CHAPTER

33

Recovery of Auditory Comprehension After One Year:

A Computed Tomography Scan Study

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Aphasiologists generally agree that auditory comprehension is impaired to some extent in most aphasia cases. In some patients, auditory comprehension is only mildly impaired, whereas in others, the auditory comprehension deficit is severe. Since the time of Wernicke, auditory comprehension impairments have been associated with lesions in the left superior temporal gyrus (Wernicke, 1874). Computed tomography (CT) scan studies that have examined the relationship between presence of lesion in the posterior two-thirds of the superior temporal gyrus (Wernicke's area) and auditory comprehension deficits have confirmed this association (Naeser and Hayward, 1978; Selnes, Knopman, Niccum, Robins, and Larson, 1983). Additionally, Naeser, Alexander, Helm-Estabrooks, Levine, Laughlin, and Geschwind (1982) have shown that lesion in the subcortical temporal isthmus area can also produce auditory comprehension deficits similar to that seen in Wernicke's aphasia.

The purpose of this study was to examine the relationship between the recovery of auditory comprehension deficits and CT scan lesion sites in a group of severely aphasic patients in the acute phase of recovery. Severity of auditory comprehension was assessed with the auditory comprehension subtests from the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass and Kaplan, 1973).

METHOD

Fifteen severely aphasic patients were included in this retrospective study. All subjects were right-handed and had suffered a single-episode left-hemisphere occlusive-vascular infarct. Subject selection criterion for severity was an overall BDAE auditory comprehension Z-score during the initial test period. Patients were selected from chart reviews of patients that met the aphasia severity criterion. Patients were excluded if there was documentation of (1) a dementing illness, (2) multiple lesions, or (3) traumatic brain injury. Patients were sorted into groups according to the results of the CT scan analysis. The CT scans were analyzed using a visual inspection method that quantified extent of lesion in specific neuroanatomical sites. All CT scans used for analysis were completed at least 2 months post-onset, a time when the CT scan lesion sites are considered to be stable. Major neuroanatomical areas were individually rated for extent of lesion using an equal-appearing interval rating scale that ranged from 0 (no lesion) to 5 (total area lesioned) (Table 33-1). Each neuroanatomical area was individually rated for extent of lesion by two experienced judges. When scores differed, they were discussed until a mutually agreeable score was obtained. Results of the BDAE auditory comprehension subtests were then examined to determine recovery patterns. The auditory com-

TABLE 33-1. SCALE USED FOR RATING EXTENT OF LESION WITHIN NEUROANATOMICAL AREAS

0	No lesion
1	Equivocal lesion
2	Small, patchy, partial lesion
2.5	Patchy; less than half of area has lesion
3	Half of area has lesion
3.5	Patchy; more than half of area has lesion
4	More than half of area has solid lesion
5	Total area has solid lesion

prehension data were obtained at two time periods. Time 1 (T1) testing was completed between 1 and 4 months post-onset of aphasia. Time 2 (T2) test results were obtained after 1 year post-onset, with most T2 (10/15) behavioral testing completed between 1 and 2 years post-onset. The following section briefly describes the neuroanatomy that was of concern for this study.

NEUROANATOMY

Figure 33-1 is a lateral view of the brain that shows the relationship between cortical language areas and the ventricular system. In this study, we were primarily concerned with Wernicke's area, which was defined as the posterior two-thirds of the superior temporal gyrus. The anterior half of Wernicke's area is seen on CT scan slice B/W. This area is seen on CT scan lateral to the widest portion of the third ventricle. The posterior half of Wernicke's area is located on slice W and is seen on CT scan anterior and lateral to the occipital horn region.

The anterior portion of Wernicke's area is represented on slice B/W and is located at the level of the maximum width of the third ventricle (Fig. 33-2). The medial border of Wernicke's area was arbitrarily set as a line drawn from the posterior inferior portion of the Sylvian fissure to the temporal horn.

The posterior one-half of Wernicke's area is found on slice W (Fig. 33-2). Wernicke's area is located anterior and lateral to the occipital horn. It is bordered medially by an arbitrary line drawn from the posterior inferior portion of the Sylvian fissure to the atrium.

The temporal isthmus is a subcortical structure that can be seen on both CT scan slices B and B/W (Fig. 33-3). It is a white matter area located between the posterior inferior portion of the Sylvian fissure and the tem-

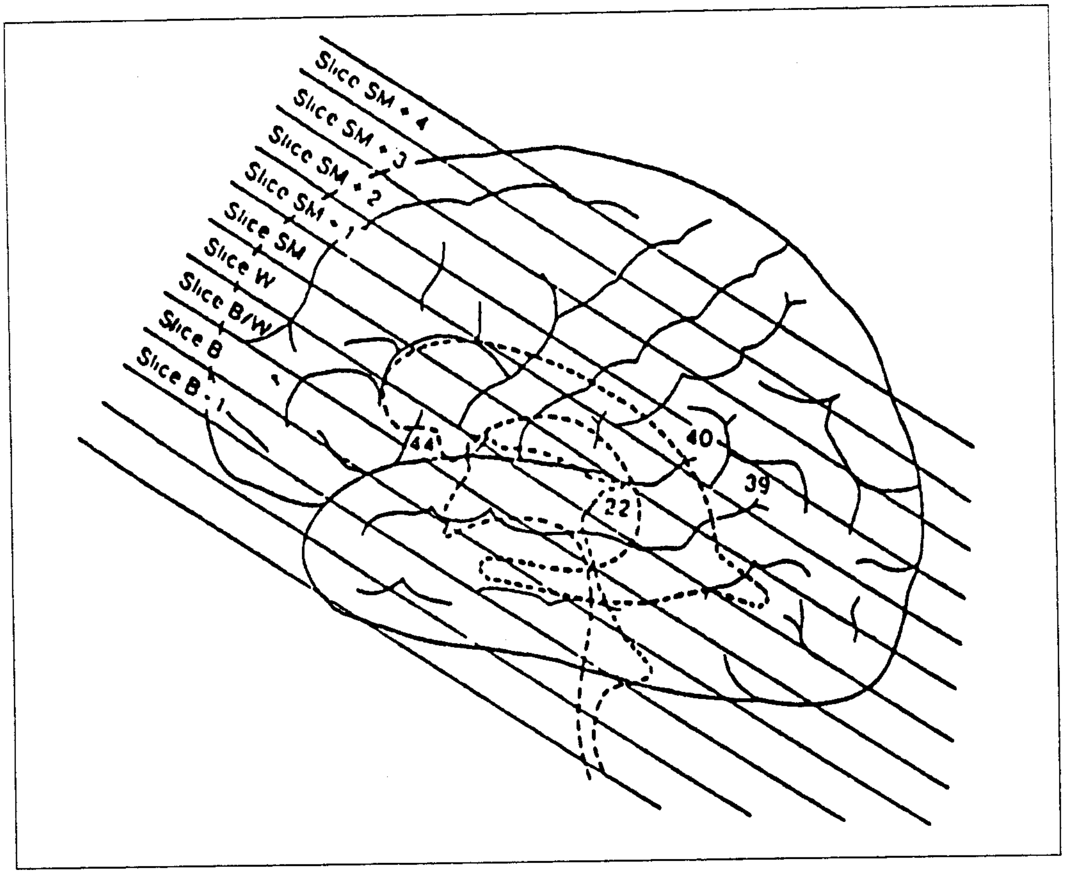


Figure 33-1. Lateral view of the brain showing the relationship of the cortical language areas to the ventrical system on CT scan slices.

poral horn. In this study we were concerned with the anterior portion of the temporal isthmus because this is the portion that contains the auditory fibers projecting from the medial geniculate body in the thalamus to primary auditory cortex. Optic radiations travel through the posterior portion of the temporal isthmus. The anterior portion of the temporal isthmus is a very small area (only a few millimeters) on CT scan.

RESULTS

NEUROANATOMICAL GROUPS

Following CT scan analysis, two groups emerged based on lesion configuration. One group was labeled the FPT group. The 10 aphasic patients in this group had cortical lesion in the frontal, parietal, and temporal lobes including cortical lesion in Wernicke's area. The second group was labeled

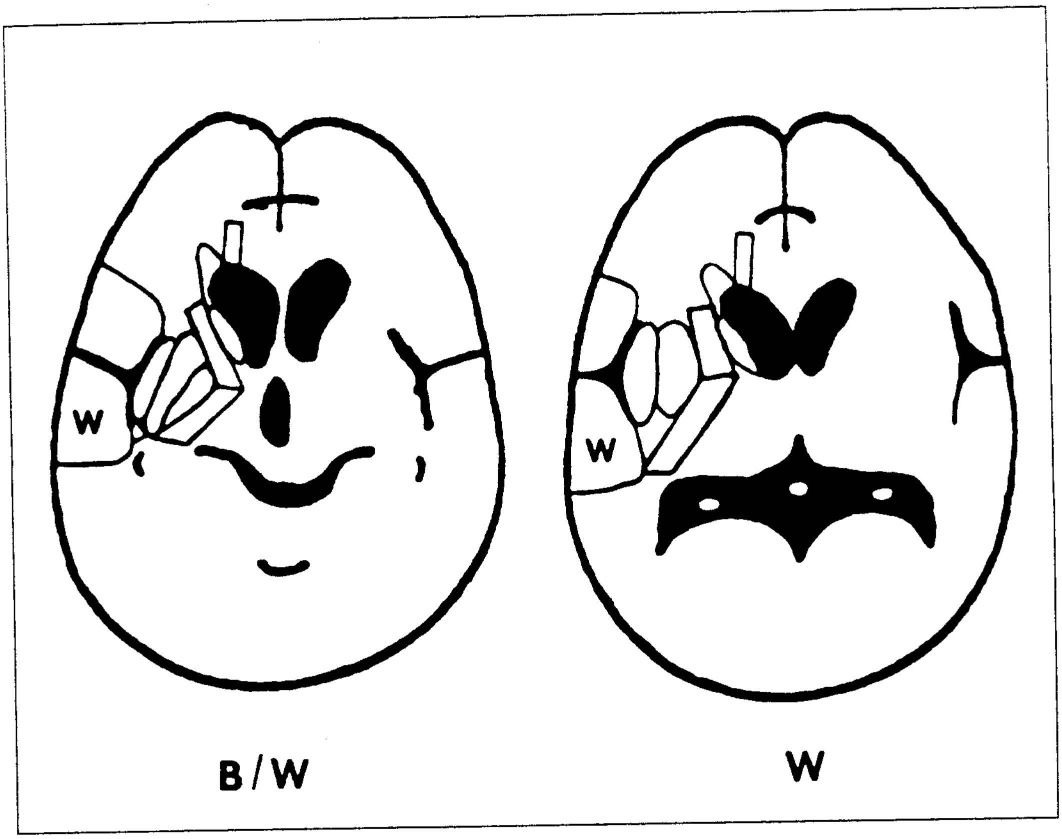


Figure 33-2. Diagram of Wernicke's area on CT scan (slices B/W and W).

the FPTi group. The five patients in this group had cortical lesions in the frontal and parietal lobes but only *subcortical* white matter lesion in the temporal lobe. Specifically, the FPTi cases had lesion in the temporal isthmus but had no cortical involvement of Wernicke's area.

To test for potential difference in lesion extent in the neuroanatomical areas assessed on CT scan between FPT and FPTi groups, t-tests were performed. There were no significant differences (.01) between the two groups for any of the neuroanatomical areas rated in either the frontal or parietal lobes or subcortical structures such as the basal ganglia or the internal capsule. Statistically significant differences were only found in temporal lobe structures including Wernicke's area and the temporal isthmus.

AUDITORY COMPREHENSION

The behavioral portion of this study was concerned with the results from the auditory comprehension subtests from the BDAE. Two recovery pat-

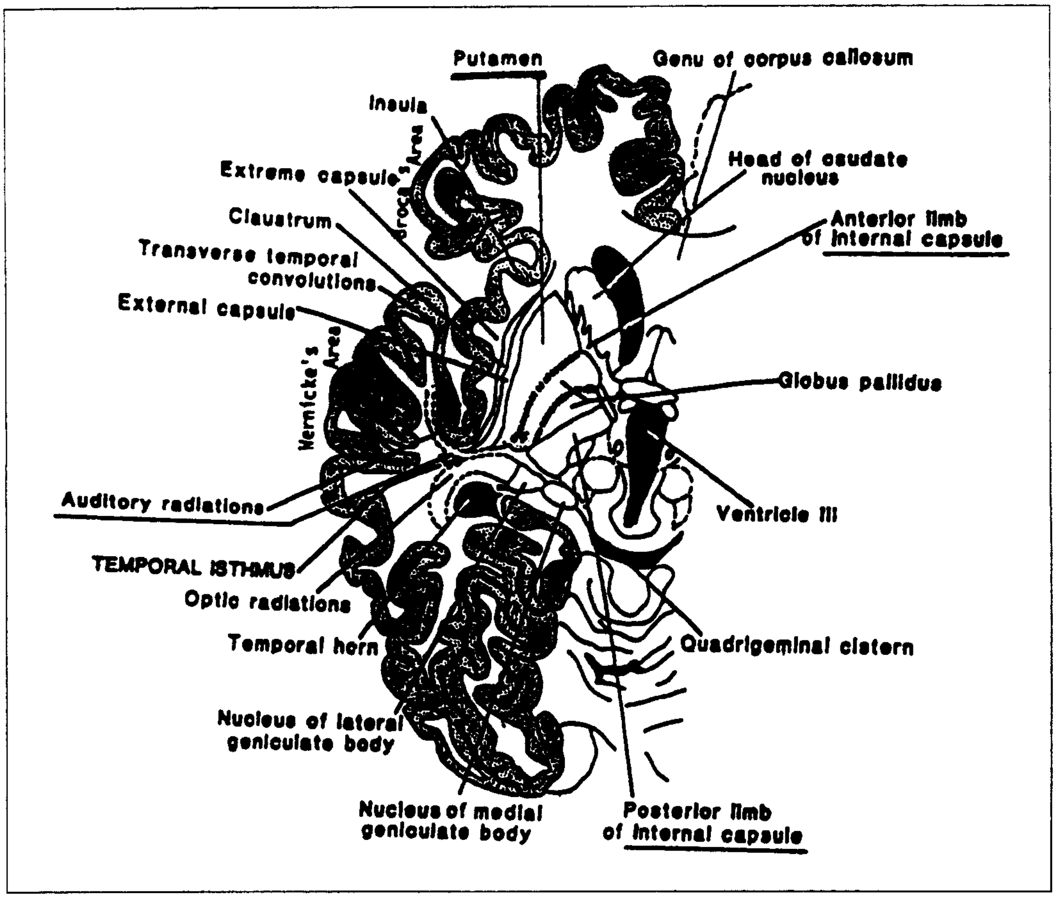


Figure 33-3. Schematic drawing of the left half of CT scan slice B/W, showing location of deep structures including the temporal isthmus, a white matter area between the posterior inferior portion of the Sylvian fissure and the temporal horn, which contains afferent auditory pathways from the level of the thalamus (medial geniculate body) to the cortical level (Heschl's gyrus).

terns emerged from these data. Figure 33-4 shows the individual BDAE overall auditory comprehension Z-scores for all subjects in both the FPT and FPTi groups. Initially, all subjects demonstrated a severe auditory comprehension impairment. No subject achieved a Z-score that was greater than −1.0 at T1. However, at T2, 80 percent (4/5) of the FPTi cases reached an overall Z-score of −.5 or greater, whereas only 20 percent (2/10) of the FPT cases achieved a Z-score of greater than −.5 at T2.

Table 33-2 lists the mean BDAT scores at T1 and T2 test periods for FPT and FPTi groups. At T1, the FPTi group demonstrated poorer performance on the overall BDAE Z-score and individual subtests. However, at T2, the FPTi group improved to a greater extent than did the FPT

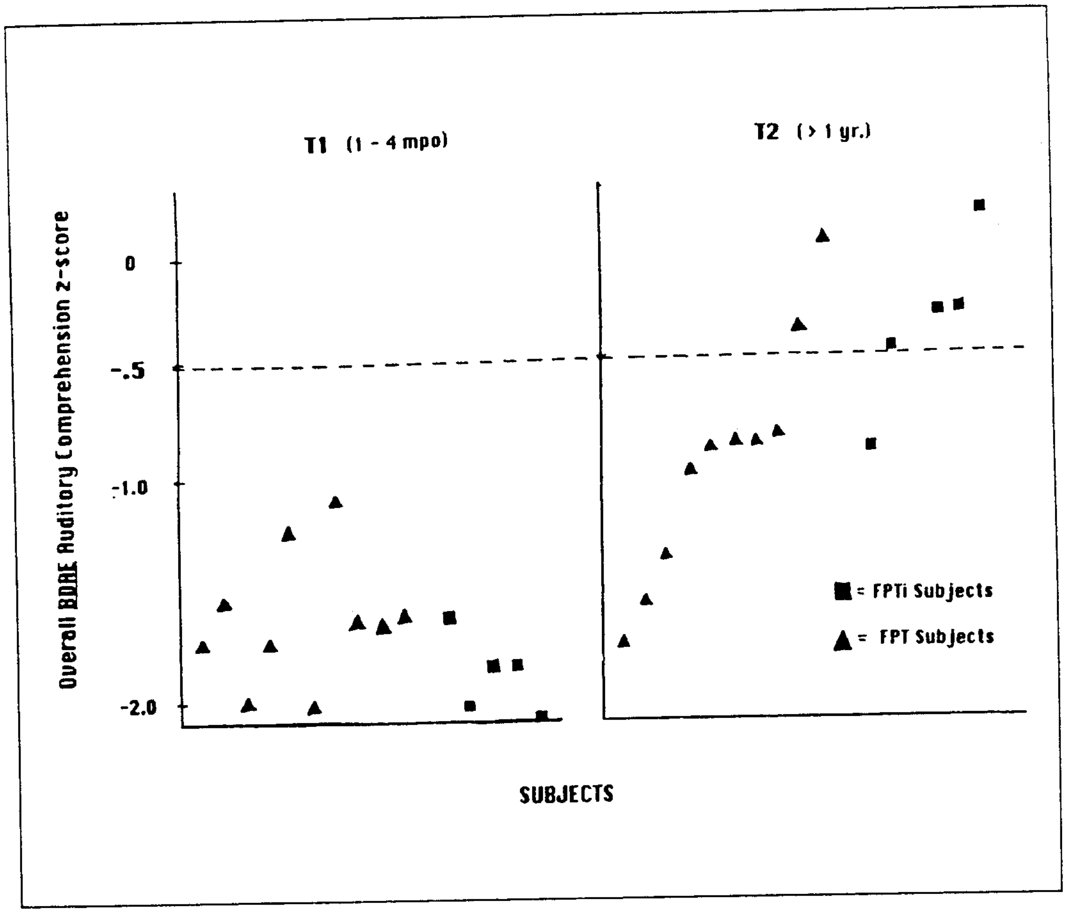


Figure 33-4. Graph of individual BDAE overall auditory comprehension Z-scores for all subjects at T1 and T2.

TABLE 33-2. MEAN SCORES FOR BOTH THE FPT AND FPTi GROUPS ON THE AUDITORY COMPREHENSION SUBTESTS OF THE BDAE.

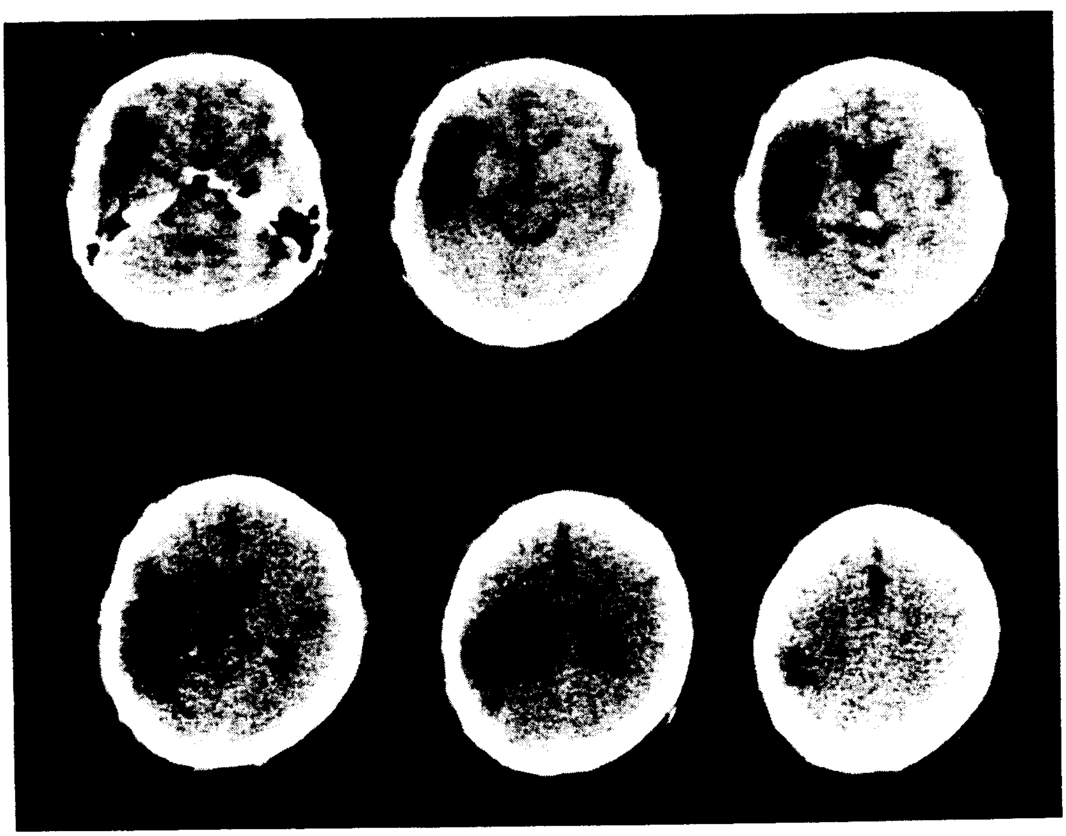
	Test period 1		*Test period 2*	
	FPT	*FPTi*	*FPT*	*FPTi*
BDAE overall Z-score	−1.65	−1.91	−.94	−.33
Word discrimination	24.7	8.7	45.2	53.8
Body part identification	2.38	1.8	6.6	14.3
Commands	2.9	2	6.4	9.2
Complex ideational material	1.1	.8	2.7	2.4

group on these measures, with the exception of the complex ideational material subtest. To test for statistically significant differences between the two groups in the relative extent of improvement over time, t-tests were calculated. There were statistically significant differences ($p < .01$) in the relative recovery between the two groups for BDAE overall auditory comprehension Z-scores, word discrimination subtests, and body part identification subtests. When the commands subtest scores were compared, the FPTi group recovered to a greater extent than did the FPT group. This difference, however, was not statistically significant.

CASE PRESENTATIONS

In order to highlight the group differences, two representative cases will be discussed. Figure 33-5 shows a CT scan of an aphasic patient (P.L.)

Figure 33-5. CT scan of an FPT patient showing cortical lesion in the frontal, parietal, and temporal lobes, including cortical lesion in Wernicke's area on both slice B/W and slice W.



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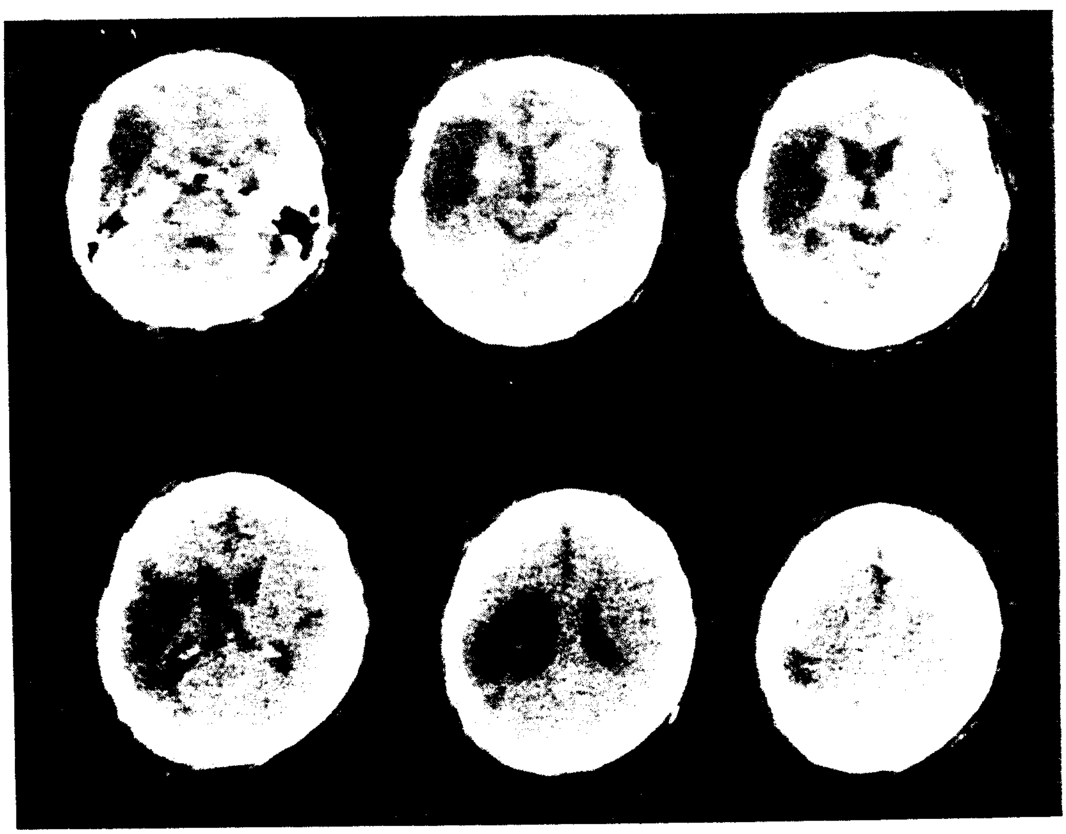

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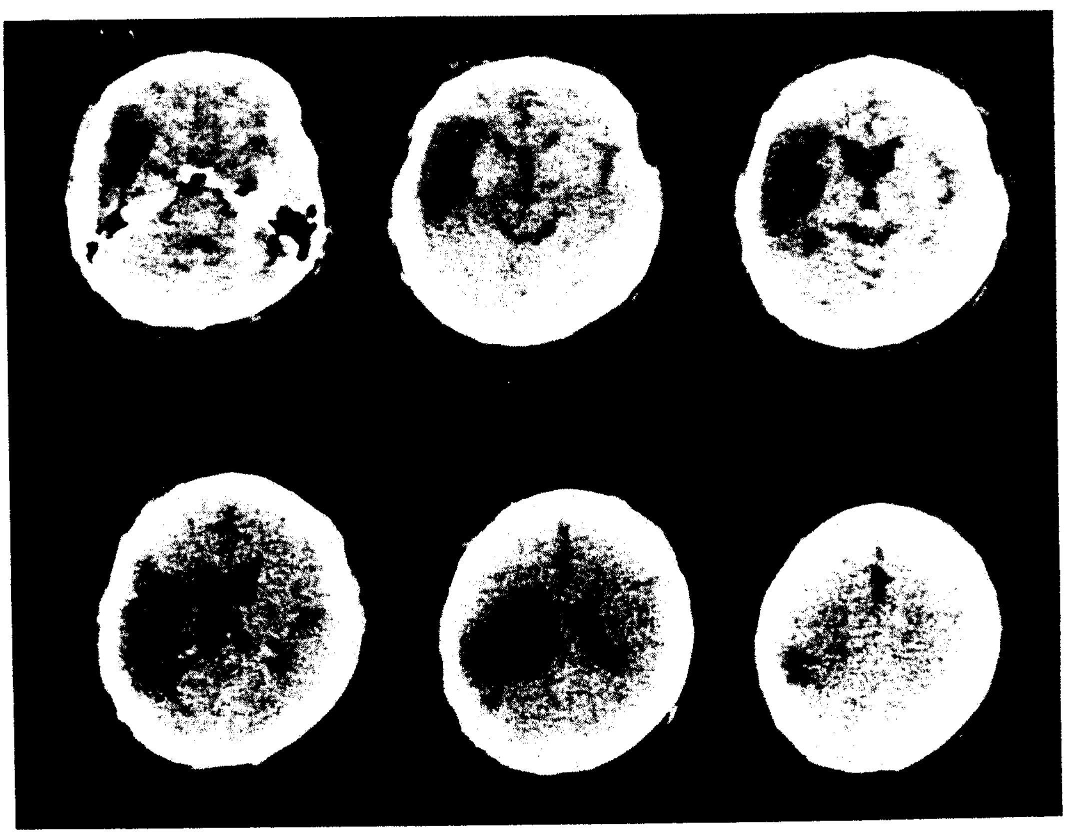
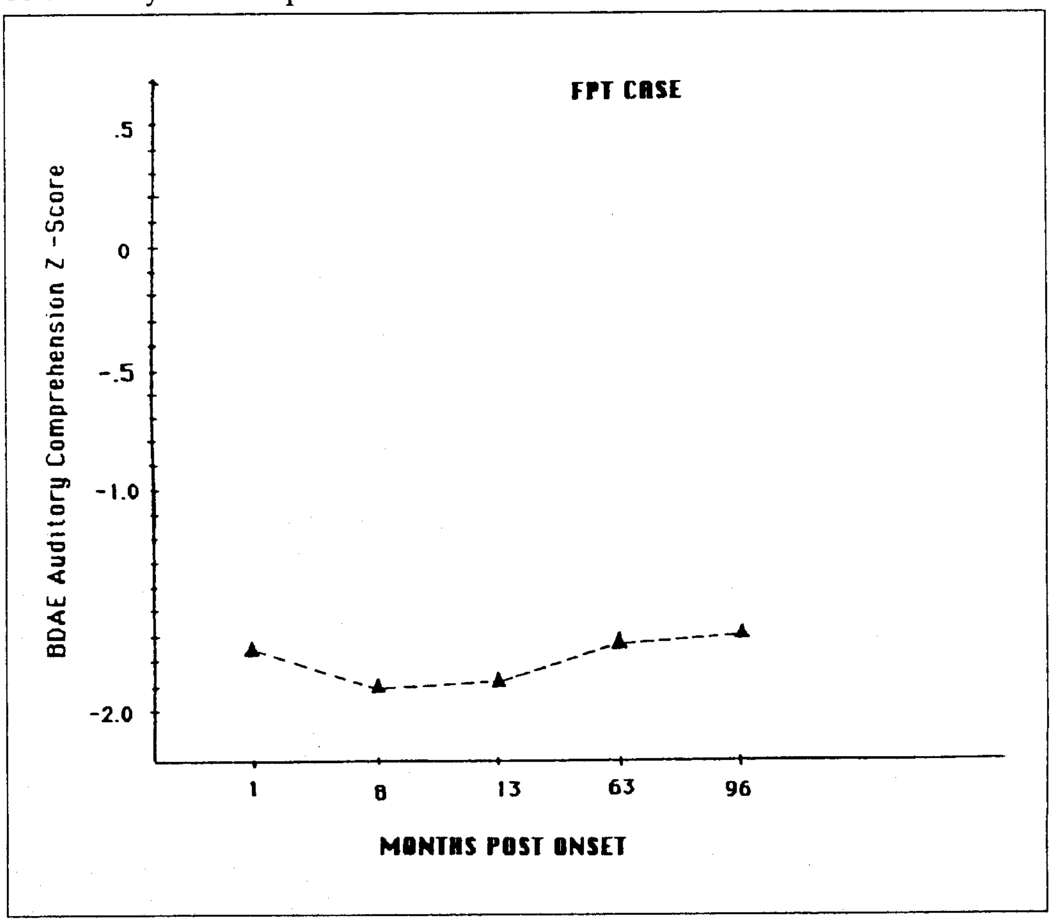


with an FPT lesion pattern. The scan indicated that there was cortical lesion present in the frontal, parietal, and temporal lobes, including cortical lesion in Wernicke's area. Figure 33-6 represents P.L.'s BDAE overall auditory comprehension Z-scores plotted over time. At 1 month post-onset, this patient achieved a Z-score of −1.76. During follow-up examination periods, P.L.'s Z-scores showed little change. Results of testing at 96 months post-onset indicated that P.L. continued to exhibit a severe comprehension deficit (Z-score of −1.67).

Figure 33-7 shows a CT scan of FPTi patient (M.K.). The scan shows cortical lesion in both the frontal and parietal lobes but only subcortical lesion in the temporal lobe. Specifically, this scan indicated that there was lesion present in the subcortical temporal isthmus, deep to cortical Wernicke's area. Figure 33-8 represents M.K.'s recovery in auditory comprehension as measured by change in BDAE Z-scores. M.K. initially had a severe auditory comprehension impairment as indicated by a BDAE Z-score of −1.85. However, during subsequent testing, M.K. demonstrated

Figure 33-6. Individual BDAE overall auditory comprehension Z-scores obtained by an FPT patient over time.



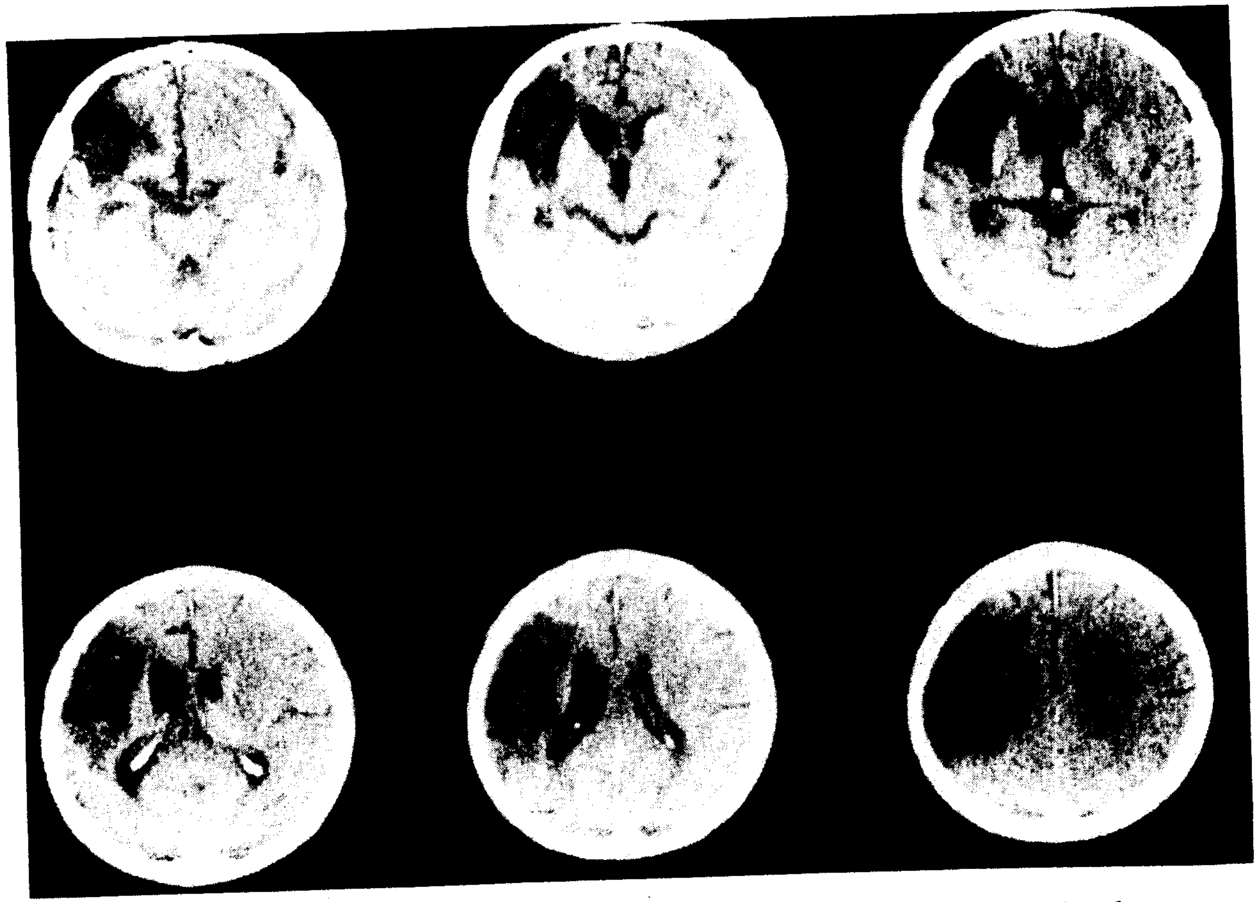
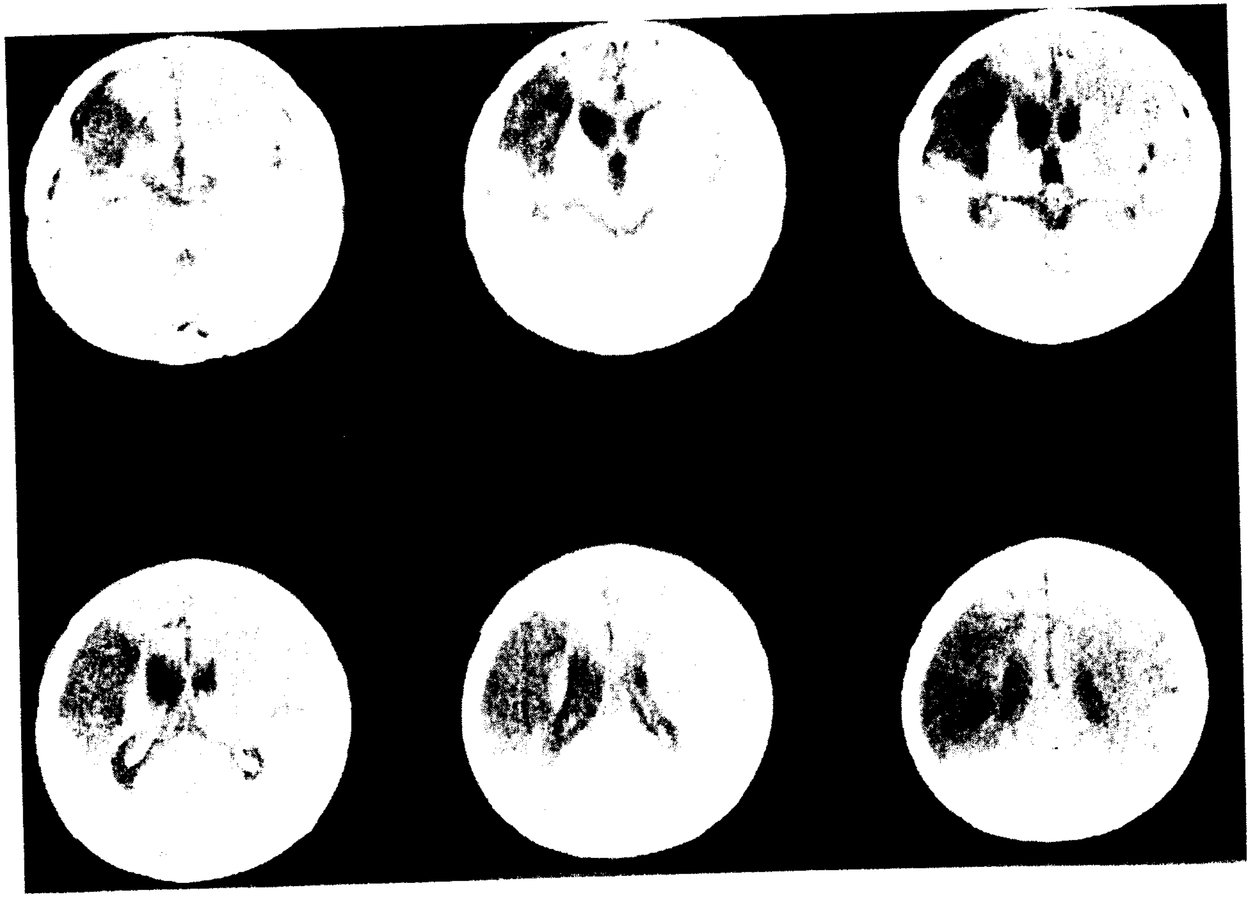


Figure 33-7. CT scan of an FPTi patient showing cortical lesion in both the frontal and parietal lobes but only subcortical lesion in the temporal lobe, including lesion in the subcortical temporal isthmus.



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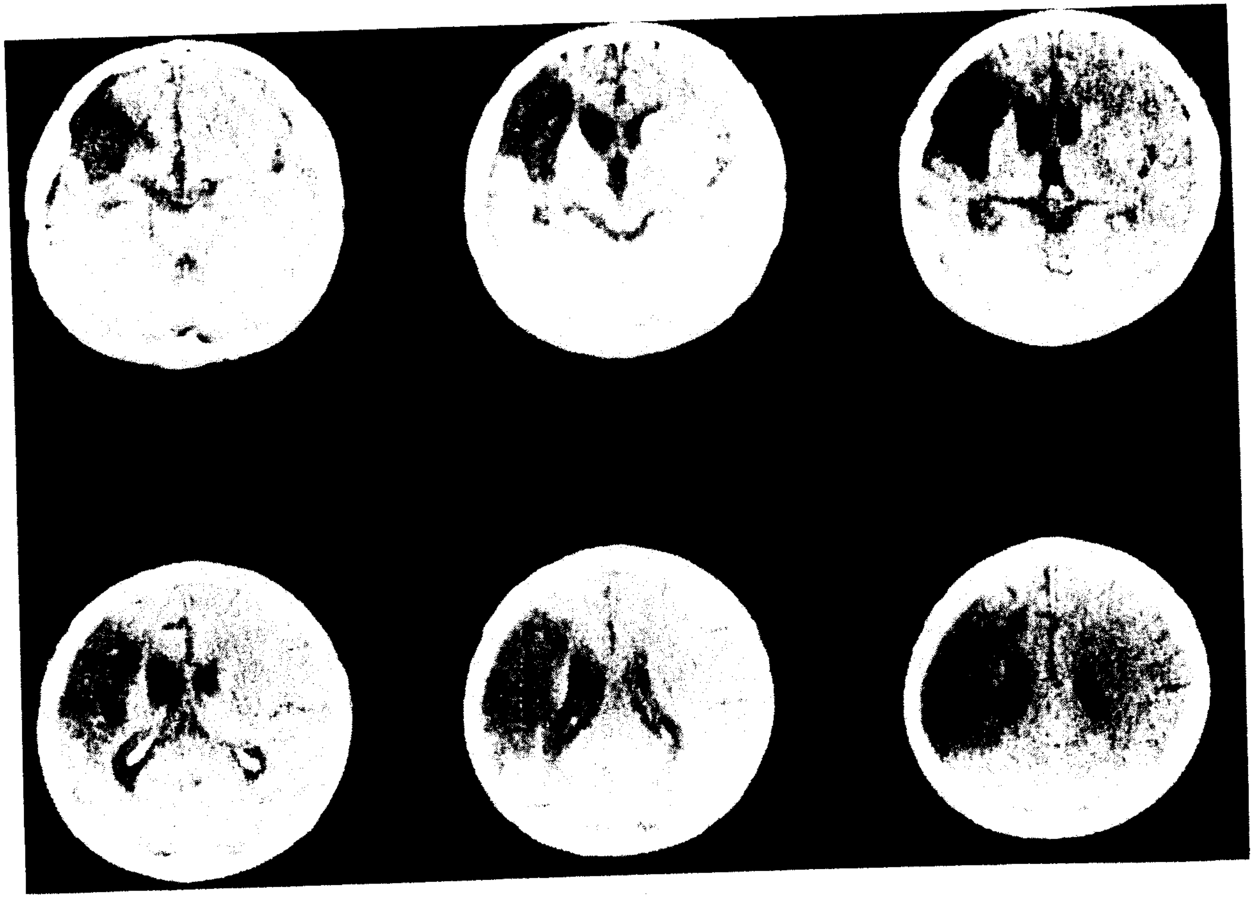

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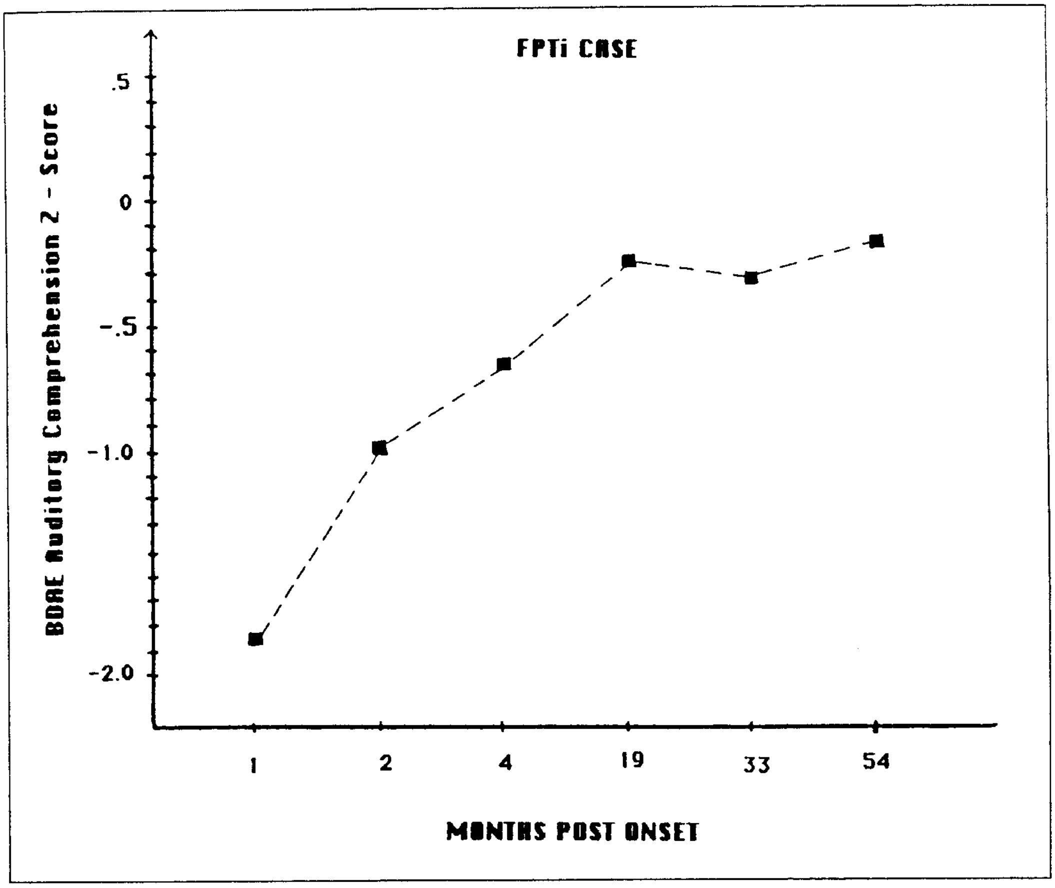

Figure 33-8. Individual BDAE overall auditory comprehension Z-scores obtained by an FPTi patient over time.

improved auditory comprehension at 54 months post-onset, M.K. achieved an overall Z-score of −.18.

In the following section, the recovery of two patients will be contrasted in more detail to highlight performances during multiple examination periods on the individual auditory comprehension subjtests from the BDAE. A brief history will be presented for each patient.

FPT CASE

P.L. was a 71-year-old right-handed male who suffered a left-hemisphere cerebrovascular accident (CVA) on 1/2/78. Age at onset was 60 years. P.L. worked as a paint contractor prior to the CVA.

FPTi CASE

J.Z. was a 69-year-old right-handed female who suffered a left-hemisphere CVA on 7/26/83. Age at onset was 64 years. J.Z. was employed as a silk presser prior to the stroke.

TABLE 33-3. INDIVIDUAL SCORES FOR P.L. (FPT) AND J.Z. (FPTi) ON THE AUDITORY COMPREHENSION SUBTESTS FROM THE BDAE

Subtest	*MPO*	*BDAE overall Z-score*	*Word discrimination*	*Body part identification*	*Commands*	*Complex ideational material*
F.L. (FPT CASE)						
1	1	−1.76	17	2	5	0
2	8	−1.9	13.5	1.5	3	1
3	13	−1.84	23	0	3	0
4	63	−1.7	28	4	0	1
J.Z. (FPTi CASE)						
1	1	−2.05	1	0	1	1
2	4	−1.04	51.5	12	1	0
3	12	−0.44	57	18	5	0
4	56	+0.22	56.5	18.5	12	5

Key: MPO = months post-onset.

Table 33-3 lists the scores achieved by each subject during four test periods. The actual test times for P.L. (FPT patient) were 1, 8, 13, and 63 months post-onset. J.Z. (FPTi case) was tested at 1, 4, 12, and 56 months post-onset. During test period one, both subjects achieved very low scores on all measures, with J.Z. achieving scores that were actually lower than P.L.'s scores on the BDAE overall Z-score as well as on the word discrimination, body part identification, and commands subtests. However, during subsequent test periods, J.Z. demonstrated relatively good recovery based on the auditory comprehension subtests from the BDAE. In contrast, P.L. essentially did not demonstrate recovery in auditory comprehension as measured by the BDAE. Finally, results from recent follow-up testing completed at 56 months post-onset indicated that J.Z. predictably improved on the auditory comprehension subtests from the BDAE. Specifically, J.Z. achieved an overall auditory comprehension Z-score of + .22 at 56 months post-onset as compared to an overall auditory comprehension Z-score of −.44 at 12 months post-onset.

CONCLUSION

In conclusion, the results of this study indicate that initial auditory comprehension severity alone is not a good predictor of potential recovery of auditory comprehension in severely aphasic patients. However, a detailed examination of cortical versus subcortical lesion on a stable CT scan may be beneficial in predicting potential recovery of auditory comprehension after 1 year post-onset in these patients.

Finally, this was a retrospective study, and although all subjects received some treatment, the kind, amount, and time post-onset that treatment was received was not controlled. This study should be replicated prospectively with these issues controlled or at least taken into account.

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DISCUSSION

Q. = question; A = answer; C = comments.

Q. I like this line of research very much. One of the things I wanted you to think about, or maybe you have, is that there have been several studies that have looked at the correlation between auditory comprehension scores on things like the Boston and performance on auditory comprehension tasks in which receptive skills were looked at in a more natural linguistic setting. What do you think your data say about performance of some of these subjects in the real world?

A. One of the reasons that it's hard for me to get a good feel for that is that I did not meet any of these subjects. This is retrospective information that I pulled from the files. I don't know whether there are studies that have looked at how severity on the BDAE correlates with functional communication. I would hope that if patients achieved higher scores on an objective test, it would correspond with some increase in functional communication in a more natural type setting.

Q. Do you think this has something to say about how long we should be working with our patients as a facilitator if these people are making improvements on these tests so long post-onset?

A. I think you can use this information when it is combined with other prognostic information to predict how a patient may recover. These data suggest that if you see a patient who only has lesion in the subcortical temporal isthmus and does not have lesion in Wernicke's area, you may expect that patient to continue to improve and *possibly* benefit more from treatment. I think it's hard to say though, because we didn't control for treatment. We can only say that without controlling for treatment, the FPTi group did improve more than the FPT group.

Q. A couple of questions. Do you think there's any role in the differential recovery in the contralateral projections from auditory cortex in the uninvolved hemisphere from collosal projections? Is that the basis for the differences seen in recovery, or do you think there is something more primary underlying the recovery differential?

A. The auditory contralateral pathway is an area that we examined for extent of lesion, and it didn't come out statistically significantly different between the two groups, which suggests that it does have something to do with the ipsilateral pathways, but why it's a subcortical instead of the cortical with the subcortical, we don't exactly know right now. I think what we need to do next is a follow-up study to this to look at the recovery of subcortical global patients versus posterior subcortical patients versus the cortical patients to see if we can determine what the differences are between the subcortical structures and the cortical structures.

Q. One other question, you showed that FPT groups, your cortically involved group, had basically flat recovery lines from one month out, whereas your FPTis all had a nice recovery phase. In a similar vein to the prior question, would you therefore suggest that if careful CT exam shows involvement of this territory on a cortical basis, that recovery won't occur and that therapy is unlikely to do anything and these patients don't change over time? If you think that, is there a difference in the time course of recovery between cortical versus subcortical lesions?

A. I think it's important to reemphasize that I only showed two cases over time. I did that to represent what we felt was the basic trend for each group. There was, however, variability. If you remember Figure 33-4, there was overlap between the two groups, and not all FPT cases showed a flat recovery; some of them did recover, and there are probably numerous explanations including neuroanatomical explanations. Also, there was one FPTi subject who did not improve; however, I don't know the explanation for this. I think this emphasizes that you must be careful in interpreting these data; it's not a "for sure" thing. Just because a patient has an FPT lesion pattern doesn't mean he/she will not recover, and conversely an FPTi lesion pattern doesn't guarantee recovery.

C. To shed a little light on the question that was asked before about functional gains. We are comparing patients who we test on our Boston assessment of severe aphasia, which has a series of questions personally related to the patient, and compared that with the sentence length stimuli on the complex ideational material subtest from the BDAE. We see patients who answer all questions related to them personally and none of the questions asked on the complex ideational material subtest. I think that's a very important question, and I don't know if I know some of the patients that Ann used in the study, but maybe afterwards I'll ask her about them and we could discuss how these patients recovered functionally. I think complex ideational material is seldom a test of how a patient does in a functional setting. For example, Broca's patients often do very poorly on that and have perfectly adequate comprehension for everyday purposes.

Q. Just as a follow-up to the previous comments, I wonder if just in a sentence or two you could summarize the advice you would give to an aphasia clinician based on the results of your study?

A. My main feeling is that I would never use just one piece of information to predict recovery. I think from my clinical experience, one of the most difficult things to do is to counsel an aphasic patient or a family and tell how they or their family members are going to look down the road. I think you can use the information obtained from our study and combine it with other information to predict recovery and influence treatment decisions.

C. Just a point of information about the question about whether or not there is a relationship between test scores that test functional communication and test scores like the Boston Diagnostic Aphasia Examination (BDAE). In the norming study for the Communicative Abilities in Daily Living (CADL), the correlation between the BDAE and the CADL was about .72, and it was statistically significant at somewhere around the .001 level not surprisingly. But, to address the other side of that issue, when we tried to predict CADL scores, we used a stepwise multiple regression analysis to look to see what predicted our observational score in the real world on functional communication, and at that point, once we entered CADL into the equation, it didn't matter much whatever tests we added after that, which addresses the other side of the issue, which is the difference between functional communication and more formalized test measures. It would be stunning to find that there is no relationship between things that are measured on an aphasia test and things that are measured in functional communication. It would also be stunning to find that there was a nice point-by-point correlation between the two.