 97.

Tests of numerical processing revealed intact performance in transcoding numerals from one form to another (e.g., 43 → forty-three) and speeded single digit multiplication and addition. On tests of numeral transcoding, P.H. responded correctly for 119/120 (99%) trials. Speeded multiplication and addition were performed accurately and quickly. When asked to respond with a spoken response to an Arabic stimulus, P.H. responded correctly to 246/250 (98%) multiplication problems and 45/45 addition problems. Average reaction times were 1644 and 1562 msec, respectively, considerably faster than expected if P.H. were using a non-retrieval strategy (e.g., solving 8×7 by adding seven 8's) to arrival at the answer (Ashcraft, 1982).

Procedure. For clinical purposes, subdural arrays of electrodes were surgically placed on the surface of the cortex. In this patient 2×8 arrays of electrodes were implanted in the frontal and parietal regions. The electrode grids allowed for electrical stimulation of up to 15 mA between two adjacent electrodes (stimulation could be repeated at the same site several times). Trials in which stimulation was applied were intermixed with control trials using the same task, and the subject was typically unaware if stimulation was being applied. At each electrode pair site, P.H. performed several screening tests while stimulation was administered—including motor tasks, word reading, responding to commands, and speeded single-digit multiplication. Multiplication problems were presented visually, and P.H. said the answers aloud.

If P.H. was impaired at multiplication while cortical stimulation was applied to a particular site, additional tasks were administered to determine the locus of the impairment: arabic numeral comprehension, arithmetic fact retrieval, or spoken numeral production.

Results. At 31 of the 32 electrode pair locations, cortical stimulation produced no impairment in multiplication. However, P.H.'s ability to perform multiplication was impaired by cortical stimulation to an electrode pair located in the anterior parietal region (AP18-26), whether the response required was verbal or typed (using a numerical keypad). Further investigation of this site revealed no comparable impairments during stimulation to tasks with similar numeral comprehension and production

TABLE 21

Response type	Stimulation	Number of problems	Number correct	Percent correct
Spoken	None	250	246	98%
	AP 18-26 site	63	17	27%
	All other sites	103	95	92%
Keypad	None	70	68	97%
	AP 18-26 site	22	14	63%

requirements, such as the spoken addition task. Tests of general language abilities during cortical stimulation to the identical site produced no impairments. Reported above (Table 21) are the number of correctly answered problems performed with stimulation to the anterior parietal site, other electrode pair sites, and control trials without stimulation.

Conclusion. Cortical stimulation applied to one specific electrode pair was found to significantly affect performance of arithmetic fact retrieval. During cortical stimulation of this electrode pair, P.H. was impaired at multiplication problems irrespective of whether the task was verbal answer production, typing the response. In contrast, no impairments of general language tasks were found. The specificity of the transient deficit is consistent with the notion that highly specific areas of the anterior parietal cortex play a vital role in the retrieval of arithmetic facts and that arithmetic facts are functionally distinct from numeral processing and general language mechanisms.

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3. Case Report: CT Scan Lesion Site and SPECT Scan rCBF in an Aphasia Patient with No Speech for 10 Years Poststroke

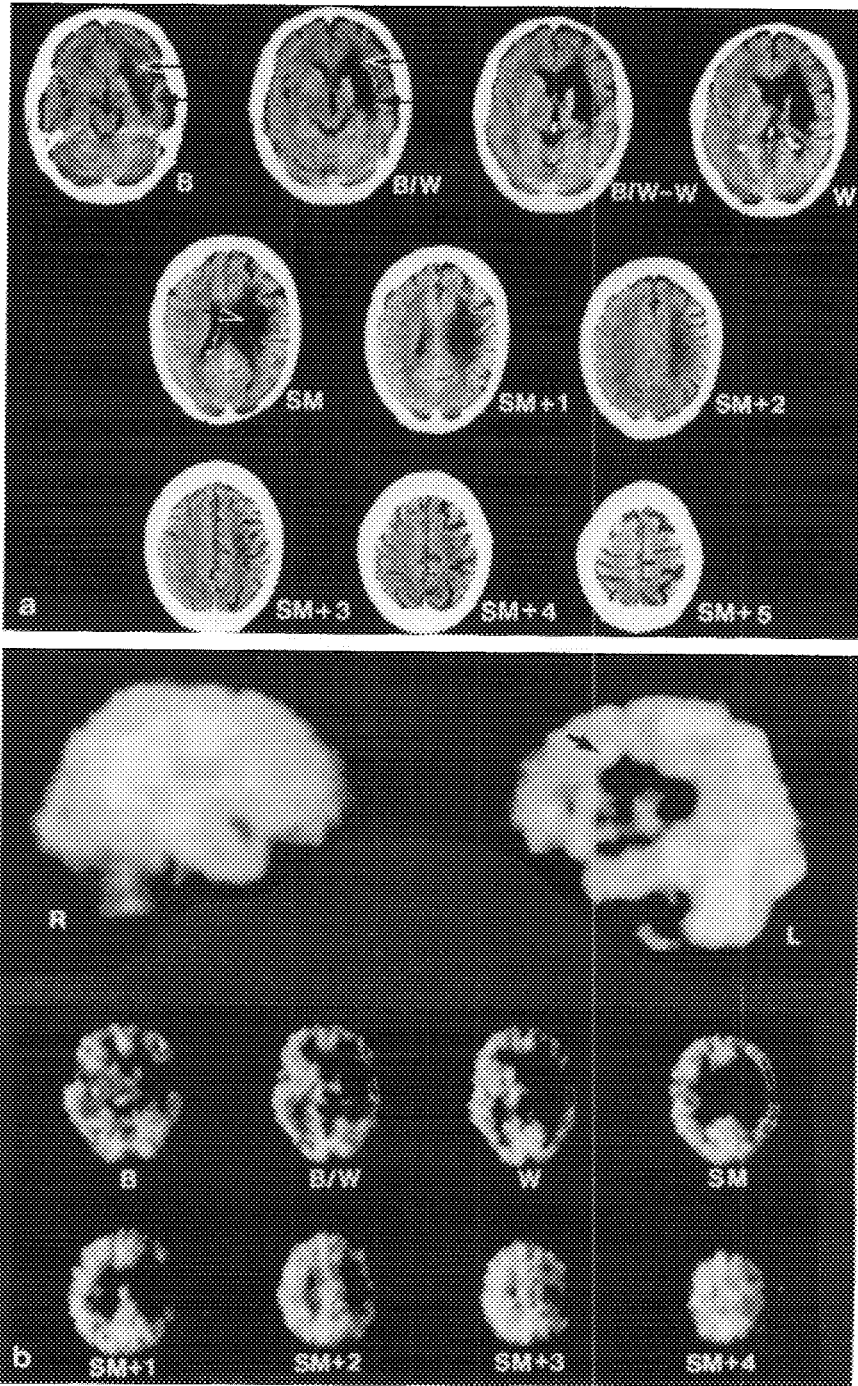
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This study used functional brain imaging (Single Photon Emission Computed Tomography—SPECT) to study an aphasia patient with subcortical lesion. The hypothesis was that SPECT imaging would reveal alterations in regional cerebral blood flow (rCBF) of *cortical* language areas in the wake of specific *subcortical* lesions associated with language deficits. This idea of decreased neuronal activity in morphologically intact brain remote from a lesion was first suggested in animal literature and is known as diaschisis (Monakow, 1914).

In 1989, we published the CT scan for a patient whose lesion was primarily *subcortical* and who had no recovery of meaningful spontaneous speech 9 months following left hemisphere stroke (Naeser, Palumbo, & Helm-Estabrooks, 1989). His speech output was limited to “yes, no” and a few short words. We hypothesized that it was probably the *cortical* pathways, disconnected by the *subcortical* white matter lesion, which ultimately produced the severe limitation in speech. We have now tested this patient, who still has had no recovery of spontaneous speech at 10 years poststroke, using SPECT to examine rCBF in cortical language areas.

CT and MRI scans were obtained for this patient at 10 years poststroke. Both scans showed primarily subcortical lesion to be present (some lesion was present in the insular cortex). Extensive lesion was present in the two subcortical white matter areas identified in our research to be associated with a lack of recovery of spontaneous speech (Naeser et al., 1989): (1) the *medial subcallosal fasciculus area*, located anterolateral to the left frontal horn, deep to Broca’s area (Fig. 24a, CT scan slices B and B/W, black & white arrow) and (2) the *middle 1/3 periventricular white matter (PVWM) area*, located deep to the left motor/sensory cortex area for mouth (Fig. 24a, CT scan slice SM). The cortical language areas were structurally intact. The patient also had lesion in the subcortical anterior



temporal isthmus area and a moderate comprehension deficit (Nielsen, 1946; Naeser, Gaddie, Palumbo, & Stiasny-Eder, 1990).

A resting SPECT scan was also obtained at 10 years poststroke for this patient. Despite structural lesion restricted primarily to *subcortical* areas as demonstrated by CT and MRI scans, the SPECT scan revealed not only a relative decrease of rCBF in the left subcortical structures, but in the left perisylvian *cortical* language areas as well (Fig. 24b). Quantitative analysis of the SPECT scan data revealed significant decrease of blood flow to specific left hemisphere cortical language regions of interest (ROI's), both anterior and posterior.

We suggest that the relative decrease of blood flow in the left *anterior* cortical language ROI's was related, at least in part, to subcortical lesion in the *middle 1/3 of the periventricular white matter area*, located deep to the motor/sensory cortex area for mouth. It is not possible with the current SPECT technology to isolate which specific intra- and interhemispheric white matter pathways are associated with the relative decrease of blood flow in specific cortical language ROI's in this case.

Regarding the relative decrease of blood flow in the left *posterior* cortical language ROI's, we suggest that this was related, at least in part, to subcortical lesion in the *anterior temporal isthmus area*, located deep to Wernicke's area. The anterior temporal isthmus area contains afferent projections from the ipsilateral medial geniculate nucleus to Heschl's gyrus (Nielsen, 1946). Thus, it is reasonable to presume that some temporal lobe afferent connections would be disrupted with a temporal isthmus lesion.

The findings in this case support results from previous functional imaging studies which have observed *cortical* hypoperfusion or decreased metabolic activity in association with *subcortical* lesion sites (Skyhoj-Olsen, Bruhn, & Oberg, 1986; Vallar, Perani, Cappa et al., 1988; Perani, Di Piero, Lucignani et al., 1988; Demeurisse, Capon, Verhas, & Attig, 1990; Metter, Riege, Hanson et al., 1983; Alexander, 1992). In this study we observed hypoperfusion in specific perisylvian cortical areas that may be associated, at least in part, with lesion in some specific subcortical white matter areas, as we had hypothesized in 1989 (Naeser et al., 1989). In addition, we have demonstrated the presence of cortical diaschisis in a patient 10 years following stroke where there was no recovery of spontaneous speech.

The implication of this study is that functional imaging (SPECT) in

FIG. 24. (a) CT scan obtained at 10 years poststroke showing left *subcortical* lesion for a 43-year-old aphasia patient with no speech. (b) Resting SPECT scan for same patient showing decreased blood flow in left *cortical* language areas. There was no recovery of speech, 10 years poststroke.

combination with CT or MRI can be used to explore, in greater detail than previously possible, connections between cortical language zones and subcortical white matter areas which comprise the neural networks that implement language functions (Mesulam, 1990).

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4. A Case of Ictal Aphasia with MRI, PET, and EEG Correlation

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A 50-year-old right-handed Black minister presented on November 3, 1993, with left-sided and generalized headaches of approximately 1 month duration and difficulty with expressive speech for 4 days. He had noted word-finding difficulty, occasional word substitutions, and he was unable to recall familiar telephone numbers. His wife stated, however, that he

had preached a well-received sermon the Sunday before, and he had also taped a television interview to commemorate Martin Luther King's birthday only 2 days earlier. He had seen a community physician who obtained a normal noncontrast head CT scan.

The past history was remarkable only for mild hyperlipidemia and a head injury 30 years before with prolonged loss of consciousness. He was on no medications.

The neurological examination showed an alert, cooperative man who had marked hesitancy in expressive speech. When asked the date he said "1960" but then wrote 1993. He could name none of a series of common objects, and he could not recall the President's name. Repetition was fluent, with only rare errors. He followed simple one- and two-step commands but had difficulty with more complex commands. He was nearly completely unable to read, either aloud or for meaning, and his attempt to write a sentence was indecipherable. He could not perform even simple calculations and recalled none of three words at 5 min. The remainder of the neurological and general physical examinations were entirely within normal limits. No fluctuations in the language deficit were noted.

The patient underwent an outpatient MRI scan, which showed increased T2 signal in a gyral pattern in the inferior, posterior temporal region. There was no enhancement with gadolinium. A 2-fluorodeoxyglucose PET scan showed marked hypermetabolism in the left posterior temporal cortex (Fig. 25), initially thought to be suspicious for a malignant tumor. An EEG, performed immediately after the PET study, showed nearly continuous spike and wave discharges arising from the

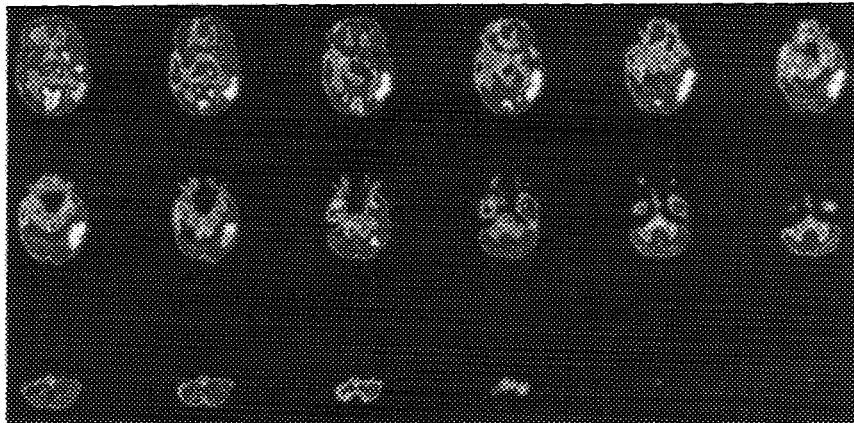


FIG. 25. Positron emission tomographic (PET) scan showing increased uptake of 2-fluorodeoxyglucose in the inferior, posterior left temporal region, consistent with hypermetabolism of this area.

left temporal region, and ictal aphasia was suspected. The EEG spike activity proved refractory to a loading dose of phenytoin and addition of carbamazepine but did eventually resolve after lorazepam and a therapeutic level of carbamazepine. A repeat PET scan then showed hypometabolism in the previously hypermetabolic area. Lumbar puncture and cerebral arteriography were entirely normal. The patient showed steady improvement in speech and language function after resolution of the EEG discharges, such that by the time of discharge on November 16 he had only mild speech hesitancy, difficulty naming, and slowed reading rate. He showed progressive improvement with outpatient speech therapy; the final Minnesota Test for Differential Diagnosis of Aphasia on January 26 was normal for expressive and receptive language performance, but there were spelling errors during writing tasks. Finally, a repeat MRI scan on December 1 showed nearly complete resolution of the increased T2 signal abnormality. The patient has had no further difficulty over 4 further months of follow-up on carbamazepine.

We present this patient as an example of prolonged ictal aphasia, or focal status epilepticus, in whom MRI, PET, and EEG correlations were all available during and after the ictus. The evidence favors a marked disruption of both expressive and receptive language functions, especially severe for naming and reading. The aphasia phenomena were consistent with Wernicke's aphasia, with alexia out of proportion to auditory comprehension deficit (Kirshner, Casey, Henson, & Heinrich, 1989). Cases of "ictal" or "epileptic" aphasia have been recognized in association with dominant temporal lobe seizure foci (Racy, Osborn, Vern, & Molinari, 1980; Rosenbaum, Siegel, Barr, & Rowan, 1986), though none have had PET and EEG correlation. A single case of prolonged Wernicke's aphasia secondary to status epilepticus has been described (Knight and Cooper, 1986).

The MRI, PET, and EEG abnormalities in our case all involved the inferior, posterior temporal region. Even the MRI abnormalities resolved, suggesting that edema from seizure activity rather than focal ischemia or encephalitis was the etiology. The posterior, inferior temporal cortex is not a classical language area; Luders, Lesser, Hahn, Dinner, & Morris (1986, 1991), however, have reported disruption of both expressive and receptive language functions with stimulation of this area in epileptic patients. This "basal temporal language area" has had an uncertain status in aphasiology, however, because its ablation in epilepsy surgery or damage through strokes or injuries has not been reported to cause aphasia. The lasting disruption of language in our patient, until well after his seizure discharges were controlled, suggests a prominent role of this area in the language function of our patient. This case provides evidence both for the existence of ictal aphasia and for the importance of the inferior temporal language cortex in language function.

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5. Semantic Memory Impairments after Hypoxic-Ischemic Injury

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Semantic memory is a component of long-term memory that contains knowledge of objects, facts, and concepts including words and their meaning (Tulving, 1972). Semantic memory deficits have been reported in various dementing illnesses (reviewed in Hodges, Patterson, Oxbury, & Funnell, 1992), infarctions of the left posterior cerebral artery (PCA) (Alexander, Hiltbrunner, & Fischer, 1989), and herpes simplex encephalitis (HSE) (Warrington & Shallice, 1984). This report describes a patient with impaired semantic memory with important features: (1) unusual etiology, (2) demonstration of brain lesion only by SPECT, (3) normal everyday memory, (4) remarkable recovery. There are lesion-specific implications for the structure of semantic memory.

Case. The patient is a 44-year-old, left-handed college professor who suffered a cardiac arrest with prompt resuscitation. He was in coma for 4 days; CT was negative. By 15 days after onset he was conversing and following commands. He remained "confused" and was referred for evaluation 1 month after onset. Developmental and past medical histories were unremarkable.

Neurological examination was normal. Behavior was appropriate and cooperative. Language was fluent and grammatical but extremely empty with occasional semantic paraphasias. On standard aphasia tests, anomia was the only prominent finding (Table 22A). Comprehension (auditory and reading) deteriorated with decreasing word frequency and with de-

TABLE 22
Language Evaluations

A. Standard aphasia tests (1:WAB; 2:BNT; 3:BDAE)									
	Auditory comprehension	Token	Reading comprehension	Repetition ¹	Object naming ¹	Picture naming ²	Oral reading ³		
							Words	Sentences	
5 weeks	9.05/10	15/16	8.5/10	10/10	2/10	1/16	10/10	10/10	
11 weeks	10/10	—	10/10	—	9.3/10	19/60	—	—	

B. Phonological assessment								
	WAIS-R digit span	Sent repetition ³	Pseudowords		Phonemic cuing		Recognition Spelled words	FAS
			Repetition	Oral reading	Objects ¹	Pictures ²		
5 weeks	19	16/16	10/10	10/10	13/13	7/15	5/5	35
11 weeks	—	—	—	—	—	35/41	—	—

C. Semantic assessment											
	WAIS-R Information	WAIS-R comprehension	Knowledge of facts			Word list generation		Famous faces		Semantic anomalies	Semantic categories
			Numbers	Colors	Maps	Animals	10 Categories	Names	Recognition		
5 weeks	4	6	13/24	8/18	4/14	0	total 15	0/56	40/56	3/10	11/20
11 weeks	8	13	16/24	14/18	14/14	8	—	10/56	—	—	9/10

creasing visual information (common objects—good, but drawings of those objects—poor). Visual, tactile, and responsive naming were equally impaired. He named one item on the BNT, and most responses did not suggest recognition, e.g., for toothbrush—“A growth, a pattern of growth—small—hanging from the end.” He could not pantomime the use of the manipulable objects. He named no body parts and only high-frequency colors. Phonemic cues were helpful, but incorrect cues were also accepted and completed. Phonological capacities were normal (Table 22B). Digit span was 9 forward. Repetition and oral reading were normal even for pseudowords. He recognized spelled words. His FAS score was 35.

Probes of semantic capacity indicated significant impairment (Table 22C). Even on the BNT items that were recognized, further knowledge of the target was extremely limited, even with multiple choice. Information knowledge from the WAIS-R was very poor. Identifying attributes, assembling objects into natural categories, identifying out-of-category items, and recognizing semantic anomalies were all abnormal.

Buccofacial and limb apraxia were normal to command. He occasionally misused objects, even ones that he could choose from multiple choice. Movements were well executed but performed with an incorrect implement.

All basic visual functions were intact: acuity, fields, attention, pursuit and saccadic eye movements, and visually guided reaching. On block designs and figure copying, configuration was maintained, but he had trouble organizing internal details. Visual imagery was impaired. He could not state which capital letters had any curved lines (6/26) or which common objects had all straight lines (2/26). Drawings of common objects were unrecognizable.

Attention was good. He was oriented. Memory was good for day-to-day events. He could describe his daily outings and recognized hospital staff. He had no knowledge of recent public events. Verbal and visual learning were impaired, limited to span (7), dependent on serial order and recency without semantic clustering on the verbal task. He had no recall or recognition of the stimuli. Rotary pursuit learning was normal and retained over delay. Autobiographical memory was good within the limits of his anomia. Famous faces were impaired without any temporal gradient.

MRI performed 6 weeks after onset was normal. SPECT performed 2 days later showed patchy decrease blood flow bilaterally with profound decrease in the temporo-occipital regions, left greater than right.

He was reevaluated 6 weeks later. There was improvement on all tasks (see table 22), but he was still anomic. He was still impaired on common semantic knowledge tests. He failed to sort 12% of common objects (verbal presentation) into their correct category. Visual imagery was normal.

Experiential memory was quite detailed and good. Word list learning was the only task with no improvement.

Discussion. Hypoxic-ischemic injury can be added to the list of causes of impaired semantic memory. In common with PCA infarctions, HSE, and some dementing illnesses that also cause semantic amnesia, damage included the temporo-occipital association regions, particularly on the left. The injury was to neurons, not to white matter. Because there was no white matter damage, the clinical deficits cannot be attributed to a disconnection (in the narrow anatomical sense) as might be claimed for HSE and PCA. Recovery may have been due to there being only partial damage (by testing and by SPECT) of a neural system that has a broad distribution. Partial damage allowed reconstitution of connections (in the psychological sense) through reexperience of visual and verbal stimuli. The absence of white matter lesions also allowed reconstitution of connections (in the anatomical sense) not available to the structural lesions of HSE and PCA.

Most cases of semantic amnesia have had, as this case did, simultaneous deficits of variable severity in three domains: (1) central semantic memory, (2) lexical knowledge, and (3) visual knowledge. The essential structure of semantic knowledge is controversial. Modality-specificity and category-specificity are often cited as key structural elements of semantic memory, but they may be derivative to modality restrictions on knowledge acquisition for different categories (DeRenzi & Lucchelli, 1994). Some knowledge is necessarily visual, some kinesthetic, some abstract, and some various mixtures. Both the consistently observed interrelationships among lexical knowledge, visual semantic knowledge, and central semantic knowledge, and their synchronous improvement in this case suggest overlap in their neural structures in posterior heteromodal association cortex and in their psychological structures, probably based on overlapping processes of knowledge acquisition.

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6. The Choice for Ellipsis: A Case Study of Stylistic Shifts in an Agrammatic Speaker

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In 1985, Kolk & van Grunsven, following up on a suggestion made by Isserlin (1922), proposed that agrammatic speech is the immediate outcome of a process of strategic adaptation. As a response to a situation of computational overload in the linguistic system, agrammatic speakers could react in one or both of the following ways.

First, they could preferentially produce simple sentence forms in order to prevent overload. This they could do by restricting themselves to simple active sentences or even by simplifying below the sentence level and make use of elliptical sentence forms. The latter type of simplification would lead to the symptom of telegraphic speech.

A second type of reaction would consist in attempting to repair the sentence representation, if, due to overload, this representation had been partially disintegrated. To do this, they would make use of normal mechanisms of overt or covert repair, as described by Levelt (1989). The consequences of such a strategy would be more pausing within the sentence and more repetitions of elements of the sentence.

A basis tenet of the proposal is that both preventive and corrective strategies are optional, rather than obligatory, as Caplan & Hildebrandt (1988) claim regarding the heuristics aphasics use to understand sentences. This hypothesis is supported by the finding that large changes in type of agrammatic speech output can occur under specific task conditions (cf. Kolk & Heeschen, 1985; Hofstede & Kolk, 1994) or spontaneously (Bastiaanse, in press). However, the evidence is indirect and it is still possible that these effects represent obligatory reactions to changes in task or situation.

The purpose of the present investigation was twofold. First, we wanted to demonstrate that it is possible, at least for some patients, to control the use of the simplification strategy in response to a direct request of the Experimenter to speak "in complete sentences." Second, we also wanted to test the repair hypothesis, by looking not only at sentence form but also at word repetitions and pauses, as reflections of repair strategies. We predicted that a shift from telegraphic speech to speech with complete sentences would more often bring the patient into a situation of overload and thereby elicit a greater reliance on corrective strategies. As a consequence, longer interword pauses and more word repetitions should be observed.

The patient, N.U., is a right-handed male who became aphasic at the age of 55. At the time of testing he was 3 years postonset. He is still suffering from a right-sided hemiparesis. The neurological report mentions an infarct of the left middle cerebral artery as the cause of his disease. No CT scan is available. He was formerly a municipal official and is now unemployed. When tested on the Dutch version of the Aachen Aphasia Test, he turned out to be unimpaired on the Token Test and on the subtests Language Comprehension and Naming. On the subtests Repetition and Written Language he scored within the range of "mildly impaired" patients. N.U. was also studied by Hofstede and Kolk (1994), where he turned out to be very sensitive to the strategy-inducing task manipulations. For this reason, he was selected for this study.

We compared the patient's speech produced under four conditions: (a) Conversation: carried out with a person well known to the patient (second author) and in his own home, (b) Formal interview: done with an unknown person with some official status (first author) and while the interview was being videotaped (We expected a more formal situation to elicit less telegraphic speech), (c) Request: the patient was asked to speak in complete sentences and this request was repeated each time an incomplete utterance was produced, and (d) Picture description: the patient was asked to describe a set of pictures. Form parameters were taken from the list of features of ellipsis in German and Dutch, published by Kolk and Heeschen (1992). For all parameters a decrease is predicted except for the substitutions which have to increase, due to the fact that there is more overload. For number of repetitions, an increase is predicted, whereas the number of words per minute (not a percentage!) should decrease.

Data are presented in Table 23. Asterisks indicate the level of significance of the difference with the baseline. The words-per-minute data were analyzed with an ANOVA, the other data, by means of a χ^2 test.

TABLE 23

Percentage	Conversation (baseline)	Formal interview	Request	Pictures
FW-omissions	68	68	18***	2***
FW-substitutions	2	0	10*	16***
Nonfin. Verb-use	86	91	24***	0***
Main-Verb-omission	72	42***	8***	6***
Subject-omission	67	40***	20***	0***
Verb-final position	69	58	56	2***
FW-repetitions	30	37	33	34
CW-repetitions	11	25*	30***	37***
Words per minute	30	25	15***	19***

From these data we can conclude that: (a) Telegraphic speech is optional for this patient. (b) More complete speech goes together with longer pausing and more repetitions, at least of content words, as predicted. (c) A formal situation also elicits more complete speech, although the effect appears to be restricted to the production of main verbs and grammatical subjects. That formality is important is also evident from the interview, available on videotape, when the patient is asked: "How would you talk when you were visiting the Queen of the Netherlands?".

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7. Mental Morphology and the Finnish Verb: Aphasiological and Normal Data

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Introduction. Based on extensive single-word studies of Finnish aphasics and normals, we have recently constructed a model of morphological processing of nouns in that morphologically rich language. The Stem Allomorph/Inflectional Decomposition (SAID) model combines features of morphological decomposition and full listing (for a review, see Niemi, Laine, & Tuominen, 1994). In the present study, we analyzed the processing of Finnish verbs, which are morphologically more complicated than nouns.

Grammatical and psycholinguistic observations of Finnish morphology. Finnish nouns have a zero-marked free-standing form (the nominative singular), and in grammatical descriptions this *citation form* is also typically regarded as the base form in noun paradigms. In contrast to nouns, Finnish verbs do not have such a free-standing morphologically simple form. Even the so-called TA-infinitive, which corresponds to, e.g.,

the infinitive in English, is polymorphemic (e.g., *kiive + tä* "climb + INF," *sopi + a* "fit/suit + INF," cf. German).

This morphological fact as well as frequency of use and other spatio-temporal facts have led some linguists to posit one of the bound stems as the base form of Finnish verbs (Karlsson, 1983, 1986). This, the so-called strong vowel stem, appears, e.g., in the third person sg. (*hän kiipeä + ä*, *sopi + i* "s/he cut + s, climb + s, fit + s"), and in some verbs it is identical to the 2nd person singular (p.sg.) imperative (as in "ask," *hän kysy + y* "s/he asks," *kysy* "ask!"). This bound stem is generally treated as the base form during early stages of language acquisition, as Finnish children produce such illegal infinitives as **sopi + ta* for *sopi + a* (Niemi & Niemi, 1987).

However, psycholinguistic studies have shown that the citation forms (e.g., the infinitive of verbs and the nominative sg. of nouns) have a special status among the members of the paradigm (see e.g., Lukatela, Gligorijević, Kostić, & Turvey, 1980, for Serbo-Croatian; Günther, 1988, for German). The question of how these two notions, the "citation form effect" and the "strong vowel stem base form" surface in processing of verbs by Finnish adults was here approached through single-word reading tasks administered to a deep dyslexic patient (for patient description, see H.H. in Laine, Niemi, Koivuselkä-Sallinen, & Hyönä, in press) and through a lexical decision experiment carried with normals.

Single-word reading in a deep dyslexic. In two reading tasks our extensively studied deep dyslexic HH performed best with the infinite forms when these were pitted against other morphosyntactic categories of the same lemmas.

Reading Task 1. In this task the infinitives (like *kysy + ä* "ask + INF") were contrasted to three finite, present-tense indicative forms: 1st p.sg. (e.g., *kysy + n* "I ask"), 2nd p.sg. (*kyst + t*), 3rd p.sg. (*kyst + y*) and to an imperative, which was identical to the strong vowel stem (*kysy*). H.H. was able to correctly read aloud 57% (12/21) of the infinitives, while the other forms received low scores (1 to 5 out of 21) ($\chi^2 = 26.2$, $df = 1$, $p < .001$). Most of the errors (37/87) resulted in the infinitive, and in some instances (12/87) the 3rd p. singular was produced. In none of the errors was the strong vowel stem used for an inflected form.

Reading Task 2. In a reading task of a verb list, in which each lemma appeared both in the infinitive and in the 3rd p. singular, H.H. scored 70% correct (28/40) on the infinitives, while the 3rd p. singulars were read with a success rate of 7.5% (3/40) ($\chi^2 = 30.3$, $df = 1$, $p < .001$). In the latter group of verbs he substituted the finite form for the infinitive in 23 instances.

Lexical decision experiment with normals. H.H. showed a clearcut preference for the infinitive but we wanted to see whether a similar effect would surface in normals as well. The stimuli of H.H.'s Reading Task 2

TABLE 24
Lexical Decision Latencies (in msec)

	Mean	SD
Infinitives (e.g., <i>kiive + tä</i>)	740	99
3rd p. sg. (e.g., <i>kiipeä + ä</i>)	759	121
Legal stem pseudoverbs (e.g., <i>sopi + ta</i>)	1044	216
Neologistic stem pseudoverbs (e.g., <i>ukasta + a</i>)	919	160

and pseudoverbs were here employed. (Each subject saw only one of the phonological forms of a particular lemma.) Half of the foils carried a legal stem (e.g., **sopi + ta*), and half carried a neologistic stem (e.g., **ukasta + a*). The lexical decision experiment was administered to 32 students (Table 24).

For the two real word blocks, the main effect was not quite significant ($F(1, 31) = 3.17; p = .08$). (However, the fact that the legal stem pseudoverbs exhibit latencies that are longer than those of the neologistic stem pseudoverbs suggests decomposition of the verbs into their stems and infinitive markers.)

Conclusion. In two reading tasks, H.H. showed a preference for the infinitive forms, both in terms of the total of forms correctly produced and in the direction of errors produced. Taken as such, these aphasic data could be interpreted to indicate that the infinitive is the base form of the Finnish verb. However, our lexical decision experiment with normals did not exhibit any difference between the infinitive and the 3rd p. singular, even though there was a tendency for the infinitive to elicit the fastest responses. Thus, it still remains open which of the forms (if any) is the psychological base form of verbs in Finnish. One reason may be that unlike nouns, verbs do not have a single form that would simultaneously be a *citation form* and the *most common form* as well as a *free-standing allomorph* (i.e., morphologically the simplest form).

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8. Consequences of Thematic Role Therapy for Speed of Processing

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The Mapping Deficit Hypothesis (Schwartz, Linebarger, & Saffran, 1985) suggests that agrammatic patients' comprehension deficit is due to an inability to integrate thematic information with syntactic information. A technique similar to Schwartz and Saffran's (1991) Mapping Therapy was used in the present study with patient M.L. Unlike previous patients treated with mapping therapy, M.L. performs accurately, although very slowly, on some tests of syntactic comprehension. We were interested in whether the therapy would improve his speed of processing on those tests he performs well and improve his accuracy on the others. Since it has been suggested that aphasic deficits may often result from slowed processing rather than a total breakdown in processing, it would be critical to know if slowed processing could be remediated.

Method. Subject: M.L., a 52-year-old male, 3 years postonset, left hemisphere CVA, is an agrammatic speaker with good single-word comprehension.

Pretesting: Prior to the therapy program, baseline measures of comprehension and production were established (see Table 25).

Comprehension measures: A standard visual sentence–picture matching task was administered. A second visual task required object manipulation, (i.e., acting out the actions in the sentence). Both tasks included the same four sentence types used in therapy. However, the object manipulation task also included cleft object sentences. In the auditory modality, two sentence–picture matching tasks were administered. These included reversible and nonreversible active and passive sentences and reversible relative clause sentences, respectively. On all tasks, response latencies were measured from the first presentation of a sentence to the execution of the response. The sentences in the baseline materials used different nouns and verbs than the sentences used in training.

As shown in Table 25, M.L.'s comprehension was slow but accurate on sentence–picture matching involving active and passive transitive and dative sentences. Accuracy was impaired for similar sentence structures on object manipulation and for relative clause sentences for both types of tasks.

Other measures: A measure of grammatical production was obtained by having M.L. tell the Cinderella story, scored according to Saffran, Berndt, and Schwartz (1989). M.L. was below the range of control subjects on both morphological and structural indices.

TABLE 25
Pre- and Post-Therapy Error Data and Reaction Time Data for Auditorily and Visually Presented Comprehension Tasks

Task	Sentence type	Percentage correct			Mn RT (sec)		
		Pre-training	Post-training		Pre-training	Post-training	
			3/93	4/93		3/93	4/93
Visual							
Sentence-picture matching							
Trans + dative	active	97	90	100	35	24	12
Trans + dative	passive	100	100	100	34	19	23
Object manipulation							
Trans + dative	active	67	100		22	74	
Trans + dative	passive	17	100		64	118	
Cleft object		35	71		83	120	
Auditory							
Sentence-picture matching							
Reversible							
	Active	100	100		12	21	
	Passive	100	100		15	19	
Nonreversible							
	Active	100	100		5	6	
	Passive	100	100		2	4	
Relative clause							
		78	82				
Word span data (1- to 3-item lists)							
	Auditory	66	83				
	Visual	62	68				

M.L. was also tested on auditorily and visually presented span tasks that were not likely to be affected by the therapy program. His span was very reduced in both modalities.

Procedure. Pretherapy: M.L. was presented first with 20 pictures and then with written sentences corresponding to the pictures. He was asked to respond verbally to questions requiring him to indicate the action, the actor, and the thing acted upon. With the picture stimuli, M.L. had no difficulty. With the sentences, he was slow but accurate.

Therapy: Forty sentences, half reversible and half nonreversible, were constructed; 10 of these were dative active, 10 dative passive, 10 transitive active, and 10 transitive passive. M.L. was presented with written sentences like those in pretherapy. The sentences were also read aloud to him. He was required to respond by highlighting the word that answered the question. Next, he checked his response by looking at a paper that had the sentence with the correct answer highlighted. This immediate feedback was the primary mechanism of therapy. He went through the therapy materials three times at weekly intervals.

After therapy, M.L. was retested on the baseline measures (see Table 25).

Results. Response latencies showed a significant decrease only on the

visual sentence–picture matching task which used the same sentence structures as those involved in therapy. This improvement remained 1 month later. Although response times were generally faster in the auditory modality than the visual modality, the failure to improve in the auditory condition could not be attributed to a floor effect since responses to nonreversible sentences were considerably faster than responses to reversible sentences.

Accuracy improved only on the visually presented object–manipulation task, with significant improvement on all sentence types, including two cleft object constructions that were not included in the therapy.

Production scores on retelling of the Cinderella story showed marked improvement. For example, the proportion of verbs inflected increased from 48 to 100%, the proportion of closed class words increased to be within normal range, and the proportion of words in sentences increased from 74 to 85%.

On the memory span tasks, no improvement with visual presentation and some improvement with auditory presentation was shown.

Conclusions. Results indicate that, at least for visually presented tasks, not only accuracy but also speed of processing can be improved through a therapy which focuses on mapping of thematic roles. These effects were durable, lasting at least 1 month after the therapy was completed.

Improved performance with visual but not auditory presentation might be attributed to the use of written materials in the therapy regime. However, the improvement in production and the transfer to nontreated sentence structures in the visual modality suggests that the treatment affected central aspects of mapping rather than an ability specific to reading.

The slowness and inaccuracies that remained after treatment may have resulted from difficulty in maintaining a sentence interpretation while choosing a picture or acting out the sentence. Consistent with this is the finding that performance was both fast and accurate on an auditory semantic anomaly judgment task administered after therapy. Therefore, therapy may have improved mapping of thematic roles in sentences but not the ability to maintain results of this analysis. An interaction with modality might thus be explained since with visual presentation, sentences were available for reanalysis if the meaning was forgotten.

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9. Syntactic Processing in Sentence Comprehension under Dual-Task Conditions

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Just, Carpenter, and their colleagues (1992) have proposed a "capacity" theory of sentence comprehension. According to this theory, humans have a limited set of processing resources that can be devoted to a variety of verbal tasks. These tasks range from controlled, verbally mediated problem solving to the obligatory aspects of language comprehension.

One piece of evidence that has been presented in support of this theory is the performance of normal subjects who vary in working memory, as measured on the Daneman and Carpenter (1980) working memory (WM) span task, that allegedly measures syntactic processing in sentence comprehension. It has been argued that subjects with greater WM capacity perform more accurately and/or quickly on these tasks (King & Just, 1991; MacDonald, Just, & Carpenter, 1992). In one such study, Miyake, Just, and Carpenter (in press) tested normal subjects who differed in their WM capacities on sentence comprehension tasks in which different types of sentences were presented word by word at two rates under rapid serial visual presentation (RSVP) conditions. They compared their results to those of Caplan, Baker, and Dehaut (1985), who documented syntactic comprehension impairments in an aphasic population and argued on the basis of this comparison that they had simulated the reduction in processing resources thought to occur in that population. On this basis, they argued that their results supported the capacity theory of sentence comprehension.

We have questioned the interpretation of these results on two grounds (Baddeley & Hitch, 1974). First, Miyake et al.'s premises are that comprehending syntactically more complex sentences (a faster RSVP rate) and producing a higher score on the Daneman and Carpenter working memory task all require more processing resources and that these resources all come from the same pool. If these premises are correct, subjects with low Daneman and Carpenter WM spans should do disproportionately worse on syntactically more complex sentences at higher RSVP rates. However, the three-way interaction between group, sentence type,

and RSVP rate was not significant. Second, Miyake et al. did not distinguish between additional processing complexity due to semantic factors (e.g., the number of thematic roles or propositions in a sentence) and that due to syntactic factors (e.g., the presence of a moved NP constituent that results in a noncanonical order of thematic roles). We have suggested that the RSVP manipulation used by Miyake et al. may not be a good simulation of the effects of processing resource reduction upon sentence processing. Rather, the RSVP condition may provide data relevant to the effects of perceptual degradation of input upon sentence processing.

A better test of the effect of resource reduction upon sentence processing is the concurrent performance of a verbal task that loads working memory. Retention of a sequence of digits equal to a subject's span is such a task (Caplan & Waters, in press). The evidence that this task disproportionately affects processing of syntactically more complex sentences is equivocal. While both errors and RTs increase for sentences with two compared with one proposition under digit load conditions in a sentence acceptability judgment task, a similar effect was only marginal when syntactically more and less complex sentences were compared (Waters, Caplan, & Hildebrandt, 1987).

To further investigate the question of the effect of resource reduction upon syntactic aspects of sentence comprehension, we studied the effects of a concurrent digit load upon syntactic processing in an object manipulation task in normal subjects who differed in WM capacity.

Subjects. Thirty-five normal subjects with no history of neurological or psychiatric disease were tested.

Working memory span. Subjects' WM spans were measured using a modification of the Daneman and Carpenter method. Subjects were divided into high, medium, and low span groups as described in King and Just (1991).

Digit span. Subjects' digit spans were established using the materials from Waters, Caplan, and Rochon (in press).

Sentence comprehension. Subjects were tested on sentences from Waters et al. (in press) and Rochon, Waters, and Caplan (1994). Ten examples of each of six sentence types that varied in syntactic complexity and number of propositions were presented auditorily. The subjects' task was to enact the thematic roles in each sentence using toy animals, as described in Caplan et al. (1985).

Procedure. Subjects were tested on the sentence comprehension task under two conditions: no interference, and while retaining a sequence of digits equivalent to their span. In the digit load conditions, subjects heard sequences of digits before each sentence and repeated them after responding to the sentence. Accuracy on both the sentence enactment task (number of correct responses) and in digit recall (number of lists correct) were dependent variables.

Results. There were 16, 10, and 9 subjects in the high, medium, and low working memory span groups, respectively. Accuracy on the sentence comprehension task was analyzed in a 3 (group: high, medium, low memory span) \times 2 (condition: no interference; digit load) \times 6 (sentence type) ANOVA with group as a between-subjects factor. There were significant main effects of group ($F(2, 32) = 4.4, p < .05$), condition ($F(1, 32) = 70.5, p < .001$), and sentence type ($F(5, 32) = 31.9, p < .001$), as well as interactions between condition and sentence type ($F(5, 32) = 15.1, p < .001$) and between group and condition ($F(2, 32) = 5.3, p = <.01$). Performance of high and low span subjects was greater than that of medium span subjects. Performance in the no interference condition was better than in the digit load condition. The effect of sentence type was due to worse performance on syntactically complex compared to simple sentences, as well as on two-proposition compared to one-proposition sentences. Analysis of the condition \times sentence type interaction showed that the effect of number of propositions, but not the effect of syntactic complexity, increased under digit load conditions. The interaction of group and condition was due to the fact that digit load increased the differences between high and low span groups compared to the medium group. The absence of a group \times condition \times sentence type interaction indicates that the effect of a digit load on the syntactic complexity effect was the same in all groups.

Accuracy on the digit task was analyzed in a 3 (group: high, medium, low reading span) \times 6 (sentence type) ANOVA. There was a main effect of sentence type ($F(5, 32) = 2.9, p < .01$). Tukey's test revealed that performance did not differ on syntactically complex compared to simple sentences, but was poorer on sentences with more propositions. The absence of a group \times sentence type interaction indicates that this was true in all three subject groups.

Discussion. The results of this study indicate that: (1) an external digit load equal to span did not interfere with the comprehension of syntactically more complex sentences more than with syntactically simple sentences and (2) subjects with lower WM spans were not more affected by syntactic complexity than subjects with higher spans, either when comprehending sentences in isolation or under a digit load. The pattern of results is consistent with the view that the resource system associated with syntactic processing in sentence comprehension is separate from a more general-purpose working memory system.

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10. Nonliteral Language Workstation Using Interactive Video: Program Development and Preliminary Results

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Background. Overlearned nonliteral expressions are frequent in everyday language use. Many of these kinds of expressions are relatively preserved in some aphasic patients, while impaired in patients with right hemisphere damage. The preserved ability might be enhanced in rehabilitation of the aphasic, while remediation of nonliteral language impairment is an option for patients with right hemisphere disease. Yet little in the way of appropriate materials is available for study or treatment of brain-damaged persons, partly because the meanings of conventional nonliteral expressions are complex and context-bound, making it difficult to produce convincing depictions using traditional formats. Thus, well-designed test and rehabilitation materials utilizing overlearned, nonliteral expressions are lacking. A new and promising interactive video Workstation for evaluation and rehabilitation of nonliteral language functioning has been made possible by combining linguistic progress with advances in computer technology. This presentation focuses on the development of the Nonliteral Language Workstation for use with adults with acquired neurogenic disorders. The purpose of the Workstation is to provide a full, scientifically motivated, and broad-based test, as well as to provide materials for training. Preliminary data from pilot testing indicate that this will be a valuable resource.

Methods: Equipment. The interactive video computer-based Nonliteral Language Test and Training Workstation has advantages over available tests: a large repertory of items; objective scoring system; no verbal or written output; no reliance on metalinguistic judgments; provides the same task using literal exemplars; meanings are represented in dramatized scenarios; no unfamiliar items.

The Workstation uses a Macintosh Quadra 950, Touch Window, and an external hard-drive. Videotaped scenes and movie clips are accessed by the HyperCard program which communicates with a laserdisc player. The size of the screen "buttons" and print has been tailored to meet the needs of viewers with visual, motor, and/or perceptual handicaps. The scoring routine tabulates each individual item and item type as well as group performance.

Methods: Stimuli. Thirty speech formulas, 30 proverbs, 30 idioms, and 30 matched literal expressions were selected because (1) speech formulas are most often preserved in aphasic production, (2) idiom comprehension deficits have been associated with right hemisphere dysfunction, and (3) deficits in proverb interpretation are associated with frontal disease. Each set of 30 target expressions was divided into 10 short (2-4 words), 10 medium, and 10 long (8 words and over). All expressions were rigorously screened for familiarity. It has been hypothesized that familiar nonliteral expressions are made up of a stereotyped form coupled to a conventional meaning. To examine these ideas, three matched foils were created for each of these 120 expressions: A literal expression phonetically similar to the target expression; an incorrect nonliteral expression; a literal expression with a meaning semantically opposite to the target phrase, for a total of 480 presentations. To examine generalization of training, only one-third of the nonliteral expressions in the Test items appear in the Training component. In the Test task, the patient sees and hears an expression presented by the computer, followed by a videotaped scene of approximately 15 sec. Test scenes written and acted by the research team appear. The subject selects one of two boxes labeled "yes" and "no" to indicate whether the scene matches the expression. No feedback is provided.

The training portion of the Nonliteral Workstation program is composed of 270 15-sec movie clips from "North by Northwest" by Alfred Hitchcock, matched with 90 overlearned nonliteral expressions. Each expression occurs with 2 correct and 1 incorrect movie clip. In the training task, the patient sees on the video screen and simultaneously hears an expression presented by the computer, followed by a movie clip displayed on an adjacent television monitor. The subject then touches the "yes" or "no" box on the computer screen to indicate a match or non-match of scene and verbal expression. Feedback is provided; if the subject makes an error, the expression/scene procedure is repeated.

Methods: Subjects. Nine right-handed, native speakers of English with left hemisphere damage due to a cerebral vascular accident at ages 46-66, with 12-16 years education, ranging between 2 and 11 years postonset with diagnoses of Broca (4), Anomic (4), and Wernicke's (1) aphasia have been tested, as well as eight age- and education-matched normal-control subjects. Patients represented a range of severity as reflected in the West-

ern Aphasia Battery Aphasia Quotient (AQ) (15.2–95.5). Patients were given standardized tests of language, right-hemisphere function, and functional communication initially and at the end of Training.

Results and conclusions. The design of this project allows for many comparisons: comprehension of speech formulas, idioms, and proverbs; comparison of these with literal expressions; stereotyped form versus conventional meanings; the effects of training on these categories; correct “yes” versus correct “no” responses (“no” responses are more difficult); performance before and after training. All patients in this heterogeneous pilot group were found to interact well with the test and training components of the Workstation. Normal-control subjects performed at 93.7 on “yes” and 87.8% on “no” responses across all nonliteral categories, compared to 81.7 and 60.1%, respectively, for aphasic patients. Individual patients differed in relative abilities to process formulas, idioms, or proverbs as a category. Preliminary analysis indicates significant differences in the pretest between aphasic and control groups across nonliteral categories whether the item is present or not in the training array ($F(1, 15) = 15.568$ and 9.131 , respectively, $p < .01$). Results on Workstation Training performance revealed a mean of 85.4 (SD = 7.98) on first trials, with 99% on the second trial. Considering that verbal memory deficits and yes–no confusion often accompany aphasia, these data suggest a highly successful Training experience. Eight patients have completed the PostTest. Figure 26 presents pretest and post-test results on nonliteral

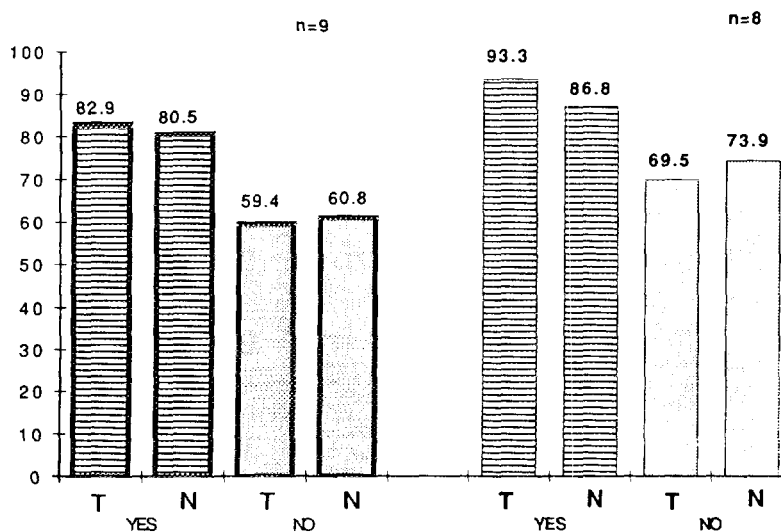


FIG. 26. Percentage correct of test items included in training (T) and those not in training (N) for correct “Yes” and correct “No” answers: pretest (left) and post-test (right).

expressions included in training compared with those not in the training, separating correct "yes" from correct "no" responses. This system has promise for evaluating a number of questions about nonliteral language abilities in brain-damaged patients and for providing effective rehabilitation in this important aspect of communication. A videotape of the Workstation will be presented at the poster.

11. Recovery and Its Implications for Cognitive Neuroscience

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Although recovery is known to occur after most focal lesions, its existence seems to have been largely overlooked in at least two areas of study: cognitive neuropsychology and behavioral/anatomic correlations. Some have claimed that one of the premises of cognitive neuropsychology is that lesions subtract existing functions, but do not add any new functions to the "normal" cognitive architecture (cf. A. Caramazza, 1986). However, a strong version of this premise does not appear to be supported by animal studies nor, to an increasing extent, by human ones. These suggest instead that a wide range of neurophysiologic alterations typically occur after focal lesions with potentially profound implications for how a given behavior is ultimately accomplished. Behavioral/anatomic correlations with CT or MRI have traditionally been done, and continue to be done, with behavioral data obtained from the "late" (>3-6 months), stable phase after lesion onset. Yet the existence of recovery processes suggests that what is being correlated with anatomy is not necessarily the absence of the normal function, but instead the absence of any recovery potential for the apparent function.

There have been many reasons why the extent of recovery processes has not been fully acknowledged or its implications taken into account. It is usually not easy to study cognitive functions during the hyperacute phase of a lesion. Lesion etiologies may often be complicated by associ-

This study supported in part by the GCRC, MO1 RR0082, and by the Memory Disorder Clinics of the State of Florida Departments of HRS-Elder Affairs and the Medical Research Service of the Department of Veteran Affairs.

TABLE 26

	20 Hours	15 Days	1 Year	3.5 Years
Auditory comp.	Simple commands only	24/90 Token Test	55/90 Token Test	84/90 Token Test
Spont. speech	Single words only	Fluent, some paraphasias	Fluent 99th%tile on FAS	Fluent no paraphasias
Repetition	None	7/10 words	7/10 words	9/10 words
Naming	Trace	78% BNT	90% BNT	87% BNT
Reading	Trace	90/90 Token Test	89/90 Token Test	89/980 Token Test
Writing	Single words only	Generally intact	Intact	Intact

ated reactive processes which complicate assignment of responsibility. Prelesion functional abilities and functional-anatomic relations are usually not known, adding to the uncertainty postlesion.

Here we present data from pre- and postlesion studies of deficits and recovery that we believe demonstrate the salience of recovery processes in the evolution of postlesion cognitive abilities.

Recovery from Wernicke's area infarction. Patient 1 (D.S.) was a 33-year-old right-handed male, left cerebral dominant by Wada testing, with a B.S. He had left temporal epilepsy, unrelieved by a 4.5-cm left anterior temporal resection. He therefore had implantation of a subdural grid for seizure and behavioral mapping. Stimulation mapping showed that receptive and other language functions were impaired by stimulation in the posterior superior temporal region, as expected. This was also the location of much of his ictal activity, so it was not considered resectable. A further anterior temporal resection was done instead. However, postoperatively he developed infarction in the territory of the inferior branch of the middle cerebral artery. Sequential postoperative language testing is presented in Table 26. Acute CT scans and MRI scans performed chronically showed comparable lesions: a nearly complete obliteration of the whole left temporal lobe (including the posterior superior temporal region), extending back to the temporo-parieto-occipital junction, and some injury to the frontal and parietal opercula, presumably representing the combined effects of the surgical resections of the temporal lobe and of the infarction. (Note. Some aspects of this case have been previously reported: Gordon *et al.*, 1989).

Recovery from acquired dyslexia from surgical resections. Patients who are thought to require focal cerebral resections for treatment of

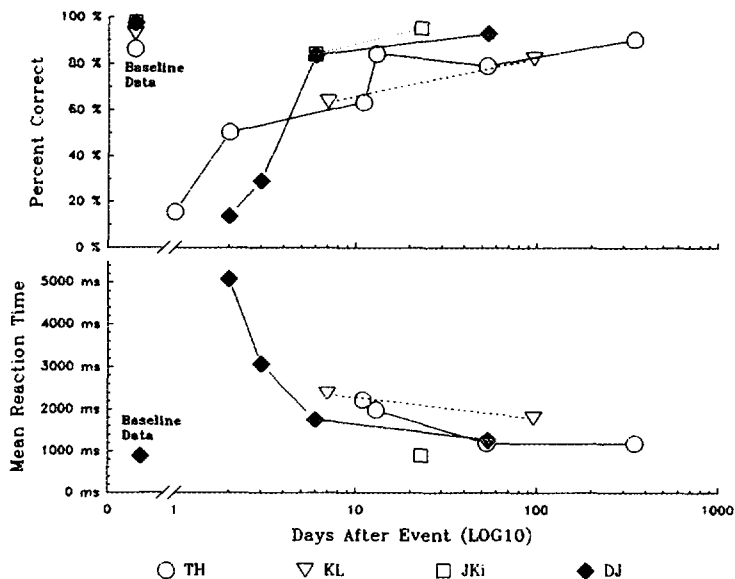


FIG. 27. Reading aloud on the set of four- to six-letter words described in the text. (top) Proportion correct. (bottom) Reading latencies. Note that time is on a logarithmic scale, from the time of surgery.

medically intractable epilepsy all have extensive preoperative testing and sequential postoperative testing in our clinical protocols. The testing includes reading aloud as well as other language functions. The reading stimuli consist of words of varying orthographic-to-phonologic mapping complexity ($n = 118$) and pseudowords. The four subjects presented here were all left hemisphere dominant for language by Wada testing and direct cortical electrical stimulation mapping. All developed temporary deficits in reading aloud after resection (in some cases, deficits were noted during resection, performed with the patient under local anesthesia). Figure 27 shows their overall reading performance.

In T.H., K.L., and J.Ki., this appeared to be the result of selective damage to orthographic-to-phonologic translation. However, there did not appear to be any selective sparing or recovery of any particular word class; even words with unique mappings recovered with approximately the same frequency and rate as did words with regular orthographic-to-phonologic mappings. Patient DJ's deficit appeared to be due to a profound impairment in her orthographic word store, but this also recovered. Figures 28–31 show the lesions (reconstructed from MRI). (Note. Aspects of these cases have been presented previously: Gordon *et al.*, 1991).

Discussion. D.S.'s language deficits had to be due to structural damage; they long outlasted simple edema. Moreover, his deficits were exactly as expected from the location of his lesion, particularly given the confirmation of this region's functional role by cortical stimulation mapping. Yet

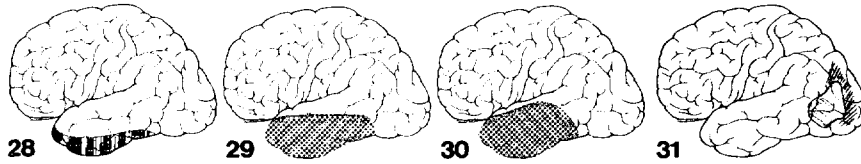


FIG. 28. Subject T.H. FIG. 29. Subject K.L. FIG. 30. Subject J.Ki. FIG. 31. Subject D.J.

the recovery of almost all of his language abilities show that he did not have a simple subtraction of functions. At the very least, it would remain to be established whether he was comprehending and speaking with the same mechanisms as he was prelesion. Also, it is clear that his behavioral-structural correlations would have been different had they been studied at different times in his course. The other patients raise similar issues, perhaps more tightly constrained functionally, since knowledge of orthographic word forms (Patient D.J.) and reading of irregular and unique words (Patients T.H., J.Ki., and K.L.) has been held to require considerable learning.

These cases cannot themselves answer the very fundamental issues that arise in considering mechanisms for recovery of function. But they do help add to the increasing body of evidence that recovery processes must be addressed in applying cognitive neuropsychologic methods and theories and in trying to correlate behavioral changes with structural lesions.

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12. Treatment for Pure Alexia via the Information Superhighway

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Introduction. How do you provide therapy to a patient with pure alexia who lives some 500 miles away? We report the application and efficacy of a computerized treatment program that a patient with pure alexia administered to himself at home.

Case history. R.S. is a 46-year-old, left-handed male who underwent subtotal resection of a left, occipital lobe hemangiopericytoma. A second surgery was subsequently performed to reduce the edema. Postoperatively, he underwent a 6-week radiation regimen. He was a professor

with a Ph.D. in engineering. At 4 months postonset he presented with a right hemianopia and pure alexia.

Rationale for treatment approach. R.S.'s reading was consistent with pure alexia (length effect, modality effect, and spelling superior to reading). Standard treatment for pure alexia focuses on training and/or improving a letter-by-letter reading strategy. There is evidence in the literature, however, that patients with pure alexia have access to another strategy, reading via the semantic reading route (Coslett, Saffran, Greenbaum, & Schwartz, 1993; Friedman, Beeman, Lott, Link, Grafman, & Robinson, 1993). Reports of treatment based on semantic route reading have been promising, but inconclusive (Cedrus, 1991). We attempted to facilitate semantic route reading by structuring the therapy according to Coslett *et al.*'s findings: presenting stimuli briefly and requiring a semantic judgment rather than explicit word identification. If the patient successfully reads through the semantic route we predict that he would exhibit a part-of-speech effect.

Method. The stimuli consisted of three sets of words. Each set was a different semantic category. Each set was composed of two lists of 20 words each: one list to be trained and the other to assess generalization. Each list contained 10 members of the given category and 10 distractor words. A distractor word was matched to each member word in orthographic similarity (at least the same first three letters), length (within two letters), part-of-speech (all nouns), and frequency of occurrence.

The study followed a multiple baseline design consisting of a baseline phase, sequential treatment phases, and maintenance phases. Probe testing was administered regularly. Training was initiated on the Occupations Set, and continued until R.S. achieved 90% accuracy on the 20 trained items during two consecutive probe tests. Training then proceeded to the Birds Set, and finally to the Animals Set, until the same criterion was achieved on each.

During his hospitalization, R.S. was seen 2 hr daily for 2 weeks. In addition, R.S. ran the treatment program himself on his own time. The stimuli were probe tested daily before treatment began. The words within each set were presented for 30 msec in random order on a Macintosh SE computer via the SuperLab program (Moss & Rothi, 1988). The task was for R.S. to decide if each stimulus belonged to the current category or not by pressing one key for yes and another for no. No feedback regarding R.S.'s accuracy was provided during probe testing. Training proceeded as did the probe testing, but now feedback was provided immediately following each trial; if R.S. responded correctly, the computer presented "right!" on the screen and if incorrectly, "wrong."

R.S. then returned to his home 500 miles away, where he continued treatment for 11 weeks. For a nominal fee the patient purchased a read-only version of SuperLab from Cedrus so he could continue his treatment at home. Once a week R.S. ran the probe programs, which present the

TABLE 27
Treatment Effect on Category Judgments of Trained and Untrained Words

Category set	Pretreat (%)	Posttreat (%)
Trained occupations	70	90
Trained birds	63	90
Trained animals	55	90
Mean trained	63	90
Untrained occupations	63	78
Untrained birds	70	70
Untrained animals	53	78
Mean untrained	62	75

words but no feedback regarding accuracy. The program records each stimulus and his response in a text file which R.S. then sent to us via E-mail for scoring. After analysis of these results, R.S. was instructed to either continue with the current set or proceed to the next one. He ran the treatment program, which does provide feedback, at least three times per week.

Results. Mean category judgments of trained words improved 27%, from mean baseline performance of 63 to 90% correct post-treatment. Mean category judgments of untrained words increased 13%, from mean baseline performance of 62 to 75% correct post-treatment (see Table 27).

Tests were administered to determine if R.S. was actually reading the words, or simply learning a response to a visual stimulus. First, we examined if the treatment effect was font or case specific. Results indicated similar accuracy on trained words presented in a different font (treated words 85%, untreated words 60%) and in all capital letters (treated words 85%, untreated words 65%). Second, we presented R.S. with the treated words from both the birds and occupations categories combined. His task was to state whether or not each word was a bird; therefore, the treated words of the occupations set that R.S. had previously been trained to respond "yes" to now required a "no" response. R.S. correctly rejected all of the occupations and accepted all of the birds; his one error was in accepting one of the bird distractor words.

Speed of reading untrained words of various lengths improved, although R.S. continued to require more time to read longer words than shorter ones.

No part of speech effect emerged after treatment, contrary to our prediction.

Discussion. R.S. demonstrated greater improvement in making semantic judgments of trained words than of untrained words. These results are particularly interesting since the patient ran the treatment program himself in his own home. It does not appear that he is reading via the

semantic reading route, as he does not demonstrate a part-of-speech effect and continues to demonstrate a length effect. Clearly the treatment has had some impact on his reading, but which reading process(es) the treatment is improving has not yet been resolved. Studies addressing this issue are ongoing.

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13. The Syntactic Framework in Verbal Number Processing: A Rehabilitation Effort

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McCloskey, Sokol, & Goodman (1986) suggest that the number system has its own lexicon and syntax and may provide an interesting analogue for the language system. The limited lexicon and simple syntactic system may allow observations regarding their interaction that may be useful in understanding the language system. The patient H.K.W. presented here demonstrates a spared phonological number lexicon but has severe difficulty inserting these lexical items into a syntactic frame. He has good access to number tables for addition and subtraction, but more difficulty with multiplication and division tables. He is unable to use calculation procedures. We examined the effect of three training methods on his ability to read verbal numbers aloud and his ability to accurately complete arithmetic calculations. These training methods were (1) the generation of tens frames within a naming task, (2) the generation of tens frames in a judgment task, and (3) direct instruction in arithmetic problem solving. If the power of 10 specification ("10 EXP3," "10EXP2," and "10EXP0" in McCloskey's notation) used to generate the syntactic frame also supports number calculation, training in generation of the frame might improve both number naming and calculation. Direct instruction in calculation methods might be expected to improve the procedures drilled, but would be unlikely to generalize to naming.

Subject. H.K.W. is a 64-year-old right-handed male who had a left parietal occipital CVA in December of 1987. H.K.W.'s speech remains

fluent and anomic, with frequent circumlocutions, but few paraphasias. His auditory comprehension is relatively good. Language function is stable. H.K.W.'s number naming demonstrates sparing of a semantic class within an impaired grammatical system (Baynes, 1992). Prior to his stroke, H.K.W. was the director of his own company. He is a college graduate in engineering with an MBA.

Pre- and post-test materials. Prior to the initial training session, H.K.W. underwent pretesting in two areas: number reading and calculations. After each training session, H.K.W. was tested again using the same materials in order to measure changes in these two areas. The stimuli for the number reading test consisted of either 10 or 20 four- to eight-digit numbers which were divided into hundreds, thousands, and millions by commas (e.g., 3,789,546). The digits within each number string were selected randomly. The stimuli for the calculations test consisted of 32 problems with eight each of addition, subtraction, multiplication, and division. In each set of 8, 4 problems had two-digit numbers and four problems had one two-digit number and one three-digit number. Problems were constructed so that all answers were positive integers.

Training materials. Condition 1 randomly displayed strings of digits from two to eight digits in length on a CRT screen. Each block of digit strings consisted of a single integer from one to nine that combined with zeros for naming (e.g., 10, 100, 1000, 10,000, 100,000, 1,000,000, and 10,000,000 with the integer 1). Displays initiated at 3 sec in duration. When 75% accuracy was attained, exposure duration was lowered or a new leading digit was introduced. The shortest exposure duration attained using this method was 998 msec.

Condition 2 did not require a verbal response. He was required to match a string of digits viewed for 499 to 399 msec with one of two digit strings that differed from the briefly presented target string only in one digit. The length of the string varied from 4 to 7. The position of the digit that failed to match the target was alternated throughout the length of the string.

Condition 3 focused on arithmetic problem solving rather than syntactic frame generation. All of the training time was spent on division since HKW was able to use a good intuitive knowledge of numbers to solve addition subtraction and multiplication problems, but seemed have lost the concept of division. Training used standard flash cards and pencil and paper problems which he worked through with guidance from the instructor. Practice in the other arithmetic operations arose incidentally from HKW's technique of adding and subtracting divisors in solving the problems and occasionally checking his answers with multiplication.

Procedure. Number and calculation tasks were administered before and between each eight-session training condition. Due to changes in H.K.W.'s schedule, about a 6-month hiatus occurred between Conditions 2 and 3. There was also a long break between sessions of Condition 3.

TABLE 28
 Percentage Correct Reading Numbers Aloud and Performing Arithmetic Calculations
 before, between, and after Training Sessions

	Number naming (%)	Calculation (%)
Pretest	50	40
Post-Condition 1		
Naming	45	25
Post-Condition 2		
Judgment	90 ^a	57 ^b
Pretest	30	34
Post-Condition 3		
Calculation	60	31

^a Post-Condition 2 naming shows a significant improvement over Post-Condition 1 ($z = 3.46, p < .001$)

^b Post-Condition 2 calculation shows a significant improvement over Post-Condition 1 ($z = 2.75, p < .01$)

Results. Results are presented in Table 28.

Conclusions. Only Condition 2 increased naming scores. There was a trend toward some improvement in calculations as well. It was surprising that Condition 1 was so ineffective, especially as H.K.W.'s performance appeared to improve during those sessions. Likewise, explicit instruction although he appeared to understand and profit by it, did not significantly change scores on our post-test. These findings suggest that generation of the power of 10 frame may be facilitated by practice in a judgment task, but that naming itself is not effective. Conclusions in a single case study are always limited. Ours is further limited by the vagaries of H.K.W.'s health and schedule. However, we consider these results encouraging and hope to be able to replicate them with this subject and extend them to others. This line of research allows an approach to understanding the role of the generation of tens frames for verbal number naming and perhaps for calculation as well.

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14. A PACE Approach to Enhancing Functional Communication in Primary Progressive Aphasia

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Background. Primary progressive aphasia is a relatively uncommon condition in which language functioning deteriorates in the face of relative sparing of other cognitive areas. Since the earliest report (Mesulam, 1982), a number of cases have been described. Because of the progressive nature of the disorder, therapy aimed at restitution of linguistic function per se is probably not feasible. However, only a handful of reports have discussed attempts at any kind of therapy for such patients, despite the fact that the relative sparing of other cognitive functions should make them good candidates for treatment aimed at enhancing functional communication.

Methods. Subject: The subject, K.M., was a 65-year-old right-handed female who, according to her family, was in good health, with no problems in speech, language, or cognition until January of 1991, when they began to notice word-finding and spelling problems. In the ensuing 3 years her language progressively deteriorated, and ultimately she was referred for evaluation at the Aphasia Center in February of 1994. The patient and her husband believed that her only impairment was in language, despite the belief of a physician that she had Alzheimer Disease. The patient continued her normal activities of daily living, although her daughter now wrote out the checks for her mother to sign.

At the time of her initial evaluation at the Aphasia Center, her expressive language was severely impaired, although she was able to convey some information at the one-word level, and in occasional short sentences. Her nonverbal intellectual ability seemed relatively preserved. Neurological examination was normal outside of cognitive processing. Magnetic resonance imaging demonstrated marked atrophy of the left temporal lobe, insula, and operculum. Single photon emission computed tomography showed diminished activity suggestive of decreased regional cerebral blood flow to left temporoparietal region.

On the Western Aphasia Battery (WAB) (Kertesz, 1982), the patient's Aphasia Quotient was 45.6, indicating severe impairment, with comprehension her best area. She performed well (57/60) on Yes/No questions and Auditory Word Recognition (54/60), and could perform one- and two-step commands, but could not complete longer or more complex commands and demonstrated no comprehension of relational words. Her expressive language was more severely impaired, with fluency and gram-

matical competence rated 3 on a scale of 1–10 (10 best). She scored 18/60 on the Naming subtest, naming three items spontaneously, three more with tactile cues, and an additional 6 with phonemic cues. She was obviously frustrated during the naming task, but used no compensatory strategies to try to communicate the words, although she repeatedly indicated that she knew what they were. She tended to repeat incorrect responses 6 or 7 times in her struggle to find the right answer. She quickly became frustrated and gave up. Reading and writing were also impaired. She could read some common words but no nonwords. Matching of single words to pictures was flawless, as was visual lexical decision. She could write some words completely and parts of others, with her knowledge of the written word appearing to “fade out” at the end of many words.

On the Raven’s Coloured Progressive Matrices (Raven, 1965), often considered a nonverbal measure of intelligence, she scored 25/37, which placed her at approximately the 50th percentile for her age and contrasted with her severe language impairment.

Treatment: Because the patient was having a great deal of difficulty communicating with her family, especially her husband, with whom she lives, it was agreed that the principal goal of therapy would be to improve her ability to communicate with her husband, with the hope that this would also improve communication with her son and daughter, whom she sees often. The treatment approach was derived from PACE (Promoting Aphasics’ Communicative Effectiveness) (Davis & Wilcox, 1981). The goal was to increase her repertoire of communicative behaviors, and at the same time decrease her counterproductive behaviors, in order to convey her message as efficiently as possible.

Therapy materials were cards with drawings representing mostly nouns, with a small percentage of verbs and adjectives. Single words were chosen because that was the principal medium of communication for the patient. The cards were placed in a stack face down, and therapist and patient took turns drawing cards and communicating to the other what was on the card in any way at except showing the card. The therapist modeled drawing, writing, gesturing use of the object, and saying the word itself, as well as combinations of these activities to convey the message. The patient was discouraged from repeating the same wrong word many times and giving up, and was encouraged instead to use additional communicative techniques.

Results. After 6 weeks of therapy, with two 1-hour sessions per week, the patient was frequently using writing to cue herself to name or to convey her message. She also used some gestures and drawing, and on a few occasions she attempted one-word descriptions of functions. On a post-test, she improved her score on the Naming subtest of the Western Aphasia Battery from her initial score of 18/60 to a score of 42/60. In addition, her husband said that he had gone from “hardly ever under-

standing" to "almost always understanding" what she meant. Her children agreed that she was communicating better.

Conclusions. It appears that this patient's communicative ability improved after therapy, not because her language ability per se was restored, but because she was able to understand that her approach was failing, and learned to direct her energy toward using many communicative techniques, rather than merely repeating her errors or giving up in frustration. On her WAB Naming subtest post-test, she struggled and took time to name at the level she did, and she achieved the naming by using various techniques to cue herself to name correctly. When first tested, she did not employ any self-cueing techniques, and thus did far less well. It appears that a functional communication approach is a promising method for improving the communicative ability of patients with Primary Progressive Aphasia, and such an approach should be investigated further in this context.

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15. Physostigmine Improves Confrontation Naming in Two Patients with Anomic Aphasia in an Open-Label, Dose-Escalating Study

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Treatment with the cholinergic drugs tetrahydroaminoacridine (THA) or physostigmine has been shown to improve anomia in patients anomic due to Alzheimer's disease (Farlow, Gracon, Hershey, Lewis, Sadowsky, & Dolan-Ureno, 1992) or to a basal forebrain lesion (Jacobs, Shuren, Gold, *et al.*, 1994). These two conditions are associated with the loss of cholinergic neurons in the basal forebrain that project to the cortex (Davies & Maloney, 1976; Mesulam, Mufson, Levey, & Wainer, 1983). Acetylcholine increases the signal-to-noise ratio in the cortex by altering the

conductance of specialized potassium channels (McCormick, 1989). Increasing the signal-to-noise ratio may facilitate lexical access and thereby improve naming.

Treatments with cholinergic agents may also benefit anomic patients who have brain lesions without basal forebrain involvement. Cortical injury may reduce signal to noise ratios either by damaging the neuronal network that stores lexical-semantic information or by impairing access to the network. Cortical or subcortical injuries may also interrupt cholinergic projections.

The present study is a preliminary investigation of physostigmine treatment in two patients with anomic aphasia due to strokes outside of the basal forebrain.

Case 1. A 56-year-old right-handed male was admitted to the Clinical Research Center for testing 8 weeks after developing numbness in his right arm and slurring of his speech. Magnetic resonance imaging showed two infarcts, one involving parts of the frontal operculum and the superior and middle frontal gyri, and a second one involving parts of the superior temporal and angular gyri posterior to the auditory cortex and parts of the superior parietal and fusiform gyri. On examination he was found to be dysarthric, to have impaired verbal fluency, spared repetition, and difficulty naming. He had increased tone and 3/5 weakness of the right wrist extensors. He had hyperreflexia on the right side with a right plantar extensor response.

Case 2. A 59-year-old right-handed woman was admitted to the CRC 3 months after developing bitemporal headaches, photophobia, nausea, and right-sided weakness. Magnetic resonance imaging showed evidence of a hemorrhagic lesion in the posterior limb of the left internal capsule impinging upon the pulvinar and posterolateral nuclei of the thalamus. The patient was awake, alert, oriented, had normal affect, calculations, digit span, and memory. She had fluent speech, with normal repetition and comprehension and impaired confrontation naming. Her elemental neurological examination showed 3/5 weakness in an upper motor neuron pattern of the arm and leg on the right side. She required a walker to ambulate. She had a right plantar extensor response.

Methods. Both patients were admitted for open-label trials of physostigmine. Physostigmine was administered incrementally, beginning at 2.5 mg every 2 hr for six daily doses, and increasing the dose by 0.5 mg per dose per day to 4.0 mg or until side-effects supervened. Cognitive tests were administered at baseline, daily during the dose-finding phase beginning at the second day (dose of 3.0 mg q 2 hr), and 48 hr after withdrawal of physostigmine (washout condition). Some items were presented tachistoscopically at midline with measurement of naming reaction time. For analysis, scores on test items over several days of physostigmine treatment were averaged. Performances on physostigmine that exceeded both

TABLE 29
Results of Naming and Reaction Time Tasks with Physostigmine

Task	Patient	Physostigmine				
		Baseline	3.0 mg	3.5 mg	4.0 mg	Washout
Naming	1*		-5% (49 to 46/64)	6% (42 to 46/63) ^a	^a	0% (43 to 43/63)
	2*		7% (32 to 36/57)	^a	5% (35 to 38/61)	2% (38 to 39/62)
Naming reaction time	1*		3.0 (0.0)	2.5 (-0.4)	^a	2.7 (-0.2)
	2*	.46	4.8 (0.0)	^a	1.9 (-1.1)	1.9 (-0.2)
Simple reaction time	1*	.46	.43	.47	^a	0.62
	2*	.73	.67	^a	.58	0.66

Note. Signifies that mean score with physostigmine treatment was better than both baseline and washout scores for a given patient. Units: Naming reaction time, median of all trials in seconds (number in parenthesis is the change from baseline on same naming items); simple reaction time, median of 15 trials in seconds.

^a Did not tolerate dose.

the baseline and washout scores were considered to be improved. Other cognitive tasks administered serially included parallel forms of a letter fluency task, tests of simple and choice reaction time, digit span, and a verbal learning and recall task.

Results. Both patients improved on confrontation naming tests during physostigmine treatment. Patient 1 showed improvement only on 3.5 mg of physostigmine, and patient 2 showed effects on both the 3.0 and 4.0 mg doses (see Table 29). The naming reaction times improved on the same days the total naming scores improved. On the simple reaction time task, both patients improved. On the choice reaction time task, letter fluency, digit span, verbal learning and recall tasks, no improvement was observed.

Neither patient proceeded to a planned placebo-controlled, double-blinded study because of an inability to tolerate the drug (persistent nausea).

Discussion. Our two patients both improved on confrontation naming and naming reaction time tasks when given physostigmine. The effect was consistent with the performance of a previous patient who was anomic and amnesic due to a basal forebrain lesion, who also improved her confrontation naming but not memory when given physostigmine both during a dose-finding trial and a subsequent placebo-controlled, double-blind study (Jacobs *et al.*, 1994). Our two patients' lack of improvement on tests of letter fluency and memory suggests that their improvement was not due to an overall improvement of cognition.

Our two patients are unique insofar as they achieved a benefit from the drug despite having lesions outside the basal forebrain. Additionally,

unlike the previous patient, the patients reported here also improved on measures of reaction time. Reaction time is thought to measure attention and arousal and may have been especially important in patient 3, who has a thalamic lesion. The thalamus contains ascending cholinergic projections that are thought to be important for attention and arousal (McCormick, 1989).

Although physostigmine is a difficult drug to administer because it frequently produces nausea, these findings suggest that pharmacologic treatments raising levels of brain acetylcholine improve naming in anomic aphasic patients.

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16. Roman Jakobson: A Linguist's View of Aphasia

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The years which followed Broca's and Wernicke's discoveries stimulated neurologists throughout the world to apply linguistic analyses to aphasia data. But Roman Jakobson (1941, 1955, 1956, 1964, 1968, 1971, 1980) was the first linguist to apply linguistic *theory* to aphasia research.

Roman Jakobson was born in Moscow on October 11, 1896, and died on July 18, 1982, in Cambridge, Massachusetts, recognized as one of the great figures in the world of linguistics, poetics, literary criticism, historical studies, and as the pioneering figure in what is now known as neurolinguistics. Following up on the insights of Ferdinand de Saussure in 1879 and Baudouin de Courtenay in 1895 who had expressed the belief that a study of language pathology could contribute to linguistics, Jakobson also stressed the other side of the coin, the contribution of linguistics to the study of aphasia, stating that "any description and classification of apha-

sis syndromes must begin with the question of what aspects of language are impaired" (1971). He despaired over the fact that "the linguist's contribution to the investigation of aphasia is still ignored" since any explanation of linguistic deficits must refer to the intact grammar and knowledge of its units, structures, and organization but he believed that "linguists are also responsible for the delay in undertaking a joint inquiry into aphasia." This delay in any serious linguistic work on the brain/language interface was to continue for too long a time probably because of the ideology of behaviorism which dominated linguistics in the period prior to Chomsky (1957).

Jakobson would have been pleased to have seen the increased "cooperation of linguists, psychologists, psychiatrists, and neurologists" (1971) in the last few of years.

His views on aphasia reflected the theory of linguistics connected with the Prague Linguistic Circle, of which he was a cofounder in 1926. He attempted to establish a universal set of principles to explain the organization of all levels of linguistic structure which in turn would account for both normal and deviant language. These theoretical concepts, including his views of grammatical categories, the hierarchical organization of phonological distinctive features, syntagmatic vs paradigmatic structures in the lexicon and the syntactic system, and the pivotal notion of contrast and of phonological and morphological markedness were applied to his analysis of aphasia.

The first linguist to follow Jakobson's lead was Blumstein (1973) who applied his theories of distinctive features and markedness to an experimental investigation of aphasic phonemic error patterns concluding that these notions provide a principled explanation for aphasic errors and that the analysis of aphasic errors in turn contributes to phonological theory. It is interesting that the same pattern of errors found in aphasics—the greatest frequency of errors involve phonemic segments distinguished by opposite values of one feature—is also found in the speech errors produced by normals. That is, as predicted by Jakobson, /n/ [+nasal] is more likely to be substituted for /d/ [–nasal] (all other feature values being identical) than, e.g., /m/ for /s/, which is distinguished by three distinctive feature differences—+ vs – nasality, + vs – labiality, and + vs – continuance. Furthermore, Blumstein also substantiated Jakobson's view that the direction of substitution was from marked features (e.g., nasality) to unmarked. (His notion of markedness is also supported in the substitution of simple stems for inflected forms, for example.) (It is not clear whether current phonological theory, in some ways sharply differs from Jakobson's views of the segment as a bundle of contrastive features, can account for aphasic errors as well. A new analysis of these data is clearly called for applying the alternative theories of phonology that are now being debated.)

As discussed by Goodglass and Menn (1985), Grodzinsky (1990), and Caplan (1987) among others, Jakobson also applied his theory of grammar and notions of the distinction between syntagmatic and paradigmatic aspects of language to account for agrammatism (which he called a "continuity disorder") and fluent aphasia and anomia (a "contiguity disorder"), respectively. His discussion of these "polar" aphasias was descriptively adequate, but his structuralist view of language and his omission of the difference between the mental representation of language and linguistic performance as expressed in the "encoding" and "decoding" of speech production and comprehension prevented an explanatorily adequate picture of Broca's and Wernicke's aphasias. He would, for example, be unable to account for the asyntactic comprehension of agrammatic patients.

A major hypothesis of Jakobson's was that "the phonological acquisition of the child and the sound disturbances of the aphasic are based on the same laws of solidarity as the phonological inventory and the phonological history of all the languages of the world" (1968). This hypothesis continues to receive reinforcement in research on child language development, aphasia breakdown, and historical change. If he contributed nothing else, Roman Jakobson would remain an important figure in the history of aphasia research.

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17. Coherence in the Language Production of Aphasic Patients

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Rationale. The coherence of a discourse depends on relevant semantic relations between the given propositions (van Dijk & Kintsch, 1983). Relevance implies that each proposition in the narrative has a specific relation, e.g., presupposition or entailment, to the macropropositions of the story (Sperber & Wilson, 1986). In a recent study of narrative production, Christiansen (in press) has shown that Wernicke's and some conduction aphasics produce an inordinate number of irrelevant propositions, diminishing the coherence of their narratives. The purpose of the current study is to determine whether the coherence violations exhibited by the Wernicke's and conduction aphasics are associated with the formulation of paragraph length discourse or associated with a more general semantic impairment which also affects the semantic associations of single sentences and words.

Methods. The subjects used in this study consisted of 13 aphasic patients (3 female, 10 male), exhibiting either Broca's, conduction, or Wernicke's aphasia. All subjects suffered from a single, left-hemisphere stroke and were evaluated at the time of testing with the Boston Diagnostic Aphasia Exam (BDAE), the Boston Naming Test, and a short form of the Token Test. Auditory comprehension for all subjects was in at least the 70th percentile on BDAE. In addition, 20 age- and education-matched normal control subjects were included.

To elicit language production at the word, sentence, and paragraph level, three production subtests were used from the Relevance/Coherence Battery (Christiansen, 1994): word list generation, sentence pair completion, and narrative production. In word list generation, the subjects were orally given eight different topic frames (e.g., FARM or HOSPITAL) and asked to give all of the words they could think of related to that topic. In sentence pair completion, the subjects were orally given 20 sentences (e.g., James failed the math test) and for each they were asked to respond with a logical follow-up sentence (e.g., he studied harder for the next one). In narrative production, the subjects were shown three five-frame wordless cartoon strips and asked to tell the story accompanying each cartoon. Each story was then parsed into its semantic propositions. Each response to the word and sentence level tasks and each story-related proposition on the paragraph level task was then rated on a 7-point Likert scale (7, most relevant) by two independent raters as to its relevance to the stimuli topic. The relevance ratings for each subject on the

TABLE 30
Performance by Aphasic Patients on Relevance Tests

	Broca's				Conduction				Wernicke's				
	MA	RO	BL	MP	PA	CA	GO	GE	GA	RI	CB	ML	LC
Words	X	—	—	—	—	X	—	—	—	X	—	—	—
Sentences	X	X	X	X	—	X	X	X	—	X	—	—	—
Narrative	—	—	—	—	—	—	—	—	X	X	X	X	X

Note. "X" indicates at least 2 standard deviations below normal.

three tasks were then converted to a 100-point score to control for the differences in the number of responses by each subject.

Results. The means and standard deviations for the relevance scores of the normal control subjects were first calculated. Then, the relevance scores for each aphasic subject were compared to the mean scores and standard deviations of the normal subjects. Aphasic subjects who scored more than two standard deviations below normal on a given task were considered impaired, as indicated in Table 30. Performance on the word list generation task was generally within normal limits, and individual difficulties were not related to any particular type of aphasia. On sentence pair completion, all Broca's and all but one of the conduction aphasics were impaired, but only one Wernicke's patient had difficulty. However, on narrative production, the opposite pattern emerged: all of the Wernicke's aphasics scored at least two standard deviations below normal, but all of the Broca's and conduction aphasics scored within normal limits.

Discussion. How can the differences be accounted for between the aphasics' ability to maintain relevance at the word and sentence level on one hand and at the discourse level on the other? While the difficulty of producing relevant responses in sentence pair completion appears to apply only to the Broca's and conduction aphasics, in fact, it is directly related to the severity of aphasia rather than aphasia type. All of those subjects ranked as 3 or below on the BDAE severity rating scored at least two standard deviations below normal on sentence pair completion, accounting for the Wernicke's patient RI; those ranked 3.5 or 4 were within normal limits, accounting for the conduction patient PA. It is possible that the more severe subjects could generate relevant responses but could not formulate them at the surface level; therefore, they strategically produced less-precise, less-relevant alternatives. In the narrative task, they were allowed more freedom to utilize their communicative strategies and could then provide relevant story propositions. The production of irrelevant propositions by the Wernicke's aphasics, regardless of their

severity, appears to be an isolated problem in formulating discourse and might be the result of a narrative strategy they employ to counterbalance an underlying difficulty in organizing story information into appropriate propositional units. Because the Wernicke's aphasics may be unable to distinguish which propositions are relevant to a particular story plot, they produce not only the essential propositions but also numerous irrelevant descriptions and details. This strategy ensures that their narratives are complete at the expense of lacking coherence. These results suggest that Wernicke's aphasics, unlike other aphasic subtypes, may possess an underlying deficit in formulating narrative macrostructures.

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18. Phonological Processing Deficits in Alzheimer's Disease

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Introduction. The nature of phonological production in probable Alzheimer's disease (pAD) has been controversial. Several investigators (Ajuriaguerra & Tissot, 1975; Appell et al., 1982; Blanken et al., 1987; Critchley, 1964) have reported that speech sound disorders in word production are rare in pAD. By comparison, other investigators (Cummings et al., 1985; Kertesz et al., 1986) have claimed that pAD patients are aphasic and produce speech errors. The results of these latter studies have been reported in tabular form, however, without any documentation of the frequency or quality of the disorder. Based on our clinical impression, we hypothesized that pAD patients have phonological processing problems that would be detectable on a repetition task. We also expected to see more errors in patients who were more severely demented. Given the frequent word-finding problems of pAD patients, we expected their pattern of phonemic paraphasic errors to be most consistent with a deficit at the level of lexical-phonological retrieval rather than phonemic plan-

ning. This would be indicated by the production of syllabic and word-initial errors, rather than errors for a particular phonemic feature (Kohn et al., 1993). We assessed the relative role of short-term memory and grammatical demands for accurate phonological production by systematically manipulating the nature of the sentences that patients repeated.

Methods. We examined phonological production in 16 right-handed native English-speakers with pAD, according to the NINCDS-ARDA criteria (McKhann et al., 1984). These patients were recruited from the Cognitive Neurology Clinic at the Hospital of the University of Pennsylvania. Exclusionary criteria included the presence of other neurodegenerative conditions or the use of psychoactive medication at the time of testing. The average age of the pAD patients was 68.68 ± 9.00 years with an average education of 13.31 ± 2.70 years. These patients were compared to 17 age-matched (mean age, 70.41 ± 10.19 years; $t(31) = 0.51$) and education-matched (mean education, 14.88 ± 1.60 years; $t(31) = 2.04$) controls.

Thirty sentences were presented that manipulated the variables of sentence length and syntactic construction. Thus, 20% of sentences were simple, 40% were terminal subordinate, and 40% center-embedded subordinate. Half of each type of sentence was padded with extra adjectives that did not change syntactic phrase structure. Subjects were presented these sentences orally one at a time and were instructed to repeat the sentence immediately following presentation. Subjects were specifically instructed not to correct any perceived errors in the sentences but to repeat each sentence verbatim "like a tape recorder."

Phonetic transcriptions of the recorded speech were made by a trained linguist using the revised IPA, and a second rater naive to the purpose of the study also evaluated the speech samples. Interrater agreement was 80%. Differences were resolved by consensus discussion. Using these transcriptions, phonological analyses were conducted on the consonants produced. The data were analyzed for the number of words containing phonemic errors and whether these resulted from phonemic substitutions, additions, or deletions. Further analyses were conducted on each type of phonemic error to determine whether they were anticipations, perseverations, metatheses, or random (i.e., nonenvironmentally induced), and to determine the position (i.e., initial, medial, or final) they occupied in the word. The features of the substitution errors were further compared to those of the target in order to determine whether the changes were in laryngeal, manner, or place features. We also noted whether repetitions contained syllabic errors (i.e., fragments) and nonwords. We ignored semantic paraphasias and voiced or silent hesitations.

Results. Using Kruskal-Wallis tests, we found that pAD patients made significantly more phonological errors than controls ($p = .005$) on the repetition task. In particular, pAD patients produced significantly more

phonemic substitutions ($p = .009$) and additions ($p = .01$) but not segment deletions ($p = .08$) in comparison to controls. Their errors were often anticipatory ($p = .02$), but not perseverative ($p = .06$) or metathetic ($p = .14$). Analyses of error position revealed that pAD patients produced significantly more errors which involved the initial position ($p = .02$) but not the medial ($p = .42$) or final position ($p = .10$) of a word. Within-group analyses indicated that pAD patients showed significant differences in errors involving the initial vs medial and final positions of a word ($p = .006$). Feature analyses revealed that pAD patients made significantly more substitution errors involving laryngeal ($p = .005$), manner of articulation ($p = .01$), and place of articulation ($p = .002$) than controls. Within-group analyses revealed that pAD patients produced significantly more place feature substitutions than laryngeal or manner errors ($p = .01$). pAD patients also made significantly more syllabic errors, as evidenced by the production of more word fragments ($p = .03$) and phonemic addition errors ($p = .01$). They also produced more nonwords ($p = .007$).

Kruskal tests also revealed that pAD patients produced significantly more phonological errors when repeating words cast in certain types of syntactic constructions. Specifically, pAD patients produced significantly more errors (i.e., random substitutions ($p = .001$), initial position errors ($p = .001$), manner errors ($p = .008$), and place errors ($p = .008$)) on terminal subordinate and object relative center-embedded sentences in comparison to controls. We failed to find any effect for sentence length. Kendall tests revealed a significant correlation between phonemic errors and the severity of dementia, but no correlation was found with age, education, or duration of disease.

Discussion. Form-related disorders in word production such as phonemic paraphasias and neologisms are claimed to be rare in the spontaneous speech of pAD patients (Appell et al., 1982; Blanken et al., 1987; Critchley, 1964; Ajuriaguerra & Tissot, 1975). Our analyses revealed, however, that pAD patients frequently produce phonological errors on a repetition task. The finding that speech errors became more obvious with dementia severity suggests that differences in earlier studies may have been due to the evaluation of different populations of pAD patients. Moreover, the finding that speech sound errors interacted with the syntactic form of a sentence but not its length emphasized that a deficit in short-term memory is not an adequate explanation for phonemic paraphasias on a sentence repetition task, but that their errors are specifically related to a deficit in a speech production system. The qualitative pattern of phonological errors seen in pAD, including syllabic form and word-initial errors, was most consistent with a lexical-phonological retrieval deficit as the basis for their phonemic paraphasias. However, greater deficits for place of articulation than manner or laryngeal features suggested a deficit at a phonemic planning level of processing as well.

19. Grammatical Processing Difficulty in Progressive Dementia: Cognitive and PET Activation Studies

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Introduction. Grammatical processing in progressive dementia has been examined in a handful of studies, and contradictory results have been reported. Several investigators have observed grammatically intact spontaneous speech and writing in probable Alzheimer's disease (pAD). Others have claimed that pAD patients encounter significant difficulty understanding sentences that contain subordinate phrases, attributing this deficit to a postinterpretive limitation in short-term memory. Patients with neurodegenerative conditions affecting primarily anterior cortices such as Pick's disease, however, have been observed to have difficulty with grammatical expression. The purpose of this study was to assess the cognitive and pathophysiologic basis of sentence comprehension and expression in a patient with progressive frontal dementia.

Methods. T.C. is a 69-year-old, right-handed, college-educated native English speaker who had progressive language and memory difficulty for 4 years. Neurological examination was normal. Mental status assessment revealed impaired verbal and visual episodic memory, and mildly compromised performance on visual processing measures. His speech was somewhat hesitant due to difficulty with speech initiation. He had a mild confrontation naming deficit, but did not have semantic memory difficulty. He was impaired on measures of executive functioning such as Wisconsin Card Sorting and was nonfluent and very perseverative on category naming and drawing procedures. His MMSE score was 27. His performance was contrasted with 25 age- and education-matched pAD patients and 25 age- and education-matched control subjects.

T.C. was studied with several tasks assessing sentence processing. He performed a sentence comprehension task where transitive verb sentences (e.g., "The cow that chased the horse was brown") varied in the presence and nature of an embedded clause (simple, terminal subordinate, center-embedded subordinate). He answered probes of oral sentences and judged the grammaticality of similar sentences. Another task assessed his truth verification of sentences cast in active, passive, and periphrastic voices (e.g., "The woman drowned the swimmer." The swimmer drowned: True or false?). A sentence completion task assessed his ability to describe pictures with passive voice, question, and subordinate phrase forms. On a study of grammatical form class, T.C. was asked to match a mass quantifier or count quantifier with one of four pictures

(e.g., "Point to the jar with many"), to judge the grammaticality of brief sentences with quantifier–noun pairs (e.g., *"The glass contains much pencils"), and to complete sentences describing pictures with a quantifier (e.g., "This jar (*pointing*) has many but this jar (*pointing*) has . . .").

T.C. was also studied with a PET activation paradigm. Our technique uses the constant infusion of [^{15}O]H $_2\text{O}$. After a 9-min infusion to attain serum equilibrium, a 10-min resting baseline scan is obtained. T.C.'s resting baseline rCBF was compared with eight neurologically intact controls and six pAD patients. Then an activation baseline scan is obtained, when subjects are shown the stimuli used in subsequent cognitive challenges but are asked only to respond as fast as possible to each successive stimulus. Cognitive challenges are then obtained. This report focuses on T.C.'s rCBF during his detection of instances of a target form class (verb) from a list of 80 familiar words. This was analyzed as ratio to the control activation condition, rCBF during his detection of instances of a target semantic category ("vegetable"). T.C.'s rCBF activation pattern was compared with rCBF in eight control subjects during identical conditions. An individualized anatomic template, based on Talairach and Tournoux, was derived from each individual's MRI. The MRI and the PET were sliced in the anterior commissure–posterior commissure plane, and the individualized MRI atlas was transferred in a user-independent fashion to the PET. In order to minimize nonspecific CBF changes during cognitive challenge, such as may occur as a result of task difficulty, all raw rCBF data were normalized to whole brain CBF for the same scan; because of differences in CBF between controls and patients, region-to-whole brain activation data were normalized to region-to-whole brain activation baseline CBF.

Results. T.C. exhibited significant difficulty appreciating grammatical features of sentences. He did not differ from chance in his responses to subordinate phrase structures (47% correct) and grammatical voices (62% correct), but differed from random in his responses to simple, active voice sentences (86% correct). Neither semantic constraint nor sentence length affected performance. He was random in his grammaticality judgments (67% correct), and had difficulty completing passive, question, and subordinate phrase sentences. He was also significantly compromised in his appreciation of the mass/count distinction on sentence–picture matching, grammaticality judgment, and sentence completion tasks.

On the resting PET scans, T.C. differed from pAD patients in the distribution of his abnormal rCBF [$\chi^2(2) = 9.01; p < .02$]. In comparison to other pAD patients, T.C. had reduced frontal rCBF, particularly in left anterior cingulate, dorsolateral, and inferior frontal regions. pAD patients had greater reductions in parietal rCBF. During the cognitive challenges, normalized rCBF in control subjects selectively increased in left anterior cingulate (4%) and left inferior frontal regions (4%) during form

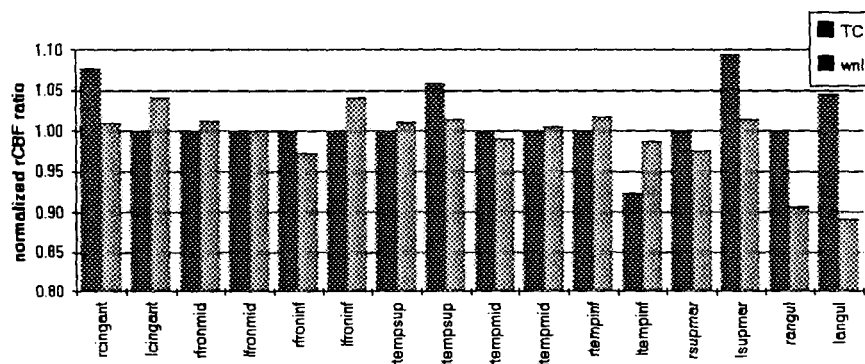


FIG. 32. Normalized regional cerebral blood flow (rCBF) during the grammatical form class challenge, using the semantic category membership challenge as the control condition. Control subjects demonstrated selective rCBF increase in left inferior frontal and left anterior cingulate cortices. TC did not recruit these brain regions during the grammatical form class challenge. Instead, he activated left inferior parietal and left posterior superior temporal cortices and right anterior cingulate cortex, more representative of the brain region activated by controls during the semantic challenge.

class detection compared to semantic category detection. During the same tasks, normalized rCBF in T.C. did not change in left frontal cortices, but increased in right anterior cingulate (8%), left superior temporal (6%), left supramarginal (9%), and left angular (7%) cortices (Fig. 32).

Discussion. T.C. appeared to have difficulty appreciating grammatical aspects of sentences. This was associated with selective difficulty recruiting left anterior cingulate and left inferior frontal cortices. Increased rCBF in left posterior peri-Sylvian and right anterior cingulate regions could not compensate for his deficits. The role of left anterior cingulate and inferior frontal cortices in sentence comprehension is discussed. We hypothesize that grammatical comprehension difficulties are due to the compromised recruitment of a left anterior network of brain regions that supports the interpretation of grammatical aspects of sentences.

PLATFORM SESSION 6

1. Dissociations between Object and Action Naming following Anterior Temporal Lobectomy

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It has been proposed that there are separate neural systems specialized for processing lexical forms designating objects (nouns) and actions (verbs) (Caramazza & Hillis, 1991; Damasio & Tranel, 1993). Aphasic patients with anterior left hemisphere lesions consistently show greater impairment retrieving verbs compared to nouns in naming tasks (Kohn et al., 1989; Miceli et al., 1984; Zingeser & Berndt, 1990) and in sentence contexts (Goodglass, 1993). Though less consistent, spared verb naming in the context of impaired object naming has been reported in certain fluent aphasics (Miceli et al., 1984; Zingeser & Berndt, 1990) (but see Kohn et al., 1989; Williams & Canter, 1987). Based on evidence from two patients, Damasio and Tranel (Damasio & Tranel, 1993) suggested that dissociation between impaired noun naming and relatively preserved verb naming results from a specific lesion in the left anterior/middle temporal lobe.

We sought to verify Damasio and Tranel's observation in a larger group of patients who had anterior temporal lobectomy for treatment of intractable epilepsy. These patients are known to have impaired object naming (Stafaniak et al., 1990), but their action naming capacity is unknown. We predicted that left temporal lobectomy (LTL) patients would show greater deficits in object than in action naming. A comparison group of right temporal lobectomy (RTL) patients was not expected to show deficits in either condition.

Subjects and methods. Thirteen LTL and 16 RTL patients demonstrated left hemisphere language dominance during the intracarotid amobarbital test performed prior to surgery (Sperling et al., 1992). Groups did not differ in presurgical IQ, age of seizure onset and brain injury, time since surgery, handedness, gender, and education. RTL subjects were slightly older than LTL subjects, a difference that should have biased results in the direction opposite to that predicted, based on findings

(Nicholas et al., 1985) that normal aging is associated with selective decline in object, but not action, naming.

Subjects were tested at least 2 weeks postsurgery and were administered the complete Boston Naming Test (BNT) (Kaplan et al., 1983) and Action Naming Test (ANT) (Obler & Albert, 1982). Only spontaneous (uncued) responses were coded. Errors were classified as; no response, circumlocution, superordinate, semantically related noun, semantically related verb, phonological/semantic distortion, visual perceptual/semantic distortion, and other errors.

Results. In a two-way ANOVA of percent correct responses the expected interaction emerged with different word-type effects seen in the two subject groups. In the RTL group BNT and ANT scores did not differ, but LTL patients were significantly more impaired on BNT than ANT. Seven LTL patients showed an ANT–BNT difference greater than 2 SD above the mean difference in the RTL group. The ANT–BNT difference was greatest in subjects tested in the first 4 weeks postsurgery and attenuated over time, suggesting that it was specific to the left anterior temporal lobe lesion.

RTL and LTL groups made similar types of naming errors, most commonly circumlocutions. There were no major differences between BNT and ANT naming error patterns, except that some noun substitutions occurred in object naming and some verb substitutions in action naming.

Discussion. Significant dissociation between poor object naming and better action naming in LTL patients is consistent with the hypothesis that the left anterior/middle temporal lobe, while important for retrieving object names, may not be as involved in retrieving verb names. The findings support the proposal that different neural systems may participate in retrieving different lexical forms. Unfortunately, our data do not speak to the cognitive mechanism(s) that underlies this dissociation.

Three psychological explanations for the apparent dissociation between noun and verb naming have been proposed, though none has received compelling support: (1) An early proposal linked anterior aphasics' verb naming deficits to their impaired grammatical processing. This account was challenged by inconsistency of association between agrammatism and verb naming problems in these patients (Bates et al., 1991). (2) Another explanation assumed differences in semantic–conceptual meaning representations for actions and objects. The former were postulated to be represented in brain regions close to motor cortex and disrupted in anterior aphasics, and the latter represented around temporal/parietal multimodal sensory association areas and vulnerable in fluent aphasics (Bates et al., 1991; Damasio & Tranel, 1993). If form-specific naming problems stem from disrupted conceptual representations for either nouns or verbs, then impaired comprehension for these same words

might be expected. In aphasics, at least, comprehension impairments do not necessarily parallel noun/verb naming disorders. (3) A final account has suggested that words are listed in mental lexicons separated according to grammatical form-class. Modality specific form-class effects in certain aphasics are difficult to reconcile with such an explanation, which would require an unimaginably large number of specialized form class/modality lexicons (Goodglass, 1993).

We suggest that breakdown in lexical access procedures, rather than disruptions in lexical-semantic representations, can explain impaired noun and preserved verb naming in anomic patients. This explanation rests on the notion that object names are more difficult to access than action names with any type of disturbance in mechanisms of word retrieval. Though represented in the same lexicon, nouns (especially concrete and proper nouns) are organized within a tight net of a few nominal associates, while verbs have a more dispersed set of lexical associates from different form classes (Fillenbaum & Jones, 1965; Gentner, 1981). When mechanisms for retrieval from such a system are disturbed, nouns would be expected to be most difficult to access through alternative routes, but verbs would remain more accessible, albeit slowly, through alternate paths. This would explain why failure to name objects and proper names is a universal feature of all anomics, and verb naming is spared only in some patient populations (anomic aphasics, LTL patients, healthy elderly). Verb naming problems, by contrast, seem to be unique to patients with anterior aphasias and are likely due to another type of cognitive deficit.

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2. Studies of Articulatory Timing in Normal and Foreign Accent Syndrome Speech

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Introduction. Deviant speech patterns have traditionally been identified by acoustic-perceptual comparison with normal speech. However, articulatory timing differences, not readily derived from acoustic analysis, offer another potential source of impaired production (Edwards & Beckman, 1988). Despite current interest, articulatory timing features and their associated neural mechanisms remain largely unspecified. To investigate these issues, we studied the time course of jaw movement during syllable production in a patient diagnosed with Foreign Accent Syndrome (FAS), an infrequently occurring aphasic disorder characterized by dysprosody or perceived "accentedness." Previous studies of FAS have identified deviant acoustic-perceptual features, including prolonged vowel duration, increased vowel tension, and abnormal pitch patterns (Blumstein, 1987; Graff-Radford, 1986). Such acoustic-perceptual features cannot, however, entirely account for the perceived accentedness of FAS speech. We hypothesized that deviations from normal articulatory timing patterns also contribute to the perception of disordered speech.

Methods. Subjects: The patient, a 52-year-old, right-handed, white male, suffered a left-hemisphere CVA from embolism. CT scan revealed acute infarction of the left superior temporal gyrus, extending into the parietal lobe. The patient had completed high school and was formerly employed by a fencing company. He was tested at 1.5 months post-onset and again at 6 months post-onset. On initial speech examination, he was diagnosed as an expressive aphasic, with mild anomia, relatively intact comprehension, and a mild right-side hemiparesis. Acute symptoms resolved within weeks, leaving a residual "accentedness" described as dysprosody. The patient was frequently mistaken for a native speaker of Norwegian. His speech was evaluated again after 6 months and found to be within normal limits on all dimensions, including prosody. Three normal volunteers were also tested, two males (ages 34 and 25) and a female (age 40), to provide normative data. All were right-handed, with no history of speech or oral-motor disorders.

Stimuli. Twenty consonant-vowel-consonant (CVC) syllables were generated. All syllables began with /s/ to provide a neutral and constant initial jaw position. Syllable-final consonants were /p/, /b/, or /m/. Bila-

bials were chosen for their associated visual cues. Different vowels appeared in syllable-medial position. Target syllables were embedded in a carrier phrase and presented in randomized list format for subjects to read aloud.

Procedures. Testing procedures were identical for both subject populations. A jaw tracker was affixed to the lower front teeth using silicon dental adhesive. Additional referents were located on the frame of glasses worn during testing. Subjects were video-taped in profile. To ensure that no perceptual degradation of speech occurred with the tracker, two normal subjects, blinded to the purpose of the study, evaluated subjects' speech with and without the tracker. No noticeable differences were reported.

Data analysis. Video-recorded speech samples were digitized at 60 frames per second. Jaw tracker and referent coordinates (x , y) were extracted for individual syllables to compute jaw displacement and velocity values. Syllable onsets were identified by the first opening gesture associated with vowel production. Syllable closure was defined as maximal bilabial closure. Coordinates were normalized to a standard reference frame to permit within-subject comparisons.

Results. Both patient and normal subjects differentiated in degree of jaw opening between high and low vowels. Both subject populations also produced similar overall velocity patterns during opening syllable gestures, regardless of vowel identity. Specifically, an increase in jaw displacement velocity was observed during initial stages of the opening gesture, followed by decreased velocity in the vicinity of maximal displacement. Maximum displacement was attained more rapidly before voiced than voiceless syllable-final obstruents. This pattern was observed across both subject groups and testing sessions (Fig. 33).

Analysis of normal speakers' closing gestures revealed additional timing differences associated with syllable-final voicing. Before final voiced obstruents, maximal jaw displacement was sustained longer (300–600 msec) than before voiceless consonants (Fig. 33a, 33b). This pattern was not observed in the patient's speech at 1.5 months post-onset (Fig. 33c, 33d). By 6 months post-onset, however, the patient's timing patterns more closely approximated those of the normal subjects (Fig. 33e, 33f), with maximum displacement sustained consistently before voiced obstruents.

Discussion. These data suggest that degree of jaw displacement is primarily responsible for perceived vowel identity, supporting previous claims of intrinsic vowel durational differences (Peterson & Lehiste, 1960). The patient demonstrated the ability to control degree of jaw displacement, potentially accounting for the perception of intact segmental production. Control of nonintrinsic durational differences, which we hypothesize to be language-specific, were disrupted during the acute post-onset stage. Specifically, whereas normal subjects sustained maximal jaw

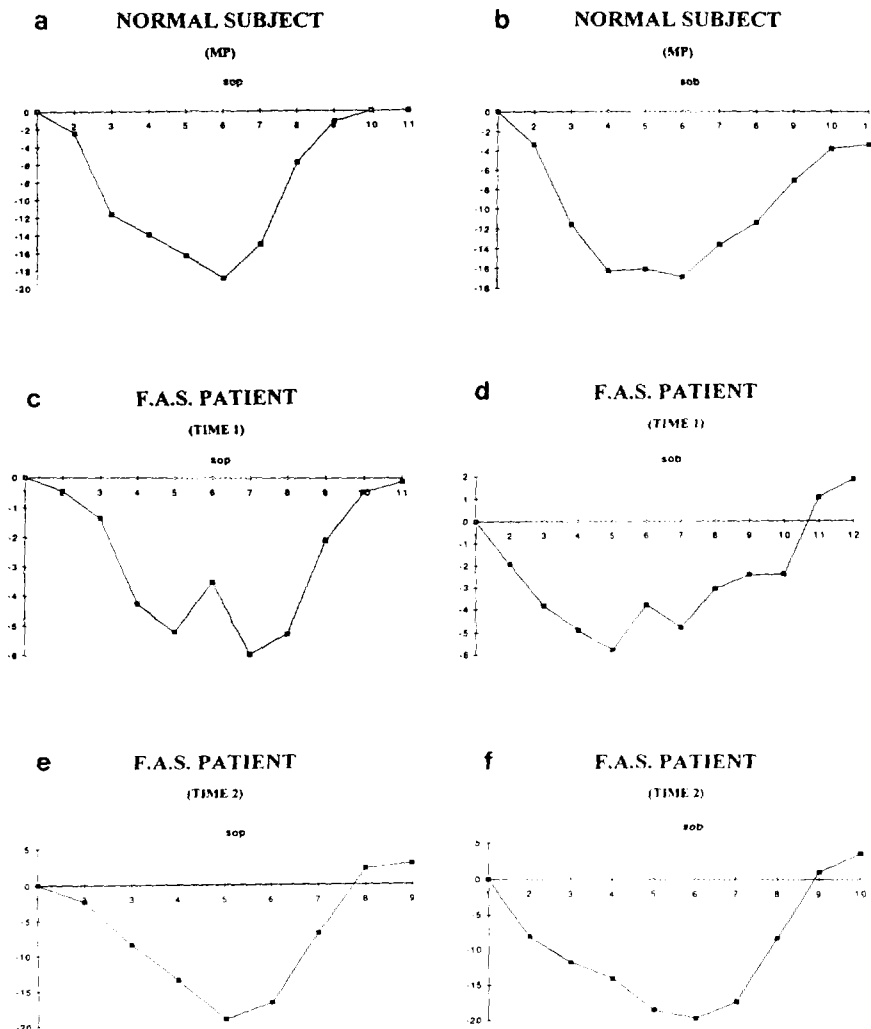


FIG. 33. (a-f) Time course of jaw displacement during production of syllables *sop* and *sob*. (a-b) Data from a normal subject. (c-d) Patient data at 1.5 months post-onset. (e-f) Patient data at 6 months post-onset.

displacement before voiced consonants, the patient did not. By 6 months post-onset, however, the patient's articulatory timing patterns approximated those of our normal subjects. Independent speech evaluations further corroborated this observation.

These data suggest that dysprosodic characteristics of FAS speech reflect impaired access to intrasyllabic timing patterns. Evidence of a selective disruption in the microprosody (Anderson, 1994) of speech, associ-

ated with a left hemisphere lesion, further indicates that articulatory timing information is encoded within the neuromotor system. These findings have implications for the treatment of speech disorders in mild and resolving stroke patients, and may account, in part, for the perceived accentedness of normal non-native speech.

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