18. Category-Specific Naming and Comprehension Deficits: Theoretical and Clinical Implications

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Accurate identification of an aphasic patient's impairments to be targeted in treatment requires an understanding of the cognitive processes that are engaged in particular language tasks. Conversely, the cognitive processes underlying each task are often revealed by patterns of performance by aphasic patients. For example, performance by patients who are unable to verbally produce the names of objects in response to pictures, despite preserved ability to write the names in the same task and preserved motor speech, provides evidence for proposing that verbal naming involves mechanisms for accessing stored pronunciations of words that are relatively independent of mechanisms for accessing the stored spellings of the same words (Caramazza & Hillis, 1990; Hier & Mohr, 1977). Such patterns of impaired performance serve as a basis for postulating not only the major components of cognitive tasks such as naming, but also the internal organization of those components. Thus, for example, spared naming and comprehension of nouns in the presence of impaired naming and comprehension of verbs in some patients, and the opposite pattern by other patients, indicate that one of the organizing principles of the meaning system respects grammatical classes of words (Miceli, Silveri, Nocentini, & Caramazza, 1988; Miceli, Silveri, Villa, & Caramazza, 1984; Zingeser & Berndt, 1988). Furthermore, within the class of nouns, patients may have preserved comprehension of abstract nouns along with impaired comprehension of concrete nouns, or the reverse pattern of performance, indicating that concreteness may be another important dimension in semantic processing (Warrington, 1981; Warrington & Shallice, 1984). A still finer organizational structure of the meaning system is indicated by reports showing that naming and comprehension can be impaired in selective semantic categories of concrete nouns, such as animals or fruits and vegetables (Basso, Capitani, & Laiacona, 1988; Geschwind & Fusillo, 1966; Goodglass & Budin, 1988; Goodglass, Klein, Carey, & Jones, 1976; Hart, Berndt, & Caramazza, 1985; McCarthy & Warrington, 1989; Sartori & Job, 1988; Semenza & Zettin, 1989; Silveri & Gainotti, 1988; Warrington & McCarthy, 1983; Warrington & McCarthy, 1987). However, the view that these studies provide evidence that the semantic system is organized along the lines of such categories has been challenged, by contending that category differences may only reflect differences in the degree of processing demands on the perceptual system needed to distinguish between category members (Humphreys & Riddoch, 1987). In this article, two cases are presented in which the category-specific performance cannot be an artifact of perceptually or otherwise "more difficult" stimuli for categories found to be impaired. The two patients showed patterns of naming and comprehension, with the same stimuli, that were essentially mirror images of one another with respect to performance across categories. Because this double dissociation between categories cannot be accounted for by differences in the degree of processing demands between categories, the cases provide evidence that it is the organization of semantic information that allows selective preservation or impairment of information in specific semantic categories.

SUBJECTS

J. J. is a 67-year-old, right-handed retired corporate executive with two years of college education who sustained a left temporal and basal ganglia stroke, confirmed by computerized tomography (CT) scan. He had no weakness or significant sensory loss, but had difficulty understanding and using appropriate words. Comprehension of spoken words, as tested by the *Peabody Picture Vocabulary Test* (Dunn & Dunn, 1981), was in the first percentile. A striking accuracy in naming pictures of animals, relative to other categories, was particularly notable, because disproportionately *impaired* comprehension and naming of animals has been reported.

P. S. is a 45-year-old, right-handed small business owner with a high school education who sustained brain injury when lumber fell on his head. CT scans revealed a large subdural hematoma in the left temporal parietal lobe and smaller focal hematomas in the right temporal lobe and deep in the left frontal lobe. A right frontotemporal epidural hematoma was evacuated by craniotomy. Four months later, his speech was entirely normal except for semantically related word substitutions (e.g., horse/cow) in selective categories. Auditory comprehension was also normal, but word comprehension was impaired for items that he could not name, which consisted of animals and vegetables.

Both patients had fluent, grammatical speech with semantic paraphasias in specific categories, and normal repetition of single words and pseudowords. Both patients showed above-average performance on the *Wechsler Memory Scale* (Wechsler, 1972) Visual Memory subtest and on *Raven's Coloured Progressive Matrices* (Raven, 1962), consistent with spared visual perception and reasoning.

MATERIALS

Stimuli for each study consisted of 144 items, from 10 semantic categories, matched for mean word length in letters and syllables. Five categories had mean word frequencies of 13.5–16.8 or 43.5–50.4 (norms from Carroll, Davies, & Richman, 1971).

PROCEDURES AND RESULTS

To document the stability of the category discrepancies, all of the stimuli were presented for oral naming once each session across seven sequential sessions, beginning 4 months after brain injury. Table 18.1 illustrates the fact that the advantage for animals over other categories in J. J.'s oral naming performance, and the opposite pattern by P. S., were remarkably stable.

To identify the processing component in which the effect arose, the same stimuli were presented in blocks for oral and written naming, oral reading, spelling-to-dictation, and word/picture verification, in counterbalanced order, so that the same item was not presented more than once each session. A correct score on spoken word/picture verification indicated acceptance of the correct picture *and* rejection of a semantically related picture and an unrelated picture, presented with the word on three separate occasions. These tasks were undertaken at 6 months post-onset; some were repeated at 13 months. Interjudge reliability in scoring of the first 52 responses on each of these tasks exceeded 90% point-to-point agreement for each patient, so only the scores by the first author are reported.

J. J.'s oral naming of animals was 77%–100% correct, compared to 8%–33% correct for nonanimal categories ($X_1^2 = 67.78$; $p << .0001$;[1] see

[1]All chi-square analyses were computed using an Ed-Sci Statistics package (Ed-Sci Development, 1981).

TABLE 18.1. ACCURACY IN ORAL NAMING ACROSS CATEGORIES OVER SEVEN ADMINISTRATIONS, IN PERCENT

	1	2	3	4	5	6	7
J. J.							
Land animals	95.0	85.0	70.0	75.0	90.0	90.0	95.0
Birds	76.9	84.6	76.9	84.6	76.9	46.2	76.9
Water animals	46.0	84.6	69.2	84.6	53.8	76.9	100
All Animals	**91.3**	**84.8**	**71.7**	**80.4**	**76.1**	**73.9**	**91.3**
Vegetables	8.3	25.0	0	8.3	0	16.7	8.3
Fruits	30.0	10.0	10.0	30.0	20.0	10.0	30.0
Transportation	25.0	50.0	25.0	25.0	33.3	16.7	33.3
Furniture	10.5	15.8	26.3	5.3	10.5	10.5	21.1
Body parts	5.0	10.0	20.0	5.0	10.0	5.0	5.0
Food	0	0	0	9.0	0	9.0	9.0
Clothing	14.3	7.1	7.1	7.1	14.3	7.1	21.4
Nonanimals	**12.2**	**14.3**	**14.3**	**11.2**	**12.2**	**7.1**	**17.3**
P. S.							
Land animals	40.0	40.0	50.0	60.0	50.0	50.0	75.0
Birds	50.0	46.2	23.1	23.1	30.8	38.5	38.5
Water animals	30.8	30.8	38.5	30.1	23.1	53.8	69.2
All Animals	**39.1**	**39.1**	**39.1**	**41.3**	**37.0**	**47.8**	**71.7**
Vegetables	25.0	25.0	25.0	25.0	33.3	33.3	41.7
Fruits	70.0	80.0	90.0	90.0	90.0	90.0	90.0
Transportation	91.7	100	91.7	91.7	91.7	100	100
Furniture	84.2	84.2	84.2	84.2	94.7	84.2	94.7
Body parts	100	100	100	100	100	100	95.0
Food	100	90.9	81.8	81.8	81.8	90.9	81.8
Clothing	85.7	92.9	92.9	100	92.9	100	92.9
All Other[a]	**88.4**	**90.7**	**90.7**	**91.9**	**94.2**	**93.0**	**95.3**

[a]All stimuli except animals and vegetables.

Table 18.2). Similar differences favoring animals over nonanimals were exhibited in written naming ($X_1^2 = 39.49$; $p << .0001$) and auditory comprehension ($X_1^2 = 12.29$; $p < .001$). There was no difference in accuracy between categories with high-frequency items and categories with mid-frequency items for any task (e.g., 30.5% vs. 35.5% correct, respectively, for oral naming).

On the same set of items, subject P. S. named animals with significantly *lower* accuracy than for items in all of the other categories combined, excluding vegetables ($X_1^2 = 29.05$; $p << .0001$ for oral naming;

TABLE 18.2. ACCURACY RATES ACROSS CATEGORIES AT 6 MONTHS POST-ONSET

	Oral Naming		*Written Naming*		*Auditory Word/Picture*	
	NO.	%	NO.	%	NO.	%
J. J.						
Land animals	19	(95.0)	18	(90.0)	18	(90.0)
Birds	10	(76.9)	7	(53.8)	12	(92.3)
Water animals	13	(100)	7	(53.8)	12	(92.3)
Vegetables	1	(8.3)	2	(16.7)	4	(33.3)
Fruits	3	(30.0)	5	(50.0)	7	(70.0)
Transportation	7	(58.3)	2	(16.7)	7	(58.3)
Furniture	4	(21.1)	4	(21.1)	15	(78.9)
Body parts	1	(5.0)	0	(0)	11	(55.0)
Food	1	(9.1)	0	(0)	4	(36.4)
Clothing	3	(21.4)	2	(14.3)	11	(78.6)
P. S.						
Land animals	8	(40.0)	7	(35.0)	19	(95.0)
Birds	6	(46.2)	6	(46.2)	12	(92.3)
Water animals	4	(30.8)	3	(23.1)	12	(92.3)
Vegetables	3	(25.0)	4	(33.3)	11	(91.7)
Fruits	7	(70.0)	7	(70.0)	10	(100)
Transportation	11	(91.7)	11	(91.7)	12	(100)
Furniture	16	(84.2)	13	(68.4)	19	(100)
Body parts	20	(100)	12	(60.0)	20	(100)
Food	11	(100)	11	(100)	11	(100)
Clothing	12	(85.7)	8	(57.1)	14	(100)

$X_1^2 = 15.75$; $p < .001$ for written naming). P. S. made comprehension errors only in the animal categories ($X_1^2 = 5.04$; $p < .03$). Error rates were lower than in the naming task, presumably because a correct response in word/picture verification does not require complete semantic information.

Initially, most of J. J.'s error responses in oral picture naming were fluent jargon (mixed English jargon and neologisms). Nearly all of his single-word errors were within-category confusions, such as *boat* named as *motorcycle*. More than 65% of P. S.'s error responses were semantic confusions of this type. Both patients also produced other associated words and circumlocutions (e.g., *vase* → *flower holder*). J. J. gave some jargon responses (10% of errors). In written naming, both patients produced recognizable semantic errors (e.g., *toe* → *hand* by J. J.; *shark* → *waile* by P. S.). Errors in auditory word/picture verification by both patients were limited to incorrect acceptance of related pictures.

Although only performance on naming and auditory comprehension will be presented in detail here, it is worth noting that both patients made errors in oral reading and spelling-to-dictation that indicated use of sublexical procedures for converting print to sound or vice versa (e.g., in spelling: *whale* → *whayl* and *beet* → *beate* by J. J.; *eagle* → *egele* and *motorcycle* → *motor ciekil* by P. S.; in reading: *pear* → *pier* by J. J. and *bread* → *breed* by P. S.).

Retesting 7 months later, when the patients' language skills had improved, showed that the category discrepancies were maintained. J. J. correctly named all animals, but only 58%–70% of items in all other categories but transportation (Figure 18.1). By that time, nearly all of J. J.'s errors were semantic coordinates of the target. The difference in accuracy between animal and nonanimal categories was still highly significant ($X_1^2 = 11.81$; $p < .001$). J. J. made no error responses to any animal names in word/picture verification, but incorrectly accepted 19.3% of the semantically related pictures presented with words in the other categories. The opposite pattern of naming in P. S. also persisted ($X_1^2 = 38.71$; $p < .001$ for animals vs. nonanimals, excluding vegetables). He was not retested on the word/picture verification task, but both he and J. J. completed another task of word comprehension that eliminated the possibility of producing a correct response by guessing. They were asked to define each spoken word as clearly and completely as possible.

J. J. defined the 144 words that had been used in the earlier tasks. His definitions were lengthy, but often very precise.[2] All of his definitions of animals were judged to be accurate by two scorers. In contrast, 15.3% of his definitions of nonanimal names were scored as "clearly wrong" and 8.2% as ambiguous. P. S. defined 70 names of animals and vegetables and 70 names of objects in the other categories previously tested, matched for word frequency. He resolved any ambiguities in his definitions by giving additional information upon request. Responses to 15.7% of animal and vegetable names were wrong; all others were accurate (Figure 18.2).

DISCUSSION

The double dissociation between categories in our subjects indicates that the sort of information that distinguishes members of one category from

[2]Definitions were recorded and independently scored by two examiners, one of whom was naive to the purpose and to the hypotheses that had been formulated. Interjudge reliability between scorers was 93.8%, so only the scores of the naive judge are reported.

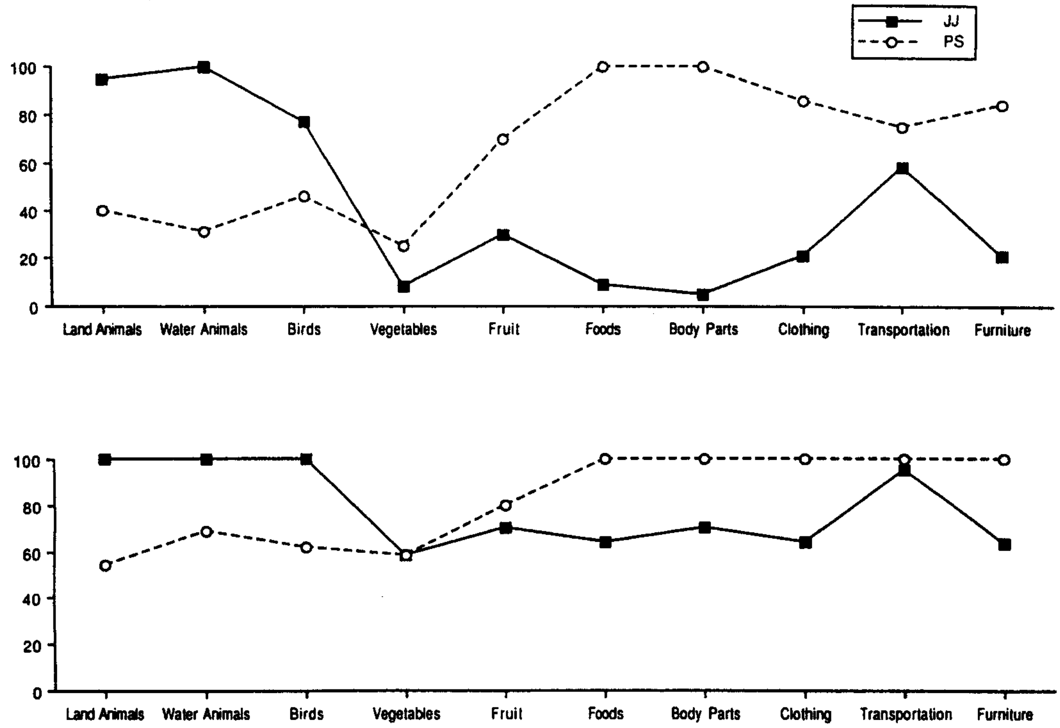

Figure 18.1. Percentage of correct oral naming as a function of category at 6 months post-onset (top graph) and 13 months post-onset (bottom graph).

another is an important dimension of the processing structure of at least one component of the complex process of naming. The similar types of errors in oral and written picture naming and word/picture verification (mostly semantic coordinates of the target), as well as comparable degrees of category effects across tasks, suggest a common source of the errors—either visual/perceptual mechanisms or the semantic system. Semantic errors reflected in definitions of spoken words in the affected categories argue against a visuoperceptual basis for the errors. Therefore, results suggest that the category-specific semantic errors of each patient were consequent to an impaired semantic system, and thus reflect the organization of this system.

These results cannot be accounted for by the hypothesis put forth by Humphreys and Riddoch (1987) that category differences may be attributable to perceptual aspects that vary by categories, such as the degree of perceptual overlap between members of a given category. They argued, for example, that the high degree of perceptual overlap among animals (four legs, a head, and so on) may account for the disproportionately impaired naming and recognition of animals by several reported patients, because of the greater demands placed on the perceptual system to discriminate among members of this category. This proposal cannot explain

J. J.

Animals

lion "A large animal, about four feet tall, maybe taller at the shoulders; it has a long body and very large paws, and stands on all four legs. It has a monstrous head with which it growls; and it has a mane—a large body of hair. It lives in Africa."

heron "This bird has a long neck and legs. It lives near water. Stands in the water . . . very tall—maybe about 6 feet. Not brown, but white and blue perhaps."

mouse "A small little animal with a pointed nose, pointed ears, and a little snout; about 1 inch high, or 1¼ inches. It doesn't have much value, except that it can be eaten by animals. Cats chase them. It eats whatever it can steal in people's houses, even in my house. They move rather quickly, climb up on things, and can stand on two feet."

Nonanimals

bench "A device you sit on, about 12 inches high with four legs. It revolves you around while sitting. Can be made of metal or wood."

apricot "I don't remember. I've heard of it. It's a fruit, but I don't remember which one. That's strange. I suppose it's sweet."

P. S.

Animals and Vegetables

panther	"A big cat with black stripes."
salamander	"Sounds familiar. A fish?"
lizard	"A mammal with a pointed head that lives in Florida."
heron	"A fish."
aardvark	"A duck, with a face that hangs down . . . no, that's something else."
brussels sprouts	"Like rice. You put meat on them."
bamboo sprouts	"Little round things."
pinto beans	"I don't know . . . sounds Mexican."
artichoke	"Looks like a pear; has a big seed in it."
leek	"An animal, I've heard of them."
Other	
apricot	"Like a peach, only smaller. You can buy them canned or dried or fresh."
ottoman	"A chair without a back, that you put your feet on."

Figure 18.2. Definitions of items in impaired and unimpaired categories.

J. J.'s category effects: His naming was *least* impaired in the categories that presumably require the most difficult perceptual discrimination.

Neither can the category effects be dismissed as reflections of differences in premorbid familiarity with certain categories. J. J. denied a particular interest in animals; his main avocations were carpentry and mechanics. Instead, it was P. S. who reported a special interest in animals; he had always watched television documentaries about animals, hunted, and visited wildlife reserves.

In conclusion, the fact that circumscribed neurological impairment can affect some categories of semantic representations and not others provides evidence that the processing structure of the semantic system is organized along lines of categories such as "animals," "vegetables," and so on. This conclusion can be accommodated by several theories of semantic processing. One possibility is that each semantic representation is stored as a discrete unit, and representations of a given category are stored in the same area of the brain. An alternative account that is consistent with aspects of semantic errors reported in other cases (Caramazza & Hillis, 1990; Hillis, Rapp, Romani, & Caramazza, 1990) is that a semantic representation consists of a set of functional, perceptual, and other "defining" features, some of which are common to members of the same category. By this hypothesis, the semantic representations of related items, say, of *dog* <animal, four-legged, furry, omnivorous . . .> and *cat* <animal, domestic, four-legged, furry, carnivorous . . .>, would consist of overlapping subsets of features, such that impaired access to a particular feature might affect a number of related items. In this example, damage to the feature <domestic>, for instance, would impede computation of the semantic representations of all domestic animals.

In either case—whether semantic representations consist of individual patterns that are stored contiguously, but independently, or are overlapping sets of features that might be stored in separate brain regions—the results reported here indicate that naming and comprehension should be tested in a variety of categories. Further, the latter hypothesis would suggest that treatment *might* be most efficient if it focused on particular features specific to items in the affected categories.

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