

## **How Many Levels of Processing Are There in Lexical Access?**

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The patterns of semantic errors in speaking and writing are used to constrain claims about the structure of lexical access mechanisms in speech and written language production. It is argued that it is not necessary to postulate a modality-neutral level of lexical representation (lemma) that is intermediate between lexical-semantic representations and modality-specific lexical representations. A dual-stage access model is proposed in which the first stage involves the selection of semantically and syntactically specified, modality-specific lexical forms, and the second stage involves the selection of specific phonological (orthographic) content for the selected lexemes.

### **INTRODUCTION**

How are words accessed in language production? Theories of speech production are in agreement on two fundamental points: (1) semantic, syntactic, and lexical form information constitute independent levels of representation, and (2) these levels of representation are probably accessed sequentially in the course of language production. The dominant view is that lexical access involves at least two distinct stages of processing. The first stage involves the selection of a semantically and syntactically specified lexical representation or lemma; the second stage involves the selection of its corresponding lexical-phonological representation or lexeme (e.g. Bock, 1982; Bock & Levelt, 1994; Burke, MacKay, Worthley, & Wade, 1991; Butterworth, 1989; Dell, 1986; Fay & Cutler, 1977; Fromkin, 1971; Garrett, 1975, 1980; Harley, 1984; Kempen &

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Huijbers, 1983; Levelt, 1989; MacKay, 1987; Roelofs, 1992; Stemberger, 1985)<sup>1</sup>. But this is where the agreement ends. On almost everything else, from the nature of the information represented at each stage or level of processing, to the overall number of processing stages, to the manner in which representations are selected, there are substantial disagreements among models. Thus, for example, models differ on whether they assume discrete or interactive stages of processing, whether they assume componential or holistic representations for meaning, whether they assume localist versus distributed representations, and whether or not they assume morphological composition.

Despite, or perhaps because of, the many disagreements, this is a vibrant area of research, and there are a number of active research programmes directed at articulating the structure and content of lexical-phonological representations and their associated access mechanisms (see, for example, Dell, 1986; Dell & O'Seaghdha, 1991; Garrett, 1988; Levelt, 1989; Levelt et al., 1991; MacKay, 1987; Martin, Weisberg, & Saffran, 1989; Meyer, 1990; Shattuck-Hufnagel, 1987; Starreveld & La Heij, 1996; Stemberger, 1990)<sup>2</sup>. Many fewer programmatic efforts have focused specifically on the nature of lemma-level representations, perhaps because semantic theory is not nearly as well developed as phonological theory, and/or perhaps because it is difficult to address questions about the syntactic properties of words by means of the single-word processing tasks typically used in psycholinguistic experiments. Nevertheless, in the last few years a number of efforts have been made to formulate explicit claims about the content and the processing structure of lemma-level representations and to provide experimental evidence on these issues (Bock & Eberhard, 1993; Bock & Levelt, 1994; Jescheniak & Levelt, 1994; Levelt, 1989; Roelofs, 1992, 1993; Schriefers, 1993; see also Garrett, 1992, for a recent review of neuropsychological evidence on this issue).

In this paper, I address the relationship among semantic, syntactic, and word form representations. I address this issue principally from the perspective of

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<sup>1</sup> A similar distinction has been made in the neuropsychological literature in order to explain the dissociation between disorders of lexical-semantic processing and disorders of lexical form retrieval. Most models of the lexical system assume a two-stage retrieval process in which the first stage involves accessing a lexical-semantic representation and the second stage involves accessing modality-specific lexical forms (e.g. Caramazza & Hillis, 1990; Ellis, 1985; Howard & Franklin, 1988; Humphreys, Riddoch, & Quinlan, 1988). This view should not be confused with a superficially similar proposal that distinguishes between cognitive and lexical form systems (e.g. Allport, 1985; Allport & Funnell, 1981). On the latter view, lexical access only involves one stage: The retrieval of lexical forms from nonlinguistic conceptual information.

<sup>2</sup> Although on a much smaller scale, in recent years there have also been a number of attempts to articulate the structure and content of lexical-orthographic representations (see, for example, Badecker, Hillis & Caramazza, 1990; Caramazza & Miceli, 1989, 1990; Jonsdottir, Shallice, & Wise, 1996; Kay & Hanley, 1994; Link & Caramazza, 1994; McCloskey, Badecker, Goodman-Schulman, & Aliminosa, 1994).

cognitive neuropsychology—that is, by considering the language production performance of brain-damaged subjects—but I will also discuss some experimental evidence from normal speech production when relevant. The paper is organised as follows. After a brief review of the arguments and evidence for the distinction between lemma and lexeme levels of representation, I discuss the most influential proposal about the nature of lemma representations. A review of recent experimental evidence concerning the relationship between syntactic features and semantic and phonological information reveals several problems with current formulations of lemma-level representations. The principal part of the paper follows, and it concerns the analysis of semantic errors in naming, reading, and writing tasks by brain-damaged subjects. A crucial aspect of the argument presented here rests on the relationship between phonological and orthographic lexical forms—the principal issue under consideration in this special issue of *Cognitive Neuropsychology*. The implications of the distribution of semantic errors in speaking and writing for the relationship among semantic, syntactic, and word form representations are explored. Finally, I present a model of lexical access that can better account for the major results on lexical access.

## THE DISTINCTION BETWEEN LEMMA AND LEXEME LEVELS OF REPRESENTATION

There are compelling arguments and empirical evidence for distinguishing between at least two levels of lexical representation. For example, the distinction between lemma and lexeme representations provides a natural account for the existence of homonyms: Words that are phonologically and orthographically identical but which differ in meaning and/or grammatical class (e.g. to watch/the watch; the bank [money]/the bank [river]). The relevant distinctions between these words are not at the level of lexical form (since they are identical) but at the level of semantic and syntactic properties. Thus, if we are to capture the lexical distinctions between the members of homonym pairs it has to be at a level other than that of phonological (orthographic) content of the word pairs. But arguments from the structure of language can only take us so far. A processing model will have to be based on empirical evidence concerning language use. Here, too, there is ample evidence in support of a dual-stage model of lexical access (for reviews see Bock & Levelt, 1994; Butterworth, 1989; Dell, 1986; Garrett, 1988, 1992; Levelt, 1989).

Various sorts of data have been cited in support of the lemma/lexeme distinction, including naturally occurring and experimentally induced speech errors or slips of the tongue (e.g. Dell, 1990; Dell & Reich, 1981; Fay & Cutler, 1977; Fromkin, 1971; Garrett, 1975, 1976; Stemberger, 1985). These data are the most extensive and the earliest evidence proffered in support of the two-stage model of lexical access. For example, Garrett (1975, 1976) noted that

the elements that enter in word and sound exchange errors, such as the examples shown in Table 1, are subject to different distributional constraints: Word exchanges tend to involve words of the same grammatical class and occur between phrases, whereas sound exchanges tend to occur in words of different grammatical classes within a phrase. Furthermore, sound exchanges but not word exchanges are usually phonologically similar elements and occur in similar phonological environments. The fact that word exchanges are constrained by grammatical features and not by phonological properties, and the fact that sound exchanges are constrained by phonological and not semantic or syntactic properties, has been taken to indicate that separate lexical access stages are involved in speech production: the first stage retrieves a semantically and syntactically specified representation; the second stage retrieves a phonologically specified representation. This conclusion, aside from debates about whether the two stages are independent or interactive (e.g. Dell & O'Seaghdha, 1991; Levelt et al., 1991), has remained a constant of all models of speech production.

Other evidence cited in support of the lemma/lexeme distinction includes the reaction time data in naming and lexical decision experiments (e.g. Jescheniak & Levelt, 1994; Kempen & Huijbers, 1983; Levelt & Maassen, 1981; Levelt et al., 1991; Schriefers, Meyer, & Levelt, 1990) and the pattern of hesitation phenomena in normal and aphasic speech (Butterworth, 1979, 1980; Butterworth & Beatty, 1978). Perhaps the most intuitively appealing evidence for the lemma/lexeme distinction is the tip-of-the-tongue (TOT) phenomenon—the feeling of knowing a word that is momentarily inaccessible for production (R. Brown & McNeill, 1966; Burke et al., 1991; Jones & Langford, 1987; Kohn et al., 1987; Koriat & Lieblich, 1974; Perfect & Hanley, 1992; Rubin, 1975; and see A.S. Brown, 1991, for review). This phenomenon has been interpreted as reflecting the failure to retrieve a lexeme in the context of successful retrieval of its lemma. And, of course, there is the evidence from aphasia, which shows there are word production disorders that can be attributed to a deficit in lexical-semantic processing (e.g. Gainotti, 1976; Hillis, Rapp, Romani, & Caramazza, 1990; Warrington, 1975) and production disorders for which the deficit can clearly be localised at the level of retrieval of lexical forms

TABLE 1  
Examples of Word and Sound Exchange Errors

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Word exchange errors:	They <i>left</i> and <i>forgot</i> it behind (Garrett, 1988)
	I left the <i>briefcase</i> in my <i>cigar</i> (Garrett, 1980)
	... writing a <i>mother</i> to my <i>letter</i> (Dell & Reich, 1981)
Sound exchange errors:	She's a real <i>rack</i> <i>pat</i> ... (Garrett, 1988)
	It comes down to a choice of <i>stummer</i> <i>sipends</i> ... (Garrett, 1980)
	... <i>lorck</i> <i>yibrary</i> ... (Dell & Reich, 1981)

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in the face of spared lexical-semantic processing (e.g. Caramazza & Hillis, 1990; Howard & Franklin, 1989; Kay & Ellis, 1987). Thus, there is a wide spectrum of evidence consistent with the two-stage model of lexical access.

Although there appears to be substantial agreement among researchers of speech production on the distinction between a lemma and a lexeme level of lexical representation, the content and processing dynamics of lemma representations remain relatively unspecified. Although everyone agrees that lemmas are modality-independent, semantically and syntactically specified lexical representations, there are different ways in which one can implement the distinction between lexical form representations (phonological and orthographic) and modality-independent, semantic, and syntactic representations.

## THE STRUCTURE OF LEMMA REPRESENTATIONS

The clearest proposal concerning the processing structure of lemma representations is to be found in a paper by Roelofs (1992) and subsequently adopted by Bock and Levelt (1994) and Jescheniak and Levelt (1994). Their model distinguishes among three levels of representation (see Fig. 1): the conceptual, the lemma, and the lexeme levels. The conceptual level represents lexical concepts as unitary nodes in a conceptual network. The meaning of a word is given by the set of labeled connections between a concept node and other nodes in the network. Each lexical concept node is connected to a lemma node; lemma nodes are modality-independent units that are connected to a set of syntactic nodes specifying such properties as grammatical class (Noun, Verb, etc.), gender, and auxiliary type (be or have). Each lemma node is connected to a lexeme node which, through its connections to segmental nodes, specifies the phonological (and orthographic) form of a word. In Fig. 1, the lexical concept [TIGER] is connected to its Italian lemma node {tigre}, which is connected to the category node N(oun) and the gender feature F(eminine), and, in turn, the lemma node is connected to its lexeme /tigre/. Lexical access in this model is represented by the sequential selection of lemma (and hence the syntactic features that define a word) and lexeme nodes through spreading activation emanating from the lexical concept node.

Several properties of this model should be stressed for present purposes. First, word meaning is represented by unitary concept nodes, with each node connected to only one lemma node. Spreading activation from the concept node only activates its corresponding lemma node. However, spreading activation within the conceptual level from the concept node to connected nodes (e.g. ANIMAL, STRIPES, WILD, etc.) will result in the partial activation of the latter nodes and, consequently, the weak activation of their corresponding lemma nodes. Second, the selection of a word's lemma node is tantamount to the selection of the syntactic nodes/features that define that word. And, third, the selection of a lexeme is mediated by the selection of the word's grammatical

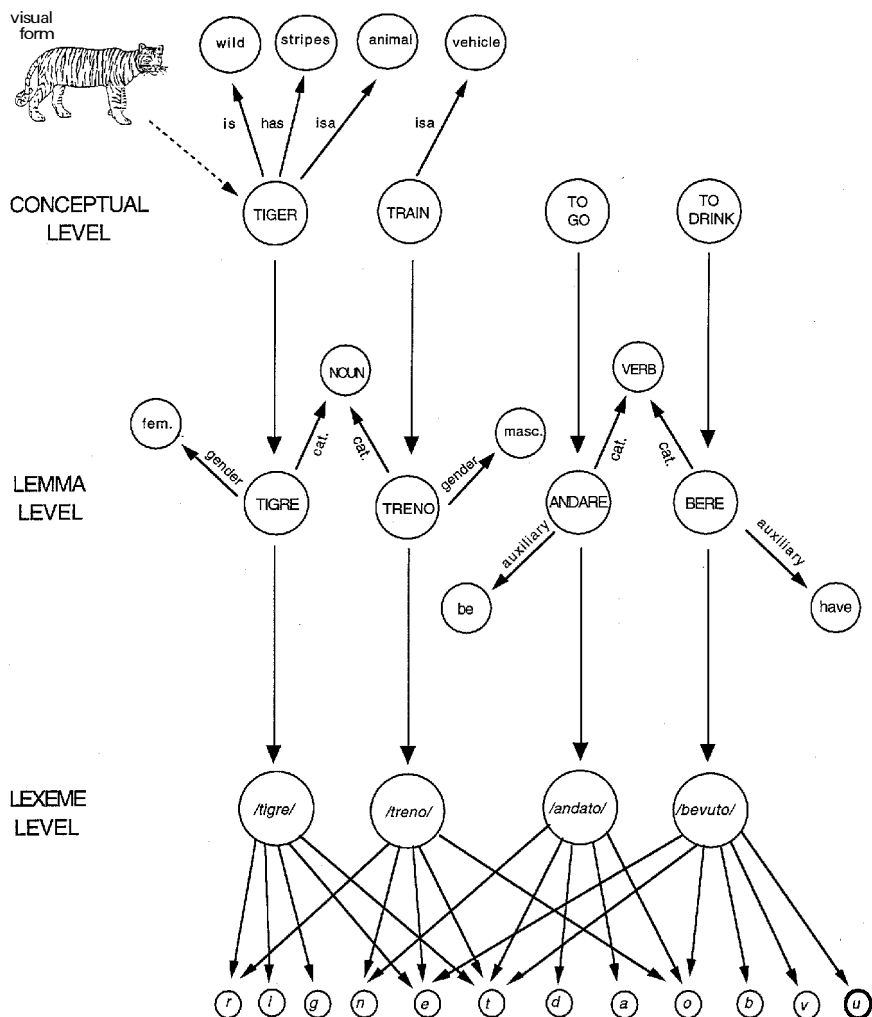


FIG. 1. Part of the lexical system showing the relation between lemma and other levels of lexical representation: The "Syntactic Mediation" hypothesis (see text). The lemma and lexeme levels show the Italian words for the lexical concepts TIGER, APPLE, TO GO, and TO DRINK. (Adapted from Bock & Levelt [1994], Jescheniak & Levelt [1994], and Roelofs [1992].)

features. Given the centrality of syntactic information in defining the structure of lemmas and in accessing lexemes, I will call this model of the structure of lemmas the "syntactic mediation" (SM) hypothesis.

In various papers, Dell (1986, 1990; Dell & O'Seaghdha, 1991) has proposed an interactive network model with a very similar hierarchy of lexical levels to that proposed by Bock and Levelt (1994), Jescheniak and Levelt (1994), and

Roelofs (1992). Dell (1990, pp. 331–332) draws a similar distinction among semantic, lemma, and lexeme representations: “The lemma node represents the lexical item as a syntactic/semantic entity. It corresponds to Dell’s (1986) ‘word node’ and is assumed to connect directly to conceptual structure and to syntactic information. Below that, the lexeme node is a single unit representing the phonological form of the word. This corresponds roughly to the morpheme node and/or to the set of syllable nodes in Dell (1986) and MacKay (1982). The lexeme node connects to phonological segments (. . .).” However, this model differs from that of Levelt and collaborators on at least two crucial points: (1) in Dell’s model, word meanings are represented in componential form, and (2) the stages of lexical processing are not discrete but interactive. Nonetheless, for present purposes, the two models make a common assumption: There is a level of representation, lemma, that is distinct from lexical-semantic and from lexical-phonological information<sup>3</sup>.

The modality-neutral lemma hypothesis—a hypothesis shared by Roelofs’ discrete stage model and Dell’s interactive model—predicts that retrieval of syntactic information is necessary for the successful retrieval of lexemes. However, reviews of experimental results with normal subjects in tasks requiring access to syntactic and word form information and of the performance of brain-damaged subjects with selective deficits in word production raise considerable difficulties for this hypothesis. I will argue that there are grounds for rejecting the hypothesis that a modality-neutral lemma node intervenes between lexical-semantic representations and word forms. However, I will also argue that there are equally compelling grounds for the autonomy of syntactic information from semantic and word form representations. These seemingly conflicting conclusions will be reconciled in a new model of the processing structure and organisation of lexical knowledge.

## THE INDEPENDENCE OF SYNTACTIC FROM SEMANTIC AND WORD FORM INFORMATION

The neuropsychological literature is replete with evidence about the crucial role of syntactic information in the organisation of lexical knowledge. The most celebrated dissociation is that between closed- and open-class words (or function and content words). Although principally discussed in the context of agrammatic and paragrammatic speech performance (e.g. Buckingham & Kertesz, 1976; Goodglass, 1976), the dissociation can also be seen in single-

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<sup>3</sup> Parenthetically, it should be noted that it is not obvious that Dell can maintain both that there are interactions between semantic and phonological levels, which he needs to explain the results showing that word substitutions are affected by both semantic and phonological similarity (Dell & Reich, 1981), and that there is a modality-neutral level of representation, lemma, intervening between lexical-phonological and semantic representations.

word processing tasks in the context of diverse clinical pictures (Andreewsky & Seron, 1975; Caramazza, Berndt, & Hart, 1981; Gardner & Zurif, 1975; see also papers in Coltheart, Patterson, & Marshall, 1980). Thus, for example, two acquired dyslexic subjects—RG (Beauvois & Dérouesné, 1979) and AM (Patterson, 1982)—could read most (>92%) content words correctly, including abstract words, but showed considerable difficulty (only 70% correct) in reading function words.

The other major grammatical class dissociation is between nouns and verbs (e.g. Berndt, Mitchum, Haendiges, & Sandson, 1997; Caramazza & Hillis, 1991; Damasio & Tranel, 1993; Daniele, Giustolisi, Silveri, Colosimo, & Gainotti, 1994; De Renzi & di Pellegrino, 1995; Hillis & Caramazza, 1995; Kremin & Basso, 1993; McCarthy & Warrington, 1985; Miceli, Silveri, Villa, & Caramazza, 1984; Miceli, Silveri, Nocentini, & Caramazza, 1988; Zingeser & Berndt, 1988). There are a number of reports of brain-damaged subjects who show a selective difficulty in producing nouns in the context of relatively spared ability to produce verbs, and those who show the opposite pattern of relative difficulties with these two classes of words. Thus, for example, De Renzi and di Pellegrino (1995) have described a subject with a frontotemporal lesion who showed a selective *sparing* of verbs. For example, in an oral spelling task he correctly produced over 93% of verbs but only about 45% of nouns and 40% of function words. His difficulties with words of other grammatical classes could not be ascribed to a deficit in processing concrete words (Breedin, Saffran, & Coslett, 1994; Warrington, 1975) because he showed no advantage for this type of words within grammatical classes. And function words, which are at least as abstract as any verb, fared no better than concrete nouns. It would seem that the effect is purely grammatical in nature.

The existence of these grammatical class dissociations implies that syntactic information is one of the dimensions along which the lexical system is organised. However, they do not establish precisely where in the lexical system syntactic information is represented, nor do they clearly specify the relation of syntactic to semantic and word form representations. Particularly relevant for the latter purpose is the performance of brain-damaged subjects who show selective difficulties in producing words of one grammatical class in only one modality of output (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Rapp & Caramazza, 1997; Rapp, Benzing, & Caramazza, 1995). For example, subject SJD showed severe difficulties writing the very verbs that she could easily produce orally. In written and oral production tasks with homonyms (e.g. to watch/the watch) she correctly produced both the noun and verb forms in speaking but was only able to write the noun forms correctly (Caramazza & Hillis, 1991). Other examples of modality-specific grammatical class effects include subjects who show double dissociations of grammatical class by modality. Thus, EBA (Hillis & Caramazza, 1995) showed a selective deficit in recognising written forms of verbs, but a selective difficulty in producing nouns



orally; KSR (Rapp et al., 1995) was selectively impaired in producing nouns in speaking, but verbs in writing; and PW (Rapp & Caramazza, 1997) has difficulties producing closed-class words in writing and open-class words in speaking. The striking commonality in these cases is the remarkable specificity of the disorder—the deficit involves words of a specific grammatical class in only one modality of output (or input).

These selective grammatical class deficits, restricted to either oral or written production, provide the evidence we need to argue that syntactic knowledge is represented independently of both lexical-semantic and word form information. We reason as follows: The fact that the deficit is restricted to one modality of output implies that the lexical-semantic system is intact; furthermore, given that the lexical-semantic system is intact and given that the impairment in these subjects is limited to one grammatical class, jointly imply that the deficit must concern a syntactic level of representation. Thus, we are led to conclude that lexical-semantic and syntactic information are represented independently.

Evidence for the autonomy of syntactic from word form information is found in the performance of anomic subjects who are able to provide information about the syntactic features of words they are unable to produce. Thus, for example, Henaff Gonon, Bruckert, and Michel (1989) described a French-speaking anomic patient who could correctly provide the grammatical gender (13/14 correct) of the nouns he failed to produce in various naming tasks. A more systematic investigation of this type of dissociation has recently been reported by Badecker, Miozzo, and Zanuttini (1995). These investigators described the performance of an anomic subject, Dante, who despite his inability to produce the names of objects, or even guess the first or last phoneme in a two-phoneme, forced-choice task, was virtually always able to recall their gender correctly. In a more recent investigation of the same subject (Miozzo & Caramazza, *in press b*), the dissociation between the retrievability of syntactic and word form information has been extended to verbs. Dante was shown to be able to provide correctly the auxiliary form of a verb (be or have) he was unable to retrieve: He correctly recalled the auxiliary of verbs he could not name in 99% of the trials, but was exactly at chance level in guessing the initial phoneme of the word. These results clearly show that a word's syntactic features are represented independently of its form, thereby permitting their independent access. However, they leave unanswered the question of how syntactic features are activated and how they are related to semantic and phonological information. Thus, for example, do syntactic features mediate between semantic and phonological information as proposed by the SM hypothesis? Tentative answers to this question are provided by normal subjects' ability to retrieve gender and phonological information in TOT states.

In a series of experiments (Caramazza & Miozzo, 1997; Miozzo & Caramazza, *in press a*), we addressed the question of whether the availability of syntactic and phonological information are correlated in TOT states. For this

purpose we compared subjects' relative ability to retrieve grammatical gender and the initial phoneme of words in TOT states. Grammatical gender is a syntactic feature of nouns that, in Italian, is not deducible from their meaning. In several experiments, we were able to show that subjects are able to retrieve both the grammatical gender and the initial phoneme of words in TOT states with well above chance-level accuracy but that performance for the two features is uncorrelated. These results demonstrate that, contrary to the SM hypothesis, access of a word's phonological features does not strictly depend on the prior access of its syntactic features<sup>4</sup>.

Converging evidence in support of the claim that access of a lexeme representation does not require successful access of its syntactic features can be found in a recent series of experiments by Jescheniak and Levelt (1994). In a study designed to explore the locus of the frequency effect in speech production, they had Dutch subjects either name a picture (Expt. 1) or make a gender decision about the name of the picture (Expt. 4). The results of the experiments are very clear: The frequency effect remains over repeated trials in the naming condition, but is not sustained in the gender decision task. In the gender condition they obtained a clear "priming" effect: It appears that once gender is retrieved, its subsequent retrieval is independent of the word's frequency. For present purposes, the important result concerns a further manipulation introduced by Jescheniak and Levelt. They wanted to determine whether the gender priming effect they observed in Expt. 4 depended on the retrieval of the lexeme or whether the direct retrieval of gender information was required. Clearly, if retrieval of a word's lexeme requires the prior selection of (all) its syntactic features, then the retrieval of the lexeme should lead to gender priming because gender, too, has been selected. To address this issue, they carried out the following two experiments. In Experiment 5a, they first gave subjects two blocks of naming trials followed by two blocks of a gender decision task with the same items; in Experiment 5b, they had the same arrangement of blocks of naming and gender decision trials but this time the naming task required subjects to produce the full noun phrase (article + noun)

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<sup>4</sup> This conclusion may be too strong. It is entirely possible that there are fundamental differences in the way in which different grammatical features of a word are represented and accessed. Thus, for example, we might want to distinguish between what I will call "intrinsic" and "extrinsic" grammatical features. The former, intrinsic features, refers to those properties that are inherently associated with a word (e.g. grammatical class and gender); the latter, extrinsic features, refers to those grammatical properties that are contextually determined (e.g. number and tense). And within the set of intrinsic features, we may want to distinguish between the more and the less arbitrary features: "gender" is a purely arbitrary feature; "noun" is not nearly as arbitrary given the meaning of the word. It may turn out that the accessibility of the different types of grammatical features for any one word is not uniform.

in naming objects. Facilitation in the gender task was only obtained in Experiment 5b. That is, facilitation in the gender decision task was only obtained when the preceding trials required subjects to retrieve gender information explicitly; the mere retrieval of a word's lexeme (Expt. 5a) did not facilitate access to its gender information. These results suggest that phonological information can be accessed "independently" of grammatical information, and may even imply, contrary to the interpretation preferred by Jescheniak and Levelt, that the selection of a lemma does not lead "automatically" to the activation of its associated grammatical features.

There is also indirect evidence from the spontaneous speech of brain-damaged subjects that is consistent with the claim that lexemes can be accessed without correct access to their gender features. These subjects make syntactic agreement errors despite their ability to retrieve the phonological form of words. For example, the Italian speaker, FS (Miceli & Caramazza, 1988) produced utterances such as the following: "Poi io ascolto *il* (masculine singular) *televisione* (fem. singular)—then I listen [to] the television"; "... perché *il* (masc. sing.) *giornate* (fem. plural) [sono] *lungo* (masc. sing.)—... because the days are long." In this example, FS correctly retrieved the lexemes *televisione* and *giornate* but not the gender information needed to select the correct article (*la* and *le*, respectively) and the proper inflection on the adjective (*lunghe*, in this case). These examples suggest the possibility that the retrieval of lexemes may be spared in the face of damage to grammatical features.

A similar case has been described by Cubelli and Perizzi (1996). They report a patient who produced utterances such as "Il nonno è seduto *sul* (masc. sing.) *panchino* (neologism)"—the grandfather is seated on the bench—instead of "Il nonno è seduto *sulla* (fem. sing.) *panchina* (fem. sing.)"; and "La palla è sotto *il* (masc. sing.) *sedio* (neologism)"—the ball is under the chair—instead of "La palla è sotto *la* (fem. sing.) *sedia* (fem. sing.)". This case, too, clearly demonstrates that the phonological representation of a word (albeit deformed) can be accessed despite access of the wrong syntactic features.

The final example I will consider here concerns a subject who made article/noun agreement errors involving the mass/count distinction (Semenza, Mondini, & Cappelletti, 1995). This subject produced utterances such as "Nella cucina c'è sempre *una panna*"—In the kitchen there's always one cream; instead of "Nella cucina c'è sempre *della panna*"—In the kitchen there's always some cream; and "*Una farina* nel sacco (. . .)"—one flour in the bag . . . ; instead of "*La farina* nel sacco (. . .)"—The flour in the bag . . . . These examples demonstrate that the subject could correctly access the phonological representation of words despite the occasional failure to access (some of) their syntactic features.

In short, the agreement errors produced by the three cases briefly reviewed here suggest that access of a word's syntactic features is not required in order to activate its lexeme.

## INTERIM SUMMARY

There is ample evidence in support of two-stage models of lexical access. None of the results I have reviewed challenges this view of the lexical system. To the contrary, the results further confirm the validity of distinguishing between a level of processing where word forms are represented and a level or levels of processing where lexical-semantic and syntactic information are represented. However, the evidence also indicates that access to a word's lemma level does not automatically lead to access of its syntactic features (Jescheniak & Levelt, 1994; Miozzo & Caramazza, *in press a*). Although the latter results are problematic for the view that syntactically specified lemma representations mediate access of lexical forms, a seemingly simple modification of the model could easily accommodate the recalcitrant results we have reviewed.

The proposed modification may be readily understood by considering the schematic representation of the model shown in Fig. 1. The model postulates the existence of autonomous lemma nodes that are directly activated by their corresponding lexical concept nodes; the lemma nodes, in turn, activate their corresponding lexeme nodes. In the original formulation of the model, the activation of the lemma node automatically spreads to its associated syntactic nodes. In this model, selection of a lemma node entails the selection of a set of syntactic features. If one drops the assumption that the selection of the lemma node implies the selection of its syntactic features and assumes instead that the selection of the lemma node merely makes it possible for the subsequent, but not necessary, selection of syntactic features, then, it might be possible to accommodate the observation that access of a word's phonological features does not presuppose access of its syntactic features. The modification entertained here essentially argues that selection of lemma is formally independent of the selection of its syntactic features. This move saves the syntactic mediation hypothesis but renders the motivation for postulating an autonomous lemma node less than compelling. The original motivation for assuming an autonomous lemma level was to capture at once the autonomy of syntactic information and the dependence of lexeme representations on their syntactically specified lexical representations. If one were to abandon the assumption that access to the lemma node entailed the automatic selection of its syntactic features, it would be unclear why one would want to have such a node in the first place—its role would have been reduced to a contentless waystation to syntactic and phonological representations: The lemma node would have been rendered superfluous.

Putting aside these considerations and granting for the moment the plausibility of the new formulation of the organisation and processing structure of the lemma level, there are empirical reasons for rejecting the postulation of a contentless lemma node. The evidence comes from the contrasting patterns of lexical production errors in speaking and writing. These data have not pre-

viously been given due consideration in the development of models of lexical access (but see an excellent review in Garrett, 1992). But, as I hope to show in what follows, the analysis of the contrasting patterns of performance in the selection of phonological and orthographic lexical forms in brain-damaged subjects can help reduce the range of plausible theories of lexical access.

In order to use lexical access performance in spelling tasks to constrain claims about the processing structure of the lemma and lexeme levels of representation, it must first be established that the relation of lemma to orthographic word forms is direct and *not* mediated by access of their corresponding phonological forms. In other words, it must first be demonstrated that access of orthographic lexemes (O-lexemes) occurs independently of access of phonological lexemes (P-lexemes) (see Fig. 2 for a schematic representation of the two hypotheses). The reason for this preliminary step in evaluating the evidence from written language production is simple: If spelling is mediated by phonology, then spelling performance will not directly reflect the interaction between lemma and lexical form access, but the complex interaction between lemma and P-lexemes and between P-lexemes and O-lexemes. However, if it could be established that access of O-lexemes is not mediated by the prior access of their associated P-lexemes, then we would be able to use lexical errors in written production to inform theories of the relation between lemma and lexeme levels of representation<sup>5</sup>.

## THE AUTONOMY OF LEXICAL-ORTHOGRAPHIC REPRESENTATIONS

Arguably, the clearest evidence for the autonomy of orthography in language production comes from the neuropsychological literature. If written production is phonologically mediated, we would expect that damage to the phonological system should necessarily result in deficits in written language production. However, it has been observed repeatedly that the ability to spell is often preserved even though phonological production is severely impaired (e.g. Alajouanine & Lhermitte, 1960; Assal, Buttet, & Jolivet, 1981; Basso, Taborrelli, & Vignolo, 1978; Caramazza, Berndt, & Basili, 1983; Ellis, Miller, & Sin, 1983; Hanley & McDonnell, this issue; Hier & Mohr, 1977; Lecours & Rouillon, 1976; Lhermitte & Dérouesné, 1974; Patterson & Shewell, 1987; Shelton & Weinrich, this issue). Although this dissociation has often been interpreted as sufficient evidence for the hypothesis of phonologically unmediated (direct) access of O-lexemes (e.g. Allport & Funnell, 1981), this conclusion would only be warranted if it could be shown that the deficit in speech

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<sup>5</sup> This conclusion does not entail that the relation between the lemma level and the corresponding P-lexeme and O-lexeme levels must be identical. However, it is more parsimonious to begin with this assumption.

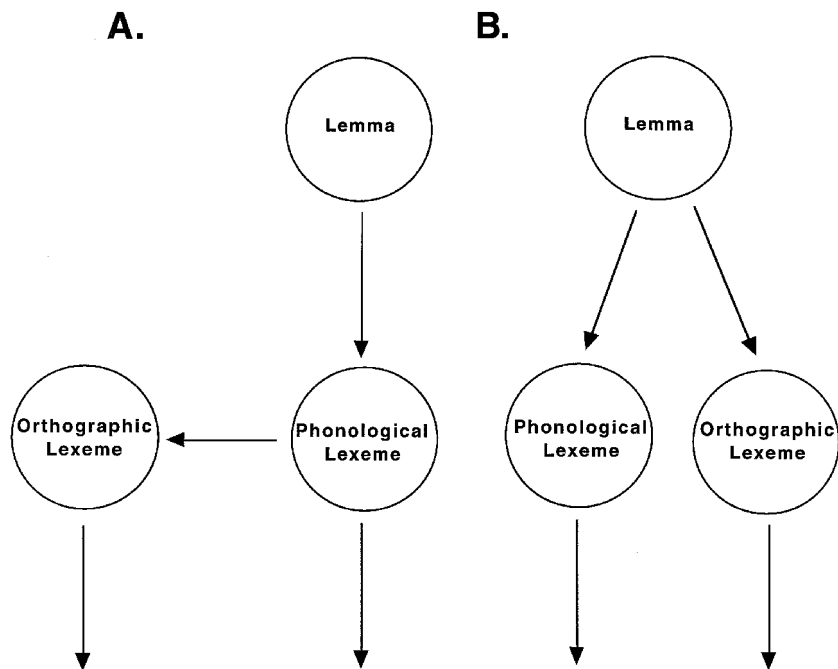


FIG. 2. Schematic representation showing the relation between lemma and lexeme representations. Panel A shows the phonological mediation hypothesis; panel B shows the orthographic autonomy hypothesis.

production was not the result of damage to post-lexical phonological processes but of damage directly to the phonological lexicon. Otherwise, it could be argued that O-lexeme access is mediated by P-lexeme access and that the observed impairment in speech production was merely the result of damage to post-lexical phonological processes. However, there are a number of results that are not subject to these reservations. The clearest examples are those where brain-damaged subjects make semantic errors in oral naming but not in written naming (e.g. subjects RGB and HW: Caramazza & Hillis, 1990) or semantic errors in written naming but not in oral naming (e.g. subject SJD: Caramazza & Hillis, 1991). The production of lexical (semantic) errors indicates a lexical as opposed to a post-lexical process as the locus of damage; the fact that the semantic errors occur in only one modality of output indicates that P-lexemes and O-lexemes are activated independently by their lemma-level representations. In other words, the fact that subjects RGB and HW were able to retrieve the correct lexical form in writing despite the production of semantic errors in speaking demonstrates that access of O-lexemes is not mediated by

prior access of P-lexemes (see also Hanley & McDonnell, this issue; Shelton & Weinrich, this issue; and Rapp & Caramazza, 1997, for discussion of other relevant evidence).

One other type of evidence in support of the orthographic autonomy hypothesis is the observation of different oral and written semantic errors in response to the same object in double, sequential naming tasks. WMA (Miceli, Benvegnù Capasso, & Caramazza, this issue) and PW (Rapp, Benzing, & Caramazza, this issue) produced semantic errors both in speaking and in writing. Crucially for present purposes, in double naming tasks they produced inconsistent lexical responses in oral and written naming of the same picture—for example, they might produce a correct response in writing followed by a “don't know” or a semantic error in oral naming—and they occasionally produced different semantic errors in oral and written naming. For example, in response to a picture of tweezers, PW orally named it “pliers,” wrote “needle,” and then orally named it again “pliers.” Similarly, the Italian subject WMA, in response to a picture of a cook (*cuoco*) said “*pietanza*” (dish) but wrote “*forchette*” (forks), and in response to a picture of peppers (*peperoni*) wrote “*tomato*” (*pomodoro*) but said “*carciofo*” (artichoke). These patterns of performance undermine the phonological mediation hypothesis of written language production, and they suggest instead that lemma representations independently activate their associated O-lexeme and P-lexeme representations. Thus, we can safely proceed to interpret the implications of contrasting patterns of P-lexeme and O-lexeme selection errors for models of lexical access and, more specifically, for theories of the structure of lemma-level representations.

## DISPENSING WITH THE CONTENTLESS LEMMA NODE

The evidence that will be used for this purpose is the pattern of dissociations of lexical errors in speaking and writing. There are several steps to the argument. I begin by briefly summarising the relevant facts.

As already noted, there are brain-damaged subjects who make semantic errors in only one modality of output. The deficit in these patients can be located unambiguously in the language production system at a stage beyond the lexical-semantic level. Especially convincing in this regard is the fact that when subjects were asked to read aloud and define words, they often made semantic errors in oral reading but invariably went on to provide the correct definition (Caramazza & Hillis, 1990). For example, HW read the word *pirate* as “money” but then went on to define the word she was supposed to read as “Has a thing over its eye . . . I would say that they don't have any anymore, but they do in business. He wants your money and your gold.” And RGB read *pharmacist* as

“drugs” and went on to define the stimulus as “He gives you your prescriptions.” Observations such as these, together with the fact that subjects performed virtually flawlessly in various comprehension tasks, confine the deficit to output processes. More important for present purposes is the observation that semantic errors were restricted to one modality of output. This implies that lemma-level representations were correctly activated. That is, since subjects could consistently select the correct lexemes in one modality of output it follows that their associated lemmas must have been correctly accessed, or it would not have been possible to produce the correct lexemes in the first place. A further relevant observation is that their semantic errors occurred in the context of unimpaired post-lexical processes. Thus, for example, HW only occasionally produced an articulatory error; RGB spoke fluently and without phonological or articulatory errors; and SJD only rarely made spelling errors. In all three cases, their errors consisted of fluently produced semantic substitutions. These facts rule out a post-lexical deficit as a determinant of the contrasting patterns of performance in oral and written naming. Thus, the locus of damage in these subjects is at a point between the correctly selected lemma-level representations and their modality-specific lexeme representations.

Having confined the possible locus of damage in subjects HW, RGB, and SJD to a point between the lemma and the lexeme levels of representation, we are confronted with a puzzle: If the correct lemma has been selected, how can the inaccessibility of a modality-specific lexeme result in a *semantic* error? It is not immediately apparent how models that postulate a “contentless” node between lexical-semantic and lexeme levels of representation can account for the occurrence of semantic errors in a single modality of output. That is, it is not clear what happens when a correctly selected lemma node fails to activate either its P- or O-lexeme. Since the lemma node has a discrete, one-to-one relationship to its P- and O-lexemes, the expectation ought to be that failure to activate one of its modality-specific lexemes would result in the absence of a response and not in the production of a semantic error. Nonetheless, although it does not flow naturally from its basic architecture, the lemma-as-abstract-node hypothesis could be made to account for the modality-specific semantic errors as follows.

It could be argued that damage to the connections between lemma and lexemes in one modality leads to the reselection of another lemma because of spreading activation within the conceptual system. The chain of events might be as follows: the correctly selected lexical concept activates the correct lemma, leading to its selection; the correctly selected lemma activates its associated P- and O-lexemes; if one of these lexemes cannot reach threshold because of damage within that level of representation, a different lexical-concept node is selected from among the set of nodes that have become activated by the spreading activation from the originally selected lexical-concept node; the newly selected lexical-concept node will activate its associated lemma node,



and so on. The way in which the abstract lemma hypothesis can motivate the reselection of another lemma is by proposing that this process is undertaken whenever the appropriate lexeme node does not reach threshold.

This account is further strained when we consider the performance of subjects WMA (Miceli et al., this issue) and PW (Rapp et al., this issue), who make different oral and written semantic errors in naming the same object. Here the story would take the following form: The reason a semantic error is made in one modality is, as previously discussed, because the target lexeme in that modality could not reach threshold and therefore a new cycle of lexical selection beginning with a related lexical-concept node would have to be undertaken. To explain the production of a semantic error in the other modality we would have to argue that in that modality, too, the target lexeme could not reach threshold and therefore yet another cycle of lexical selection would have to be undertaken for production in that modality. What has to be explained, however, is why a different lexical concept is selected the second time. We know that the reason for this is not because the process of selection of alternative lexical concepts from one trial to another is random. This is shown by the fact that consecutive responses in the same modality always resulted in the same response—it was only across modalities that different lexical responses were produced to the same stimulus. Thus, the selection of a different semantically related lexeme must be due to the failure to select successfully the other modality lexeme of the previously selected lemma. An example should make this clear. Subject PW produced the following sequence of responses to a picture of tweezers: “pliers,” “needle,” and “pliers,” in oral, written, and oral production respectively. To explain this performance we would have to assume that the P-lexeme representation /tweezers/ could not reach threshold and consequently the next lexical-concept node selected was “pliers.” This cycle could be brought to completion because the P-lexeme /pliers/ could reach threshold and was selected. We would then have to argue that in trying to write the name of tweezers, PW again selected the lexical-concept node correctly and proceeded as before, only to encounter difficulty in selecting the O-lexeme for tweezers. At this point we would expect that the same alternative lexical-concept node as the one selected in the previous trial (pliers) would again be selected (as in within-modality consecutive trials). But since the subject produced a different semantic error in writing, we must assume that the O-lexeme for “pliers” could not reach threshold and therefore a completely new cycle of lexical selection had to be undertaken. In the new cycle the lexical-concept node “needle” was selected and this time the cycle could be brought to completion.

The two cases considered here do not constitute knock-down arguments against the abstract lemma hypothesis. And it might even be argued that it has been shown that the abstract lemma hypothesis is able to account for the supposedly recalcitrant results. However, the way in which the model has been forced to account for the results provides the most compelling argument against

the hypothesis. The explanation proposed for the contrasting patterns of semantic errors across modalities of output gives absolutely no role to the abstract lemma node. Had we completely omitted all mention of this node, we would have produced a formally equivalent argument. That is, the burden of explanation for the existence of contrasting semantic errors in oral and written naming was completely carried by the “interaction” between lexical-semantic and lexeme representations. Thus, once again, we find that the notion of an abstract lemma node may be quite superfluous.

To this point I have presented various results and arguments against the lemma-as-abstract-node hypothesis. Singly, each observation or argument may be insufficient to reject this hypothesis since each observation may be challenged or alternative interpretations offered. However, the combined weight of all the evidence is not easily dismissed on one pretext or another, and is sufficient to raise profound scepticism about the explanatory value of the hypothesis. This scepticism about the validity of the syntactic mediation hypothesis of lemma-level representation encourages the consideration of alternative forms of organisation of the lexical system. One such possible alternative is considered next.

## THE INDEPENDENT NETWORK MODEL OF LEXICAL ACCESS

The Independent Network (IN) model of the lexicon assumes that lexical knowledge is organised in sets of independent networks connected to each other by a *modality-specific lexical node*. The lexical-semantic network represents word meanings as sets of semantic properties, features, or predicates. The lexical-syntactic network represents a word's syntactic features such as grammatical category, gender, auxiliary type, tense, and so on. The nodes in this network are organised in subnetworks corresponding to the different syntactic functions. Thus, there is a subnetwork consisting of category nodes (N, V, etc.); one consisting of gender nodes (M, F); one consisting of auxiliary types (be, have); and so on. Nodes within a subnetwork have inhibitory links since they are in competition. The P- and the O-lexeme networks consist of the modality-specific representations of lexical items (more specifically, lexical stems). Nodes in these networks are also linked inhibitorily since they are in competition.

The production of a word involves the following sequence of events. A selected lexical-semantic representation propagates activation toward the lexical-syntactic and the P- and O-lexeme networks<sup>6</sup>. Not all syntactic features can be activated by the semantic network. For example, with the exception of

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<sup>6</sup> The lexical-syntactic network also receives input from outside the lexical system—from sentence generation mechanisms. However, these inputs will not be considered here.

natural, gender-marked words (e.g. uomo [man] in Italian), gender features do not receive activation from the semantic network. However, grammatical category and verb tense features, for example, do receive activation from the semantic network (see footnote 4, p. 186). Under normal circumstances the activation of syntactic nodes from the semantic network<sup>7</sup> is *not* sufficient for a grammatical feature to reach threshold. Selection of the full set of grammatical features of a word requires the prior activation and selection of the modality-specific lexical node.

Activation and selection of a modality-specific lexical form (P- and O-lexemes) results in activation of its associated phonological and orthographic properties. Thus, in this model, the selection of grammatical features typically occurs temporally prior to the selection of the specific phonological and orthographic content of a word<sup>8</sup>. However, since the selection of the lexeme node does not depend on the prior selection of its associated syntactic features, the phonological and orthographic content of the lexeme nodes may, under special circumstances (e.g. TOT states, brain damage), become available independently of their grammatical features. A schematic representation of the IN model is shown in Fig. 3.

The IN model shares many properties with other models of the lexical system: lexical-semantic information is represented independently of syntactic and word form representations as in the models proposed by Bock and Levelt (1994), Dell (1990), and Roelofs (1992); lexical-semantics is componential as in Butterworth (1989) and Dell (1986), but unlike Garrett (1992), Jescheniak and Levelt (1994), and Roelofs (1992); it is a forward activation model as in Butterworth (1989) and Roelofs (1992), but unlike Dell (1986) and Stemberger (1985); however, unlike all previous models, the activation from the selected lexical-semantic representation spreads simultaneously and independently to the lexical-syntactic and the word-form networks. Furthermore, unlike these earlier models it does not postulate a modality-neutral lemma representation; instead, it only postulates direct links between lexical-semantic representations and modality-specific (phonological and orthographic) lexical representations. The latter representations may be called phonological lexemes (P-lexemes) and orthographic lexemes (O-lexemes), if we wanted to stress the modality-specific nature of the representations, but they could also be called phonological lemma (P-lemma) and orthographic lemma (O-lemma), if we wanted to stress the fact

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<sup>7</sup> We can think of the effect of the activation propagated from the semantic network to the syntactic feature network as a form of priming of the target features that will eventually be selected when additional activation is provided by the lexeme node.

<sup>8</sup> The fact that the model assumes that syntactic nodes reach threshold before lexeme-level representations does not mean that subjects should be able to "report" syntactic information more rapidly than word form information. Whereas the production of word forms is a natural function of the lexical system, the metalinguistic task of reporting syntactic features may be quite difficult and slow.

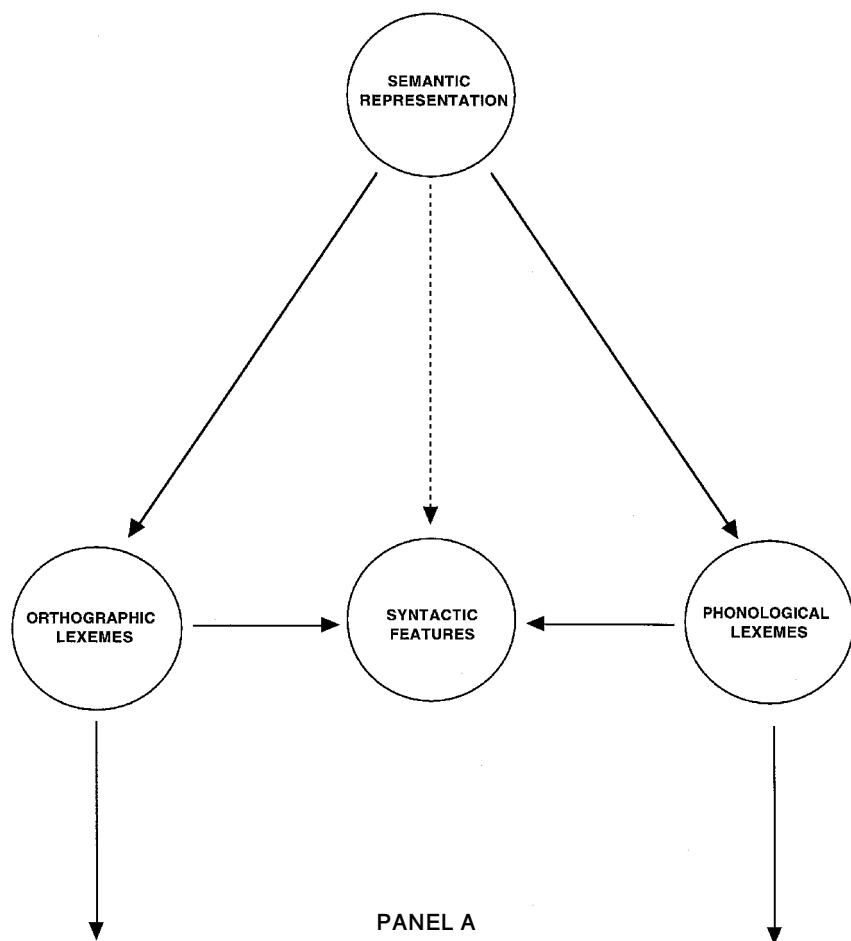


FIG. 3A. Panel A (see also Panel B, Fig. 3B, opposite) presents a schematic representation of the Independent Network model showing the relation among semantic, syntactic, and lexical form representations.

that they are semantically and syntactically specified lexical representations. I will use the terms P-lexeme and O-lexeme.

The IN model can readily account for the results we have reviewed in this paper. It accounts for the contrast between word exchanges and sound exchanges by assuming that lexical access occurs in two separate stages: the first stage involves the selection of a modality-specific, syntactically and semantically specified representation; the second stage involves the selection of the lexeme's phonological (orthographic) content. The general features of the TOT phenomenon are also explained by assuming that lexical access occurs in two

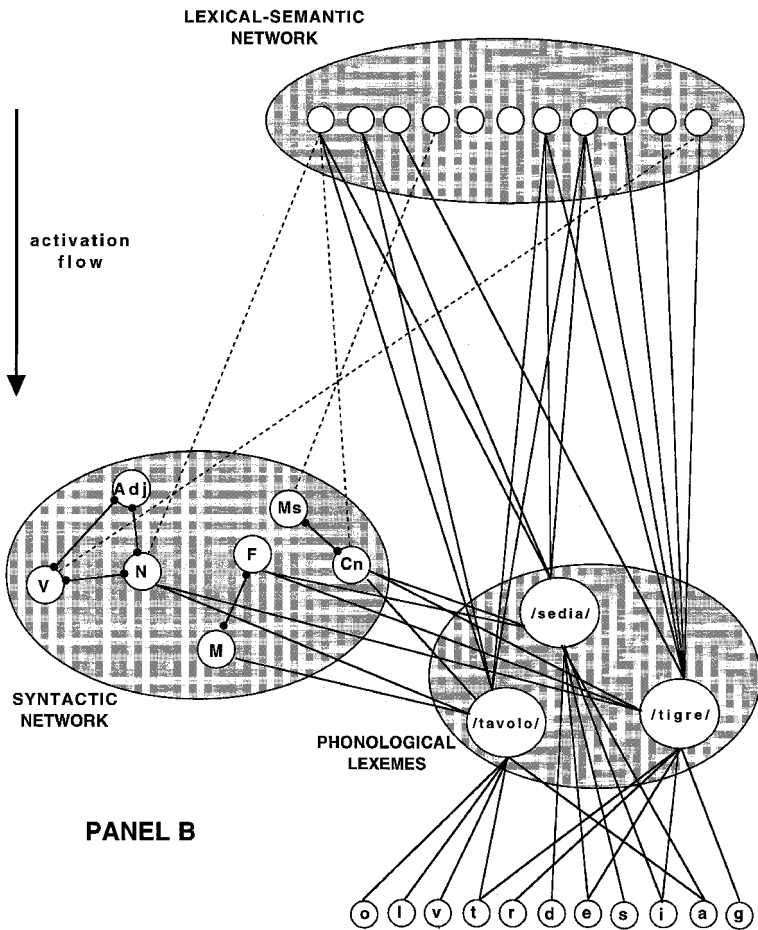


FIG. 3B. Panel B (see also Panel A, Fig. 3A, opposite) shows a more detailed representation of the model. The O-lexeme network is not shown in this figure to avoid excessive crowding. The flow of information is from semantic to lexeme and syntactic networks and then on to segmental information. N=noun; V=verb; Adj=adjective; M=male; F=female; CN=count noun; Ms=mass noun. Dotted lines indicate weak activation. Links within a network are inhibitory.

stages. The more specific results concerning the nondependence of phonological information on the prior retrieval of syntactic features (Caramazza & Miozzo, 1997; Miozzo & Caramazza, in press a) follow naturally from the assumption that the selection of a lexeme does not guarantee the selection of the full set of its associated syntactic features. And the results of Miozzo and his collaborators (Badecker et al., 1995; Miozzo & Caramazza, in press) concerning the performance of Dante, which showed that gender and auxiliary

type information was consistently available in the face of a complete inability to provide information about the phonological features of inaccessible noun and verb lexemes, are explained by assuming a deficit in accessing the phonological content of the correctly selected lexeme representations.

The IN model naturally accounts for the pattern of dissociations and associations of semantic errors across modalities of output. Semantic errors can arise either from damage to the lexical-semantic level or from damage in accessing lexeme representations. As for the other models considered here, in the IN model, damage to the lexical-semantic level should result in quantitatively and qualitatively similar semantic errors in all lexical processing tasks. This pattern of performance has been documented in subjects with dementing disorders (e.g. Chertkow & Bub, 1990; Warrington, 1975) as well as in subjects who have sustained extensive focal brain damage (e.g. Hillis et al., 1990).

More pertinent to the present discussion are those cases of semantic errors restricted to one modality of output. This pattern of performance follows naturally from two characteristics of the IN model: the assumption that meanings are componential, and the assumption that a selected lexical-semantic representation activates in parallel the lexemes of all words that share semantic features with the selected meaning (Caramazza & Hillis, 1990; Dell, 1986; Hillis & Caramazza, 1995). A consequence of these assumptions is that under normal circumstances the cohort of activated lexemes is defined semantically—all the entries that share semantic features. In the eventuality of a problem in accessing the target lexeme, either because of damage directly at the lexeme level or because of damage to the connections from the semantic network to the lexeme level, the lexeme with the highest activation will be selected. This lexeme has a high probability of being semantically related to the target response.

The proposed structure of semantic/lexeme interaction in the IN model also naturally explains the pattern of contrasting semantic errors across oral and written naming in some brain-damaged subjects. On the assumption of damage to both the P- and O-lexeme networks, resulting in the temporary inaccessibility of some lexemes (typically low-frequency items), the most active lexeme in each network will be produced in response to the activation from the selected lexical-semantic representation. The selected lexemes will be semantically related to the target response. However, since the lexeme networks are activated independently of each other, and directly from the selected lexical-semantic representation, there is no expectation that the selected lexemes in the two networks will always be the same (although they are more likely than not to be the same if such factors as frequency and semantic similarity determine the selection of the lexeme). In other words, a natural consequence of the functional architecture and processing dynamics of the IN model is precisely the pattern of performance observed in subjects WMA (Miceli et al., this issue) and PW

(Rapp et al., this issue) in conditions where access to the P- and O-lexeme networks is impaired.

Finally, in order for the IN model to account for the selective deficits for words of one grammatical class in only one modality of output, we must make an additional assumption about the organisation of lexical knowledge in the brain. We must assume either that syntactic information about different grammatical classes is represented in different areas of the brain or that lexeme representations are organised by grammatical class in different parts of the brain<sup>9</sup>. We could, then, explain the patterns of spared and impaired production of nouns, verbs, and function words as the result of selective damage to either one of the spatially segregated networks. Some similar assumption is needed by all models of lexical production.

It would seem that the IN model can readily and naturally account for the full pattern of results discussed in this paper. However a problem remains to be addressed. In the IN model, much of the burden for explaining the observed patterns of semantic errors in brain-damaged subjects is carried by the assumption that meanings are componential—it is because of the componentiality assumption that a semantic representation activates multiple lexemes. This assumption has not gone unchallenged over the years (e.g. Fodor, Garrett, Walker, & Parkes, 1980). Levelt (1989, 1992) has recently raised a further objection in the form of what he calls the “hyperonym” problem: Why don't people speak in hyperonyms (i.e. produce “animal” instead of “dog,” “furniture” instead of “table,” “artefact” instead of “furniture,” and so on) if meanings are componential? This is a non-trivial problem that must be addressed by proponents of componential theories of meaning. Indeed, as Levelt (1992) has correctly noted, a simple, unadorned componential theory of lexical semantics is fatally flawed. Here I propose a solution to this problem within a parallel activation, componential theory of meaning.

## A SOLUTION TO THE HYPERONYM PROBLEM

Levelt (1992, p. 6) states the hyperonym problem as follows: “When lemma A's meaning entails lemma B's meaning, B is a hyperonym of A. If A's conceptual conditions are met, then B's are necessarily also satisfied. Hence if A is the correct lemma, B will (also) be retrieved.” Thus, if a speaker intended to produce “dog,” the set of semantic features selected at the level of the semantic network would fully satisfy not only the word “dog” but also “animal.” Why, then, don't speakers say animal when they intend to say dog?

Levelt (1992) has proposed two solutions. One solution, within a componential account of meaning, is to adopt what he has called the “principle of

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<sup>9</sup> An implication of the latter assumption is that there are independent lexeme representations for homonyms such as to play/the play (the position that was taken in Caramazza & Hillis, 1991).

specificity.” This principle states that given that the activation conditions for multiple lexemes are satisfied by the selected lexical-semantic representation, speakers select the most specific lexeme. Thus, speakers intending to say “table” will select “table” instead of “furniture”; and speakers intending to say “furniture” will select “furniture” instead of “artefact.” However, as Levelt notes, it is not obvious how to implement such a principle in current network models of language production.

The other solution proposed by Levelt is to give up altogether the assumption of componentiality and adopt a holistic conception of semantics, where word meanings are represented by lexical-concept nodes and the set of labelled connections among the concept nodes (e.g. Collins & Quillian, 1969). On this view, there is a node in conceptual memory corresponding to every lexical entry in the language. These nodes are directly connected to their corresponding lemma representation in a one-to-one fashion (as already discussed). Thus, the conceptual node DOG would be connected to its lemma “dog,” and the conceptual node ANIMAL would be connected to its lemma “animal.” This solution to the hyperonym problem may face other problems, however (see Bierwisch & Schreuder, 1992, for discussion).

There is another solution possible within the IN model that does not require the implementation of the “principle of specificity.” The solution is quite simple, and follows naturally from the assumptions of componentiality and parallel activation that form part of the basic structure of the IN model. All that needs to be assumed is that the amount of activation passed onto the next level by any one “feature” is a weighted proportion of the number of selected features. So, for example, if the meaning of a word is represented by 10 features, the amount of activation passed on by each feature is (roughly) 1/10th of the amount of activation propagated from the lexical-semantic network to the lexeme level<sup>10</sup>. A further assumption is that the amount of activation normally needed by the activated lexemes to reach threshold is the full unit of activation propagated from the lexical-semantic network. Consequently, the lexeme most likely to reach threshold (ignoring other factors such as resting state levels of different lexemes) will be the one that receives activation from *all* the selected semantic features—the only one that receives the full complement of activation propagated from the lexical-semantic level. The hyperonym lexeme will, by definition, receive activation from only a fraction of the selected features and therefore not enough to reach threshold (see example in Fig. 4). On this view, it is not even necessarily the case that the most active alternative lexeme to the target lexeme will be the hyperonym; a very similar co-hyponym (e.g. dog, given that cat has been selected at the lexical-semantic level) could reach a greater level of activation than the hyperonym (animal).

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<sup>10</sup> I say roughly because the amount of activation propagated by each feature may also be weighted by its importance to the meaning of the word.



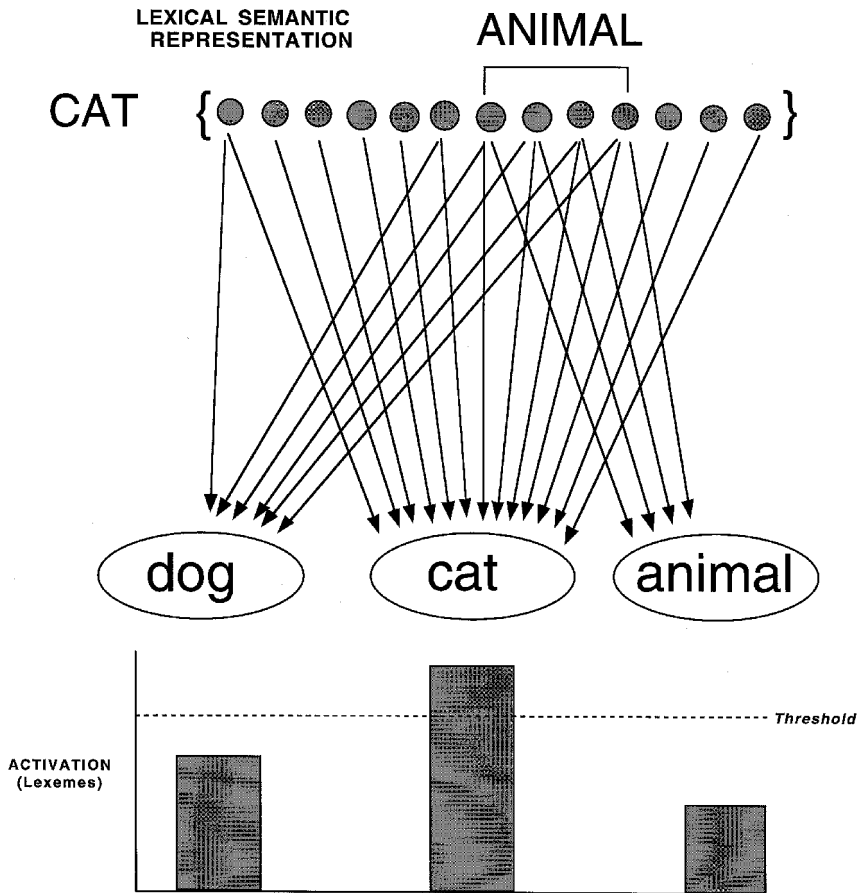


FIG. 4. Example of activation levels reached by various P-lexemes in response to the selection of the semantic representation CAT.

The proposed solution to the hyperonym problem does not solve the inverse problem also associated with componential theories of meaning—the “hyponym problem.” If people intend to say “animal,” why don’t they sometimes say “dog” or “elephant” instead? The solution proposed for the hyperonym problem could lead to hyperonym errors—producing “dog” instead of “animal”—since the amount of activation reaching the hyponym (dog) would be the same as that reaching the intended target (animal). So, why don’t people regularly make hyponym errors? To solve this problem we must make an additional assumption: The maximum amount of activation contributed by a single link to a node is a direct function of the number of links that feed into the node. Specifically, we assume that the maximum activation contributed by any one connecting link to a lexeme node that has  $N$  links feeding into it will be  $1/N$ th the total activation

needed for selection of a lexeme node (or some other arbitrary value just greater than threshold). In this way, the activation reaching the lexeme "dog" when the semantic representation ANIMAL has been selected will necessarily be smaller than the activation reaching the lexeme "animal."

## CONCLUSION

In this paper I have been concerned with whether it is necessary to postulate a modality-neutral level of lexical representation (lemma) that is intermediate between lexical-semantic representations and modality-specific lexical representations. I have argued that there is no compelling reason for postulating such a level of representation and that, in fact, its postulation has undesirable empirical consequences. I have also attempted to articulate a hypothesis about the relations among lexical-semantic, syntactic, and word form representations that is compatible with the facts of cognitive neuropsychology, normal speech errors and experimental evidence with normal subjects.

Two facts, in particular, have been stressed in this criticism of the lemma-as-abstract-node hypothesis: the existence of brain-damaged subjects with selective grammatical class deficits restricted to either oral or written production, and the existence of subjects who make semantic errors only in speaking or only in writing. The reason for stressing the importance of these facts is because the peculiar nature of these dissociations allows us to specify relatively precisely the locus of functional damage in these subjects. Thus, we can be confident that the locus of damage in subjects who only make semantic errors in speaking, say, must directly concern the inaccessibility of P-lexeme representations. The reason for this conclusion is simple: As the subject can produce the target response correctly in the other modality of output—writing, in this example—we must conclude that the lexical-semantic level of representation is undamaged. Furthermore, since the errors are well-formed lexical substitutions, we must conclude that lexical-phonological knowledge is also undamaged. The only remaining possible locus of damage is at the level of the connections leading to the activation of lexeme representations. And since a consequence of this damage is the production of *semantic* errors, we are invited to infer that the damaged relation concerns a mapping between meaning and lexical forms—that is, between lexical-semantic representations and P- and O-lexeme representations. This conclusion is incompatible with the syntactic mediation hypothesis of lexeme access proposed by Bock and Levelt (1994), Dell (1990), Jescheniak and Levelt (1994), and Roelofs (1992).

Another important source of evidence for the organisation of the lexical system concerns the observation that selective grammatical class deficits, such as difficulties in producing verbs, can be restricted to either oral or written production. Here again we can rule out damage to the lexical-semantic level because the subjects could produce verbs correctly in the unaffected output

modality. Furthermore, the fact that the modality-specific deficit was restricted to only one class of words allows us to exclude a post-lexeme deficit as the cause of the observed impairment. We are thus invited to draw the following inferences: lexical-semantic and grammatical information are independent since we can damage one without affecting the other; and syntactic and word form information are also independent of each other for the same reason.

The two conclusions reached on the basis of the neuropsychological evidence find further support from research with neurologically intact subjects. It has been found that access to a word's lexical-semantic representation does not guarantee access to its syntactic features, and that access to the word's phonological features can occur independently of access to its syntactic features (at least for gender; Caramazza & Miozzo, 1997; Miozzo & Caramazza, *in press* a). Also, in a study involving the analysis of priming effects in object naming and gender decision tasks (Jescheniak & Levelt, 1994), it has been found that access of a word's lexeme facilitated a second retrieval of that lexeme but not access of its syntactic features. Thus, experimental evidence with normal subjects converges with that from neuropsychological investigations in showing that access of lexeme representations does not depend on the prior selection of (all) the grammatical features of a word.

The evidence reviewed here finds a plausible account within a model of lexical access that shares many features with current theories of the lexical system but differs from them in some important respects. The central assumptions of the Independent Network (IN) hypothesis are:

1. The lexical-semantic, syntactic, and modality-specific form representations of a word are independently stored in separate networks.
2. P-lexeme and O-lexeme representations are independently activated by semantic representations.
3. Lexical-semantics is componential and it activates in parallel the syntactic nodes and the P- and O-lexemes, but whereas the former nodes only receive enough activation to be primed, the lexeme nodes can receive enough activation for independent selection.
4. The selected lexical-semantic representation activates in parallel all the lexemes of words that share semantic features with the selected lemma.
5. Activation from selected lexeme converges on the grammatical features already primed by activation from the lexical-semantic network.

The fact that there is a direct link between the lexical-semantic and the lexeme levels provides a natural explanation for the occurrence of semantic errors only in writing or in speaking; the fact that syntactic features are represented autonomously allows a natural explanation for the occurrence of selective deficits of grammatical classes in only one modality of output.

There are several empirical and theoretical issues that have not been addressed here. For example, what is the time course of activation of different

levels of representation? And, what are the dynamics (discrete vs. continuous; strictly forward vs. forward and backward propagation) of activation and selection of representations at different levels of processing? These issues are currently the focus of concerted experimental and theoretical analysis (e.g. Dell & O'Seaghdha, 1991; Levelt et al., 1991). It remains to be seen whether closer scrutiny of the IN hypothesis in light of these other issues will confirm the optimistic conclusion reached here.

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