Abstract

A longitudinal study of oral and written naming and comprehension of nouns and verbs in an individual (M. M. L.) with nonfluent primary progressive aphasia (PPA) is reported. M. M. L. showed progressive deterioration of oral naming of verbs well before deterioration of written naming of verbs and before deterioration of oral or written naming of nouns. Her comprehension of both nouns and verbs remained intact, at least relative to oral naming of verbs. Her performance is compared to that of two other individuals with nonfluent PPA, who were tested at two time points. These patients showed similar patterns with respect to grammatical word class (verbs more impaired than nouns) and modality (spoken production more impaired than written production), but somewhat different courses of deterioration. The modality-specific nature of the observed verb production deficits rules out a semantic locus for the grammatical class effects. The results provide a new source of evidence for the hypothesis that there are distinct neural mechanisms for accessing lexical representations of nouns and verbs in language production.

INTRODUCTION

There is strong evidence that nouns and verbs are represented in the brain in such a way that focal brain damage can disrupt processing of one grammatical class much more than others. Such evidence comes from numerous reports of disproportionate impairment in naming verbs relative to nouns due to stroke (Tranel et al., 2001; Berndt, Mitchum, Haendiges, & Sandson, 1997; Miceli, Silveri, Villa, & Caramazza, 1984) or focal degenerative disease (Bak, O’Donovan, Xuereb, Boniface, & Hodges, 2001; Cappa et al., 1998; Daniele, Giustolisi, Silveri, Colosimo, & Gianotti, 1994; McCarthy & Warrington, 1985), as well as the opposite pattern—disproportionate impairment with nouns relative to verbs (Shapiro, Shelton, & Caramazza, 2000; Berndt et al., 1997; Tranel, Damasio, & Damasio, 1997; De Renzi & di Pellegrino, 1995; Damasio & Tranel, 1993; Zingeser & Berndt, 1988; Miceli et al., 1984). Disproportionate impairment in naming verbs has generally been observed in patients with frontal lesions and nonfluent aphasia, whereas selective impairment in naming nouns has generally been observed in patients with posterior temporal lesions and fluent aphasia (Tranel et al., 2001; Damasio & Tranel, 1993; Zingeser & Berndt, 1990; Miceli et al., 1984), although exceptions to this lesion-deficit association have also been reported (see Daniele, 2001, for a review; De Renzi & di Pellegrino, 1995; Hillis & Caramazza, 1995; Caramazza & Hillis, 1991). Other evidence for distinct neural substrates of verbs versus nouns (in frontal vs. temporal regions, respectively) has been obtained through functional imaging studies and repetitive transcranial magnetic stimulation (rTMS). Some PET studies have revealed distinct regions of neural activation during processing of verbs compared to nouns (Perani et al., 1999; Tranel et al., 1997; Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995), although other PET studies have not confirmed these results (Tyler, Russell, Fadili, & Moss, 2001; Warburton et al., 1996). Electrophysiological studies have also implicated the left frontal cortex in verb processing (Federman, Segal, Lombrozo, & Kutas, 2000; Dehaene, 1995). Finally, a recent study using rTMS to create temporary dysfunction in left prefrontal cortex interfered with processing of verbs but not nouns (Shapiro, Pascual-Leone, Mottaghy, Gangitano, & Caramazza, 2001).

Despite the wealth of evidence on the dissociation of impairments of nouns and verbs, the interpretation of these observations remains controversial. Do the dissociations reflect specifically grammatical class effects or do they reveal the effects of semantic properties correlated with the grammatical classes “noun” and “verb”? Because verbs typically denote actions and are more abstract (or low imageability), whereas nouns typically denote objects and are more concrete (or high imageability), it has been proposed that the observed dissociations reflect the organization of semantic knowledge rather than effects of the grammatical properties of words (Breedin, Safran, & Schwartz, 1998; Marshall, Chiat, Ronson, & Pring, 1996; McCarthy & Warrington,
1985). For example, it has been argued that selective impairment in processing verbs reflects difficulty in processing low-imageability words, resulting in greater impairment for verbs only because these words tend to be of low imageability (Bird, Howard, & Franklin, 2000; but see Caramazza & Shapiro, in press; Berndt, Haendiges, Burton, & Mitchum, 2002, for arguments and evidence that challenge the strong version of this hypothesis).

Another important issue that has not been addressed adequately in most of the cited studies concerns the level of processing at which nouns and verbs might be distinctly represented. The selective disruption of verbs or nouns might occur at any one of several levels: The level of semantics, the level of accessing the phonological or orthographic representations of words for output, or even at a presemantic level of processing where picture stimuli are recognized as actions versus objects (see Druks, 2002, for a review). There is evidence that focal dementia, such as the frontal variant of fronto-temporal dementia (FTD) can progressively disrupt the conceptual or semantic representation of verbs relative to nouns (Bak, 2000; Bak et al., 2001; see also McCarthy & Warrington, 1985). However, it is unclear whether such deficits concern specifically the grammatical class “verb” or whether they reflect damage to semantic representations that are more importantly associated with verbs (e.g., semantics of actions) than nouns. There is also evidence that stroke can selectively disrupt orthographic or phonological representations (written and spoken word forms) of either nouns or verbs while sparing the semantic representation of both word classes. For example, Caramazza and Hillis (1991) described a stroke victim, S. J. D., who was very poor in writing the names of pictured actions (verbs) as well as in writing verbs to dictation, but was accurate in saying the names of the same pictured actions and in reading aloud verbs. In contrast, a second stroke victim, H. W., could write the verbs in both written picture naming and dictation but was very poor in saying the same verbs in oral naming and oral reading, despite relatively intact oral naming and oral reading of nouns. Both H. W. and S. J. D. had “intact” semantic representations of verbs and nouns, as indicated by their relatively spared naming of verbs in one modality and by flawless

Figure 1. M. M. L.’s oral naming of nouns and verbs over time. In this and other figures, the minimal score shown just above the x-axis represents 0% accuracy.
performance on word comprehension tasks. Importantly, Hillis and Caramazza (1995), using the same stimuli, described a stroke victim, E. B. A., who showed the opposite pattern with respect to word class in one modality only: selective impairment in naming nouns compared to verbs in oral naming and oral reading, with intact comprehension of nouns and verbs. There are now various reports of individuals who, after a stroke, were impaired in naming either nouns or verbs in only one modality of output despite intact comprehension of words (Berndt et al., 1997; Rapp & Caramazza, 1997, 2002; De Renzi & di Pellegrino, 1995). These reports of selective impairment of one grammatical category only in spoken or in written output (or in spoken or in written input) indicate that there may be distinct neural mechanisms for the representation/processing of nouns and verbs, independent of semantics. Thus, there is accumulating evidence that grammatical class dissociations may reflect both the effects of semantic organization as well as the effects of organization of grammatical processes at the level of modality-specific lexical forms.

In this article, we report a new type of evidence supporting this claim. We report a longitudinal study of oral and written naming and comprehension of nouns and verbs by a patient, M. M. L., who had nonfluent primary progressive aphasia (PPA). M. M. L.’s oral naming of verbs progressively deteriorated while her oral naming of nouns, as well as her written naming and comprehension of nouns and verbs, remained relatively intact, at least until very late in the course of the disease. We compare M. M. L.’s performance to two other patients (A. T. N. and H. M. S.) with nonfluent PPA who also showed modality-specific impairments in naming verbs, but with slightly different patterns of deterioration.

RESULTS

M. M. L. was tested approximately every 6 months over the course of 3 years, on oral and written naming and word–picture verification of a set of stimuli described by Zingeser and Berndt (1990; see Methods). In addition,
she was administered parts of the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1972), and other standardized and nonstandardized tasks. Her accuracy in oral naming of verbs deteriorated steadily, while her oral naming of nouns remained at a relatively high level (above 80% correct) until the last session (Figure 1). The difference between nouns and verbs was highly significant at every session ($\chi^2 = 5.5, df = 1, p < .02$ at 8 years after onset to $\chi^2 = 45.9, df = 1, p < .00001$ at 10 years after onset). In contrast, her written naming of nouns and verbs remained comparable and relatively accurate, until the last session when verbs were written significantly more poorly than nouns ($\chi^2 = 13.3, df = 1, p < .003$; Figure 2). Oral naming remained more impaired than written naming for verbs (compare Figures 1 and 2). By the last session, her oral naming was more impaired than written naming for nouns (53% vs. 97% correct; $\chi^2 = 30.0, df = 1, p < .00001$) as well as verbs (23% vs. 70%; $\chi^2 = 13.1, df = 1, p < .0003$). Unfortunately, by 11 years after onset, M. M. L.’s hand tremor became so severe that she could no longer write any legible words.

H. M. S. and A. T. N. were administered the same stimuli at three different time points. H. M. S. showed significantly better oral naming of nouns than verbs at 3 years after onset ($\chi^2 = 5.5, p < .02$) but 100% accurate written naming of both nouns and verbs. However, 1 year later, her oral naming was profoundly impaired for both nouns and verbs ($\chi^2 = 1.6, df = 1, ns$), whereas her written naming was significantly more accurate for nouns than verbs ($\chi^2 = 25.7, df = 1, p < .00001$). The same pattern persisted, although at a lower level, the following year (65% correct nouns vs. 20% correct verbs in writing; $\chi^2 = 11.6, df = 1, p < .001$; Figure 3).

A. T. N. showed a pattern initially similar to M. M. L.: better oral naming of nouns than verbs at 5 years after onset of symptoms ($\chi^2 = 20, df = 1, p < .000001$) and a year later ($\chi^2 = 9.0, p = .002$). However, her oral naming deteriorated substantially in both word classes, while written naming remained relatively spared until about 7 years after onset. By that time, her oral naming had deteriorated to 0% correct for both word classes, and written naming had deteriorated more severely for verbs than nouns ($\chi^2 = 17.4, df = 1, p < .0004$), as also found for M. M. L. and H. M. S. (Figure 4).

Examples of responses in oral versus written naming of nouns versus verbs are given in Table 1 for all three patients.

All three patients were 100% correct in word–picture verification with both nouns and verbs (using the same items as in the naming task) at the initial and the last sessions in this investigation.

### DISCUSSION

The three subjects with nonfluent PPA in this study showed modality-specific deterioration in naming verbs, in the face of relatively intact comprehension of words.

### Table 1. Examples of Oral and Written Naming of Nouns and Verbs (+ = Correct Response)

<table>
<thead>
<tr>
<th>Picture Stimulus</th>
<th>Oral Name</th>
<th>Written Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M. M. L.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melt [s]</td>
<td>melting (+)</td>
<td></td>
</tr>
<tr>
<td>Rob gun</td>
<td>robbing (+)</td>
<td></td>
</tr>
<tr>
<td>Decorate icing</td>
<td>decorating (+)</td>
<td></td>
</tr>
<tr>
<td>Spill water</td>
<td>spill (+)</td>
<td></td>
</tr>
<tr>
<td><strong>Nouns</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clown</td>
<td>clown (+)</td>
<td>clown (+)</td>
</tr>
<tr>
<td>Raft</td>
<td>raft (+)</td>
<td>raft (+)</td>
</tr>
<tr>
<td>Butterfly butterfly (+)</td>
<td>butterfly (+)</td>
<td></td>
</tr>
<tr>
<td>Witch</td>
<td>witch (+)</td>
<td>witch (+)</td>
</tr>
<tr>
<td><strong>H. M. S.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit [maba]</td>
<td>sit (+)</td>
<td></td>
</tr>
<tr>
<td>Read [tortor]</td>
<td>read (+)</td>
<td></td>
</tr>
<tr>
<td>Melt snowman</td>
<td>melt (+)</td>
<td></td>
</tr>
<tr>
<td>Hang</td>
<td>no response</td>
<td>hand (+)</td>
</tr>
<tr>
<td><strong>Nouns</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desk</td>
<td>desk (+)</td>
<td>desk (+)</td>
</tr>
<tr>
<td>Glass</td>
<td>glass (+)</td>
<td>glass (+)</td>
</tr>
<tr>
<td>Fox</td>
<td>fox (+)</td>
<td>fox (+)</td>
</tr>
<tr>
<td>Crutch</td>
<td>crutch (+)</td>
<td>crutch (+)</td>
</tr>
<tr>
<td><strong>A. T. N.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verbs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit</td>
<td>no response</td>
<td>sit (+)</td>
</tr>
<tr>
<td>Read</td>
<td>no response</td>
<td>read (+)</td>
</tr>
<tr>
<td>Add</td>
<td>no response</td>
<td>add (+)</td>
</tr>
<tr>
<td>Erase</td>
<td>no response</td>
<td>erase (+)</td>
</tr>
<tr>
<td><strong>Nouns</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wagon</td>
<td>wagon (+)</td>
<td>wagon (+)</td>
</tr>
<tr>
<td>Desk</td>
<td>desk (+)</td>
<td>desk (+)</td>
</tr>
<tr>
<td>Skull</td>
<td>skull (+)</td>
<td>skull (+)</td>
</tr>
<tr>
<td>Raft</td>
<td>raft (+)</td>
<td>raft (+)</td>
</tr>
</tbody>
</table>
We cannot rule out subtle word comprehension deficits that were not detected by our word–picture verification task. However, such deficits could not be the basis for the observedgrammatical class effects, since these were specific to a modality of output. M. M. L., whose performance is the focus of this study, showed steady deterioration in oral naming of verbs, even when she could repeat and write them very well (through 10 years after onset). At 10.5 years after onset, she began to make more errors in writing verbs compared to nouns, although written naming of verbs was still much more accurate than oral naming of verbs. This pattern of deterioration, most likely due to the frontal variant of FTD in her case, indicates that the neural mechanisms subserving the lexical–phonological processing of verbs for output are sufficiently distinct from those involved in processing the lexical–orthographic representation of verbs and the lexical–phonological and lexical–orthographic representations of nouns, such that only the first can be initially impaired in focal degeneration. The fact that M. M. L.’s oral naming of nouns eventually deteriorated severely before written naming of nouns or verbs (a pattern also observed in A. T. N. and H. M. S.) indicates either that the mechanisms subserving lexical–phonological representations of nouns and verbs are adjacent (and therefore vulnerable to spread of the degenerative processes) or that a mechanism common to oral naming of both nouns and verbs (e.g., motor speech programming or articulation of speech) was affected before mechanisms common to written naming of nouns and verbs. The fact that both M. M. L. and A. T. N. could still correctly repeat both nouns and verbs at the final session (albeit with stiff, but minimally distorted articulation) favors the former account. H. M. S.’s repetition of all words was impaired at the last session, suggesting that she might have also developed a motor speech impairment.

The observation that each of these patients eventually showed deterioration in written naming of verbs (significantly worse than nouns) also has at least two possible explanations. First, the neural mechanisms subserving lexical–orthographic representations of verbs might be adjacent to those subserving their lexical–phonological representations, so that they are vulnerable to “spread” of the degenerative process. Alternatively, there might be a mechanism common to oral and written naming of verbs (e.g., semantics of actions), which is affected relatively late. Although all three patients performed accurately on word–picture verification at the last session, we cannot rule out a subtle semantic deficit, particularly for verbs, since picture naming likely requires more intact semantic information than word–picture verification. This possibility is supported by the performance of other cases in the literature. Bak et al. (2000, 2001) reported deterioration in semantic processing of verbs relative to nouns in patients with the frontal variant of FTD (a likely cause of at least M. M. L.’s nonfluent PPA), using a semantic triad task with pictures of verbs (the “kissing and dancing test”). Similarly, Daniele et al. (1994) reported that their patients showed deterioration in processing lexical representations of verbs earlier than deterioration in semantic representations. The nonfluent progressive aphasic patient described by McCarthy and Warrington (1985) was also impaired both in comprehension and oral naming of verbs, at least late in the course of the disease. However, earlier in the course of the disease, at a time when spoken production of verbs was already impaired, the patient showed intact word comprehension as measured by the Peabody Picture Vocabulary Test (which includes verbs). This result indicates that the patient’s access to lexical–phonological representations of verbs very likely deteriorated prior to his semantic representations of verbs.

It is also notable from the figures that the actual rate of decline for nouns and verbs (in each modality) might be similar, although the nouns deteriorated later. One conceivable explanation for the earlier decline in verbs is that verb naming was not influenced by a practice effect, whereas noun naming was supported by a practice effect over time. This explanation is implausible, since the patients were tested only once every 6–12 months and had progressive language deficits. Furthermore, even if “practice” were sufficient to maintain noun naming but not verb naming, this observation would indicate that nouns were somehow “easier” or more accessible than verbs. That is, one could argue that the phonological and orthographic representations of verbs are just “more difficult” to access than those of nouns, since they are more complex and are acquired later by children (Gentner, 1981). Such an account of our results is undermined by earlier reports of patients who showed more impaired oral naming of nouns than verbs, using the same stimuli as in this study (Shapiro et al., 2000; Berndt et al., 1997; Hillis & Caramazza, 1995; Zingeser & Berndt, 1990). Hence, the observation that the M. M. L., A. T. N., and H. M. S. showed earlier deterioration on verbs initially only in the oral modality provides evidence that a neural mechanism more critical for the production of verbs than nouns is impaired in these patients.

Another account of impaired naming of verbs relative to nouns that does not ascribe the observed effects specifically to the grammatical status of the words is that verbs are more abstract than nouns. However, if the patients reported here had difficulty with abstractness per se, this difficulty would be expected to arise at the semantic level, affecting both oral and written naming of verbs at the same time, which was not observed. Finally, it might be argued that pictures do not depict verbs as well as they depict nouns, so that naming of pictured verbs might be less accurate than naming of pictured nouns. However, the patients reported here clearly produced nouns more accurately.
than verbs also in spontaneous speech (see Appendix), ruling out the possibility that the effect results from difficulty in processing action pictures. Furthermore, Berndt et al. (1997) found that naming of verbs was equally impaired whether the stimuli were presented as black and white pictures (the stimuli used in this investigation) or as videotaped presentation of actions, indicating that relative impairment of verb naming was not attributable to conceptual difficulty in naming actions depicted in drawings.

The results reported in this study are the first to demonstrate that at least early in the course of dementia, access to the lexical–phonological representations of verbs can be impaired even when access to lexical–orthographic representations of the same verbs is intact. The fact that these patients could correctly write the names of verbs that they could not name aloud also indicates that, at least at that point, their semantic representations of verbs were spared. These results have strong implications for the structure of the lexical system and its neural basis. The fact that a grammatical class effect—the selective impairment of verbs—was restricted to one modality of output—spoken production—suggests that grammatical class information is specified at the level of modality-specific lexical representations. An implication of this conclusion is that grammatical processing of words (e.g., morphological operations) is carried out directly with modality-specific lexical forms (Caramazza, 1997). A further implication is that grammatical class (or the type of processes carried out over words of a given grammatical class) is an organizing principle of linguistic information in the brain, or that there are neural structures or processes that are more critical for one grammatical class than another.

The results reported here are consistent with the proposal that the lexical (and semantic?) representations of verbs are processed in frontal regions, such as the left premotor cortex, whereas the representations of nouns are processed more posteriorly, such as in the left anterior and medial temporal cortex (Shapiro et al., 2001; Tranel, Adolphs, Damasio, & Damasio, 2001; Damasio & Tranel, 1993; Danielli et al., 1994). However, other reported cases are not consistent with this hypothesis. For example, both E. B. A. (Hillis & Caramazza, 1995) and Mario (De Renzi & di Pellegrino, 1995), who showed selectively spared naming of verbs relative to nouns and intact comprehension of both verbs and nouns, had relatively large infarcts in the distribution of the superior division of the left middle cerebral artery that included the premotor cortex. One explanation for the fact that they could name verbs despite damage to the left premotor cortex and Broca’s area is that both patients showed reorganization of structure/function relationships, such that they recovered access to the lexical–phonological representations of verbs even though initially they may have been impaired both in the production of nouns and verbs. The fact that both patients were studied three or more months after onset of stroke allows this possibility. Nevertheless, the fact that these patients remained impaired in naming nouns indicates that neural substrates for the lexical representations of verbs and nouns are unlikely to be widely separated. It is likely that distinct but adjacent regions or cell groups within the frontal–temporal regions are essential for accessing the lexical representations of nouns and verbs. Some support for this hypothesis is provided by our findings that M. M. L., A. T. N., and H. M. S. showed some deterioration of oral naming of nouns after (but overlapping temporally with) their deterioration in oral naming of verbs.

In summary, we have reported progressive deterioration in oral naming of verbs prior to deterioration of oral naming of nouns, and prior to deterioration of written naming or comprehension, in three patients with nonfluent PPA. These data provide a new source of evidence for the hypothesis that the neural mechanisms responsible for accessing lexical–phonological representations of verbs are relatively independent and separable from those responsible for access to lexical–phonological representations of nouns.

METHODS

Subjects

M. M. L. is a 75-year-old right-handed woman who was first evaluated 8 years prior to onset of a progressive disturbance in spoken output. At that time, she was living alone and was independent in all activities of daily living except use of the telephone. She took care of her own finances and could write effectively to communicate. Her mood was somewhat labile, and she was mildly disinhibited, prone to “swearing” and inappropriate laughter. Her neurological examination was normal, except for her impaired speech and language, a mild resting tremor, and more significant postural and action tremor. There was no oral or limb apraxia. Her past medical history was significant only for hypercholesterolemia, nephrolithiasis, lumbar laminectomy, and a single episode of shingles. Her family history was negative for any dementia. Her performance on the BDAE indicated relatively intact auditory comprehension with occasional errors in comprehension syntactically complex sentences. There were no errors in reading comprehension. Spontaneous speech and sentence repetition were nonfluent and agrammatic, with laborarted articulation. (For examples, see her descriptions of the “cookie theft” pictures from the BDAE; Appendix.) Visual confrontation naming was intact for objects, numbers, and colors, but impaired for actions. Word fluency was poor. However, oral reading and repetition of nouns, verbs, and pseudowords were accurate. Reasoning, judgment, insight, visual attention, clock construction, and nonverbal memory were all
Figure 5. MRI scans of M. M. L. at 10 years after onset.
spared. Given that speech and language skills had deteriorated for more than 2 years, without evidence of nonlinguistic cognitive deficits, she met criteria for PPA (see Mesulam, 2001).

Over the next 2 years, M. M. L.’s spontaneous speech became even more limited, to single nouns and a few familiar phrases (see Appendix). She became more impulsive, prone to “temper tantrums,” incontinent of urine, and showed some manic behavior. For example, she constantly purchased items she did not need or use from mail-order catalogues. She moved in with her sister, who eventually took over her financial affairs. Her tremor worsened, to the degree that she could no longer write any legible words at 11 years after onset. She could no longer whistle, but there was no other evidence of buccofacial speech or limb apraxia. There were no other cranial nerve or other neurologic abnormalities, except for mild cogwheeling in both arms and hyperreflexia. An MRI scan showed atrophy especially in the left frontal—temporal region (Figure 5). Evaluation for treatable causes of dementia was negative. By 11 years after onset, she met the Lund–Manchester criteria for FTD (Brun et al., 1994).

H. M. S. is a 76-year-old woman who presented at 5 years after onset of progressive speech and language disturbance. Past medical history was notable only for cataract surgery and herniated disk repair. There was no family history of dementia. On the BDAE, auditory comprehension was minimally impaired, with no errors in word discrimination, one error on a five-part command, and rare errors in answering questions about stories read to her. Reading comprehension was comparably good, with only occasional errors at the paragraph level. Spoken output was limited to occasional single nouns, with poor articulation, although she initially could repeat and read aloud words of all grammatical classes. She could not repeat “Methodist Episcopal,” or sentences beyond three words in length. Confrontations naming and naming to definition were intact for objects, colors, numbers, and shapes. Neuropsychological testing revealed intact visual attention, constructional skills, nonverbal reasoning, calculation, and insight.

Over the next year, she became nearly mute, but could write sentences well to communicate effectively. Throughout this study, she remained independent in all daily activities, including all financial affairs. She balanced her checkbook accurately each month. She developed no buccofacial or limb apraxia. There were no neurologic abnormalities except in speech and language. There was no change in behavior or personality, except mild depression. Nonverbal cognitive skills and insight and other neurological functions remained spared; she met criteria for PPA. Work-up for treatable causes of dementia was negative. MRI scan showed mild atrophy, periventricular white matter changes consistent with age, and widening of the Sylvian fissure particularly on the left (Figure 6).

A. T. N. is a 60-year-old right-handed woman who presented at 5 years after onset of progressive speech and language impairment. She had previously been very healthy. Family history was notable for stroke in her father and dementia in an uncle. Her speech was nonfluent, agrammatic, and hypophonic. She made only rare phonemic errors. On the BDAE, her auditory and reading comprehension were intact for words and syntactically simple sentences. She made occasional errors on syntactically complex sentences and at the paragraph level. She wrote in short phrases and grammatically correct sentences, with rare spelling errors. Repetition was impaired for polysyllabic words (e.g., continental) and sentences. On neuropsychological testing, judgment, insight, and nonverbal attention, memory, and reasoning were intact. Calculation was moderately impaired. She remained independent in all daily activities. Except for a flat affect, her cranial nerve, motor, and sensory examination remained normal. There was no buccofacial or limb apraxia and tremor. Her husband denied any change in behavior or personality, except that she was “less animated.” Her clinical profile was consistent with PPA.

A. T. N. became progressively depressed and difficult to test due to reluctance to respond in any modality. MRI scan showed diffuse atrophy, particularly left frontal, temporal, and parietal, and minor periventricular white matter changes consistent with her age, and widening of the Sylvian fissure, particularly on the left (Figure 6). Complete sets of scans are not included here (because of space and the fact that the scans do not impact on the conclusions of this study), but are available by e-mail from the first author.

**Procedures**

For oral and written naming and word–picture verification, stimuli consisted of 30 pictures of “unambiguous” verbs, 30 pictures of “unambiguous” nouns matched in
surface frequency to the verbs, and 30 pictures of “unambiguous” nouns matched in cumulative frequency to the verbs (described in detail in Berndt et al., 1997). The pictures were black and white line drawings, prepared by a graphic artist for Berndt et al. (and were the identical stimuli used by Berndt et al., 1997). The patient was shown each picture and asked, “What is the name of this?” (for nouns) or “What is this person doing?” (for verbs). For each modality separately, 30 nouns were presented, then 30 verbs, then 30 nouns. The order for oral versus written naming was chosen randomly for each session. Oral responses were scored as correct if they were phonemically correct productions of the target word (although the phonemes could be slightly distorted or stiff, as long as they were recognized as the target phonemes). Written responses were scored as correct if they were correctly spelled renditions of the target word. If the subject produced a name that was a synonym or a superordinate of the target, they were asked if they could think of another word for the picture, or a more specific word. These stimuli were also presented for naming by 10 control subjects with no neurological impairment, with a mean age of 44 ± 12 years and mean education of 11 ± 1.9 years, who named them with 100% accuracy (the stimuli had been selected for good name agreement; Berndt, personal communication). We also administered these stimuli to 5 controls each with 12 years of education and with a mean age of 68.4 ± 3.1 and to a consecutive series 25 patients hospitalized for acute, left hemisphere stroke with various types and severity of language deficits. The five controls named the nouns with 97–100% accuracy (mean = 98.8% for each word class) in both oral and written naming. Of the 25 patients, 2 were significantly more impaired in naming nouns than verbs and 4 patients were significantly more impaired in naming verbs than nouns. The remaining 19 patients were equally impaired in naming nouns and verbs (range of scores: 0–97% correct). Similar findings were reported for chronic aphasic patients studied by Berndt et al. (1997). There were no time limits for responding, and the final response was scored. Responses to the two sets of nouns were collapsed, as there were no significant differences in scores for the two sets (as also found by Berndt et al., 1997; Zingesser & Berndt, 1990).

For word–picture verification, each picture was presented three times, once with a semantically related word (e.g., eat/drink), once with an unrelated word, and once with the correct name, in a random order. Correct rejection of both foils and acceptance of the correct name were required for an item to be scored as correct. This scoring avoids pseudocorrect scores that result from saying “yes” to all items or “no” to all items. We have found this word–picture verification task to yield approximately the same rate of errors as oral and written naming in patients with selective impairment of lexical–semantics caused by stroke (e.g., Hillis, Rapp, Romani, & Caramazza, 1990; Hillis, 1991). Our five age-matched control subjects were each 100% correct on this test.

APPENDIX: DESCRIPTIONS OF THE “COOKIE THEFT” PICTURE FROM THE BDAE

M. M. L. at 8 years after onset:
The water is overflowing. The stool is gonna ... is gonna happen. The people are ... the boy and girl, and they had to ... stumble. Also ... he's ... falling back. The mother is ... She's wash ... , wiping the dishes.

M. M. L. at 10.5 years after onset:
uh, uh, boy ... uh, uh, girl ... and ... cookies ... uh, uh, uh

H. M. S. at 3 years after onset:
mother ... water ... dishes ... curtains ... cupboard.

H. M. S. at 4 years after onset:
boy ... girl ... water. (She spontaneously wrote at the same time: “Boy se cookies. Girl wash dishing. Water flo stool dish.”)

A. T. N. at 5 years after onset:
Stealing cookies ... Sink is overflowing ... He’s about fall ... stealing cookies ... sharing them.

A. T. N. at 6 years after onset:
Sink overflowing. Boy falling down.

Acknowledgments

The research reported in this article was supported by NIH grant DC 05375 to A. H. and DC 04542 to A. C. Reprint requests should be sent to Argye E. Hillis, Department of Neurology; Johns Hopkins Hospital, Meyer 5-185, 600 North Wolfe Street, Baltimore, MD 21287, USA, or via e-mail: argye@jhmi.edu.

REFERENCES


