Lexical–Semantic Aspects of Language Disorders

RITA SLOAN BERNDT

Words are the primary units of human communication. They are abstract symbols that can be expressed in a number of distinct forms to convey ideas and refer to the physical world. In modern society, adults are typically proficient users of words in two forms, spoken and written.1 Estimates are that the average high school graduate knows the meanings of approximately 60,000 root words plus their morphological variants (Miller, 1991). Psycholinguistic studies of word processing, i.e., of the use of words in speaking, writing, reading, and listening, refer to the component of the language system dealing with words and their meanings as the “lexical–semantic system,” to distinguish these elements from components dedicated to structural (syntactic) and phonological aspects of language. This chapter will follow that terminology, and will focus on the impairment of spoken and written words produced and/or understood outside the context of a sentence. Almost by definition, all aphasic patients have some difficulty with words. These impairments can take a surprising number of different forms, ranging from almost total inability to produce comprehensible words to very selective difficulties with words of a particular type. The study of these varieties of impairment in individual aphasic patients, and comparison of impairments across patients, can provide important information about how the normal lexical–semantic system is likely to be organized. Moreover, detailed study of such impairments can isolate the apparent source(s) of a patient’s symptoms so that treatment may be focused on the appropriate level of processing (e.g., Conway et al., 1998).

This chapter will consider word-level deficits in patients with aphasia and, to a lesser extent, with progressive neurologic disorders. We will organize this discussion around issues that are critical to the development of a model of the lexical–semantic system to illustrate the importance of data from aphasia to cognitive theory, and to demonstrate the value of a model in motivating the systematic study of patients’ symptoms. We will leave to other chapters in this volume the questions of how words are phonologically encoded, and how they are incorporated into sentences.

SYMPTOMS IMPLICATING LEXICAL–SEMANTIC ASPECTS OF LANGUAGE

All aphasia test batteries include subtests in which the aphasic person is required to produce, understand, read, or repeat isolated words.2 The classical typologies of aphasia are based in part on the long-recognized fact that an individual patient’s performance can vary markedly across these tasks, even when the same words are the targets. For example, a patient with poor comprehension and naming will typically be classified as a Wernicke’s aphasic if the patient has difficulty repeating, and as a transcortical sensory aphasic if he or she does not; a patient with frequent phonemic paraphasias and poor repetition will most likely be labeled a Wernicke’s aphasic if comprehension is poor, and a conduction aphasic if it is not.

Here we are not concerned with accounting for these differences across syndromes in aphasia, but with understanding the elements that must be included in the hypothesized lexical–semantic system to allow this variety of symptoms to occur.

ISOLABILITY OF SYMPTOMS

As these clinical examples suggest, it is possible to find aphasic patients whose word-processing impairments are relatively isolated to a specific task, or to a single modality of input or output. The neurological literature of the nineteenth century is replete with examples of exquisitely selective deficits or sparrings difficulty naming objects when they are viewed but not when touched or described orally (“optic aphasia”; Freud, 1888); difficulty comprehending spoken words despite the ability to repeat and to read them aloud (“word meaning deafness”; Bravewell, 1897); severe difficulty reading aloud words that can be easily written (“pure alexia”); Dejerine, 1892). These and other interesting patterns were interpreted primarily in terms of neuroanatomical theories of brain–function relationships, although some functional model of language organization was often implied or explicated as well. More recently, these same symptom patterns have been interpreted with the goal of creating a cognitive, rather than a neuroanatomic, framework that can accommodate them. In the long run, of course, both are critical to understanding how the brain processes words.

CONTRASTING PATTERNS AND THE IMPORTANCE OF DOUBLE DISSOCIATIONS

One important problem in interpreting the occurrence of isolated symptoms concerns the possibility that the symptom reflects inherent differences in task “difficulty,” a construct that is not easily measured or quantified. One might argue, for example, that spared repetition in the context of otherwise apparent aphasia (ability, e.g., Whilaker, 1976) simply reflects the relative ease of repetition (“even a parrot can do it”) compared to other language functions. On the other hand, one might just as easily argue that repetition is particularly vulnerable to injury because it is relatively unpracticed and has little functional value in human communication. The impact of these types of arguments can be blunted by the description of double dissociations of symptoms, i.e., of two different patients with contrasting performance patterns. A model that can explain the occurrence of patients whose repetition is selectively spared, and of patients whose repetition is selectively impaired, will need to provide an account of the cognitive demands of repetition compared to other language tasks.

The importance of the double dissociation in the interpretation of aphasic symptoms has been discussed in detail elsewhere (Shallice, 1988; McCarthy and Warrington, 1990). One important contribution of an emphasis on double dissociations is the identification of contrasting patterns that, though perhaps less striking than the classic cases mentioned above, have been important in illuminating the structure of the lexical–semantic system. Examples of these dissociations will be discussed below.

IDENTIFYING COMPONENTS OF THE LEXICAL–SEMANTIC SYSTEM

Many of the assumptions currently made about the structure of the lexical–semantic system have been motivated by patterns of impairment and sparing in aphasia.

FORM VS. MEANING

There is evidence from a number of sources that the meanings of words are represented separately from their forms. It has long been noted that normal subjects in a “tip-of-the-tongue” state have detailed knowledge of a word’s meaning, yet remain unable to produce its spoken form (Brown and McNell, 1966).
This phenomenon is magnified in the symptom of anomia, in which a patient's attempts to name objects often provide compelling evidence of knowledge of meaning. In one study of a severely anomia patient (H.Y.), we elicited many accurate descriptions of objects that the patient could not name (Zinggser and Berndt, 1988). For example, H.Y.'s attempt to name a camera elicited "to take a picture"; his attempt to name lamp elicited "turns the lights on in the evening." These examples illustrate that H.Y.'s recognition of the picture and his understanding of the concept that was to be named by the elusive word were largely intact. But the lexical form associated with the object was rarely produced in picture-naming tasks.

A contrasting pattern of impaired meanings and relatively intact access to spoken word forms has been described in studies of patients with progressive dementia illnesses. In the variant known as "semantic dementia" (Hodges et al., 1992), semantic deterioration appears to progress more rapidly than does the ability to produce spoken word forms. For example, patient W.L.P. (Schwartz et al., 1986) showed a profound semantic impairment for words that she could read aloud and repeat without difficulty. Perhaps even more surprising is a pattern described in a patient with Alzheimer's disease who could name objects normally while performing significantly worse than controls on numerous tests of semantic knowledge for the same objects (Shuren et al., 1993).

These examples indicate that the lexical-semantic system must represent word meaning largely independently of word form; different types of brain damage can selectively affect either meaning or form, or (perhaps more frequently) can affect them both but to very different degrees.

### The Organization of the Semantic System

The semantic component of the lexical-semantic system must contain a wide range of information of different types in order to encode the meanings of all of the concepts and categories that human speakers understand. How this information is organized within the cognitive system has been debated for many years; currently there are at least two basic views. One argument is that meanings are composed of networks of discrete semantic features (Bierwisch and Schreuder, 1992). A concept such as dog might be represented by features such as [living], [four-legged], [domestic], etc. Another view holds that meaning is non-decompositional, i.e., that there is a single semantic concept associated with each known lexical concept (Roelofs, 1993). In this view, the meaning of dog is represented through its network of connections to other (superordinate, coordinate, and subordinate) lexical concepts such as *animal*, *cat*, *dog*, etc. Interpretations of neuropsychological data have generally adopted the decompositional (i.e., feature) model, assuming that a set of primitive features jointly determines a concept's meaning.

Another contentious issue about the organization of semantics is motivated by findings from patients with modality-specific semantic deficits. The most studied phenomenon among these is optic aphasia, in which the patient can name objects when they are described aloud or touched, but not when they are simply viewed (Freund, 1989; Beauvois, 1982). Importantly, patients with optic aphasia are often reported to show some spared knowledge of viewed objects and may be able to gesture their use appropriately, indicating residual recognition. This type of pattern and analogous modality-specific naming impairments such as tactile aphasia (Beauvois et al., 1978) have led to the proposal that there are separate semantic systems linked to specific sensory modalities (Shallice, 1987, 1988). The idea is that such patients succeed in gaining access to a modality-specific semantic system (visual semantics in the case of optic aphasia), which allows them to gesture appropriate use of viewed objects and demonstrate other limited understanding. A separate verbal semantic system is also assumed to be intact, since objects can be named when encountered via non-affected sensory modalities. The problem, it is argued, lies in transmitting information from intact visual semantics to intact verbal semantics. This type of framework is depicted in Figure 5-1.

This "multiple semantics" hypothesis has been challenged by proponents of a model such as that shown in Figure 5-2 with a single, amodal semantic system that can be accessed through all sensory modalities (Riddoch et al., 1988; Caramazza et al., 1986; Shelton and Caramazza, 1989). The primary arguments in favor of this position involve natural differences in the relationships that hold between objects and their meanings on one hand, and words and their meanings on the other. Whereas words have a completely arbitrary relation to meaning, objects do not. For example, nothing about the spoken or written word form "scissors" gives a hint of its meaning, while the viewed object scissors (even if it is not identified) may be readily interpreted as something to be grasped with the hand and manipulated. Thus, if a single, amodal semantic system were impaired, patients might still be able to gesture an object's use or give other minimal evidence of understanding of its function, but still fail to access the full semantic representation needed to generate its name.

Another approach to this issue has been offered by Corsell and Saffran (1989, 1992), who carried out detailed studies of two optic aphasic patients. These investigators argue that the demonstration of some residual recognition of visually presented objects (and words), despite inability to name such objects, reflects a rudimentary semantic system available in the right hemisphere that is disconnected from left hemisphere verbal capacities. The right hemisphere semantic system does not constitute a "visual semantics system" that supports all pro-
processing of the meaning of viewed objects, but has limited ability to process objects and highly imageable written words (see also Coltheart, 1980).

Although we will adopt here the proposal of a single, amodal semantic system, we will revisit this issue below in the context of semantic category-specific effects.

**ARE THERE SEPARATE LEXICONS FOR SPOKEN AND WRITTEN INPUT AND OUTPUT?**

Another basic but controversial question concerning the structure of the lexical–semantic system involves the number of separate lexical components that must be posited to accommodate a range of results from patients. Traditional linguistic models of the language system have assumed a single lexicon containing phonological entries abstract enough to support acoustic–phonetic input and articulatory–phonetic output (see Coleman, 1988, for a recent review of arguments). Linguistic conceptions of the lexicon do not generally touch upon written language, but when they do they are explicit in their argument that lexical knowledge is "medium neutral," accessible for use in spoken and written domains (Lyons, 1981). Such a framework is depicted in Figure 5–3.

In contrast, cognitive models, especially those incorporating data from neuropsychology, have assumed that there are separate lexicons for input and output, and separate phonological and orthographic lexical systems to support spoken and written words, respectively (Ellis and Young, 1996; Shelton and Caramazza, 1999). This framework is shown in Figure 5–4.

The single, amodal lexicon depicted in Figure 5–3 has difficulty accommodating a number of symptom dissociations found among aphasics. For example, patients with "word meaning deafness" (Bramwell, 1987; Franklin et al., 1994) cannot understand spoken words that they can repeat and, in some cases, spell to dictation (Hall and Riddoch, 1997). These patients can also understand written words, suggesting that word meanings can be accessed through the visual modality and are not themselves compromised. This pattern appears to require a very specific degradation of transmission between speech and the semantic system that will allow successful processing of spoken words for repetition and spelling. It is not clear how such fine distinctions could arise in a single lexicon model. Allport and Funnell (1981) discuss other evidence from patients weighing against the idea that all lexical processing gains access to an amodal store of lexical representations.

![Figure 5-3](image1.png) **Figure 5–3.** Schematic representation of a model with a single, amodal lexicon that supports spoken and written input and output.

![Figure 5-4](image2.png) **Figure 5–4.** Schematic diagram of a model with separate lexical representations for spoken and written input and output.

If the single-lexicon approach cannot be supported, does that necessitate adoption of the four-lexicon model shown in Figure 5–4? There seem to be compelling reasons to require independent spoken (phonological) and written (orthographic) lexicons, and this distinction will be discussed further below. However, the additional separation of phonological and orthographic systems into stores dedicated to input and output processing is not so clearly mandated by the patient data. This is so because the mechanisms that mediate between lexical information and the outside world (i.e., the acoustic, articulatory, visual, and motor components that stimulate receptive processes and execute expressive processes) have not been specified, and might themselves be selectively affected by brain injury. Thus, findings that appear to compel a separation of input and output lexicons might be explainable as selective disruption of pathways into or out of a single phonological or orthographic lexicon. It has proven to be extremely difficult to distinguish between these possibilities using data from normal subjects (e.g., Monsell, 1987).

The attempts to address this issue using neuropsychological data appear to support different conclusions for spoken and written words. The need for separate input and output lexicons for spoken words is supported by findings that the same words that appear to be no longer accessible for production remain easily accessible for comprehension. For example, Howard (1995) described an aphasic patient who showed a very consistent inability to produce specific lexical items across a variety of tasks, even when given phonemic cues. The same words, when spoken to the patient, were rec-
recognized and understood normally. The severity, specificity, and consistency of this patient's production impairment, within the context of normal word recognition and comprehension, is difficult to accommodate in a model with a single, amodal lexicon. Martin and colleagues (1999) reached a similar conclusion based on detailed analyses of the performance of an anomic patient on memory tasks requiring retention of input vs. output phonological codes.

In contrast to these findings for spoken words, similarly detailed studies across orthographic input and output tasks have thus far supported the existence of a single orthographic lexicon (Coltheart and Pumphrey, 1987; Behrmann and Bub, 1992; Greenwald and Berdik, 1999). A framework incorporating these spoken and written differences might look something like that in Figure 5-5.

**RELATIONSHIP BETWEEN SPOKEN AND WRITTEN WORD PROCESSING**

The idea that there are separate input and output lexicons for speech and a single lexicon for written words, may be unappealing because of its lack of symmetry. Nonetheless, it is possible that the differences in the manner in which spoken and written words are acquired during development are responsible for this asymmetry. That is, the understanding and production of spoken words are emergent abilities of the human cognitive system that may be tightly connected with the sensory (auditory) and motor (speech) systems on which they rely. Written language is (for the most part) acquired through formal training that may blur distinctions between input and output. In fact, some techniques for the teaching of reading may mandate processing across modalities, as words are not only read aloud but spelled aloud and written as they are being learned. These speculations suggest that there may be reasons to expect that the lexical systems supporting spoken and written words may be differently organized.

An even stronger view about the differences between spoken and written words, which also has its roots in ontogenetic considerations, is that written word processing is in some sense parasitic on spoken word processing (Luria, 1966; Geschwind, 1989). This issue has been especially contentious in the cognitive literature as it relates to normal reading (Van Orden et al., 1988; Coltheart and Coltheart, 1997), but it is equally relevant to spelling (see Ellis, 1988, for review). The argument is that the recognition and production of written words require prior translation (to or from) phonological forms.

Recent neuropsychological evidence strongly suggests that there is no such requirement; rather, written words can be recognized and produced even when phonological systems are largely inoperative. The patients with word meaning deafness, described above, provide one source of evidence. These patients have no difficulty understanding words in written form, but cannot understand the same words in their spoken form. Thus, obligatory translations from orthographic to phonological form would result in degraded written word comprehension in these patients. Evidence from aphasia also supports independent orthographic and phonological representations for the production of words. For example, Shelton and Weinrich (1987) described a patient (E.A.) whose written picture naming was far superior to his spoken naming of the same pictures. Furthermore, E.A.'s ability to perform sublexical sound-to-print conversion was essentially abolished, suggesting that written picture naming was lexically mediated. These and other studies (Miceli et al., 1997; Rapp et al., 1997) support the view that written word production and comprehension are not dependent on intact phonological representations but should be regarded as independent lexical components as depicted in Figures 5-4 and 5-5.

**STIMULUS VARIABLES AFFECTING PATIENT PERFORMANCE**

To this point, our discussion has focused on the effects of processing modality (auditory vs. visual) and type of task in highlighting the symptom dissociations that constrain construction of a model of the lexical–semantic system. Other types of performance dissociations appear to be related to characteristics inherent in the target words that must be produced or comprehended. The effects of these stimulus variables have frequently been interpreted as indicating a potential locus of patients' impairments within the lexical–semantic system.

**FREQUENCY, IMAGEABILITY, AND AGE OF ACQUISITION**

A long-standing clinical maxim is that aphasic word production is affected by word frequency (Hosey, 1964). Frequency effects (found in both normal and aphasic subjects) are typically interpreted as reflecting heightened activation levels or lowered response thresholds for frequent word forms. Recent studies have emphasized the fact that lexical frequency is highly correlated with other variables such as subjective familiarity, age of acquisition, and length (Nickels and Howard, 1995). It is difficult to distinguish statistically the separate effects of these intercorrelated variables (Ellis et al., 1995); however, several recent studies have produced findings indicating that age of acquisition is a more reliable predictor than frequency of naming latencies in normal subjects (Morrison and Ellis, 1995) and of naming success in aphasic speakers (Frey et al., 1988; Nickels and Howard, 1995). In a detailed study of a single anomic patient, Hirsh and Ellis (1994) demonstrated that production of words in spoken naming, written naming, and oral reading was affected by words' rated age.

---

**Figure 5-5. Diagram of a model with separate input and output lexicons for spoken words, and a single orthographic lexicon supporting reading and writing.**
of acquisition, but not by imageability or frequency when age of acquisition was controlled. The authors argue that the age at which words are acquired affects the stability (and vulnerability) of phonological word forms. Since frequency and age of acquisition are highly correlated, it may seem unimportant to determine the relative contributions of each to normal or apraxiaic performance. However, resolution of this issue has important implications for models of lexical processing. Some models of how words are retrieved, for example, postulate a frequency-sensitive search process; others exhibit global frequency sensitivity because of the mechanisms hypothesized to underlie the dynamics of an interactive network (see Morrison and Ellis, 1995, for discussion). The age-of-acquisition findings suggest that words that are learned early have an advantage in normal processing over words that are learned late, and are less vulnerable to brain injury, even when they are not the words used more commonly later in life. This suggests that lexical retrieval mechanisms based on frequency of use, or recency of use, are likely to be incorrect.

The imageability of words' referents is another variable that may affect patient performance in tasks that do not require the testing of "pictureable" words, such as oral reading (Coltheart, 1980), auditory comprehension (Franklin et al., 1994), writing to dictation and repetition (Howard and Franklin, 1988). The typical (and quite common) finding is that words with imageable referents (i.e., "concrete" words) are more likely to be correct than are words that refer to abstract concepts. Highly imageable words are also more likely to have been acquired early in development than less imageable words; this variable has not been systematically investigated in studies of imageability effects.

Unlike frequency, which has been assumed to exert its effects on lexical forms (especially forms in a poor input lesion), imageability effects have been attributed to differences in words' semantic specifications. One hypothesis is that the semantic representations associated with more concrete referents necessarily include a wider range of semantic features that encode distinctions related to different sensory modalities. One effect of the learning of concrete concepts through multiple modalities might be that they are represented in both cerebral hemispheres, whereas most abstract concepts (which are learned primarily in verbal contexts) might be uniquely represented in the left hemisphere (Coltheart, 1980).

Another interpretation of the semantic differences between abstract and concrete concepts is that the latter are simply "richer" in terms of the information represented. This idea has been incorporated into computational models of lexical-semantic processing as a difference in the number of semantic features associated with words—i.e., more imageable (concrete) words are represented by more features (Plaut and Shallice, 1995). These accounts of imageability effects easily accommodate the typical finding that imageable words are more likely to be retained following brain damage, but they do not account for patients who show a reverse concreteness effect (Warrington, 1991; Breedin et al., 1994).

Although only a few patients have been described, they form an important part of a double dissociation based on word imageability/concreteness. The patient studied by Breedin and colleagues (D.M., who suffered from semantic dementia) showed widespread semantic difficulties on clinical testing. He demonstrated significantly better understanding of abstract than concrete words across a range of tasks, including defining words, synonym judgments, and word–picture matching. Further testing suggested that D.M.'s impairment with concrete words was related to poor appreciation of visual–perceptual features. This problem was reflected in his word definitions, in which concrete objects were defined largely without reference to their appearance. For example, carrot was defined as "some kind of food you eat," and ink as "something that covers." In contrast, abstract words (which can be defined without the necessity of visual descriptors) elicited more identifiable definitions: try, "to endeavor to accomplish something"; opinion, "your concept or perspective."

Clearly, as Breedin and colleagues argue, the role of imageability/concreteness in word processing must be complex enough to allow different types of neural input to lead to relatively selective disturbance of either concrete or abstract words; no unidimensional account based on number of semantic features can easily explain both patterns. It should also be noted that the reverse concreteness effect conflicts with results reviewed above, suggesting that the words most likely to be retained in conditions of brain damage are those learned early in life; here, less imageable words, which are generally learned later, are the words that are retained. This conflict may simply reflect the fact that concreteness effects, and age-of-acquisition effects, are operating at different levels of the lexical–semantic system (semantic representations and phonological output representations, respectively). Ultimately, however, a full account of the effects of these variables should incorporate an explanation of all of these phenomena.

**SEMANTIC CATEGORY**

Another variable that has been shown to affect patient performance is the semantic category of target words. Many apraxia batteries include tests that separately sample patients' knowledge of categories such as colors, letters, and body parts (e.g., Cooper and Kaplan, 1983). As should be clear from the discussion thus far, before assuming that semantic category effects are real, it is critical to ensure that words from different categories are matched on other variables that are known to affect performance.

The most robust effect of semantic category to be revealed is the distinction between biological categories and human-made artifacts, usually referred to as the "animate/inanimate" contrast. In a review of this issue, Saffran and Schwartz (1994) listed 13 patients with relative impairment for living things, most of whom suffered from herpes simplex encephalitis affecting (often bilaterally) the temporal lobes. Several additional cases have now been reported. Fewer patients have been described who show a pattern of poorer performance on nonliving things, and their etiologies and correlated lesion sites are more variable (see Saffran and Schwartz, 1994).

The observance of this double dissociation is important because of the particular difficulty of matching the items tested in living/nonliving categories on all of the relevant variables. Funnell and Sheehan (1992) and Stewart and colleagues (1995) have argued that the early studies demonstrating a category-specific deficit for living things failed to match the categories adequately on variables such as familiarity and visual complexity. Such arguments may have some validity, but they do not apply to all relevant cases. For example, Hilis and Caramazza (1991) tested two patients on the same materials and found opposite patterns of selective disturbance for animate vs. inanimate objects. Clearly, both patterns could not arise because of failure to control confounding variables in a single set of stimuli. Assuming, then, that category-specific deficits for living things vs. artifacts are real, what is the implication of this finding for models of lexical–semantic processing? One proposal is that the dissociation reflects differences in the types of features of objects that are most important in their semantic representations (Allport, 1985; Saffran and Schwartz, 1994). Examples of the category living things (animals, plants, etc.) are distinguished primarily by their perceptual properties (color, size, shape, etc.), while members of the category artifact are distinguished primarily by their function. As discussed above, it has been proposed that separate semantic systems are needed to encode semantic features that are tightly linked with specific sensory modalities. The relative impairment of such a sensory-specific semantic system (e.g., "visual semantic") could lead to category-specific effects.

The proposal that the living/nonliving dissociations reflect a distinction between perceptual and functional semantic features was supported by studies that manipulated the extent to which test questions were based on perceptual vs. functional information. For example, Silveri and Gainotti (1988) reported a patient with category-specific deficit for animals who was very poor (1/11 correct) at naming animals on the basis of a visual description (e.g., for zebra: a black and white striped wild horse). Performance improved markedly (3/4 correct) when the probe was a metaphorical expression (for: king of the jungle) or emphasized a distinctive sound and/or function (e.g., for
sheep: the farm animal that bleats and supplies us with wool. Thus, this patient not only shows a category-specific impairment for living things but is particularly impaired for the visual-perceptual characteristics of living things.

The argument that category-specific deficits reflect a brain organization in which certain types of semantic features are tightly linked with specific sensory modalities has considerable appeal. As noted by Saffran and Schwartz (1994, p. 530), the implication of this view is that "information in semantic memory bears the stamp of the channels through which it was acquired"—i.e., semantic features may differ qualitatively on the basis of their links to different sensory modalities. Although it might be expected that such a sensory-based account of semantic deficits might lead to straightforward neuroanatomic correlations for semantic categories, this does not appear to be the case from current lesion data (Damasio, 1990).

A challenge to the sensory-specific semantics view has been mounted by Caramazza and Shelton (1998), who favor a semantic system in which all information is represented in a single propositional format (Caramazza and Shelton, 1998; Shelton and Caramazza, 1999). Caramazza and Shelton report data from a patient (E.W.) with a category-specific impairment for animals who was equally impaired in demonstrating knowledge within that category for visual-perceptual properties ("has four legs?"") and nonperceptual attributes ("lives on land"). Furthermore, E.W. was unimpaired in making visual-perceptual judgments about inanimate objects. The authors argue that previous demonstration of a dissociation between animate and inanimate category impairments and visual-perceptual features had inadequately matched the probe items for difficulty.

Caramazza and Shelton (1998) propose that the categories that have been distinguished in category-specific impairments (animals, plants, and inanimate things) constitute evolutionarily motivated conceptual–semantic domains with dedicated neural circuitry. Within the domains of animals and plants, which have obvious evolutionary significance, concepts will tend to have highly intercorrelated features (i.e., things that have eyes will tend to be self-lumining, will ingest food, etc.) Such intercorrelations among semantic features, it is argued, create a textured semantic network with considerable overlap among features within particular domains. Category-specific impairments arise when brain damage selectively affects specific areas of semantic space.

GRAMMATICAL CLASS

Another important performance dissociation found in aphasia that may be related to semantic category is grammatical class, i.e., the designation of how words are used within the context of a sentence. One of the most obvious contrasts found among aphasic patients involves the dissociation between noun production (good in Broca's aphasics and poor in severe anomic and Wernicke's aphasics) and the production of grammatical function words (poor in Broca's aphasics and good in anomic and Wernicke's aphasics). However, since nouns are generally more imageable than grammatical words, and grammatical words are more frequent than nouns, it is possible that this double dissociation can be reduced to a difference based on these other variables (see, e.g., Ellis et al., 1985, for one argument along these lines). Other explanations for context-function word dissociations implicate syntactic processes and are therefore outside the scope of this chapter (see Berndt, 2001, for discussion).

Another double dissociation based on grammatical class is that between nouns and verbs, which can be matched for other variables that might affect performance. Numerous cases have now been described of patients whose production of nouns is either much better or much worse than their production of frequency-matched verbs in picture naming (Micelli et al., 1984; Zingesser and Berndt, 1990; Berndt et al., 1997b). These results were initially linked to the clinical categories of Broca's aphasia (verbs impaired) and anemia (nouns impaired), which was consistent with neuroanatomic findings suggesting a frontal lobe locus for verb deficits and a temporal lobe locus for noun deficits (Damasio and Tranel, 1993). However, exceptions to the correlations with both clinical category and responsible lesion locus have been reported (Caramazza and Hills, 1991; Berndt et al., 1997a).

LEXICAL-SEMANTIC ASPECTS OF LANGUAGE DISORDERS

Most of the follow-up studies on grammatical class effects have focused on relative impairment of verbs, but it is important that some patients show the opposite pattern of poorer performance with nouns. Thus, it cannot be argued that verbs are simply more difficult, and more vulnerable to brain injury, than nouns, perhaps because of their complex relationships to sentence processing. It is also true that most studies to date have shown selective verb impairments only in production tasks (but see Miceli et al., 1984; McCarthy and Warrington, 1985). Studies that have looked for but failed to find verb impairments in comprehension comparable to those found in production (Caramazza and Hills, 1991; Berndt et al., 1997b) are always subject to the criticism that comprehension tasks (involving forced choice, etc.) may be inherently easier than production tasks.

The status of patients' comprehension of verbs is a critically important issue in evaluating the theoretical importance of modality-specific verb deficits in production. Caramazza and Hills (1991) described two patients with problems producing verbs relative to nouns: only one patient showed a verb-specific impairment only when speaking, and the other, only when writing. Because neither patient demonstrated an apparent problem understanding verbs, the authors argued that the locus of the patients' impairment must be in a component of the lexical–semantic system that is dedicated to only one modality of output, i.e., to the phonological or the orthographic output lexicon in a four-lexicon model such as that shown in Figure 5–4 (Caramazza, 1997). This argument has generated considerable controversy, since grammatical class has typically been viewed as an element of an amodal component of lexical representations (Levelt, 1989; Bock and Levelt, 1994; see Garrett, 1992, for discussion).

Further complicating interpretation of grammatical class effects in aphasia are results indicating that different underlying functional deficits might lead to selective problems with verbs. Breedin and Martin (1996) studied four aphasic patients who had more difficulty naming action than object pictures. The patients were tested with six tasks probing production and comprehension of different aspects of verbs, including elements of their meaning, of the thematic roles associated with different verbs, and of their subcategorization frames. The patients showed distinct impairments across the tasks, suggesting that different aspects of verb representations were affected in different patients. This result suggests that grammatical class impairments may arise for a number of different reasons, and that some of them may also affect comprehension and may be closely linked with the role of the word in sentence processing (see also Berndt et al., 1997a).

CURRENT ISSUES AND FUTURE DIRECTIONS

This review has described some of the components of the lexical–semantic system that appear to be required, based on neurophysiological data. The primary goal has been to use patient data to decide how hypothesized components of this system are organized and interconnected, and at the same time to use the model to interpret a variety of symptom patterns. We have not yet considered important issues regarding the dynamics of this skeletal system, i.e., the direction and chronology of information flow.

Much contemporary psycholinguistic research on this issue characterizes perturbations in information availability during lexical processing as reflections of differences in activation levels across networks of lexical or semantic units, usually referred to as "nodes" (Dell, 1986; Bock and Levelt, 1994). In some cases, such lexical networks have been implemented as computational models so that different processing dynamics can be tested in attempting to model experimental data. Performance patterns found in aphasic patients have been used to test aspects of such models, especially within the domain of word production.

For example, Dell and colleagues (1997) simulated picture-naming error patterns from 21 fluent aphasic patients using a two-step interactive model in which semantic features activate word nodes, which in turn activate the relevant phoneme nodes. Critically, the model allows feedback from later levels (e.g., activa-
tion of phoneme nodes) to influence earlier levels. The parameters of the model were chosen to fit patterns produced by normal speakers, and the model was "simplified" by altering two parameters: global connection weight (which results in an overall decrease in flow of activation spreading through the network) and global decay rate (which increases the rate at which each unit in the network loses activation). Patients' error patterns were simulated by individually fitting these parameters to the data. These parameter values were then used to make predictions about other aspects of patients' errors, about recovery, and about their word repetition pattern. Manipulation of these two parameters successfully reproduced the major characteristics of the error patterns, and most predictions were upheld. However, there is continuing debate about the importance of performance patterns that were not successfully simulated (Foygel and Dell, 2000; Runolfsdottir and Caramazza, 2000).

The view that semantic and phonological information can mutually influence one another, which is instantiated in Dell's interactive activation model, is not shared by all models of lexical production. An opposing view is that word production proceeds strictly serially from semantics to phonology, without the possibility of phonological influences on semantic processing (e.g., Levelt, 1989). Using computational models in which the degree and type of interaction was systematically manipulated, Rapp and Goldrick (2000) evaluated the success of serial and interactive models in accounting for naming data from three aphasic patients. These studies led to the conclusion that, although some degree of interaction appears to be required to account for patients' error patterns, there are also clear limits on the types of interaction that might be allowed. For example, there was compelling evidence for the need for feedback from phoneme nodes to lexical nodes, but considerably less evidence for the need for feedback from word nodes to semantics.

These types of studies can be expected to play an increasingly important role in analyses of the implications of aphasic data. Moreover, the idea that word processing involves distributed networks of nodes specialized for different types of information is consonant with a broad view of language-brain relationships that are emerging from functional neuroimaging studies (see Small and Burton, 2001, for review). In contrast to earlier views in which neural "centers" were dedicated to specific language operations (e.g., comprehension), functional imaging studies suggest that the performance of specific aspects of language is associated with widespread cortical activation. It has frequently been suggested that computational models of cognitive processes that employ interactive networks of nodes constitute "neurobiologically plausible" accounts of information representation, and efforts are now being made to combine functional brain imaging, computational modeling, and behavioral analyses (e.g., Horwitz et al., 1999). This review suggests that such studies need to incorporate detailed consideration of the patterns of word processing impairments that occur following brain damage.

ACKNOWLEDGMENTS
The preparation of this chapter was supported by grants ROI-DK02086 and RO3-DK06099 from the National Institute on Deafness and Other Communication Disorders to the University of Maryland School of Medicine.

NOTES
1. Another type of word form that has been studied is experimental investigation is the graphic-phonemic system of American Sign Language, which is affected by focal brain damage in native users of sign in much the same way as is spoken language in auditory-lexical language users (for a recent review, see Hickok and Binkofski, 2001). Other word forms (e.g., coded signal systems such as Morse code, tactile systems such as Braille, etc.) are also available to some word users.
2. Although such tasks can be very revealing, and in fact are the basis of the studies discussed here, it should be kept in mind that these uses of words are quite divorced from the normal use of words in sentences, in the service of communication.
3. Again, it is important to note that a contracting pattern has been found in some patients with Alzheimer's disease who are better able to name objects from visual presentation than from auditory definitions (Shuman et al., 1991; Laun-Greene et al., 1997). This finding indicates that no simple explanation based on the relative difficulty of object naming or the relative vulnerability of visual processes is a tenable explanation for optic aphasia.

REFERENCES
Clinical Neuropsychology


