Cognitive Neuropsychological Analysis and Neuroanatomic Correlates in a Case of Acute Anomia

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We describe an analysis of lexical processing performed in a patient with the acute onset of an isolated anomia. Based on a model of lexical processing, we evaluated hypotheses as to the source of the naming deficit. We observed impairments in oral and written picture naming and oral naming to definition with relatively intact semantic processing across input modalities, suggesting that output from the semantic system was impaired. In contrast to previous reports, we propose that this pattern represents an impairment that arises late in semantic processing prior to accessing mode-specific verbal and graphemic output lexicons. These deficits were associated with a lesion in the posterior portion of the middle temporal gyrus or area 37, an area of supramodal association cortex that is uniquely suited as a substrate for the multimodal deficit in naming. © 1997 Academic Press

INTRODUCTION

Impaired word retrieval or anomia is a common sign in patients with acquired aphasia (Kohn & Goodglass, 1985), and researchers focus much interest on understanding its basis. Recent investigations have incorporated a cognitive neuropsychological approach to analyze the naming deficits of aphasic patients. This approach posits a model of the functional processes involved in word retrieval and explains the anomia as a disruption at some point in the system (Ellis & Young, 1988; Rothi, Raymer, Maher, Greenwald, & Morris, 1991).

As shown in Fig. 1, the process of word retrieval presumably relies on a semantic system that contains meaning information for familiar words and

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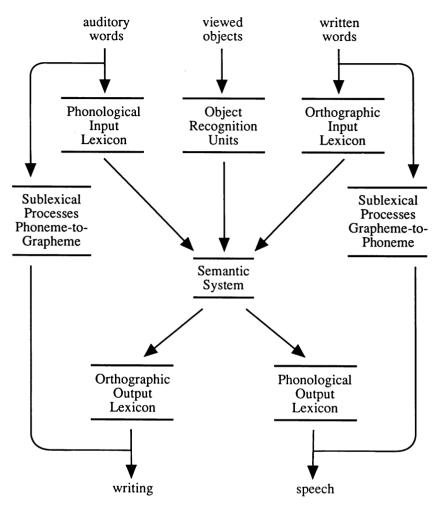


FIG. 1. Model of lexical processes involved in oral naming.

phonological and orthographic output lexicons storing the word forms for pronunciation and spelling of familiar words. Depending upon the task in which subjects name items, activation of input structural descriptions (phonological input lexicon, orthographic input lexicon, and object recognition system) for familiar words or pictures may be necessary to engage information in the semantic system. The coordinated functioning of these modular systems is necessary for performance of various lexical tasks, including oral and written picture naming, naming to auditory definitions, oral word reading, and writing to dictation. In addition, tasks of oral reading and writing to dictation presumably involve sublexical processes (grapheme-to-phoneme conversion and phoneme-to-grapheme conversion) independent of the semantic system (Ellis & Young, 1988).

Failure in naming tasks can result from impairment at a number of functional loci in the lexical system. To account for word retrieval failure in a given patient, analysis of accuracy and error patterns across lexical tasks may provide converging evidence that implicates a particular locus of deficit. For example, disruption of object recognition units or early visual processing can lead to difficulty in picture naming, a task typically used to assess word retrieval skills. However, in the case of visual processing failure the naming impairment would be modality specific, as in visual agnosia, and is outside the range of deficits that are considered anomias. More commonly, word retrieval deficits occur subsequent to impairment of either the semantic system or the phonological output lexicon (Gainotti, 1987).

The predicted pattern of performance associated with a semantic impairment includes multimodal naming failure (i.e., oral and written naming) for all forms of input (e.g., pictures, auditory definitions) (Rothi et al., 1991) and errors that are typically semantic in nature. In addition, auditory and reading comprehension deficits should be evident, particularly when demands of the tasks increase using semantically related distractors. Abilities in oral reading and writing to dictation will be dependent upon the functioning of sublexical processes available for completion of these tasks. If sublexical processes are sufficiently impaired, semantic errors may be anticipated in oral reading and writing to dictation as well. Finally, item-specific error consistency may be demonstrated across tasks (Shallice, 1988). Researchers have described patients with this form of lexical impairment (Howard & Orchard-Lisle, 1984; Hillis, Rapp, Romani, & Caramazza, 1990).

In contrast, deficit of the phonological output lexicon is characterized by mode-specific oral naming failure, with intact written naming and comprehension (Rothi et al., 1991). Once again, if sublexical reading processes are also impaired, oral reading performance may parallel that in oral naming in terms of accuracy and error pattern. Two patients described as representing selective deficits of the phonological output lexicon produced different error patterns in verbal output tasks. A patient of Kay and Ellis (1987) produced a preponderance of phonologic errors. In contrast, the patient reported by Caramazza and Hillis (1990) made numerous semantic errors. This is likely due to differences in the mechanism of impairment of the output lexicon (i.e., access failure, heightened thresholds for activation, impaired representations). Hence the type of errors observed will not be the deciding feature in proposing a functional impairment at this level of the lexical system.

Miceli and colleagues (Miceli, Giustolisi, & Caramazza, 1991) recently described a patient whose performance exhibited characteristics that may reflect impairment of either semantic or lexical output modules of the naming system. Specifically, consistent with a semantic deficit, the patient demonstrated reduced performance in both oral naming and written naming tasks.

The patient's naming errors were predominantly failures of omission (no response) and were consistent across tasks and across time. However, in keeping with a deficit of the output lexicon, performance in comprehension tasks was excellent. The authors attributed their patient's naming deficit to co-occurring deficits of the phonological output lexicon and the orthographic output lexicon, and not the semantic system. Their patient will be considered in more detail in the discussion in relation to the performance of the anomic patient we describe in this paper.

In considering these case studies of anomia reported in the literature, we noted that none of the analyses described naming impairment in patients at an acute stage of the language deficit and in whom the naming deficit is a relatively isolated aphasic sign. Benson (1979) noted that anomia in these different conditions may represent distinct phenomena. In this paper we describe a patient, HH, whose acute anomic aphasia we evaluated incorporating the cognitive neuropsychological framework.

An additional goal of neuropsychological analysis is to learn how the different modular components of language can be mapped to specific brain structures (Caplan, 1987). Although controversial (Coltheart, 1984), anatomic localization may provide information regarding brain-behavior relationships. For example, although word retrieval deficits are observed in conjunction with lesions throughout the cerebral cortex and subcortical structures such as the thalamus, Benson (1979) posited a role of the posterior portion of middle temporal gyrus or the lower angular gyrus (Brodmann's area 37) in cases of pure anomia, but did not report any such cases. Others focused on posterior temporal cortex lesions in cases of naming failure as well (Cappa, Cavallotti, & Vignolo, 1981; Kremin, 1988). However, to our knowledge, no detailed analysis has been presented regarding an anomic patient with a circumscribed lesion in this brain region. We include an anatomic localization of the lesion associated with acute anomia in our patient.

CASE HISTORY

HH, a 66-year-old, right-handed man, was previously employed as a precision stone mason. He had a ninth grade education and reportedly experienced developmental reading and spelling difficulties in school. In spite of this developmental history, HH reported that he was an avid reader including daily Bible reading. His medical history included a transient ischemic event in 1982 and a nonfocal event subsequent to coronary artery bypass surgery in 1989 with no resulting sensory or motor deficits and only vague residual "personality changes." In 1945 he sustained a traumatic war injury leading to left leg amputation. HH denied any changes in language abilities following his earlier neurologic events.

Two weeks prior to our experimental testing, HH suffered a left hemisphere ischemic infarction characterized by an acute onset of aphasia. In

ANALYSIS OF ACUTE ANOMIA

Subtest	Score	
Spontaneous speech	18/20	
Information content	9/10	
Fluency	9/10	
Comprehension	8.9/10	
Yes/No questions	51/60	
Auditory word recognition	57/60	
Sequential commands	70/80	
Repetition	9.4/10	
Naming	6.0/10	
Object naming	36/60	
Word fluency	8/20	
Sentence completion	8/10	
Responsive speech	8/10	
Aphasia quotient	84.6/100	

TABLE 1 HH's Performance on the Western Aphasia Battery

our initial neurologic examination, we noted fluent spontaneous speech with frequent word-finding pauses and circumlocutions. His confrontation naming was severely impaired to visual and tactile presentation. He was able to indicate the use of objects by pantomime and was able to select named objects from an array of five objects. His reading was impaired, with a tendency to read some words letter-by-letter and an inability to read nonsense words. The remainder of his examination was normal. The results of HH's formal language examination with the Western Aphasia Battery (Kertesz, 1982) demonstrated an aphasia quotient of 84.6 and was consistent with the pattern of anomic aphasia (Table 1). Also, HH had difficulty with reading and writing subtests beyond the single word level of performance. In nonword subtests of the Battery of Adult Reading Function (unpublished test, Rothi, Coslett, & Heilman), HH read aloud 3/30 nonwords and wrote to dictation 6/30 nonwords. On the Boston Naming Test (Goodglass, Kaplan, & Weintraub, 1983), HH named 17 of 60 items correctly and was prompted with a phonemic cue for an additional 7 items. Errors included semantic and phonemic paraphasias (e.g., "halloween" for mask, "heldacopter" for helicopter).

A magnetic resonance imaging scan performed two days after the acute event revealed a recent lesion in the left posterior inferior temporal lobe extending from the caudal two-thirds postero-laterally to the temporo-parieto-occipital junction (Fig. 2). The lesion spared Wernicke's area and the supramarginal and angular gyri. Additional small lesions were also noted in the left high parietal, right anterior temporal, and right frontal deep white matter regions.

Five independent examiners plotted the acute temporal lobe lesion as ob-

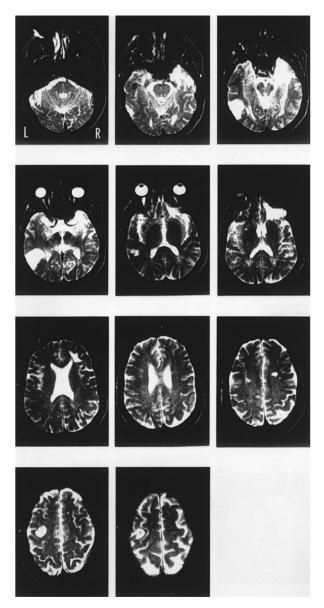


FIG. 2. Magnetic resonance imaging scan of HH's lesion obtained two days post onset of aphasia.

served on axial sections using the technique of Damasio and Damasio (1989). The ablated area was compared to templates that displayed cytoarchitectonic areas. All examiners agreed that the patient had a lesion in the superior and lateral aspect of Brodmann's area 37 (Fig. 3).

EXPERIMENTAL TESTING

The purpose of the experimental testing was to define HH's selective naming deficit with respect to a proposed model of lexical processing. We proposed to test three different hypotheses. First, if naming impairment relates to defective visual object processing, deficits should be specific to picture naming tasks and no naming impairment would be predicted in naming tasks dependent upon alternative input modalities such as naming to auditory definition. Second, if naming failure is a result of a semantic system deficit, HH should be impaired in all naming and comprehension tasks dependent upon semantic processing (i.e., oral picture naming, written picture naming, naming to definition, and word-picture matching) and a similar error pattern should be observed across naming tasks. Oral reading and writing to dictation may be similarly impaired if sublexical processes are deficient. Third, if naming failure is due to impairment of the phonological output lexicon, HH should show a dissociation between verbal output and graphic output abilities in that oral naming should be impaired relative to written naming. Further, if sublexical reading processes are significantly impaired, we would predict the same error pattern for oral naming and oral reading.

Naming Tasks

To evaluate these hypotheses, HH completed a set of lexical output tasks that included oral picture naming, written picture naming, oral naming to auditory definition, oral word reading, and writing to dictation. The tasks incorporated the same 120 items from 12 different semantic categories (e.g., clothing, transportation, fruits). The set included 40 high, 40 middle, and 40 low frequency words in the English language (Francis & Kucera, 1982). HH completed the oral picture naming task on two separate occasions at the beginning (time 1) and end (time 2) of the one week testing period. Pictures for oral and written naming were $3'' \times 5''$ black and white line drawings. Written words for oral reading were printed in block letters on $3'' \times 5''$ cards. In naming to definition, the examiner read aloud each definition and repeated as necessary to assure that memory difficulties did not account for errors in naming. Stimulus items were presented in randomized blocks across sessions to avoid order effects across tasks. HH completed testing within 1 week, during which he participated in twice daily sessions.

Two trained examiners coded oral and written naming responses using a system similar to that described by Mitchum and colleagues (Mitchum, Ritgert, Sandson, & Berndt, 1990). Responses were scored as correct if HH

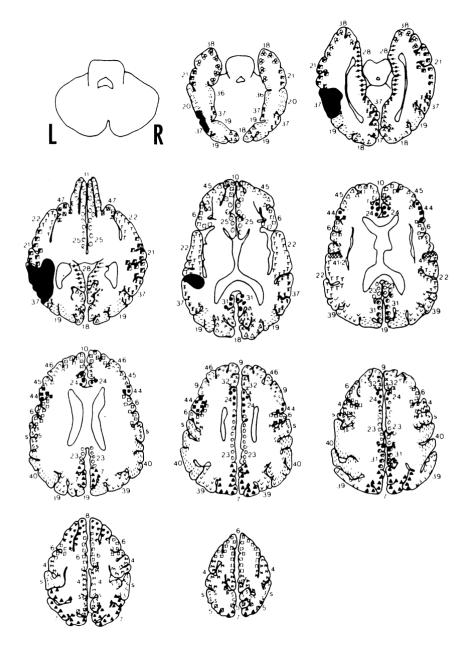


FIG. 3. Localization of HH's lesion using the technique of Damasio and Damasio (1989).

Developmental Reading and Spennig Floblenis) in Five verbal and Graphic Output Tasks				
Task	НН	Developmental problem controls $(n = 2, range)$	Normal controls $(n = 4, \text{ range})$	
Oral picture naming (time 1)	50	83-85	94–98	
Oral picture naming (time 2)	58		_	
Written picture naming	53	77-85	95-100	
Oral naming to definition	55	92-93	90-98	
Oral reading	55	84-90	100	
Writing to dictation	90	78–93	100	

 TABLE 2

 Accuracy (% Correct) for HH and Matched Control Subjects (With and Without Reported Developmental Reading and Spelling Problems) in Five Verbal and Graphic Output Tasks

produced the target word or an acceptable synonym. Error categories included semantic (i.e., coordinate, associate, superordinate, definition, or circumlocutory responses), phonemic, semantic + phonemic, visual (misperception), unrelated word, no response, and other. In scoring oral reading responses, we combined the categories of visual and phonemic because many of these types of responses could not be distinguished from one another with certainty. Finally, in scoring written naming and writing to dictation, a more liberal criterion had to be applied because of HH's developmental spelling difficulties. In addition to a small number of correctly spelled responses, we coded as correct those target words that HH misspelled (e.g., t-h-u-n for thumb; f-a-r-k for fork). Across all five tasks, we scored HH's first response and noted any subsequent self-corrections. Point-to-point reliability of error coding for the two examiners ranged from 93 to 100% across the five tasks. Consensus was reached for each disagreement.

Control subjects. To serve as control subjects, six hospitalized men also completed the experimental tasks. Four men comparable to HH in age (61-69 years) and education (10-12 years) were neurologically normal and reported no history of developmental reading and spelling difficulties. Each of these patients completed the test battery. Two men matched to HH in age (68-70 years) and education (8-9 years) reported they had experienced reading and spelling problems in school. Because of their medical circumstances, these two men completed only one-half of the experimental tasks. Accuracy results. As shown in Table 2, HH's accuracy for the verbal tasks,

Accuracy results. As shown in Table 2, HH's accuracy for the verbal tasks, oral picture naming (time 1 and time 2), oral naming to definition, and oral word reading was 50–58% correct as was his performance in written naming (53% correct). Accuracy for writing to dictation surpassed that of the other tasks with more than 90% of his lexical responses correct. Normal control subjects performed at ceiling, and developmental control subjects produced a moderate number of errors across tasks. HH was significantly impaired compared to the lowest scoring subject in all tasks except writing to dictation

Task	High $(n = 40)$	$\begin{array}{l} \text{Middle} \\ (n = 40) \end{array}$	Low $(n = 40)$
1 dSK	(n - 40)	(n - 40)	(n - 40)
Oral picture naming (time 1)	63	45	43
Oral picture naming (time 2)	65	63	48
Written picture naming	63	45	53
Oral naming to definition	63	65	38
Oral reading	75	48	43
Writing to dictation	95	85	95

TABLE 3 HH's Accuracy (% Correct) for High, Middle, and Low Frequency Sets of Words

(oral naming: $\chi^2 = 30.0$, p < .001; written naming: $\chi^2 = 14.36$, p < .001; oral naming to definition: $\chi^2 = 41.25$, p < .001; oral reading: $\chi^2 = 24.12$, p < .001). In writing to dictation HH scored in the range of control subjects.

Table 3 reports HH's performance for high, middle, and low frequency sets of words among the five verbal output tasks. Chi square analyses contrasting the numbers of correct and incorrect responses for each frequency band indicated significant effects for naming to definition ($\chi^2 = 7.46$, p < .05) and oral reading ($\chi^2 = 9.90$, p < .01). The effect failed to reach significance for oral picture naming (time 1: $\chi^2 = 3.80$, n.s.; time 2: $\chi^2 = 2.95$, n.s.), written picture naming ($\chi^2 = 2.48$, n.s.), and writing to dictation ($\chi^2 = 3.52$, n.s.).

The effect of semantic category on HH's naming performance was evaluated across three naming tasks: oral picture naming (time 1), written picture naming, and naming to auditory definition (i.e., a total of 30 naming responses per semantic category). HH produced a mean of 15.8 of 30 items correctly among the twelve semantic categories examined. Based on a 95% confidence interval constructed for this mean, naming performance for three semantic categories was beyond the limits of expected performance. HH correctly named 24/30 body parts, 29/30 animals, and 9/30 musical instruments. However, what appears to be a semantic category effect may in fact be related to word frequency for those categories. Body parts and animals were the categories with highest overall frequencies among the 12 categories, and musical instruments was the third lowest frequency category overall.

Error pattern. Further information regarding HH's lexical performance is derived from an analysis of his error pattern in each lexical output task. As seen in Table 4, the largest category of errors in the three naming tasks was semantic errors (oral naming time 1: 31/60, 52%; oral naming time 2: 42/50, 84%; naming to definition: 44/54, 81%; written naming: 28/56, 50%). Examples of these semantic errors, shown in Table 5, included many semantic coordinate and associate responses and circumlocutions that conveyed semantic information. HH produced no semantic errors in oral reading and

	Oral naming		Written	Name to	Oral	Write to
Errors	Time 1 $(n = 60)$	Time 2 $(n = 50)$	naming	definition $(n = 54)$	reading	dictation $(n = 10)$
Semantic	52	84	50	81	0	10
Phonemic	7	2		0	_	_
Semantic + Phonemic	3	_		4		_
Unrelated	33	14		9	0	_
Visual/Phonemic		_			85	_
Other	3			2	13	_
Uninterpretable			20			90
No response	2	—	30	4	2	—

 TABLE 4

 HH's Error Pattern (%) in Five Verbal and Graphic Output Tasks

only one in writing to dictation (i.e., l-i-m-e-s for lemon). Rather, the prevailing error (46/54 errors) produced in oral reading was visually/phonologically related word or nonword responses (e.g., "scaerf" for scarf; "house" for horse). HH's error pattern contrasts with the naming errors produced by the two control subjects with developmental problems. Those two subjects produced many errors that reflected visual distortions of the pictures (e.g., "pen" for flute), or words that were both visually and semantically related to the target responses (e.g., "swing" for hammock).

Interpretation of lexical output performance. We evaluated HH's performance in the initial lexical output tasks with respect to earlier hypotheses regarding the source of his significant anomia. First, contrary to the object recognition deficit prediction, HH demonstrated impaired lexical retrieval in

and Oral Naming to Definition				
Target	Oral naming	Written naming	Name to definition	
Chin	Thumb	_	Jaw	
Van	Sedan	Carn	Truck	
Pepper	Mango	Mango	Trees	
Cherry	Apricot	Peach	Apple tree	
Glass	Plate	Water cuck	Water cup	
Robe	Shirt	_	Jacket	
Toothpaste	Toothbrush	Trushbruse	Toothbrush	
Sofa	Table	Table	_	
Stamp	Penny	_	_	
Pliers	Screwdriver	Wire bruch	_	
Drum	Band	—	—	

TABLE 5 Examples of HH's Semantic Errors in Oral and Written Picture Naming and Oral Naming to Definition

naming to auditory definitions, a task that presumably is not dependent upon visual object processing. In addition, HH produced semantic errors in conversational speech, a finding contrary to a deficit of visual object processing.

Alternatively, considering overall accuracy levels, HH's comparable performance in the three verbal output tasks (oral picture naming, naming to definition, and oral reading) and in written naming may lead one to attribute his naming difficulties to co-occurring deficits of the phonological output lexicon and the orthographic output lexicon as in the patient of Miceli and colleagues (1991). However, because of the frequent occurrence of semantic errors in oral picture naming, oral naming to definition, and written picture naming, a common source of naming failure may underlie HH's performance in the naming tasks. Hence, evidence favors the hypothesis of a semantic deficit to account for HH's naming failure across tasks.

HH's pattern of performance in oral reading and writing to dictation contrasts with his naming performance. Poor performance in preliminary testing with nonword stimuli in both oral reading and writing to dictation indicated that sublexical abilities were limited for HH. We might then expect a similar error pattern in these two tasks as in naming tasks. However, HH produced virtually no semantic errors in oral reading and writing to dictation. His poor oral reading skills may reflect aspects of his developmental reading problem and/or acquired difficulties relating to visual graphemic input processing. In contrast, his relatively preserved abilities in writing to dictation and the absence of semantic errors in oral reading may reflect intact processing by one of two possible means to circumvent the semantic impairment: direct lexicalnonsemantic activation of lexical output from lexical input without semantic mediation (e.g., Patterson, 1986; Coslett, 1991), or partial sublexical activation combined with partial semantic information to activate lexical output (Miceli et al., 1991).

If a semantic impairment underlies HH's significant anomia, additional predictions arise. As in the patients reported by Howard and Orchard-Lisle (1984) and Hillis and colleagues (1990), deficits of comprehension should be observed, particularly as semantic demands of the tasks are increased. Furthermore, item-specific error consistency may be noted among tasks. We examined these issues in further analyses.

Semantic Comprehension Tasks

HH performed a number of tasks that investigated his comprehension of the 120 words included in the naming tasks. We constructed three picture matching tasks in which HH selected the target picture from an array of four semantic coordinate pictures (e.g., apple-cherry-pear-orange). We anticipated that such an array would place greater demands upon semantic processing in the matching task. In auditory word/picture matching, HH pointed to the picture corresponding to the word spoken to him. In written word/

vermeation Task				
Picture condition	Word condition	Performance		
Correctly named Correctly named	Correct word Related word	100.0% (35/35) 88.6% (31/35)		
Incorrectly named	Correct word	97.1% (34/35)		
Incorrectly named	HH's error word	85.7% (30/35)		

TABLE 6 HH'S Performance Accuracy in an Auditory Word/Picture Verification Task

picture matching, HH read the printed word on a $3'' \times 5''$ card and then pointed to the correct picture. Finally, in auditory definition/picture matching, the examiner read aloud a definition and HH pointed to the described target picture.

HH's performance in these three tasks was slightly reduced compared to the six control subjects who scored 98–100% correct. HH selected the correct picture for 114/120 (95.0%) items in auditory word/picture matching, 107/ 120 (89.2%) items in written word picture matching, and 111/120 (92.5%) pictures in auditory definition/picture matching.

HH also completed category sorting tasks to test semantic processing further. Sorts were based upon distant categories (e.g., transportation vs. furniture), closely related categories (e.g., fruits vs. vegetables), or a within-category distinction (e.g., jungle animals vs. farm animals). HH received 120 items (40 distant, 40 close, and 40 within) in a picture sorting condition and a written word sorting condition. Again, HH performed well in this task. In picture sorting, HH's two errors were for a within-category distinction. In written word sorting, HH made only 11 errors (two distant, five close, and four within) in spite of reported developmental reading difficulties.

Because of HH's relatively minimal difficulty in the first two sets of comprehension tasks, we administered a final task in an attempt to reveal any mild semantic impairment. In this auditory word/picture verification task, HH responded yes or no whether the spoken word corresponded to the given picture. The task included 35 pictures that HH correctly named in the oral picture naming task and 35 pictures that HH misnamed. Each correctly named picture was paired once with the correct word and once with an incorrect closely related word (e.g., "knife" paired with the picture of fork). Each misnamed picture was paired once with the correct word, and once with HH's incorrect error word (e.g., "toothbrush" paired with the picture of toothpaste).

Although the results shown in Table 6 indicated minimal overall difficulty in the verification task, HH's performance was significantly better in recognizing correct words (69/70 correct) than incorrect words (61/70 correct) (Fisher's exact test, p = .02). However, no difference was evident in the

comprehension of words HH correctly named and those he incorrectly named (Fisher's exact test, p < .75).

Results of comprehension testing indicated minimal overall difficulty in tasks constructed to reveal deficits related to semantic processing. This pattern of performance is unlike that of patients described by Howard and Orchard-Lisle (1984) and Caramazza and Hillis (1990) and is similar to the patient described by Miceli and colleagues (1991). These results undermine the hypothesis of a semantic impairment underlying HH's severe anomia.

Consistency Analyses

If impaired performance in multiple tasks is a result of a common functional locus of impairment in the lexical system, we may expect higher consistency of responses, either consistently correct or consistently incorrect, for an item across tasks. For example, Hillis and colleagues (1990) reported their patient with semantic impairment demonstrated high levels of item consistency across multiple semantic tasks. Hence, it would be informative to evaluate item specific error consistency in HH, if a semantic impairment underlies his crossmodal naming difficulties.

As reported earlier, word frequency influenced HH's naming performance to some extent. Therefore, it was important to consider consistency effects with respect to word frequency in that item consistency may be artificially inflated due to ceiling effects for high frequency words (Coltheart & Funnell, 1987). In our case, we examined the consistency of performance for the 120 items overall and for the subset of 40 low frequency items. Because we found no difference in the two analyses, consistency effects will be reported for the 120-item analysis.

We examined three different item consistency comparisons: (1) oral picture naming (time 1) compared item by item to responses in oral picture naming (time 2), (2) oral picture naming (time 1) versus oral naming to definition, and (3) oral picture naming (time 1) versus written picture naming, that is, a cross-modal comparison. *Consistent* responses were items for which HH responded correctly on both occasions and for which he responded incorrectly on both occasions. *Inconsistent* responses were items for which performance in task 1 and task 2 varied (correct on one occasion and incorrect on the other).

In all three comparisons, we observed more consistent than inconsistent items (Table 7). The degree of consistency indicated by Cohen's Kappa was high in the comparisons of the two oral picture naming tasks and the oral picture naming versus written picture naming tasks (oral naming time 1 vs. oral naming time 2: K = 0.43, p < .01; oral naming time 1 versus written naming: K = 0.47, p < .01; oral name time 1 vs. name to definition: K = 0.22, n.s.). Note that the same high level of item consistency was observed in a comparison within the verbal output mode and in a comparison between verbal and graphic output modes.

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Comparison	Correct/	Error/	Correct/	Incorrect/
	Correct	Error	Incorrect	Correct
Oral name time 1/Oral name time 2	48/120	38/120	12/120	22/120
Oral name time 1/Name to definition	39/120	34/120	20/120	27/120
Oral name time 1/Written name	46/120	42/120	14/120	18/120

 TABLE 7

 HH's Response Consistency for Items across Naming Tasks

High item consistency was observed among the comparisons, a finding similar to that noted in other reported cases of lexical deficits (Hillis et al., 1990; Miceli et al., 1991). Although HH's pattern of relatively preserved word comprehension argues against a semantic deficit underlying his severe anomia, patterns of high item consistency between verbal and graphic output support a common basis for naming failure across modes of output. However, Miceli and colleagues have argued that high crossmodal item consistency may be the result of concurrent deficits of the phonological and orthographic output lexicons. This hypothesis will be considered in greater detail in the final discussion.

Rhyming Tasks

If a hypothesis of concurrent failure of both phonological and orthographic output lexicons must be entertained regarding HH's crossmodal naming failure, it is of interest to determine how much phonological information is available to HH regarding pictures to be named. One potential means to investigate this question is in rhyming tasks in which the phonological form of the word must be sustained in order to complete the task accurately.

We gave a rhyme judgment task in two conditions to HH. In the picture condition, he looked at two pictures and decided whether or not their names rhymed. In the auditory condition, the examiner spoke the two words to him and he decided whether or not they rhymed. Of the 55 picture/word pairs, 30 rhymed and 25 did not rhyme. In the rhyming pairs, 14/30 had visually similar spellings (e.g., coat-boat), and 16 were visually dissimilar (e.g., wheel-seal). Also, 11 of the 25 nonrhyming pairs were visually similar (e.g., shoe-toe).

HH's performance in the two conditions of the rhyming task differed. In the auditory condition, he was correct in 53/55 decisions indicating that he understood the concept of rhyming and could perform the task. In the picture condition, HH was correct for only 33/55 items (60%). He was better for pictures that rhymed (21/30, 70% correct) than for those that did not (11/25, 44% correct), but there was no difference for rhyming decisions based on spelling similarity (15/25, 60% correct for similar pairs; 17/30, 57% correct for dissimilar pairs). Overall, the results of HH's performance in the

rhyming task suggested that little phonological or orthographic information is available for words that he cannot name.

DISCUSSION

We evaluated HH to determine the functional basis of the acute onset of his anomic aphasia. However, before examining hypotheses with respect to the proposed naming model, an alternative basis for his naming disorder has to be considered. Some individuals with developmental reading disorders may report associated developmental dysnomia (Wolf & Goodglass, 1986). Although HH reported that he had developmental reading and spelling difficulties, he denied having experienced word retrieval difficulties in his past. Rather, HH reported that his word retrieval difficulties developed acutely the night prior to his hospital admission. Moreover, HH experienced much greater difficulty in experimental tasks than did matched control subjects with reported developmental reading and spelling problems. Therefore, it seems unlikely that HH's significant naming deficits were developmental in origin. However, because of HH's developmental history, the generalizability of his findings to other patients with a similar lesion site await replication.

When evaluating the functional basis of HH's anomia, deficits related to visual input processing (agnosias) were ruled out because naming failures were observed in naming to auditory definition and spontaneous speech, tasks that presumably do not rely upon visual processes. Furthermore, results do not support a selective deficit related to either the phonological output lexicon or the orthographic output lexicon in that HH demonstrated naming deficits across verbal and graphemic output modes, and he produced semantic errors in both oral and written naming tasks. Moreover, the consistency of errors was greater than expected both within verbal output naming tasks and between verbal and graphemic naming tasks. Rather, such a pattern of crossmodal failure is consistent with a common deficit at the level of the semantic system. However, evidence for a semantic system impairment is undermined in that HH in a variety of tasks demonstrated relatively preserved comprehension.

This overall pattern of preserved and impaired lexical performance is similar to that reported by Miceli and colleagues (1991) for their patient, SF. In interpreting SF's pattern of impairments, they proposed co-occurring deficits of the phonological output lexicon and the orthographic output lexicon. Because both output lexicons are probably sensitive to similar factors (e.g., word frequency, part of speech), they suggested that co-occurring deficits should lead to similar patterns of errors for both oral and written naming.

An alternative explanation for the performances of our patient HH and SF (Miceli et al., 1991) may relate to the phonological output lexicon itself. If the phonological output lexicon is involved in activation of the graphemic output lexicon as suggested by Ellis and Young (1988), a failure to appropri-

ately activate the phonological output lexicon would lead to concurrent graphemic output failure. However, descriptions of patients whose performance is impaired for verbal naming and not written naming undermine this account (e.g., Caramazza & Hillis, 1990), providing evidence for direct activation from the semantic system to orthographic representations. To account for HH's deficit, one would have to invoke a less parsimonious argument that impairments at the level of the phonological output lexicon and in accessing orthographic representations by way of semantics lead to HH's cross-modal naming failure.

A final proposal relates to the variety of semantic deficits that can occur (Howard & Franklin, 1988; Shallice, 1988). Specifically, breakdown could occur with respect to semantic processes relevant to input, more central stores, or output. For example, Hart and Gordon (1990) described three patients with semantic comprehension difficulties and relatively preserved oral naming skills. They attributed the deficit to an input stage in semantic processing. In contrast, Howard and Franklin (1988) attributed the crossmodal naming failure of their patient MK, who could comprehend words adequately, to a deficit of output from semantics. Farah and Wallace (1992) invoked a similar argument to account for their patient's selective naming impairment for the category of fruits and vegetables for which comprehension was intact. Specifically, they proposed that a more locally represented semantic representation may be necessary to mediate access from more distributed semantic information to the phonological output lexicon. We propose that an impairment arising at such a late stage of semantic processing may account for our patient's pattern of naming failures. Hence, there may be a different functional basis for HH's naming failure than that proposed for SF (Miceli et al., 1991). Although our patient HH and their patient SF performed in similar ways across input and output tasks, important differences were noted. Most relevant is that the predominant error type noted for SF was omission (no response), whereas that of HH was semantic error.

We have proposed that HH has an impairment as the semantic system accesses lexical output mechanisms. This proposal seems contrary to our finding that HH demonstrates high item response consistency. Shallice (1988) considers high item consistency a measure of a storage deficit as opposed to an access deficit. However, Rapp and Caramazza (1993) have argued that one may conceive of instances where consistency may in fact be a characteristic of either a disorder of storage or of access. We propose that findings of high item consistency for HH reflect a common source of impairment underlying his deficient oral and written naming, but not that a storage deficit is the basis for his crossmodal impairments.

Miceli and colleagues (1991) proposed that sublexical information (orthography-to-phonology and phonology-to-orthography) is ultimately available at the level of the output lexicons and when combined with partial semantic information is able to constrain responses and avoid semantic errors in oral reading and writing to dictation. It is interesting to note that our patient, HH, was virtually unable to read and write nonwords (whether due to developmental deficits or the vascular event is uncertain). Hence, we might have expected semantic errors to occur in oral reading and writing to dictation. This was not the case. In examining HH's nonword performance, we noted that responses were not completely devoid of correct phonological information (e.g., "andle" for andon). Therefore, although sublexical processes are disordered, sufficient phonological information may be available, particularly regarding initial phonological segments of the nonwords, that semantic errors can be overridden. In fact, the only semantic error noted for HH in writing to dictation was the response "1-i-m-e-s" to the target lemon. It is interesting to note that the initial phonological segment is shared in these close semantic coordinates, and therefore HH probably had insufficient phonological information to avoid a semantic error in this case.

Although additional lesions were visible on MRI, in keeping with Benson (1979) we propose that HH's naming disorder was associated with the lesion that involved a portion of the posterior temporal lobe or Brodmann's area 37. It is doubtful that the older lesions located outside the language regions caused his acute anomia. Although the connectivity of area 37 is not well defined, we know that area 37 comprises the caudal two-thirds of the lateral aspect of the middle and inferior temporal gyri extending inferiorally to the mesial temporal cortex (Brodmann, 1905; Economo & Koskinas, 1925; Lashley & Clarke, 1946). Given that area 37 is strategically located between ventral systems important for object recognition (Mishkin, Ungerleider, & Macko, 1983) and the auditory association cortex important for lexical processing, it may be a portion of the supramodal association cortex that subserves semantic associations for objects. Corroborating evidence from functional imaging studies support the role of area 37 in semantic functions (Anderson, Cheng, Smith, Blonder, Kirsch, & Avison, submitted; Williamson, Crosson, Rothi, Shurla, Honeyman, Heilman, & Nadeau, 1995). Based on HH's behavioral and anatomic analysis, one could propose that Brodmann's area 37 is critical for allowing the semantic system to gain access to stored lexical information. Damage to the superior and lateral portion of area 37 may have induced the deficit of semantic output leading to our patient's anomic aphasia.

HH provides a neuroanatomical/functional contrast to the three patients described by Hart and Gordon (1990) with selective semantic comprehension deficits or deficits of semantic input associated with lesions of the posterior temporal and inferior parietal cortex (portions of areas 21, 22, 39). The lesions in these patients were immediately superior to the area 37 lesion noted in our patient, HH, and the functional deficit in which processing was impaired as it input to the semantic system contrasts with HH, whose impairment affected output processing from the semantic system. The comparison of Hart and Gordon's patient with our patient demonstrates that semantic

processing can be fractionated and that different but adjacent lesions may underlie the contrasting functional deficits.

Finally, we have emphasized the acute onset of HH's word retrieval difficulties. Benson (1979) suggested that acute anomia may differ substantially from chronic anomia. Most patients described in the literature using the cognitive neuropsychological framework have deficits of longstanding origin. Therefore, the role of recovery involving other functional-anatomical (contiguous or contralateral) regions must be considered in the ultimate behavioral manifestations of the disorder, making brain-behavior correlations a more risky venture. For HH, we had the opportunity to examine his circumscribed neuropsychological deficit at the onset and to associate his impairment with a discrete cerebral lesion. These observations provide us greater confidence that area 37 plays a critical role in normal semantic output processing.

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