

Category-Specific Naming Deficit for Medical Terms after Dominant Thalamic/Capsular Hemorrhage

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Postmortem, retrograde degeneration, and electrical stimulation studies have implicated the anterior pulvinar in language processing. We examined a patient who, after a hemorrhage affecting the dominant pulvinar and internal capsule, exhibited a circumscribed anomia for medical items and conditions. No other language disturbance was noted. Five category-specific word lists, matched for word frequency, were administered in a naming-to-definition format. Results indicated that the patient exhibited a significant category-specific naming deficit for medical items and conditions compared to matched control subjects. Although medical item lists were found to differ from nonmedical item lists in imageability and abstractness, B.C.'s category-specific deficit did not seem to be caused by word frequency, concept familiarity, imageability, or abstractness. Nor could the patient's performance be explained on the basis of deficits in broader semantic classifications (i.e., animate vs inanimate or man-made vs natural). The patient was unable to retrieve medical items even when given phonemic cues for those he could not name. Findings indicate that subtotal damage in the dominant pulvinar may create category-specific deficits. © 1997 Academic Press

Category-specific naming impairments, or preservation, in aphasia have engendered considerable interest within cognitive neuropsychology and have been documented for a variety of categories including body parts (Dennis, 1976), fruits and vegetables (Farah & Wallace, 1992; Hart, Berndt, & Caramazza, 1985), letters (Goodglass, Wingfield, Hide, & Theurkauf, 1986), country names (McKenna & Warrington, 1978), all proper names (Semenza & Zettin, 1988), indoor (as contrasted with outdoor) objects (Yama-

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dori & Albert, 1973), and animals (Hart & Gordon, 1992; Hillis & Caramazza, 1991; Stewart, Parkin, & Hunkin, 1992; Temple, 1986). There is also a large literature on anomia for colors (see Hécaen & Albert, 1978; Heilman & Valenstein, 1979 for references and discussion).

Though not widely reported, a category-specific naming deficit for medical items has appeared in the literature. Weinstein and Kahn (1955) described a case of a 52-year-old woman who underwent a craniotomy to remove a frontal meningioma extending bilaterally back to the optic chiasm. In the period of recovery following her operation, the patient reportedly misnamed only objects related to the hospital environment. For example, she was observed to call a syringe "part of a percolator," and a tongue depressor an "emery board." This patient's deficit in the naming of medical items, however, was given a largely psychological explanation (i.e., denial).

A growing literature on category-specific recognition deficits suggests that organization of knowledge related to semantic category is possible for visual recognition (e.g., Damasio, Damasio, Tranel, & Brandt, 1990; Farah, Hammond, Mehta, & Ratcliff, 1989; Farah, McMullen, & Meyer, 1991; Warrington & Shallice, 1984) and auditory-verbal comprehension (Hillis & Caramazza, 1991; McCarthy & Warrington, 1988; Warrington & Shallice, 1984), as well as naming. The most common dissociation in recognition appears to be living versus nonliving items, and concomitant deficits in auditory-verbal as well as visual identification suggest that the deficits can cut across modality of input in some cases (Warrington & Shallice, 1984). It is of some interest that Warrington and Shallice's (1984) patient had a deficit in defining diseases as well as in defining living things and foods (p. 843, Table 10, item 20). Difference in functional significance versus sensory features was the dimension Warrington and Shallice used to explain the deficit identifying living compared to nonliving items. These authors suggested that specific diseases might have limited functional distinctions but were identifiable by sensory features (p. 850).

Explanations for category-specific anomias have also been offered which rely on dimensions other than semantic category. Stewart et al. (1992) found they could eliminate a category-specific anomia for animals in one patient by controlling for word frequency, concept familiarity, and visual complexity. Likewise, Funnell and Sheridan (1992) demonstrated an instance where familiarity accounted for an apparent deficit in naming living things.

On the other hand, Hart and Gordon's (1992) patient had a deficit in naming animals that persisted even when frequency, familiarity, and visual complexity were controlled. Her animal naming deficit was further compartmentalized in that she could not verbally retrieve or verbally recognize the physical attributes of animals (e.g., color). Yet, for nonphysical properties of animals (e.g., functional properties), the patient's access to verbal knowledge was unimpaired. When physical attributes were tested visually as opposed to verbally (e.g., whether the color of a picture of an animal was cor-

rect), she was unimpaired. Thus, the authors concluded that not only was she unable to name animals, but also that compartmentalized knowledge about visual attributes stored within the language system was impaired. Sacchett and Humphreys also (1992) found that frequency, familiarity, and complexity could not explain their patient's deficit in naming artifactual objects and body parts. Rather, their patient also showed some difficulty accessing semantic information about these objects which may have accounted for his deficit.

Farah and Wallace (1992) examined a patient with a category-specific deficit in naming fruits and vegetables. As demonstrated by multiple tasks, their patient had intact semantic knowledge about fruits and vegetables. Furthermore, he cooked with and grew a number of fruits and vegetables in his garden; thus, a lack of familiarity could not account for his deficit. Because the patient was also able to recognize fruit and vegetable names that were given to him, these investigators concluded that the deficit was specific to verbal output and did not involve auditory-verbal input. However, the deficit was not caused by a loss of the corresponding items from the phonemic output lexicon (i.e., the spoken word forms) because the patient consistently retrieved the correct word on failed items once he was given a phonemic cue. Thus, this patient's problem must have involved the mapping of semantic information onto items in the output lexicon and could be referred to as lexical-semantic in nature. Farah and Wallace proposed that local semantic representations, corresponding to semantically similar words, assist in accomplishing the transition between distributed semantic information and phonological word forms. The authors suggested that at least some of these local semantic representations, which are necessary for naming, are implemented by relatively focal neural substrates.

Category-specific naming deficits after thalamic lesion are rare. To our knowledge, the only two cases previously reported involved anomia for proper nouns (Luchelli & DeRenzi, 1992; Moreaud, Pellat, Charnallet, Carbonnel, & Brennen, 1995). Both cases had anterior thalamic lesions, in the tuberothalamic artery territory. We are aware of no previous cases of category-specific deficits with posterior thalamic lesions in or around the pulvinar.

While the literature concerning the function of the dominant pulvinar in language has been controversial, cases of hemorrhagic lesion appear to support the involvement of this structure in language (Ciemans, 1970; Crosson, Parker, Warren, LaBreche, & Tully, 1986; Kameyama, 1976/1977; Mohr, Watters, & Duncan, 1975). A role for the pulvinar in naming is further supported by retrograde degeneration (Van Buren, 1975; Van Buren & Borke, 1969), electrical stimulation (Ojemann, 1976), and postmortem (Kameyama, 1976/1977) studies.

In the current study, we present the data of a man who suffered a relatively circumscribed hemorrhagic lesion in the posterior thalamus, with extension

into the internal capsule. He demonstrated a category-specific naming deficit for medical items and conditions. Word lists were developed and administered to further evaluate the existence of this category-specific deficit, and precise localization of the lesion was undertaken to define the specific thalamic regions that may contribute to such a phenomenon.

METHODS

Clinical Data

B.C., a 46-year-old, right-hand dominant, Caucasian male was a self-employed antique dealer. His past medical history included a 20-year history of poorly controlled hypertension, which had been treated within only the 2 years preceding his stroke, and 2 prior heart attacks. No other significant injuries or illnesses were reported. There was no prior history of neurological disorder, head injury, loss of consciousness, seizures, learning disability, or alcohol/drug abuse. He completed 14 years of education. On the day of his stroke (February 11, 1990), he presented with a sudden onset of lethargy, aphasia, and a dense right hemiparesis. Records indicate that his language disturbance rapidly resolved, with the primary residual symptoms being the continued paresis of his right arm and leg.

Anatomic Studies

An initial CT scan at admission revealed a small hyperdense lesion in the posterior region of the left thalamus with extension into the internal capsule. Five months (158 days) poststroke, an MRI with a 1.5-T magnet (Siemens Magnetom) was obtained to aid in the precise localization of the lesion (see Fig. 1). Seven-millimeter contiguous slices were obtained in the axial plane, parallel to the anterior commissure–posterior commissure (AC–PC) line, using T_1 ($T_R = 680$ ms, $T_E = 19$ ms), proton density ($T_R = 2000$ ms, $T_E = 19$ ms), and T_2 ($T_R = 2000$ ms, $T_E = 90$ ms)-weighted imaging. The field of view was 23 cm, matrix size 256×256 . Using T_1 -weighted images, the lesion was localized using the Schaltenbrand and Bailey (1959) atlas. Briefly, this method involved finding the location of the lesion in relation to the AC–PC line (Archer, Ilinsky, Goldfader, & Smith, 1981; Graff-Radford, Schelper, Ilinsky, & Damasio, 1985). As can be seen in Fig. 2, the lesion included the left posterior thalamus with extension into the posterior limb of the internal capsule. Specifically, portions of the anterior, lateral, and medial pulvinar nucleus and portions of the posterior limb of the internal capsule were involved. A portion of the nucleus reticularis surrounding the pulvinar was also involved as were portions of the lateral posterior, centromedian, central lateral, ventral posterior lateral, and ventral posterior medial nuclei. The lesion extended into the pretectal area as well.

Language and Neuropsychological Assessment

B.C. was administered a comprehensive assessment of language (Western Aphasia Battery, Boston Naming Test) at 59 days postonset (approximately 2 weeks before the testing of his category-specific naming deficit) and of cognitive functions at 180 days postonset. Table 1 summarizes the results of language evaluation, and Table 2 summarizes neuropsychological results. As can be seen, language skills were generally within normal limits for these standardized measures, with no gross evidence of aphasia. The naming index from the Western Aphasia Battery was reduced slightly by his decreased performance on the word fluency subtest. Although the neuropsychological evaluation was performed almost 6 months after this initial language evaluation, the results provide some insight into residual deficits. The evaluation

revealed mild memory problems, decreased word fluency, and moderate difficulty on a test of problem solving and set shifting (Wisconsin Card Sorting Test). Despite the absence of aphasia, the patient complained of a pronounced inability to name common medical items with which he came in contact around the hospital. These reports were subsequently confirmed by hospital staff and his attending physicians. No naming deficits were apparent for other categories of items. Based on these observations, experimental testing was undertaken.

Experimental Naming Tasks and Procedures

The experimental task required naming objects corresponding to spoken definitions. We did not attempt to assess visual confrontation naming because many of the medical conditions used as stimuli were not amenable to visual reproduction (e.g., infection). Word lists were generated to assess naming performance across five categories. These categories included: (1) living things, (2) nonliving man-made items, (3) nonliving natural items, (4) man-made medical items, and (5) medical conditions, medical personnel, medical signs, and anatomical terms (hereafter referred to as medical conditions⁺). Each list consisted of 37 items, and lists were matched for overall word frequency as reported in Francis and Kucera (1982). The mean numbers of occurrences per million for words from each of the lists were as follows: living things mean = 12.27, *SD* = 13.53; nonliving man-made items mean = 10.30, *SD* = 13.93; nonliving natural items mean = 12.38, *SD* = 13.00; man-made medical items mean = 10.60, *SD* = 20.86; medical conditions⁺ mean = 12.27, *SD* = 13.53. These five naming-to-definition lists were administered to B.C. at 72 days postonset, and a second time at 80 days postonset. They were also administered to 11 normal controls and 2 anomic patients for purposes of comparison.

After administration of the five word lists to B.C. and the 11 controls, a different set of 8 normal controls was asked to judge the familiarity, imageability, and abstractness of each word on each of the five lists. Familiarity judgments were based on criteria established by Stewart et al. (1992). Familiarity was defined as "the degree to which you come into contact with, or think about the concept." Subjects were instructed to judge each item according to "how usual or unusual the item is in your realm of experience." A 5-point rating scale was used, with 1 indicating "very unfamiliar" and 5 "very familiar." Imageability was defined as "the degree to which you can visualize, or imagine this item." Subjects judged each list item according to "the degree to which you can visualize, or imagine this item." On the 5-point rating scale, 1 indicated "very poor image" and 5 "very clear image." Subjects rated abstractness according to "how simple or abstract the item is in your realm of experience." On the rating scale, 1 indicated "very simple" and 5 "very abstract or complex." This procedure was done to determine if the word lists differed on these dimensions and to analyze B.C.'s responses within a list on those dimensions where controls perceived differences between lists.

One problem that was considered in developing the experimental lists should be briefly mentioned. When responses of normal subjects are at ceiling (i.e., 100% correct), it is difficult to determine the sensitivity of a test. Items might be challenging enough to detect problems in mildly impaired patients, or the items might be so easy as to be insensitive to subtle deficits. Since B.C. exhibited no generalized language deficits, we considered it likely his deficit in naming medical items, if it existed, might be relatively mild. For this reason, we chose to include some difficult items on our lists to ensure that we could distinguish more subtle deviations from normal performance. Items and definitions are presented in Appendix A.

In addition to the aforementioned word lists, the patient was administered a lexical-semantic battery (the Florida Semantics Battery: see Table 3) made up of 7 tasks assessing 120 items from 12 semantic categories (based on Rothi, Raymer, Maher, Greenwald, & Morris, 1991). This battery was administered between 144 and 145 days postonset. B.C. performed within the normal range on all tasks from this battery.

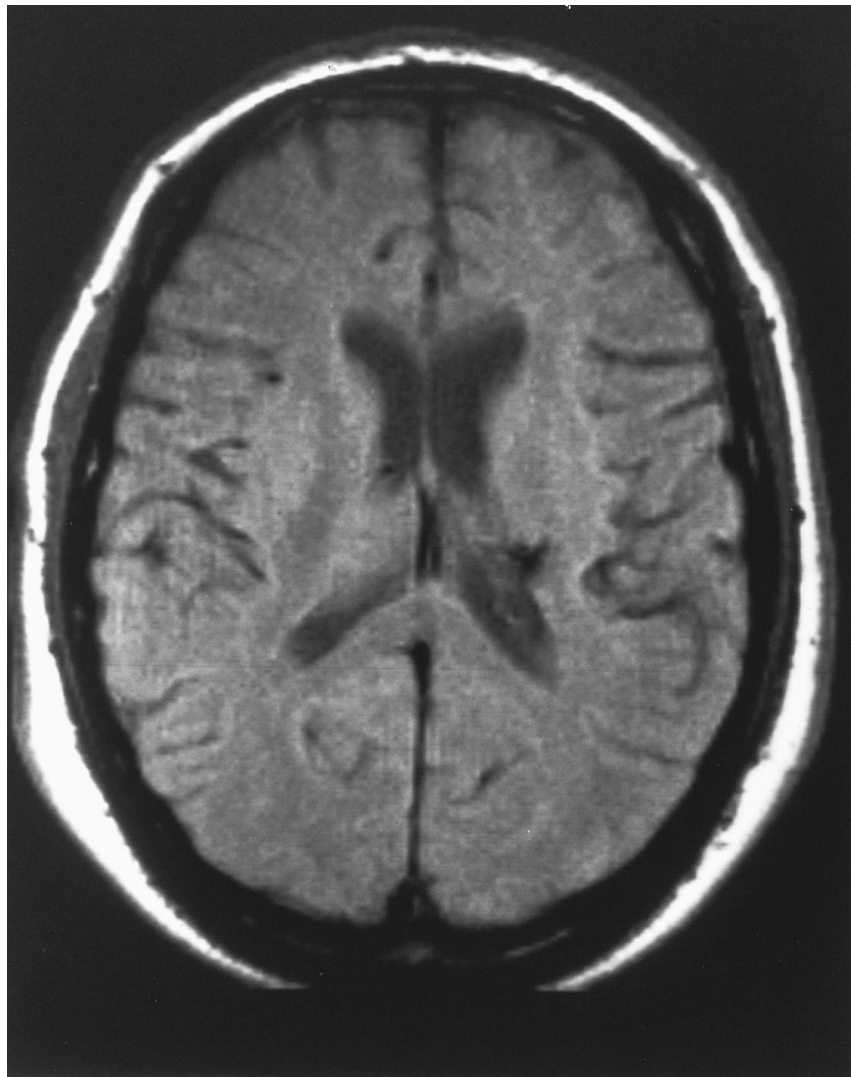


Fig. 1. Three slices from T_1 -weighted MRI scan showing hemosiderin deposit from old hemorrhagic lesion.

Comparison Subjects

A group of 11 neurologically normal control subjects was recruited and administered the five word lists in the naming-to-definition format. This group matched B.C. in age (mean = 45.2) and education (mean = 14.5). None of these 11 control subjects evidenced any history of neurological disorder, stroke, head injury, loss of consciousness, seizures, learning disability, or alcohol/drug abuse.

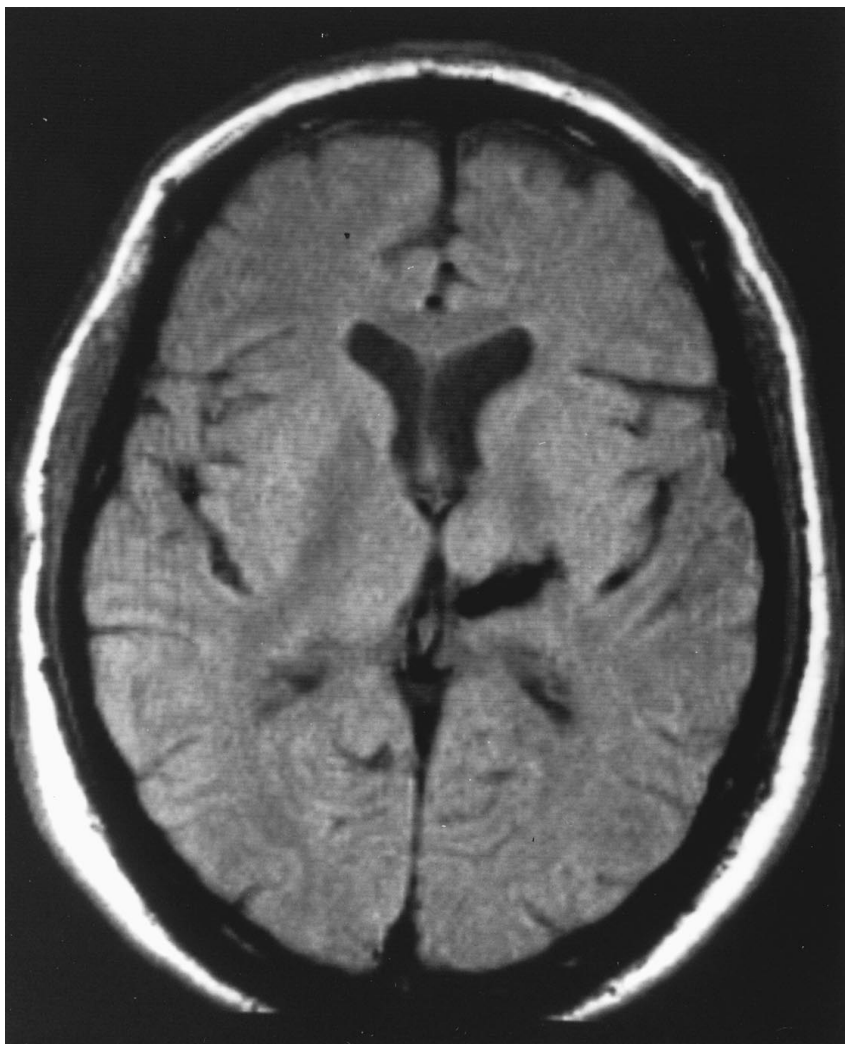


Fig. 1—*Continued*

A second group of eight neurologically normal controls was recruited to judge familiarity, imageability, and abstractness of the words on each of the five lists. These controls were similar to B.C. in age (mean = 45.3), education (mean = 15.1), and ethnic background.

For purposes of comparison, two anomic patients were also administered the five naming lists. Brief histories of these two patients are as follows:

Anomia case 1. T.H. was a 55-year-old Caucasian male with 16 years of education and was employed as a parole officer. Approximately 2 months prior to our evaluation, he suffered a thrombosis of the left middle cerebral artery. He presented acutely with a right hemiparesis and fluent aphasia with significant deficits in auditory-verbal comprehension and spoken output. His language and motor deficits gradually resolved, and at the time of our testing, his

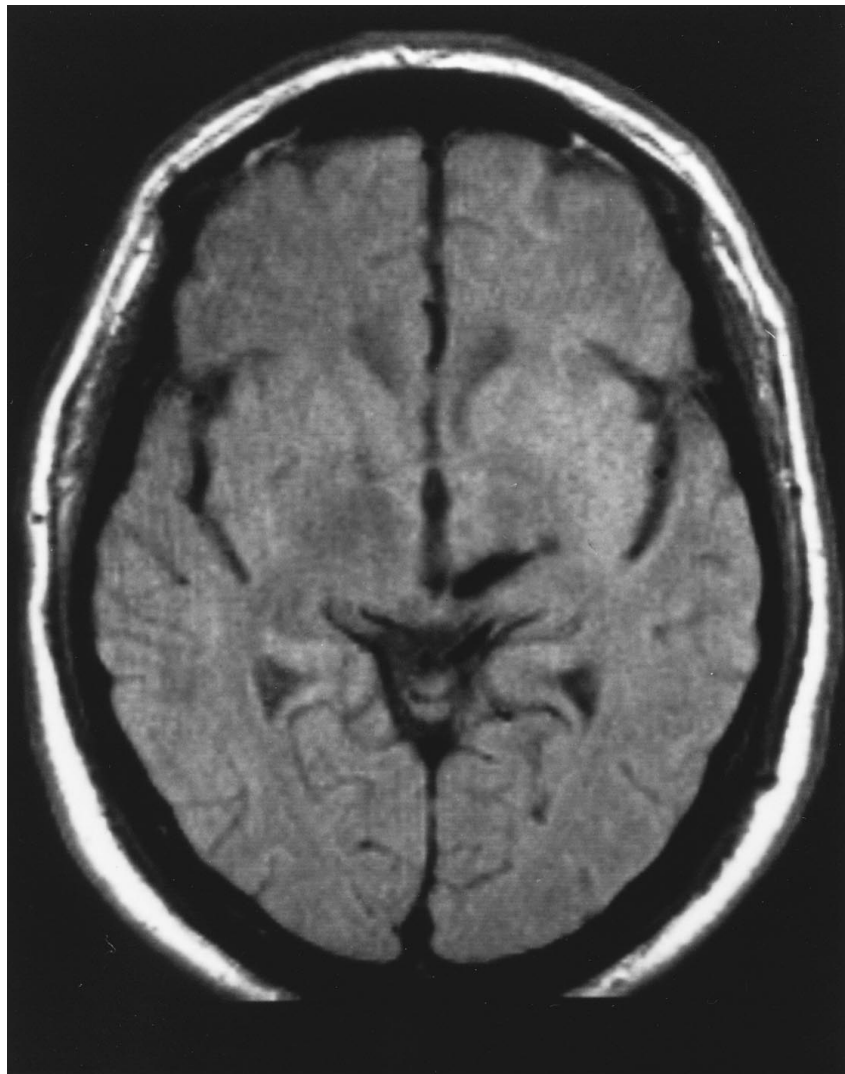


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most prominent residual deficits were continued word-finding problems and circumlocutions in running speech. His WAB Aphasia Quotient was 94.0 with primary residual difficulty in naming. In addition, his performance on the BNT fell approximately 2 standard deviations below the mean for his age and education group (BNT = 50/60).

Anomia case 2. A.S. was a 50-year-old Caucasian male with 14 years of education. At the time of his stroke, he was employed as a pipe-fitter for the local water company. On hospital admission, he presented with right hemiplegia and speech difficulty. Radiologic studies revealed an occlusion of the left middle cerebral artery, with a lesion in the left parieto-occipital

region. At the time of our testing 2 months postonset, his speech was fluent, but reduced in rate, with significant word-finding difficulties evident. His WAB Aphasia Quotient was 93.4, with his lowest scores occurring on the naming subtests. His score on the Boston Naming Test (BNT = 41/60) also was compatible with a diagnosis of anomia.

RESULTS

Naming to Definition and Additional Naming Tasks

Results of the testing (Fig. 3) revealed that B.C. exhibited a significant category-specific naming deficit for both man-made medical items ($z = -6.31, p < .001$) and medical conditions⁺ ($z = -5.43, p < .001$) compared to matched controls.¹ His naming performance for man-made medical items and medical conditions⁺ was at 73 and 68% accuracy, respectively. This performance stands in marked contrast to matched, neurologically normal controls whose naming accuracy was 97% for man-made medical items and 93% for medical conditions⁺. As can be seen in Fig. 3, no other significant naming differences were noted between the patient and the neurologically normal controls on any of the nonmedical word lists. B.C.'s naming errors for the medical word lists were as follows: man-made medical (two semantic, eight no response), medical conditions⁺ (three semantic, nine no response). B.C.'s specific responses to items, as well as the number of errors for controls on each item, are presented in Appendix B.

It was possible that B.C.'s performance on medical items and medical conditions⁺ was a reflection of a greater difficulty of these items that might not have been detected in the performance of neurologically normal controls because the latter subjects' performance was above 90% correct on all lists. To control for this possibility, the performance of two anomic patients was analyzed (Fig. 3). In contrast to B.C.'s naming performance, these anomic patients were significantly below controls on all word lists ($z = -10.00, p < .001$ for living things; $z = -8.79, p < .001$ for man-made items, $z = -7.58; p < .001$ for nonliving natural items; $z = -8.79, p < .001$ for man-made medical items; $z = -8.57; p < .001$ for medical conditions⁺). There was little difference in performance between lists for these anomic patients, indicating that B.C.'s deficit for naming medical items or conditions was not a function of differences in difficulty between the word lists.

For B.C., naming to definition was also assessed for another 12 categories of items (Florida Semantics Battery) 9 to 10 weeks after the five word lists were administered. As can be seen in Table 4, B.C. did not evidence any deficit in other categories. Notably, he did not demonstrate the living/nonliving discrepancy often described in the literature. The number of errors was slightly greater for naming pictures as opposed to naming from definition

¹Statistical analysis was accomplished using a test for significance of difference between two proportions (Bruning & Kintz, 1977).

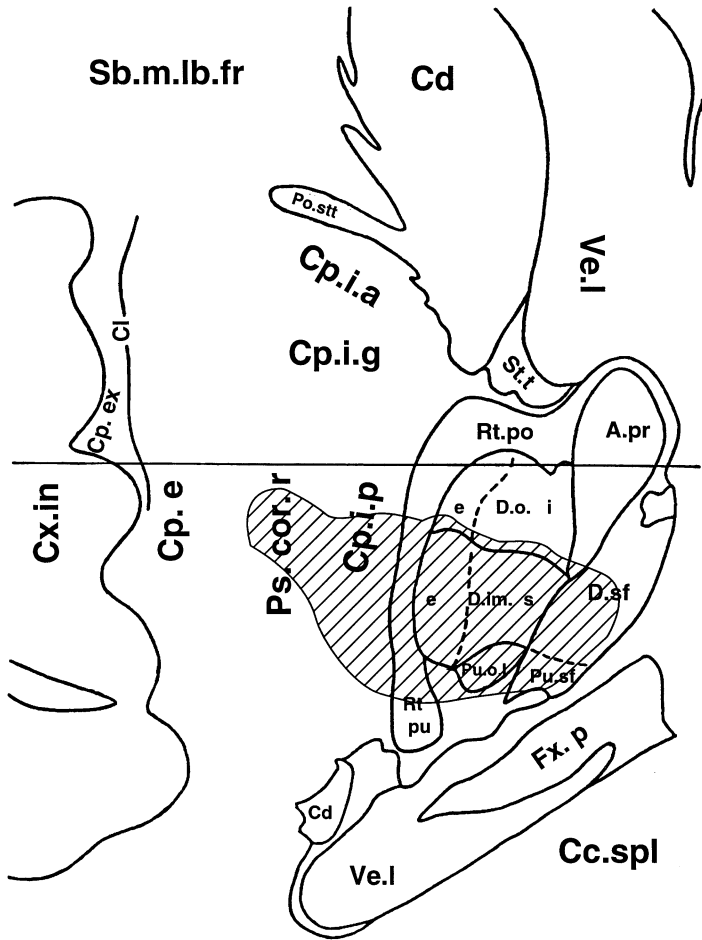


Fig. 2. Reconstruction of B.C.'s old left thalamic hemorrhage from MRI to axial plates of Schaltenbrand and Bailey (1959) atlas. Plates are 14, 7, and 0.5 mm above the anterior commissure–posterior commissure (AC–PC) line. Where possible, the following anatomic terms have been translated into the terminology of Jones (1985) to facilitate comprehension. *Abbreviations*: Plate 53 (H.d.+14,0). Cp.i.p, posterior limb of internal capsule; D.im.e, D.im.s, lateral posterior nucleus; D.sf, nucleus dorsalis superficialis; Ps.cor.r, corona radiata (pes); Pu.o.l, anterior pulvinar nucleus; Pu.sf, medial pulvinar nucleus; Rt.pu, reticular nucleus (posterior portion). Plate 54 (H.d.+7,0). Ce.mc, centre median nucleus; Cp.i.p, posterior limb of internal capsule; M.c.e, M.c.i, mediodorsal nucleus (posterior or parvicellular division); Pu.o.l, Pu.o.v, anterior pulvinar nucleus; Pu.m, Pu.m.i, medial pulvinar nucleus; Pu.l, lateral pulvinar nucleus; Rt.pu, reticular nucleus (posterior portion); Z.c.e, Z.im.e, Z.im.i, central lateral nucleus. Plate 55 (H.d.+0,5). A.aq, anulus aqueductus; A.prtc, pretectal area; Ce.mc, centre median nucleus; F.Fo, central tegmental bundle; F.l.m, medial longitudinal fasciculus; FM, fasciculus retroflexus; V.c.a.e, V.c.p.e, ventral posterolateral nucleus; V.c.a.i, V.c.por, ventral posterior medial nucleus.

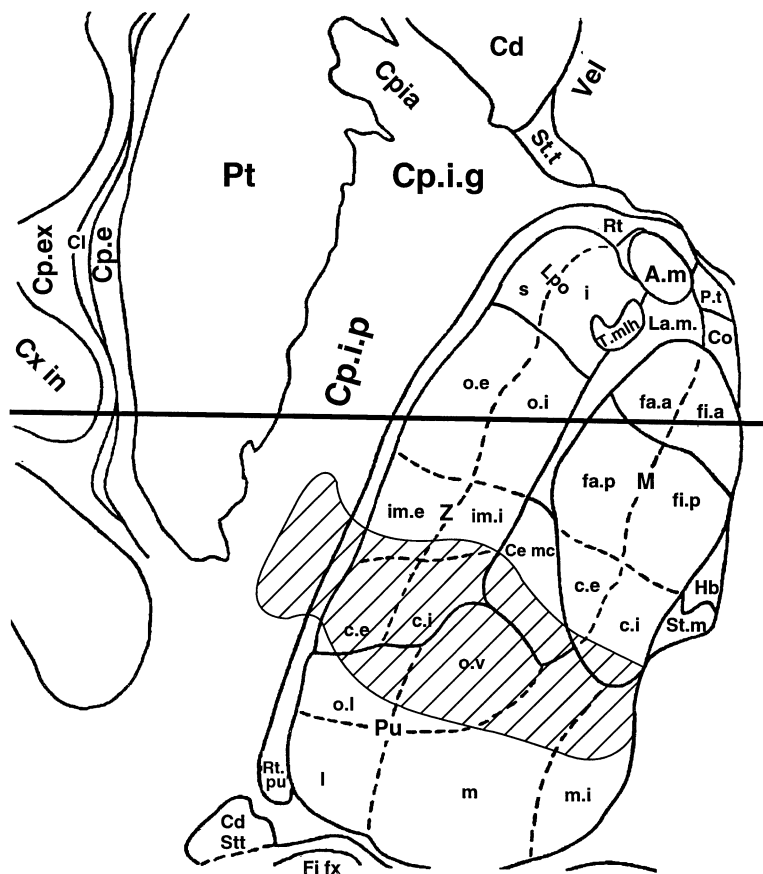


Fig. 2—Continued

in this battery. The categories in which errors were made were not consistent across input modalities. Naming within each category was generally in the 90–100% range, considerably higher than it had been for medical items and conditions.

Frequency Effects

Shallice (1988) has stressed that a more sensitive way of assessing the effects of word frequency on naming performance is to examine within-category effects, that is, to compare mean frequency for correct and incorrect items within each specific category. In order to assess any word frequency effects on the obtained results, point-biserial correlation analyses were conducted on B.C.'s naming to definition data. Because the number of errors in nonmedical lists was too small to allow a meaningful analysis, only re-

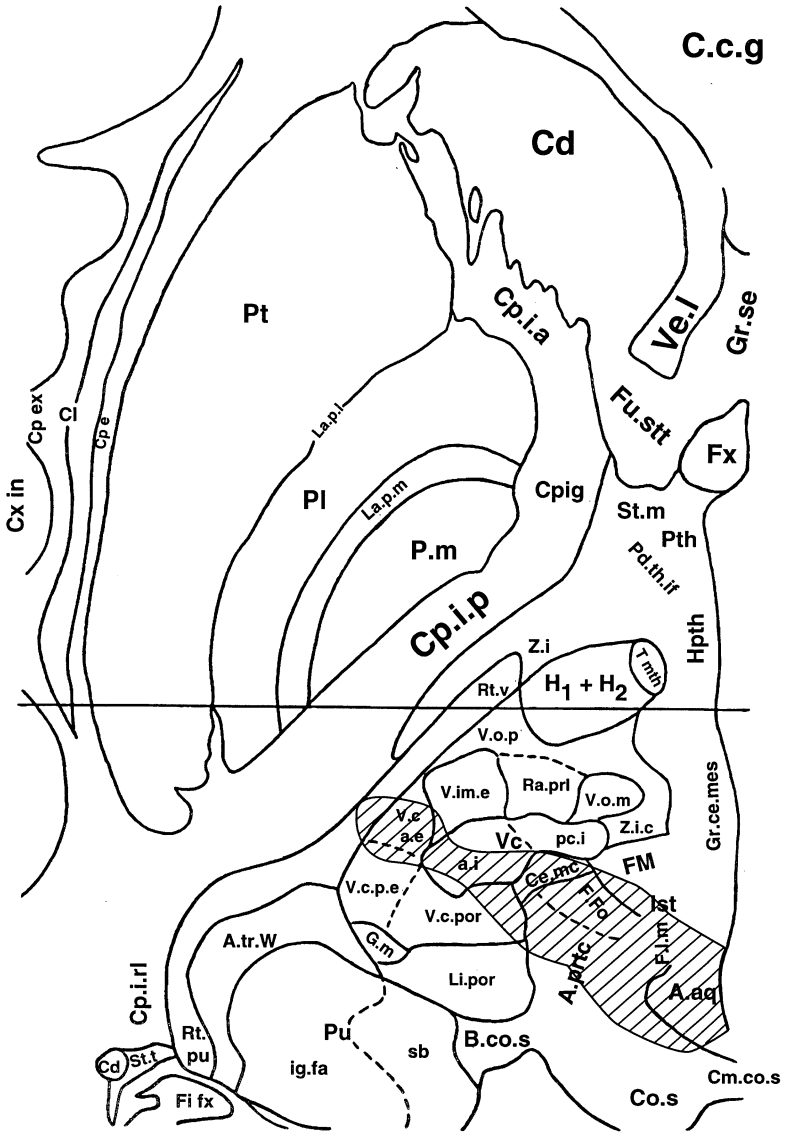


Fig. 2—Continued

sponses from the two medical lists were analyzed. Both point-biserial correlations and *t* tests are provided to illustrate the proportion of variance accounted for as well as the relative differences between mean frequency of errors vs correct responses. These analyses did not reveal a significant relationship between errors and word frequency for man-made medical items [*r*

TABLE 1
Language Test Results

Western Aphasia Battery	
Aphasia quotient	97.4/100
Spontaneous speech	20/20
Comprehension	10/10
Repetition	10/10
Naming	8.7/10
Reading	8.4/10
Boston Naming Test	59/60

= .13, $t(35) = .794$, $p > .05$], nor medical conditions⁺ [$r = .02$, $t(35) = .134$, $p > .05$]. In addition, analysis of errors and correct responses collapsed across all five experimental categories did not yield significant frequency effects ($r = .07$, $p > .05$).

Effects of Familiarity, Imageability, and Abstractness

Familiarity was one cause of category-specific naming deficits in some previous cases (Funnell & Sheridan, 1992; Stewart et al., 1992), though not in other cases (Hart & Gordon, 1992; Sacchett & Humphreys, 1992). Visual

TABLE 2
Neuropsychological Test Results

Wechsler Adult Intelligence Scale	
Verbal IQ	99
Performance IQ	96
Full-scale IQ	98
Wechsler Memory Scale Revised (WMS-R)	
Logical memory immediate	86th %ile
Logical memory delayed	78th %ile
California verbal learning test	
Learning trial 1	6/16
Learning trial 2	10/16
Learning trial 3	9/16
Learning trial 4	7/16
Learning trial 5	11/16
List B	5/16
Short delay free recall	9/16
Short delay cued recall	11/16
Long delay free recall	10/16
Long delay cued recall	12/16
Recognition trial hits	16/16
Recognition trial false-positives	2/28
Wisconsin Card Sorting Test	3 categories, 33 perseverative errors
Controlled Oral Word Association	21 (3rd %ile)
Hooper Visual Organization Test	26.5/30%

TABLE 3
Florida Semantics Battery

	Total % correct
Oral picture naming	96.7
Written picture naming	92.5
Name to auditory definition	98.3
Oral word reading	100.0
Write to dictation	89.2
Auditory word/picture match	100.0
Written word picture match	100.0

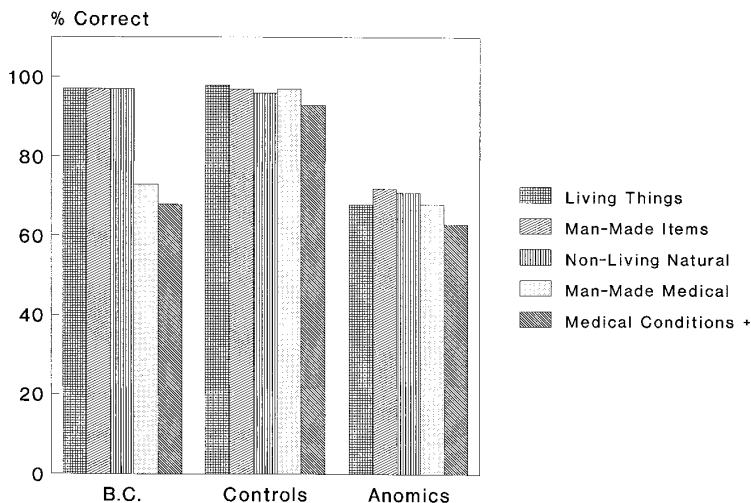


Fig. 3. Percentage correct on naming to definition across five categories: B.C., anomic patients, and neurologically normal controls.

TABLE 4
Picture Naming and Naming to Definition: B.C.'s Responses to Specific Categories

Category	Definition (%) ^a	Picture (%) ^a	Category	Definition (%) ^a	Picture (%) ^a
Body parts	100	90	Clothing	100	100
Transportation	100	100	Animals	100	100
Vegetables	100	90	Personal items	100	90
Fruits	100	80	Furniture	100	90
Kitchen utensils	100	90	Office items	90	100
Tools	100	100	Musical instruments	90	100

^a Percentage of correct responses within each category.

TABLE 5
Control Subjects' Mean (Standard Deviation) Ratings of Experimental List Items for
Familiarity, Imageability, and Abstractness (5-Point Scales)

Category list	Familiarity	Imageability	Abstractness
Man-made medical	3.62 (0.12)	3.06 (0.12)	2.40 (0.08)
Medical conditions ^a	3.45 (0.15)	2.79 (0.13)	2.56 (0.09)
Living things	3.54 (0.13)	3.75 (0.15)	2.17 (0.11)
Man-made items	3.56 (0.13)	3.84 (0.16)	2.29 (0.13)
Nonliving natural	3.60 (0.19)	3.91 (0.21)	2.50 (0.11)

^a Medical conditions, medical personnel, medical signs, and anatomical items.

characteristics (e.g., complexity) have apparently played a role in some category-specific naming deficits (Stewart et al., 1992) but not in others (Hart & Gordon, 1992). In order to deal with such issues, eight neurologically normal controls were asked to rate all words from the five naming-to-definition lists on three dimensions: familiarity, imageability, and abstractness. Results of these ratings on 5-point scales are shown in Table 5.

Analysis of these ratings across the experimental word lists (*t* tests) revealed that the medical categories did not differ from the other three lists with regard to familiarity (all *ps* > .05). However, in general, the medical lists were rated significantly less imageable and more abstract than the other word lists (*ps* < .05). In order to assess the impact of these characteristics on B.C.'s naming performance, a comparison of B.C.'s correct and incorrect responses made on the medical lists was conducted using the mean ratings for familiarity, imageability, and abstractness. If any of these variables accounted for B.C.'s difficulty, then he should have more difficulty naming the less familiar, less imageable, or more abstract medical items. As can be seen (Table 6), familiarity, imageability, or abstractness ratings did not differ between correct and incorrect responses. Further, since the anomic patients responded at similar levels of accuracy to all lists, medical and nonmedical,

TABLE 6
Comparison of B.C.'s Errors vs Correct Responses
on Familiarity, Imageability, and Abstractness

Familiarity	
Man-made medical	$t[35] = -0.66, p = ns$
Medical conditions ⁺	$t[35] = -0.88, p = ns$
Imageability	
Man-made medical	$t[35] = -0.90, p = ns$
Medical conditions ⁺	$t[35] = -0.19, p = ns$
Abstractness	
Man-made medical	$t[35] = 1.18, p = ns$
Medical conditions ⁺	$t[35] = -1.06, p = ns$

this suggests that these variables do not have any differential impact on naming performance for patients with generalized naming impairment. Thus, there is no evidence that familiarity, imageability, or abstractness of test items contributed to B.C.'s difficulty naming man-made medical items and medical conditions⁺, even though the medical lists differed from the other lists on some of these dimensions.

Item Consistency, Error Analysis, and Phonemic Cuing

Consistency with respect to which items are missed across repeated testings has been shown both for patients with category-specific deficits (e.g., Farah & Wallace, 1992; Stewart et al., 1992) and for some patients whose deficits have not been reported as category-specific (e.g., Miceli, Silveri, Villa, & Caramazza, 1984). In order to address consistency, B.C. was readministered the five naming lists 8 days after the first test. For purposes of analysis, the two medical lists were combined into a pool of 74 medical terms. Of the 22 errors made on the medical lists in the first testing, 16 identical errors were made on the second testing. Only 2 errors were made during the second administration that were not made during the first. This response distribution yielded a ϕ coefficient of .73, $p < .001$, demonstrating a high degree of consistency. This pattern of performance suggests that B.C.'s naming impairment involves a specific subset of representations rather than affecting a wider set of representations more variably.

Errors for neurologically normal controls, B.C., and anomics consisted either of a failure to respond or a substitution of a semantically related item. The percentage of total errors which were response failures or semantic errors were compared for B.C. and neurologically normal controls on medical items and medical conditions⁺. Error analysis revealed that B.C. made significantly more response failures than did neurologically normal controls (77% versus 19%, respectively, $z = 7.94$, $p < .001$), the remainder of the errors being semantic (B.C. = 23%, controls = 81%). Anomic patients showed similar proportions of errors to B.C. on medical and nonmedical lists (80% response failures, 19% semantic errors); therefore, there was no significant difference in proportion of response failures between B.C. and anomics ($z = -0.31$, $p > .05$). Thus, control subjects rarely made errors, but when they did, errors tended to be semantic. B.C. and anomics, on the other hand, were unable to give any response on a majority of the items they missed. Given the similarity between the error patterns of B.C. and those of anomic patients, the high proportion of response failures for B.C. cannot be considered atypical compared to a more general anomia.

During the initial presentation of the five naming-to-definition lists, B.C. was given a phonemic cue for each item he missed. Generally, the cue consisted of the first two or three phonemes of the word. Of particular interest was whether B.C. could respond to phonemic cuing for medical items and

the medical conditions⁺. The provision of phonemic cues did not aid B.C.'s performance; of 22 phonemic cues given after errors on medical items or conditions⁺, B.C. was able to provide the correct word on 3 (14%). The high degree of consistency in errors between administrations and the lack of facilitation by phonemic cuing suggest that the patient had problems with specific representations at the lexical level.

DISCUSSION

The current data provide striking evidence of a category-specific naming-to-definition deficit for medical items and medical conditions⁺ following a lesion of the posterior thalamus and posterior limb of the internal capsule. To our knowledge, this is the first reported case of a category-specific naming deficit with posterior thalamic lesion. Both categories of medical terms (man-made medical items and medical conditions⁺) were equally impaired relative to the performance of neurologically normal controls and relative to B.C.'s performance on the other naming-to-definition lists. His performance on the two medical categories did not differ significantly from each other. B.C. did not demonstrate any impairment in other categories of items. Most notably, he did not show the living/nonliving distinction described in other studies. Anomic controls, on the other hand, showed relatively equal impairments in the categories covered by all five naming-to-definition lists. Analysis of word frequency, familiarity, imageability, and abstractness effects in B.C.'s performance did not yield significant results.

To date, no single explanation for category-specific deficits accounts for all such cases. Some investigators (Damasio et al., 1990; Shallice, 1988) have suggested that category-specific deficits for object recognition do not result directly from an impairment of semantic categories per se. Rather, they suggest that these deficits are due to a variety of factors including: the sensory modalities through which a class of objects becomes learned and distinguished from other objects, the objects' function, movements which involve the objects, an individual's history with the class of objects, and so on. Indeed, some studies (Funnell & Sheridan, 1992; Stewart et al., 1992) have shown that controlling for frequency, familiarity, and/or complexity of items eliminates apparently specific deficits for naming animals or living things.

Yet, Sacchett and Humphreys (1992) and Hart and Gordon (1992) noted that these factors were not sufficient to explain a deficit for naming artificial objects or animals, respectively. Sacchett and Humphreys proposed that their patient had a loss of semantic knowledge about the impaired items. Hart and Gordon (1992) suggested a representational deficit that involved not only animal names but also verbal representation of visual knowledge about animals. Neither item attributes nor loss of semantic knowledge could account for the fruit and vegetable naming deficit in Farah and Wallace's (1992)

case. Further, the deficit was not related to phonological lexical representations because the patient could produce the words in response to phonemic cues. Presumably, the deficit was not semantic because it did not impact auditory-verbal comprehension, i.e., access to semantic knowledge via the phonological input lexicon. Rather, they proposed that the impairment seemed to affect the mapping of semantic knowledge onto the lexical forms for spoken output. Farah and Wallace hypothesized a level of local representation analogous to "hidden units" in computer models that mediates the mapping of distributed semantic knowledge onto spoken lexical forms and suggested that some of these local representations were organized in a spatially discrete area of the brain.

The only other cases of category-specific naming deficit after thalamic lesion of which we are aware involved anomia for proper names (Lucchelli & DeRenzi, 1992; Moreaud et al., 1995). Unlike B.C.'s lesion, the lesions in these cases were in the anterior thalamus. Lucchelli and DeRenzi (1992) demonstrated that their patient could give semantic information about the persons he was unable to name. When they demonstrated that he could not learn arbitrary associations or associate new names and faces, these authors concluded that the deficit reflected an inability in pairing arbitrary labels with the faces. In other words, because there was no semantic information in a proper name per se, the patient could not associate that label with a face.

Regarding B.C.'s deficit for naming items in medically related categories, item attributes such as word frequency, item familiarity, imageability, and abstractness do not appear to account for his deficits, in spite of the fact that the two medical lists contained items which controls rated on the average as less imageable and more abstract. First, if lower imageability and higher abstractness were to make the items from medical lists generally more difficult to name, then anomic patients should have shown greater difficulty with medical than nonmedical items. Instead, anomic patients showed equal difficulty in naming medical vs nonmedical items. Second, it might be argued that B.C. could have a deficit specific to items of lower imageability and/or higher abstractness. Perhaps preserved visual knowledge assisted in naming more imageable items. Or, perhaps less imageable, more abstract concepts are organized differently with respect to the language system. If these factors accounted for B.C.'s deficit, then he should have missed items within the medical lists that were less imageable and more abstract than other medical items. This clearly was not the case, as there were no differences between medical items that B.C. answered correctly and those he answered incorrectly regarding imageability and abstractness, at least as these qualities were rated by controls.

Of course regarding the familiarity dimension, it might be argued that it was B.C.'s own familiarity with medical items that was important and not that of controls. Perhaps the ratings of controls do not reflect his individual familiarity with medical items. Further, one might conjecture that B.C. was

never familiar with the items he missed. This explanation is unlikely for several reasons. First, it was B.C.'s own impression that he could no longer find the words for medical items he once knew that led us to test him in the first place. Had he never known the items, it is unlikely he would have spontaneously complained about this problem. Second, B.C. missed items such as crutch, medication, scar, and cancer which are in most persons' vocabulary. It is unlikely he was unfamiliar with such words. Third, we interviewed B.C. extensively in an attempt to ascertain whether he was more or less familiar with medical items than others of his age and education might be. Although B.C. felt like he should be more familiar with some of the items on our medical lists because he had studied psychology in college, we found no evidence that he should be generally more or less familiar with medical items than controls of similar age and education. Fourth, we administered B.C. the five experimental lists a third time on October 14, 1994, 56 months after his hemorrhage. At this time, he missed one nonmedical and five medical items; i.e., his deficit in naming medical items had abated completely or almost completely. His improvement in performance suggests some familiarity with medical items. Given the history he gave us, we presume this familiarity was not acquired entirely *post ictus*.

It should also be mentioned that broader classifications more commonly eliciting category-specific naming or recognition deficits could not account for B.C.'s deficit naming medical items. More specifically, our experimental lists were constructed to identify deficits in naming either living things or man-made artifacts. B.C. did not have problems with these broader categories, either between the two medical items lists (man-made medical items vs medical conditions⁺) or between the three nonmedical items lists (man-made items vs nonliving natural items vs living things).

Unfortunately, the data collected on B.C. shed less light on whether his deficit was at the lexical level of processing, at the semantic level of processing, or at the interface between the lexical and the semantic levels. His access to semantic information about medical items was not formally assessed; we know only that it was his impression that he knew many of the items which were defined, he just could not find the matching lexical item. It is also of some interest that phonemic cues did not help B.C. retrieve lexical items, in contrast to the case of Farah and Wallace's (1992) patient who consistently retrieved the correct word for failed items once he was given a phonemic cue. From this piece of information, Farah and Wallace were able to conclude that their patient had not lost lexical items or access to them; he had lost the means for accessing the lexical items based on semantic information. Since it is highly likely that the neuronal activity patterns representing lexical items are primarily cortical in nature, we can conclude that B.C. did not lose the ultimate mechanism for expressing these patterns. However, he was unable to access these items based on semantic information provided through auditory channels or based on this information plus phone-

mic cues. We are uncertain if other means of access would have been more effective, but we conclude that the thalamus plays some role in lexical access. Based upon previous cases of proper name anomia with anterior thalamic lesion (Lucchelli & DeRenzi, 1992; Moreaud et al., 1995) and our case of medical items anomia with posterior thalamic lesion, it appears likely that the patterns of thalamo-cortical connectivity for a specific nucleus and the role of the related cortical areas in lexical-semantic processing determine the nature of the category-specific deficit.

Because it is somewhat unusual, B.C.'s pattern of errors (i.e., primarily response failures) is of some interest. For example, we recently reported two cases with more anterior infarcts of the dominant thalamus whose naming errors were primarily semantic (Raymer, Moberg, Crosson, Nadeau, & Rothi, 1997). However, since our anomic patients in this study showed a similar pattern of errors across all lists, we must conclude that the error pattern is a function of our lists and/or our presentation format as opposed to an indication of the type of deficit B.C. had. The reader may recall that we specifically constructed our lists to try to avoid ceiling effects. This means that we had included items that were of greater difficulty than items frequently used to test patients with aphasia. While this factor may have affected anomics and even B.C. to some extent, it should be remembered that B.C.'s errors were not significantly related to the frequency of items in the English language.

Given the controversy regarding the existence and origin of category-specific naming deficits, and given our lack of evidence regarding whether B.C.'s deficit was at the lexical level, the semantic level, or the interface between these levels, it is difficult to specify a precise role for the posterior thalamus in naming items from specific categories. Nonetheless, a few general comments are in order. First, as noted above, the cortex is a more likely site for the realization of lexical, semantic, and lexical-semantic information than the thalamus. Thus, it is the thalamo-cortical and perhaps the cortico-thalamic projections of the affected thalamic nuclei that are of interest. Goldman-Rakic and Porrino (1985) have documented topographically organized projections from the medial pulvinar to various cortical areas in monkeys. Thus, if category-specific naming deficits are evidence of focal category-specific representations, as suggested by Farah and Wallace (1992), then a partial lesion of the pulvinar, such as that experienced by B.C., could affect some focal representations but not others, producing category-specific deficits. However, the conclusions of Farah and Wallace must be considered conjectural at this point in time and await confirmation in future studies. Second, the existence of a category-specific naming deficit in thalamic lesion raises the possibility that thalamic nuclei contribute input to cortical structures which is necessary to establish patterns of neuronal activity representing various lexical, semantic, or lexical-semantic constructs. Third, whatever the role of the thalamus, B.C.'s improvement in naming medical items

over the 54 months after the first administration of the experimental lists suggests that partial damage to posterior thalamic nuclei does not permanently disable the neural systems involved.

In summary, to our knowledge, B.C. is the first case of category-specific naming deficit reported after a lesion confined to the posterior thalamus and internal capsule. Alternative explanations regarding this deficit, including item frequency, familiarity, imageability, or abstractness, do not seem to be able to account for the deficit. Nor did the deficit appear to be the product of difficulty with a broader category of objects. Many questions remain to be answered, most importantly the lexical vs semantic vs lexical-semantic origin of such deficits. Our speculations regarding cortico-thalamic connections and regarding thalamic contributions to patterns of neuronal activity for representing constructs must be considered hypotheses awaiting further study.

APPENDIX A

Experimental Word List Target Items and Definitions

Living Things

Dog: The most common name for the domestic canine. Also known as man's best friend.

Butterfly: The name for any of the slender-bodied insects with broad, often brightly colored wings.

Frog: The name of the green, hopping, toad-like creature found in lakes or ponds.

Tomato: The name of the red, vine-grown fruit often used in making sauce for spaghetti.

Mosquito: The name of a small, winged fly which sucks the blood of warm-blooded animals and leaves bites that itch.

Eagle: The name of the once-endangered, predatory bird that is the symbol of the United States of America.

Deer: The name for the large, four-legged forest creature which is a favorite for hunters. Bambi was one of these.

Monkey: The general name of the smaller version of ape, but it has a tail.

Turkey: The name of the large bird often served for Thanksgiving dinner.

Sharks: The general name of the toothy, predatory fish of the sea who are attracted to the scent of blood.

Moth: The name of a nocturnal insect that is often feathery, with a stouter body, duller coloring, and proportionately smaller wings than the butterfly. These insects often eat clothing and are attracted to light at night.

Salmon: The name for the large, silvery game fish with pink meat that breed in freshwater rivers, and are known to vigorously swim upstream to spawn.

Vulture: The name for the scavenging, naked-headed bird that lives chiefly, or entirely on dead animals or carrion.

Pineapple: The name for the delicious, sweet, yellow tropical fruit that has a rigid, spiny outside covering. Grown extensively in Hawaii.

Banana: The name for the long, yellow, tapering tropical fruit, whose inside is soft and white. This fruit is a favorite of monkeys.

Tiger: The name of the large, carnivorous member of the cat family, who has a striped orange and black coat.

Elephant: The name for the huge, large-eared mammal, with trunk and tusks. Found in Africa.

Oyster: The name for any marine bivalved shellfish. These are often eaten on the half-shell.

Wolf: The name for a large predatory mammal that resembles the related dog. It can be found in packs, and can be destructive to livestock.

Coconut: The name for the round, hard fruit of the palm tree, whose shell contains thick edible meat and milk.

Mink: The slender-bodied mammal, closely related to the weasel, which has a very valuable soft fur or pelt.

Fox: The name for an alert, carnivorous animal of the dog family, which is thought to be clever, cunning, and crafty.

Mouse: Small rodent which is the cat's favorite prey.

Pony: The name for a small horse. Children often ride these.

Dandelion: The name of a small yellow weed that often infests your lawn. It has small floating seeds, and can be made into a tea.

Alligator: The name of a 16–18 foot amphibious reptile which has a powerful tail and extremely strong jaws. Often poached for its hide to make shoes and purses. It is common in Florida.

Rose: The name of a popular red flower often given by the dozen on Valentine's Day.

Ant: The name of a tiny insect that lives in a hill. Are often found at picnics. Can be red or black, and can bite.

Spider: The name of a round, eight-legged insect which spins a web.

Turtle: The name of a reptile that crawls slowly and is covered by a hard shell.

Seagull: The name of the white ocean bird seen flocking around the shore near the water.

Twins: The name for two identical children born at the same time to the same mother.

Nut: You can eat the meat of these hard-shelled fruit after you have cracked them open.

Grass: Another name for a typical green lawn.

Apple: The name of a round, red fruit with a stem that grows on trees.

Donkey: The name for a small horse-like animal used to carry heavy loads up mountains. Not a burro.

Fireman: The name for the civil servant whose job it is to put water on buildings that are burning.

Nonliving Natural Items

Eggshell: The name of the hard, white outer surface of the oval object laid by a chicken.

Sandbar: The name of a partially submerged or submerged area of earth formed by currents that is found in a river or in coastal waters.

Iceicle: The name of frozen water which has an inverted cone shape and typically is found hanging off roofs and other objects in the winter season.

Flood: The name of the natural disaster which occurs when a river or ocean has dramatically risen and overflowed its customary banks.

Desert: The name of a geographical area in which there is typically little or no rain, is very hot, and which often has many sand dunes.

Star: The name for a natural bright body visible in the sky, especially at night. Not the moon.

Tide: The name for the alternate rising and falling of the surface of the ocean that usually occurs twice a day.

Lava: The name for the molten rock which comes from a volcano.

Oxygen: The element in air that humans must breathe to survive.

Pearl: The name for the valuable round object found in an oyster.

Silver: The name for a valuable metal often used to make tableware.

Diamond: A clear valuable gem that can cut glass and is known as the hardest mineral.

Rubies: Valuable red gems are called this.

Emeralds: The name of a green valuable gem used in making jewelry.

Coal: A hard black fossil fuel which is mined. Can be burned for heat.

Peninsula: The name for a portion of land nearly surrounded by water and connected with a larger body by a relatively small strip of land.

Salt: Another name for sodium chloride. This white substance is often used to season food.

Cave: The name for an underground chamber which is open to the surface. Prehistoric man is thought to have lived in them.

Den: The name for the lair of a wild animal, usually predatory.

Waterfall: The name for the cascading of water from a higher point, such as a cliff, to a lower point.

Rainbow: The colorful arc seen in the sky immediately following a rain-storm.

Comet: The name of a celestial body which when seen passing the earth has a bright and lengthy tail. Haley's is an example of this.

Nest: Birds make their home in one of these.

Rubber: The black, natural substance from which automobile tires are made.

Dirt: The common name for loose or packed soil or sand. Also a filthy or soiling substance.

Ocean: Another name for a large open body of salt-water called the sea.

Volcano: The name for a cone-shaped mountain which may erupt and send ash and rock into the air.

Gravel: The name for small, crushed stones often used in driveways or landscaping.

Cloud: The name for a white, billowy formation seen in the sky.

Mountain: The name for a land-mass that projects substantially above its surroundings, and is higher than a hill. Everest is an example of this. You can ski on it.

Earthquake: The name for a natural disaster in which the ground shakes and trembles.

Hurricane: The name for a natural disaster which occurs in coastal areas in which great winds exceed 70 miles per hour and is usually accompanied by rain and flooding.

Tornado: The name for a violent, destructive, whirling wind accompanied by a funnel-shaped cloud which progresses in a narrow path over the land.

Hail: Rain in the form of small balls or lumps of ice which fall and often cause destruction.

Granite: A very hard igneous rock used especially for monuments and tombstones.

Eclipse: The name for the celestial event in which the moon lies between the Earth and the sun, and the sun is no longer visible.

Glacier: The name for this ice-mass which carves out and shapes valleys. These are thought to be remnants of the ice-age.

Man-Made Items

Albums: A general name for phonograph records.

Basket: The name for a container made of interwoven material.

Blackboard: The name for the large, rectangular slate in front of classrooms, on which we draw with chalk.

Billboard: The name for the common, large advertising sign found along roads and highways.

Knob: The name for the round, metal object you turn to open a door.

Binoculars: The name for the hand-held optical instrument composed of two sets of lenses used to magnify distant objects. It is often used at sporting events.

Perfume: The name of a fragrant, liquid substance women apply to smell sweetly.

Carpet: The name of the wall-to-wall, heavy-woven or felted fabric used as a floor covering.

- Vase:* The name of a usually round vessel, of greater depth than width, used chiefly as an ornament or for holding flowers.
- Keg:* A small cask or barrel, having a capacity of 30 gallons or less; one is often tapped in beer parties.
- Clock:* The name of the timepiece typically found on a wall or shelf.
- Sailboat:* The name of a ship that is powered by the wind.
- Toothbrush:* The name of the bristled instrument used everyday with paste to prevent cavities.
- Sandpaper:* The name of a sheet covered on one side with an abrasive material glued fast, used for smoothing and polishing wood.
- Tripod:* The name of the tubular three-legged stand which can be used to support a camera or a surveyor's scope.
- Glasses:* The name for the device worn on the head to correct poor vision, consisting of lens, rim, and frame.
- Bicycle:* The name for the two-wheeled, pedaled vehicle often ridden by children.
- Wallpaper:* The name for the decorative, fabric covering often glued to the sides of a room.
- Fork:* The pronged or tined eating utensil, used for spearing food.
- Desk:* The piece of office furniture at which you sit to work and write, which has a flat surface as well as drawers and compartments.
- Firecracker:* The name for a small, harmless, explosive object set off during the Fourth of July or other celebrations.
- Torpedo:* The name for a cylindrical, explosive object fired by a submarine toward an enemy ship.
- Shoestring:* The name for the lace used to fasten footwear.
- Typewriter:* The name for the machine used for printing letters; it has many keys. Secretaries most often use it.
- Baggage:* Another name for suitcases, what you check in at the airport.
- Couch:* The name of a long, stuffed piece of furniture that you can sit or lie on.
- Catalogue:* The name for a large book put out by different companies advertising their products. You can order items from this book.
- Ribbon:* The name for thin pieces of satin cut into strips and often worn in the hair of women.
- Pocket:* The name for the small pouch sewn onto the front of your shirt or on your pants for putting things into.
- Cup:* The name of a small, glass or plastic, cylindrical container with vertical sides, used to drink hot drinks.
- Spoon:* The name of an eating utensil with a shallow bowl and handle, often used to stir coffee.
- Tape:* The name of the thin piece of fabric or plastic with adhesive on one side that is used for sealing packages.

Cigarette: The name for finely cut tobacco rolled in thin paper.

Skyscraper: The name for a tall building with many stories.

Antifreeze: The name of the thick liquid you pour in the radiator of your car to keep it from overheating.

Bulbs: The name for a small glass globe that you screw into a socket, and it gives light.

Stamps: The name for the small adhesive paper that you lick and place on a letter before you mail it.

Man-Made Medical Items

Stethoscope: The name for an instrument that the doctor listens to your heart with.

Syringe: The name for the plastic plunger attached to a needle; it pushes fluid through the needle.

Bandage: The name for a piece of cloth you put over a wound to protect it.

Stretcher: The name for the bed on wheels used to transport patients around the hospital.

Wheelchair: The name for the seat that rolls; people sit in this when they can't walk.

Cane: The name for a thin piece of metal or wood that helps support you when you walk. You use this to help you balance when you walk. You hold it with one hand.

Scalpel: The name of the knife that the doctor uses to cut you open when he does an operation.

Catheter: The name for a tube which is inserted into the body to help in removing liquids, usually urine.

X-ray: The name for the procedure where electromagnetic waves are passed through your body to produce a picture of your bones.

Thermometer: What you use to measure a person's temperature.

Dentures: The name for false teeth that can be easily removed.

Cast: The name for the plaster device which holds a leg in place in order to mend a broken bone.

Anaesthesia: The name for the type of medication they give you so you will be unconscious during an operation.

Needle: The name for a sharp, thin, metal object which punctures the skin and allows medicine to flow in. The tip of a shot.

Hospital: The name of the place you go to stay and be treated at when you are sick.

Medication: The name for the pills or liquids the doctor gives you to make you well. He gives you a prescription for these.

Surgery: When the doctor cuts you open to remove or fix something.

Hospice: The name of an institution where people go to die.

Tongue-depressor: The name of the wooden blade that the doctor places in your mouth.

Intravenous: The name for the container of medicine that is attached to a tube and injected into your arm.

Stitches: The name for the knots used to close a wound after surgery.

Splint: What do you call a piece of wood that the doctor attaches to an injured arm or leg to keep it from bending?

Tonsillectomy: The name for the surgery in which the little thing which hangs in the back of your throat is removed.

Centrifuge: The name for the machine in which test tubes are placed, and that spins very rapidly in order to separate substances of different densities.

Incubator: The name for the chamber in which premature infants are placed to keep them warm.

Dialysis: The name for the procedure in which a kidney patient's blood is filtered.

Biopsy: The name for a procedure in which a tissue sample is removed from a living body and examined.

Kidney: The name of the bean-shaped organ in the abdomen that secretes, collects, and discharges urine and metabolic waste products.

Hearing-aide: The name for the small device often placed in the ear to help those with partial deafness.

Pacemaker: The name for the electrical device for stimulating or steadying the heartbeat; it is usually implanted in the chest.

Crutches: The name for the support that usually are placed under the armpit, for use by the disabled in walking.

Sling: The name for the piece of cloth around the shoulder and the arm, used to support and carry a broken arm.

Microscope: The name for an optical instrument consisting of a lens or combination of lenses that make small things look larger. Slides are often placed in this device to allow very close examination.

Ambulance: The name of the emergency vehicle that rushes to the scene of an accident and transports the victim to the hospital.

Walker: The name of the four-legged tubular device used to aide a crippled or handicapped person move around.

Morgue: The name for the place where bodies of persons found dead are kept until identification by relatives or release for burial. Most hospitals contain one.

Sonogram: The name of the procedure where sound waves are passed through the body in order to produce a visual image of the organs. Pregnant mothers often undergo this to determine the sex and health of their child.

Medical Conditions⁺

Stroke: The name for the rupture or blockage of a blood vessel in the brain which often causes paralysis on one side of the body, as well as weakness and difficulty in speaking.

Reflexes: The name for the involuntary response that the doctor tests when he hits your knee with a rubber-tipped hammer.

Nurse: The name of the woman who helps the physician take care of you in the hospital.

Bruise: The name for the dark spot you get on your skin when someone punches you hard.

Pulse: The name for a measured beating of the heart; they test for this at your wrist.

Artery: The name for a large blood vessel that carries blood away from the heart.

Infection: The name for the process in which bacteria enter a cut and cause it to become contaminated.

Fracture: Another name for a broken bone.

Tumor: The name for an abnormal, sometimes malignant, lump inside your body.

Cancer: The name of a condition where abnormal cells grow and spread throughout your body.

Fever: The name for the condition where your body temperature gets hot.

Antibodies: The name for the good cells in your body that fight infection.

Cyst: The name for a closed sac having a distinct membrane and developing abnormally in a cavity or structure of the body. Often contains pus.

Tremor: The name for a trembling or shaking usually from physical weakness, emotional stress, or disease.

Brain: The general name of the large organ inside of the skull which is responsible for all of our thoughts and bodily functions.

Diabetes: The name for the disorder in which your blood sugar is abnormal. Often characterized by inadequate secretion or utilization of insulin.

Epilepsy: The name for the disorder marked by disturbed electrical rhythms of the brain, and typically manifested by seizures.

Vein: The name for one of the three types of blood vessels. This vessel carries blood from the capillaries toward the heart. The nurse often inserts a needle into this vessel to deliver medication.

Concussion: The name for the condition where a sharp blow is received to the head, often resulting in a very brief loss of consciousness. This event typically is not serious, and does not involve fracture of the skull.

Skull: The name for the skeleton of the head that forms a bony case that encloses and protects the brain.

Muscle: The name for the thing in your arm that stretches and contracts to produce motion. One of these is known as the bicep.

Eardrum: The name for the structure inside of your ear that sometimes can be ruptured as the result of a very loud noise.

Ventricle: The name for a chamber of the heart which receives blood from the corresponding atrium and from which blood is forced into the arteries.

Cerebellum: The name for the small portion of the brain concerned with the coordination of muscles and the maintenance of body equilibrium, situated between the brainstem and the back of the brain.

Lung: The basic respiratory organ in the chest which is necessary for breathing.

Joint: What is a name for things like the elbow, knee, wrist, shoulder, and ankle? For example, it allows for the rotation of a limb as well as for flexibility.

Impotent: The name for the condition which describes a male's inability to generate an erection sufficient for intercourse.

Circumcision: The name for the removal of the foreskin of the penis, often as part of a Jewish rite.

Paralyzed: A person is said to be this when they are unable to move a part of their body.

Scar: The name of the mark left on the skin by the healing of injured tissue.

Pupil: The name of the black, round circle in the iris of the eye.

Leukemia: The name for the cancer of the blood, often seen in children. Often requires a bone-marrow transplant.

Leprosy: The name for the disease in which there is a wasting of skin and muscle, producing deformities and mutilations. In biblical times patients with this disease were shunned and stoned.

Bone: The skeleton is composed of these.

Spine: Another name for the backbone.

Asthma: The name for the respiratory condition in which an individual periodically has significant problems breathing.

Nerve: The band of tissue made up of axons and dendrites that connect it with other organs. It conducts electrical impulses. There are both cranial and spinal sets of these.

APPENDIX B

B.C.'s Errors and Controls' Numbers of Errors for Each
Experimental List Item

Living things	B.C. administered no. 1 response	B.C. administered no. 2 response	Controls total number of errors
Dog			
Butterfly	Dragonfly	Dragonfly	
Frog			
Tomato			
Mosquito			
Eagle			
Monkey			
Turkey			
Sharks			
Moth			
Salmon			
Vulture			2
Pineapple			
Banana			
Tiger			
Elephant			
Oyster			2
Wolf			
Coconut			
Mink			
Fox			
Mouse			
Pony			
Dandelion			
Alligator			
Rose			
Ant			
Spider			
Turtle			
Seagull			
Twins			
Nut		No response	1
Grass			1
Apple			
Donkey			1
Fireman			1

APPENDIX B—*Continued*

Nonliving man-made	B.C. administered no. 1 response	B.C. administered no. 2 response	Controls total number of errors
Albums			1
Basket			
Blackboard			
Billboard			
Knob			
Binoculars			3
Perfume			
Carpet			
Vase			
Keg	Drum	Drum	
Clock			
Sailboat			
Toothbrush			
Sandpaper			2
Tripod			
Glasses			
Bicycle			
Wallpaper			2
Fork			
Desk			
Firecracker			
Torpedo			
Shoestring			
Typewriter			
Baggage			
Couch			
Catalog			
Ribbon			1
Pocket			
Cup			1
Spoon			
Tape			
Cigarette			
Skyscraper			1
Antifreeze			
Bulbs			
Stamps			

APPENDIX B—*Continued*

Nonliving natural	B.C. administered no. 1 response	B.C. administered no. 2 response	Controls total number of errors
Eggshell			1
Sandbar	Island	Island	6
Icele			
Flood			
Desert			
Star			
Tide			
Lava			
Oxygen			
Pearl			
Silver			
Diamond			
Rubies			
Emeralds			5
Coal			
Peninsula			1
Salt			
Cave			
Den			
Waterfall			
Rainbow			
Comet			
Nest			
Rubber			
Dirt			
Ocean			
Volcano			
Gravel			
Cloud			
Mountain			
Earthquake			
Hurricane			
Tornado			
Hail			
Granite		Marble	3
Eclipse			
Glacier			

APPENDIX B—*Continued*

Man-made medical	B.C. administered no. 1 response	B.C. administered no. 2 response	Controls total number of errors
Stethoscope			1
Syringe			
Bandage			
Stretcher			
Wheelchair			
Cane			
Scalpel		No response	
Catheter			1
X Ray			
Thermometer			
Dentures	No response	No response	
Cast			
Anesthesia			
Needle			
Hospital			
Medication	No response		
Surgery			
Hospice	Hospital	Hospital	6
Tongue-depressor	No response	No response	
Intravenous			
Stitches			
Splint			
Tonsillectomy			
Centrifuge	No response	No response	
Incubator	No response	No response	1
Dialysis			
Biopsy			
Circumcision	No response		
Hearing aide			
Pacemaker			
Crutches	No response		
Sling	No response	No response	
Microscope	Projector		1
Ambulance			
Walker			
Morgue			1
Sonogram			

APPENDIX B—*Continued*

Medical conditions	B.C. administered no. 1 response	B.C. administered no. 2 response	Controls total number of errors
Stroke			
Reflexes	No response	No response	
Nurse			
Bruise			
Pulse			
Artery	Vein		1
Infection			
Fracture	No response	No response	
Tumor			
Cancer	No response	No response	
Fever			
Antibodies	No response	No response	1
Cyst	Boil	Boil	1
Tremor			
Brain			
Diabetes			
Epilepsy		No response	
Vein	No response	Aorta	
Concussion	No response	No response	1
Skull			
Muscle			
Eardrums			1
Ventricle	No response	No response	2
Cerebellum	No response	No response	10
Lung			
Joint			
Impotent			
Kidney			1
Paralyzed			1
Scar	Scab		
Pupil			
Leukemia			
Leprosy			2
Bone			
Spine			
Asthma			3
Nerve	No response	No response	4

Note. A blank space indicates no errors.

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