The importance of language mapping in patients who will undergo anterior temporal lobectomy for intractable epilepsy remains unresolved. Although some authors recommend stimulation mapping and tailored resections in all patients,24,26 others have found no or minimal long-term verbal deficits following standard resections,4,13 which in addition to mesial resections generally include at least 4 to 5 cm of the middle and inferior temporal gyri and 3 cm of the superior gyrus.3,9,33

The crux of this debate centers around two questions: 1) how frequently are essential language areas encountered in the anterior temporal lobe? and 2) what are the neuropsychological ramifications of removing them? At the New York University Hospital for Joint Diseases, patients with left hemisphere epilepsy routinely undergo mapping by means of extraoperative stimulation. We reviewed 67 patients in whom naming and reading errors and arrest of speech (spontaneous counting) were tested to ascertain the frequency with which stimulation during each function identified essential language areas between 1.5 and 5.5 cm from the temporal tip. Because resections are routinely tailored to avoid language areas identified preoperatively, we could not directly examine the effect of removing them. However, by identifying demographic criteria that correlate with the presence of anterior language areas and by comparing these with previously published results of demographic criteria associated with dysphasia following standard anterior temporal lobectomy, we hypothesized that the language areas located most anteriorly are a result of early left hemisphere insult, which induces dispersion

Preoperative predictors of anterior temporal language areas

THEODORE H. SCHWARTZ, M.D., ORRIN DEVINSKY, M.D., WERNER DOYLE, M.D., AND KENNETH PERRINE, PH.D.

Department of Neurological Surgery, The Neurological Institute of New York, Columbia-Presbyterian Medical Center, New York, New York; and Departments of Neurology and Neurological Surgery, Hospital for Joint Diseases, New York University School of Medicine, New York, New York

Object. Although it is known that 5 to 10% of patients have language areas anterior to the rolandic cortex, many surgeons still perform standard anterior temporal lobectomies for epilepsy of mesial onset and report minimal long-term dysphasia. The authors examined the importance of language mapping before anterior temporal lobectomy.

Methods. The authors mapped naming, reading, and speech arrest in a series of 67 patients via stimulation of long-term implanted subdural grids before resective epilepsy surgery and correlated the presence of language areas in the anterior temporal lobe with preoperative demographic and neuropsychometric data.

Naming (p < 0.03) and reading (p < 0.05) errors were more common than speech arrest in patients undergoing surgery in the anterior temporal lobe. In the approximate region of a standard anterior temporal lobectomy, including 2.5 cm of the superior temporal gyrus and 4.5 cm of both the middle and inferior temporal gyri, the authors identified language areas in 14.5% of patients tested. Between 1.5 and 3.5 cm from the temporal tip, patients who had seizure onset before 6 years of age had more naming (p < 0.02) and reading (p < 0.01) areas than those in whom seizure onset occurred after age 6 years. Patients with a verbal intelligence quotient (IQ) lower than 90 had more naming (p < 0.05) and reading (p < 0.02) areas than those with an IQ higher than 90. Finally, patients who were either left handed or right hemisphere memory dominant had more naming (p < 0.05) and reading (p < 0.02) areas than right-handed patients with bilateral or left hemisphere memory lateralization. Postoperative neuropsychometric testing showed a trend toward a greater decline in naming ability in patients who were least likely to have anterior language areas, that is, those with higher verbal IQ and later seizure onset.

Conclusions. Preoperative identification of markers of left hemisphere damage, such as early seizure onset, poor verbal IQ, left handedness, and right hemisphere memory dominance should alert neurosurgeons to the possibility of encountering essential language areas in the anterior temporal lobe (1.5–3.5 cm from the temporal tip). Naming and reading tasks are required to identify these areas. Whether removal of these areas necessarily induces long-term impairment in verbal abilities is unknown; however, in patients with a low verbal IQ and early seizure onset, these areas appear to be less critical for language processing.

Key Words • brain mapping • electrical stimulation • epilepsy surgery • language • speech • temporal lobe
and abnormal distribution of areas that, in these patients, appear to be less critical for language processing.

Clinical Material and Methods

Patient Population

From a consecutive series of 243 patients surgically treated for seizures between May 1992 and August 1996, we identified 109 with left hemisphere complete and partial ictal onset and left hemisphere language by using the intracarotid amytal (Wada) test. Of these 109 patients, three did not undergo language mapping, 19 underwent mapping intraoperatively, and 87 underwent mapping extraoperatively by using long-term implanted subdural grids. Of these 87 patients, 67 met the following criteria: 1) age older than 16 years; 2) full scale intelligence quotient (IQ) greater than 70 (based on the Wechsler Adult Intelligence Scale–Revised37); 3) absence of any lateral, neocortical temporal lobe lesions; and 4) complete records with well-documented maps. Eleven patients had structural lesions other than mesial temporal sclerosis in locations other than lateral temporal lobe neocortex. There were three mesial temporal cavernous malformations, five anterior temporal pole lesions (two arteriovenous malformations [AVMs], two low-grade neoplasms, and one cyst), two deep frontal lesions (one AVM and one low-grade neoplasm), and one tuber of the contralateral lateral ventricle. The patients’ demographic data are presented in Table 1. Six patients had bitemporal language representation and 13 were either bilingual or spoke English as a second language.

Extraoperative Mapping

All mapping was conducted extraoperatively with stimulation of long-term implanted subdural grids. The patients underwent an initial craniotomy for subdural grid placement and were returned to an intensive care unit where subdural electrode video–electroencephalography (EEG) recordings (64-channel Beehive System; Telefactor, West Conshohocken, PA) were obtained and cortical stimulation was performed. The patients returned for a second craniotomy to remove the subdural electrodes and to resect epileptogenic cortex 6 to 14 days following the first craniotomy. A stimulator (model S12; Grass Instruments, Quincy, MA) with built-in constant current/stimulus isolation circuitry delivered a biphasic square waveform at a frequency of 50 Hz, with a 0.3-msec pulse duration and amperage ranging from 2 to 15 mA. Stimulation was applied between adjacent pairs of electrodes separated by 10 mm on an implanted subdural grid. In earlier cases we used grids with 5-mm electrodes embedded in Silastic (model PMT; Chanhassen, MN), whereas in later cases we used grids with 4-mm electrodes embedded in Silastic (Ad-Tech, Racine, WI). Various combinations of 64- and 32-contact subdural grids were used. For some cases, positive sites were further studied with stimulation of one electrode referenced to a distal electrode located in the silent cortex. Afterdischarges were determined by increasing amperage until a functional response or afterdischarge was elicited. Amperage for functional stimulation was set 1 mA below the afterdischarge threshold, which was determined separately for each site. Afterdischarges were monitored using other portions of the subdural grids. None of the results reported here contain data from trials in which afterdischarges were elicited. Stimulation sites in all patients were selected in the vicinity of the anticipated resection, as determined by video-EEG monitoring of interictal activity and seizure onsets on the subdural grids.

Three tasks were examined during stimulation. The majority of the grid contacts were first surveyed using sequential counting for speech arrest. All contacts were then tested for visual confrontation naming of a line drawing (for example, a pumpkin); the patient made use of the carrier phrase “This is a . . .” while naming to differentiate speech arrest (no verbal output) from anoma (verbal output but with inability to name the displayed object accurately). Finally, we tested oral reading of a visually presented stimulus sentence with a word missing at the end; the patient read the sentence aloud and completed the sentence with a contextually relevant word (for example, “We went to the airport to catch a plane”). Stimulation onset began before the patient initiated the functional task and stimulation offset followed completion of the task. Stimulation did not exceed a train duration of 10 seconds. Sites were considered to register positive for the mapped function if the error rate obtained with stimulation exceeded a baseline error rate without stimulation at a significant level (p < 0.05) as determined by the binomial single sample test or if a clearly pathognomonic performance relative to baseline was elicited during stimulation. For this study we did not distinguish between types of errors—hesitation, slurring, distortion, or perseveration—for any of the functions tested.

Surgical Resection

A modified standard anterior medial temporal lobectomy was performed in all cases. This involved removing

### TABLE 1
Demographic data in 67 patients *

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Patients</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>age of patient (yrs)</td>
<td>67</td>
<td>32 ± 9</td>
<td>16</td>
<td>53</td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>full scale</td>
<td>61</td>
<td>88 ± 12</td>
<td>71</td>
<td>128</td>
</tr>
<tr>
<td>verbal</td>
<td>52</td>
<td>90 ± 13</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>performance</td>
<td>51</td>
<td>89 ± 14</td>
<td>59</td>
<td>127</td>
</tr>
<tr>
<td>age at seizure onset</td>
<td>67</td>
<td>12 ± 10</td>
<td>0.1</td>
<td>45</td>
</tr>
<tr>
<td>handedness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ambidextrous</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left hemisphere</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right hemisphere</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bilat†</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unknown</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>febrile seizure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* — = not applicable.
† No clear dominance.
the anterior pole, middle and inferior gyri, and 4 cm of the hippocampus. The extent of neocortical resection was based on the results of extraoperative subdural grid ictal and interictal recordings and language mapping. Multiple subpial transections (MSTs) were performed if there was definite ictal onset from within a language area. Intraoperative subdural grid ictal and interictal recordings were used for localization of language areas, that is, a DS greater than 1 indicated right hemisphere memory dominance, a DS greater than 1 indicated left hemisphere memory dominance, and a DS of −1 to 1 was considered bilateral.

Because speech arrest was infrequently encountered over the anterior temporal lobe, only patients tested for naming and reading errors were divided into the five distinguishing categories. Error rates were calculated as a percentage of times a particular area was tested in a given language function for each group. These graphs were then superimposed on a schematic image of the neocortical surface with an anteroposterior diameter of 15 cm. Comparisons between error rates at different sites were made using chi-square and Fisher’s exact tests.

To determine the overlap between the various demographic categories, we used Mann–Whitney U, chi-square, and Fisher’s exact tests to identify significant group correlations.

Postoperative Language Assessment
The Boston Naming Test (BNT) was used as an indicator of pre- and postoperative language function.16 Follow-up data were available for 30 patients at a mean ± standard deviation (SD) of 10.2 ± 6.5 months after surgery. To examine the effect of MSTs, a repeated-measures (preoperative–postoperative BNT scores) analysis of variance was performed between patients who had MSTs and those who did not have MSTs. Separate repeated measures (preoperative–postoperative BNT scores) analyses of variance were performed between patients based on the same criteria as those used for localization of language areas, that is, gender, verbal IQ of 90 or higher versus lower than 90, history of febrile seizures, seizure onset prior to age 6 years versus at 6 years or later; and atypical versus typical handedness and memory dominance. These tests were performed only in patients who did not undergo MSTs to separate the effect of MSTs from the preoperative demographic criteria.

Results
Language Mapping
Speech arrest was mapped in 67 patients, naming errors...
in 63 patients, and reading errors in 57 patients. The total number of patients in whom each 1-cm² site was sampled and the locations of the sites tested are displayed in Fig. 1. The percentage of patients in whom stimulation induced errors in either spontaneous counting, picture naming, or sentence reading for each 1-cm² site is displayed in Fig. 2. The number of essential language areas increased gradually, moving from the front of the grid posteriorly and from the bottom of the grid superiorly. Between 1.5 and 3.5 cm posterior to the temporal tip, there were no language areas encountered in the most inferior row of the grid that lay over the inferior temporal gyrus. In the middle two rows of the grid, however, over the middle temporal gyrus language areas were found in 3 to 5% of patients tested in each of the four 1-cm² sites. In the top row of the grid, over the superior temporal gyrus, the probability of encountering language areas increased to between 7 and 10% for each of two 1-cm² sites. In the posterior half of the grid, between 3.5 and 5.5 cm back from the temporal tip, language areas were encountered in 6 to 11% of patients tested in each of the six 1-cm² sites over the inferior and middle temporal gyri. This number increased to 17 to 29% of patients in the two 1-cm² sites in the superior temporal gyrus.

By pooling the four 1-cm² sites in each column on the grid, we determined the percentage of patients with language areas in each centimeter from 1.5 to 5.5 cm from the temporal tip (Fig. 3). Language areas were found from 1.5 to 2.5 cm in 13.8% of the patients, from 2.5 to 3.5 cm in 11.8%, from 3.5 to 4.5 in 20.9%, and from 4.5 to 5.5 in 35.4% of the patients. We also pooled the area within a standard anterior temporal lobectomy, here defined as 2.5 cm of the superior temporal gyrus and 4.5 cm of both middle and inferior temporal gyri, and found essential language areas in 14.5% (nine of 62) of the patients tested. The entirety of this area was not sampled in all of these patients; hence, this number underestimates the actual percentage.

Arrest of speech was infrequently encountered in this area of the temporal lobe compared with errors in naming and reading. Between 1.5 and 3.5 cm from the temporal tip, there were only two patients in whom spontaneous counting was interrupted following stimulation. These areas appeared only in the superior temporal gyrus in 2 to 3% of patients tested in each of the two 1-cm² sites. Naming and reading, on the other hand, were more frequently disturbed (naming p < 0.03, reading p < 0.05; Fig. 4). Errors were made in 3 to 9% of patients tested in each of six 1-cm² sites over the middle and superior temporal gyri for both functions. From 3.5 to 4.5 cm back from the temporal tip, speech arrest was encountered in 2 to 9% of patients tested in each of the four 1-cm² grid sites. Although not statistically significant, naming and reading errors were both more frequently encountered in 5 to 18% of patients tested. A similar trend was found between 4.5 and 5.5 cm from the temporal tip. Speech arrest was found in 2 to 19% of patients tested in each of the four 1-cm² grid sites. In contrast, naming and reading were disturbed in 6 to 24% of the patients tested.

Predictors of Language Localization

Of the five demographic criteria examined, only three revealed statistically different probabilities of encountering either naming or reading errors following stimulation of the anterior temporal lobe. Patients with a verbal IQ lower than 90 had more naming areas located between 1.5 and 3.5 cm from the temporal tip (p < 0.05) and more reading areas from 1.5 to 4.5 cm (p < 0.02; Fig. 5) than patients with a verbal IQ higher than 90. The age of the patient at seizure onset was also significant. Patients in whom seizure onset occurred before age 6 years had more naming (p < 0.02) and reading (p < 0.01) areas located from 1.5 to 3.5 cm back from the temporal tip than patients in whom seizure onset occurred after age 6 years (Fig. 6). Finally, patients who were either left handed or right hemisphere memory dominant had more naming (p < 0.05) and reading (p < 0.02) areas located from 1.5 to 3.5 cm back from the temporal tip than patients who were right handed with left or bilateral memory lateralization (Fig. 7).
Gender or presence of febrile seizures did not significantly affect the distribution of language areas in the anterior temporal lobe. Statistical tests on the five demographic criteria indicated that patients in whom seizure onset occurred before age 6 years also had a lower mean verbal IQ (mean ± SD IQ 81.4 ± 9.1) than patients in whom seizure onset occurred after age 6 years (mean ± SD IQ 95 ± 11.8; p < 0.0002). Similarly, patients with a verbal IQ below 90 had an earlier age of seizure onset (mean ± SD 9.5 ± 9.6 years) than patients with a verbal IQ higher than 90 (mean ± SD 16.5 ± 10.92 years; p < 0.005). Not unexpectedly, there was a trend for patients with earlier seizure onset to have a history of febrile seizures (p = 0.1). Forty-three percent of patients in whom seizure onset occurred before age 6 years had febrile seizures compared with 23% of patients in whom seizure onset occurred after age 6 years. Gender, handedness, or memory lateralization showed no statistically significant bias, although there was a slight preponderance of left handedness and right-sided memory lateralization in patients in whom seizure onset occurred before age 6 years (p = 0.24).

Postoperative Language Ability

Postoperative results of the BNT were available for 30 patients. Twelve underwent MSTs of their language areas and 18 did not have MSTs. Patients who had MSTs scored significantly worse than those who did not have MSTs, collapsed across preoperative and postoperative BNT scores (F = 4.42, p < 0.05). There was also a significant interaction between MSTs and preoperative to postoperative status (F = 7.60, p < 0.01). Patients who had MSTs showed a much greater decline in BNT scores after surgery (t = 3.94, p < 0.002) than patients who did not have MSTs (t = 2.21, p < 0.04). Although there was an overall decline in the mean BNT scores postoperatively (Table 2), of the 18 patients who did not have MSTs, five showed improvement.

For patients who did not have MSTs, there were trends for a greater decline in postoperative BNT scores in patients with a verbal IQ greater than 90 or seizure onset after age 6 years; however, this was not the case for differences in gender, history of febrile seizures, or handedness/memory dominance (Table 2). Analysis of variance did not show these trends to be statistically significant.

Discussion

We found that tests of naming and sentence reading were more sensitive than arrest of speech (spontaneous counting) in identifying anterior temporal language areas. As in prior studies, these areas were more frequently encountered in the superior temporal gyrus than in the middle or inferior gyrus. Within the confines of a standard anterior temporal lobectomy including 2.5 cm of the superior temporal gyrus and 4.5 cm of the middle and inferior gyri, we identified essential language areas in 14.5% of
patients tested. This number is probably an underestimate of the actual percentage because the entirety of the anterior temporal lobe was not sampled in all patients because of limitations imposed by grid placement and time. These anterior areas were significantly correlated with markers of early left hemisphere damage such as early age of seizure onset, lower mean verbal IQ, left handedness, and right-sided memory. Not surprisingly, early seizure onset correlated with lower verbal IQ. The presence of anterior language areas was not associated with a history of febrile seizures or gender, although febrile seizures were associated with early age of seizure onset. Hence, febrile seizures, in and of themselves, may not cause sufficient temporal lobe damage to induce reorganization of language areas, but do contribute to the development of early-onset seizure disorders.

We found a higher incidence of anterior language areas in patients with evidence of early brain injury. Early left hemisphere damage has been associated with altered language lateralization, particularly following injury to the rolandic or parietal regions. Similarly, left handedness without a family history of sinistrality, presumably due to cortical damage, has also been linked to right-hemisphere language. Memory dominance also reflects hemispheric injury and has been shown to lateralize contralateral to the ictal onset zone, particularly if the onset is in the mesial rather than the lateral temporal lobe.

Damage caused early in life may have a different effect on language organization in temporal than on frontal regions. In an earlier report on a smaller group of patients, Devinsky, et al., reported a higher incidence of anterior temporal language areas in the superior temporal gyri of varying sizes, it is unclear how to translate their percentages to the region of a standard anterior temporal lobectomy. The issue is further clouded by the results of Uematsu, et al., for whom the location of the sensorimotor cortex, as identified by stimulation mapping of subdural electrodes, varied considerably among individuals. Davies and colleagues found speech arrest in only 3% of patients within 4.5 cm of the temporal tip, but did not test naming or reading. Therefore it is difficult to compare our results directly with those of prior studies.

The incidence of anterior temporal language areas in this study is higher than, but comparable to, those reported in prior studies. In their series of 117 patients, Ojemann, et al., reported an incidence of 5% in the temporal lobe anterior to the rolandic cortex excluding the superior temporal gyrus. Within the superior temporal gyrus, language areas were identified in 14% of patients tested. Because these authors anatomically referenced their measurements to the rolandic cortex and not to the temporal tip to avoid pooling data from patients with temporal lobes of varying sizes, it is unclear how to translate their percentages to the region of a standard anterior temporal lobectomy. The issue is further clouded by the results of Uematsu, et al., for whom the location of the sensorimotor cortex, as identified by stimulation mapping of subdural electrodes, varied considerably among individuals. Davies and colleagues found speech arrest in only 3% of patients within 4.5 cm of the temporal tip, but did not test naming or reading. Therefore it is difficult to compare our results directly with those of prior studies.

The incidence of anterior temporal language areas in this study is higher than, but comparable to, those reported in prior studies. In their series of 117 patients, Ojemann, et al., reported an incidence of 5% in the temporal lobe anterior to the rolandic cortex excluding the superior temporal gyrus. Within the superior temporal gyrus, language areas were identified in 14% of patients tested. Because these authors anatomically referenced their measurements to the rolandic cortex and not to the temporal tip to avoid pooling data from patients with temporal lobes of varying sizes, it is unclear how to translate their percentages to the region of a standard anterior temporal lobectomy. The issue is further clouded by the results of Uematsu, et al., for whom the location of the sensorimotor cortex, as identified by stimulation mapping of subdural electrodes, varied considerably among individuals. Davies and colleagues found speech arrest in only 3% of patients within 4.5 cm of the temporal tip, but did not test naming or reading. Therefore it is difficult to compare our results directly with those of prior studies.

We found a higher incidence of anterior language areas in patients with evidence of early brain injury. Early left hemisphere damage has been associated with altered language lateralization, particularly following injury to the rolandic or parietal regions. Similarly, left handedness without a family history of sinistrality, presumably due to cortical damage, has also been linked to right-hemisphere language. Memory dominance also reflects hemispheric injury and has been shown to lateralize contralateral to the ictal onset zone, particularly if the onset is in the mesial rather than the lateral temporal lobe.

Damage caused early in life may have a different effect on language organization in temporal than on frontal regions. In an earlier report on a smaller group of patients, Devinsky, et al., reported a higher incidence of anterior temporal language areas in the superior temporal gyri of
patients with early seizure onset as well as a wider spatial distribution in the temporal lobes of patients with poor verbal skills and lower intelligence. In series conducted by Ojemann and colleagues, lower verbal IQ was also associated with a larger total language area, increased variability in parietal areas depending on gender, and a preponderance of naming errors in the superior temporal gyrus and reading errors in the middle gyrus. Hence, whereas early left hemisphere injury can shift frontal areas to the opposite side, temporal areas shift anteriorly, inferiorly, and posteriorly. This theory is consistent with the observation that among patients with refractory epilepsy and right-hemisphere language functions, there is often a dissociation between fluency and comprehension in cases in which fluency localizes more readily to the right side than either naming or comprehension. Basal temporal language areas, on the other hand, are more frequently found in patients in whom seizure onset occurred after age 5 years and, hence, are probably not a result of cortical reorganization in response to injury.

The issue for neurosurgeons is whether these anterior language areas produced by early damage are critical for language function or resectable with minimal postoperative dysfunction. If 14% of patients with chronic epilepsy have anterior temporal language areas, as our data show, then postoperative neuropsychometric testing should demonstrate a significant dysphasia in a subset of patients following nontailored surgery. Although no one has deliberately resected an essential area, studies by Ojemann and colleagues have indicated that severity of dysphasia correlates with the proximity of the resection to language areas. Similarly, MSTs of language areas clearly induce a significant dysphasia that resolves considerably over time, but usually never returns to baseline. We also found that MSTs in language cortex disrupt function more severely than resecting only nonessential cortex. Some language areas, on the other hand, are clearly resectable, such as a subset of basal temporal areas and lateral areas where stimulation interrupts language only intermittently, particularly if stimulation of a nearby area is more consistent.

Neuropsychometric testing following standard anterior temporal lobectomy shows short-term dysphasia in 1 to 52% of patients, presumably from postresection edema and retraction injury. Studies on long-term results are conflicting. Davies and colleagues reported no deficits at 1 year in a group of 53 left hemisphere–dominant patients. Langfitt and Rausch, on the other hand, showed a significant increase in word-finding difficulty in 25% of patients at 1 year, and Ivnik and coworkers reported problems with language-dependent cognitive tasks at 7.7 months. Several groups have noted minimal overall dete-
rioration in postoperative language ability, yet identified subgroups at higher risk for decline. Chelune and associates and Hermann, et al., reported a decline in postoperative language in patients with higher preoperative IQs and later age of seizure onset. Saykin and coworkers reported a decline in confrontation naming only in patients with no early risk factors for epilepsy. This group also had significantly later age of seizure onset and a higher mean verbal IQ. Overall, there does appear to be a decline in language ability after standard resections. Curiously, this decline occurs predominantly in the subset of patients whom we found to be the least likely to have anterior temporal language areas, namely those with high preoperative verbal IQ and later age of seizure onset. In our series of tailored lobectomies, postoperative naming ability also declined in a subset of patients. Although not statistically significant, we also found an association with higher preoperative verbal IQ and later age of seizure onset.

To understand the lack of decline in patients with early seizure onset and lower verbal abilities, who have more anterior language areas and more widely distributed language areas, these anterior areas must be less critical. Perhaps they play a small role in a widely distributed unconsolidated dysfunctional system that was disturbed by early cortical insult. Resection of these areas may cause a tran-

---

**TABLE 2**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Patients</th>
<th>BNT Score Preop</th>
<th>BNT Score Postop</th>
<th>Mean Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>no MST</td>
<td>18</td>
<td>45 ± 10.1</td>
<td>40.8 ± 9.0</td>
<td>-4.2 ± 8.5</td>
</tr>
<tr>
<td>no MST</td>
<td>12</td>
<td>42.9 ± 12.4</td>
<td>28.1 ± 12.4</td>
<td>-14.8 ± 14.5</td>
</tr>
<tr>
<td>verbal IQ ≤90</td>
<td>9</td>
<td>39.8 ± 10.8</td>
<td>37.3 ± 7.6</td>
<td>-2.5 ± 5.4</td>
</tr>
<tr>
<td>verbal IQ &gt;90</td>
<td>8</td>
<td>51.1 ± 6.0</td>
<td>45.0 ± 9.6</td>
<td>-6.1 ± 10.6</td>
</tr>
<tr>
<td>seizure onset &lt;6 yrs</td>
<td>6</td>
<td>38.7 ± 10.1</td>
<td>38.7 ± 6.2</td>
<td>-0.1 ± 4.7</td>
</tr>
<tr>
<td>seizure onset ≥6 yrs</td>
<td>12</td>
<td>48.2 ± 8.8</td>
<td>41.8 ± 10.1</td>
<td>-6.4 ± 8.9</td>
</tr>
<tr>
<td>LHRM</td>
<td>5</td>
<td>49.6 ± 10.8</td>
<td>45.8 ± 8.2</td>
<td>-3.8 ± 4.0</td>
</tr>
<tr>
<td>RHLM</td>
<td>13</td>
<td>43.2 ± 9.7</td>
<td>38.9 ± 8.8</td>
<td>-4.3 ± 9.7</td>
</tr>
<tr>
<td>male</td>
<td>9</td>
<td>45.2 ± 9.6</td>
<td>40.9 ± 9.1</td>
<td>-4.3 ± 7.3</td>
</tr>
<tr>
<td>female</td>
<td>9</td>
<td>44.8 ± 11.1</td>
<td>40.7 ± 9.3</td>
<td>-4.1 ± 10.1</td>
</tr>
<tr>
<td>febrile seizure</td>
<td>7</td>
<td>44.4 ± 10.6</td>
<td>40.4 ± 11.2</td>
<td>-4.0 ± 11.5</td>
</tr>
<tr>
<td>no febrile seizure</td>
<td>11</td>
<td>45.4 ± 10.2</td>
<td>41.0 ± 7.8</td>
<td>-5.0 ± 6.5</td>
</tr>
</tbody>
</table>

* Values are expressed as the mean ± SD. Abbreviations: LHRM = left handed or right hemisphere memory dominance; RHLM = right handed or left hemisphere memory dominance.

---
sient postoperative dysphasia, but no significant long-term decrement in an already compromised processing system with multiple widespread components. Our postoperative neuropsychometric data support this conclusion because they are similar to the data from nontailored surgeries that imply that preservation of anterior areas is not as important as preoperative verbal abilities in predicting functional outcome. In patients with more normal verbal skills and later seizure onset, however, removal of an anterior lateral language area would be more devastating, in which case stimulation mapping is critical.

References

Manuscript received April 28, 1997. Accepted in final form July 24, 1998. Address reprint requests to: Theodore H. Schwartz, M.D., Department of Neurological Surgery, The Neurological Institute N-102, Columbia–Presbyterian Medical Center, 710 West 168th Street, New York, New York 10032. email: ths4@columbia.edu.