

GRAMMATICAL CLASS IN LEXICAL PRODUCTION AND MORPHOLOGICAL PROCESSING: EVIDENCE FROM A CASE OF FLUENT APHASIA

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We present the case of a fluent aphasic patient who is impaired at producing nouns relative to verbs in picture naming, sentence completion, and sentence generation tasks, but is better at both producing and comprehending concrete nouns than abstract nouns. Moreover, he displays a selective difficulty in producing the plural forms of some nouns and pseudowords presented as nouns, but was able to produce the phonologically identical third-person singular forms of corresponding verb homonyms and of the same pseudowords presented as verbs. This pattern of performance casts doubt on the hypothesis that grammatical class effects are *always* epiphenomena of more general semantic impairments that affect the naming of actions or of concrete objects, and suggests that these effects may arise instead from damage to syntactic processes pertaining specifically to the grammatical properties of words. We also discuss the implications of such damage for models of morphological processing.

INTRODUCTION

Several studies have demonstrated that brain damage can selectively disrupt access to words of different grammatical categories. There are reports of aphasic patients who are impaired at producing verbs relative to nouns (Berndt, Mitchum, Haendiges, & Sandson, 1997a; Berndt, Haendiges, Mitchum, & Sandson, 1997b; Breedin, Saffran, & Schwartz, 1998; Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Kohn, Lorch, & Pearson, 1989; McCarthy & Warrington, 1985; Miceli, Silveri, Villa, & Caramazza, 1984; Rapp & Caramazza, 1998; Silveri & di Betta, 1997; Williams & Canter, 1987), whereas other patients show the opposite pattern of disruption (Bates, Chen, Tzeng, Li, & Opie, 1991; De Renzi & di Pellegrino, 1995; Miceli et al., 1984; Rapp & Caramazza, 1997; Robinson, Rossor, & Cipolotti,

1999; Silveri & di Betta, 1997; Zingeser & Berndt, 1988, 1990). Although the very existence of a double dissociation in naming makes it unlikely that grammatical category effects arise because one class of words is inherently harder to produce than another, no consensus exists among researchers as to what the functional sources of such deficits really are.

Because most clear demonstrations of noun-verb dissociations have relied on words that can be pictured or described by a concrete definition (Kohn et al., 1989), it is possible that selective grammatical class impairments always involve semantic deficits for the categories of objects or picturable actions. McCarthy and Warrington (1985) proposed that the severe “verb” impairment demonstrated by the patient they studied was attributable to just such a semantic category-specific deficit for actions.

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Indeed, there is some evidence to support the contention that semantic factors play a role in noun-verb differences in some patients. A recent study by Berndt and colleagues (1997a) reported three patients with better production of nouns than verbs in reading, but only for words with high imageability ratings. No noun-verb difference emerged with nonimageable words. Hence for these patients, what initially appeared to be a grammatical class deficit may actually have been a semantic impairment.¹

A direct attempt to link a deficit in grammatical class to a general semantic deficit was made by Breedin and colleagues (1998), who reported data from a group of eight aphasic patients with difficulties in verb production relative to noun production. They found that most of these patients were better at retrieving semantically complex or "heavy" verbs than simpler "light" verbs (e.g., *run* vs. *go*) in a delayed repetition task. A similar pattern obtained when "specific" verbs were contrasted with "general" verbs (e.g., *wipe* vs. *clean*). The authors concluded that the relative advantage for heavy and specific verbs could be related to the notion that the semantic representations of such verbs include more distinct semantic features than do those of their less complex counterparts, making complex verbs in some way easier to access for these patients.

An earlier report of a patient DM (Breedin, Saffran, & Coslett, 1994), who performed poorly on tests of semantic knowledge that relied on an ability to identify perceptual properties of objects, seems to illustrate a reversal of this "complexity effect." The authors proposed that DM's loss of knowledge of perceptual features might account for his superiority at producing abstract over concrete words and even perhaps an advantage for verbs over nouns. In marked contrast to the verb-impaired patients reported in Breedin et al. (1998), DM showed an advantage for those verbs with fewer features relating to manner (*speak* as opposed to *whisper*, for instance). If we suppose that the former patients also showed sensitivity to perceptual prop-

erties of verbs in naming, a simple story begins to take shape. Perhaps "anomic" patients like DM are more radically hindered in production for words whose lexical representations include many perceptual features—a large number of which happen to be nouns. Relatively "verb"-impaired patients, on the other hand, may be able to make use of perceptual feature components to facilitate retrieval.

Breedin et al. (1998) venture cautiously along this line of reasoning, and remain equivocal with respect to the distinction between loss for a specific type of semantic feature and an ill-defined general effect of representational complexity. A somewhat stronger stance is taken by Marshall, Pring, Chiat, and Robson (1996a; Marshall, Chiat, Robson, & Pring, 1996b). Their patient RG displayed a reverse concreteness effect within the category of nouns (Marshall et al., 1996a), while among verbs he seemed better at accessing those whose meanings depended on thematic rather than perceptual information (Marshall et al., 1996b). Overall RG showed an advantage for producing verbs over nouns, but this difference was interpreted as reflecting a semantic/conceptual rather than a grammatical class impairment. By extension, it was predicted that relative skills with verbs should be associated with abstract word skills in all patients. Skills with nouns, by contrast, should co-occur with a relative propensity for producing highly concrete words. In the words of Marshall et al. (1996b),

... it would be anticipated that other people with a reverse concreteness effect might also reveal abilities with the grammatical aspects of verbs. Similarly, people who are poor at abstract meanings might also show particular difficulties with verbs' thematic properties. Conversely, we should not see dissociations between these skills (p. 258).

For brevity's sake, let us call this the "associated skills hypothesis." Certainly the claim made here is a strong one, but it is not intuitively unreasonable; verbs tend to be more abstract and less imageable than nouns (Paivio, Yuille, & Madigan, 1968) and, semantically, nouns for the most part represent objects or ideas, whereas verbs represent events or

¹All of the patients, however, displayed generally poor performance in reading abstract words, suggesting that dissociations based on grammatical class may have been obscured by floor effects. Moreover, the same study reported two other patients with relative impairments in reading unambiguous verbs relative to nouns, irrespective of imageability.

states (Wayland, Berndt, & Sandson, 1996). At least for some patients, a selective disadvantage for nouns or verbs may be associated with relative difficulties in retrieving perceptual or thematic information.

However, it seems unlikely that the associated skills hypothesis can account for *all* patients with grammatical class deficits. Notably, the hypothesis is difficult to reconcile with reports of patients who present with difficulties producing nouns or verbs only in one modality of output (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Rapp & Caramazza, 1997, 1998). For example, patient HW showed a deficit for verbs relative to nouns in naming and oral reading tasks, but not in writing; a second patient SJD showed the same dissociation only in written naming and spelling to dictation, but not in speech (Caramazza & Hillis, 1991). A third patient, EBA (Hillis & Caramazza, 1995), presented with a double dissociation for modality-specific tasks involving grammatical class: She produced more errors on nouns than verbs in spoken output tasks, but showed greater impairment for verbs than nouns in written word comprehension and lexical decision tasks. Such results seem to rule out at least a straightforward association of these patients' categorical deficits with some aspect of semantic representation. The possibility remains, however, that there is a subtle interaction between the semantic and syntactic features of words.

In order to consider the relationship between such features in greater detail, we must have reference to a model of lexical access. Many current theories of language production (e.g., Garrett, 1992; Levelt, Roelofs, & Meyer, 1999) assume that information about grammatical class is stipulated at a level of lexical representation—the “lemma” level—prior to the point at which the modality-specific lexical representation of a word (its “lexeme”) is selected. Such theories claim that syntactic as well as semantic features of a word are the

exclusive domain of the lemma, to which the lexeme level of representation has no direct access. Caramazza (1997) labels this the “syntactic mediation” (SM) hypothesis. But there are neuropsychological data that militate against the SM model. Patients who make semantic errors in only one modality of output and also show a grammatical class effect (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995) are especially difficult to accommodate within this type of framework (but see Miozzo & Caramazza, 1998; Roelofs, Meyer, & Levelt, 1998). Also, studies of tip-of-the-tongue states indicate that the probability of recalling phonological information is not affected by the availability of syntactic features (Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997; Vigliocco, Vinson, Martin, & Garrett, 1999), indicating that access to the segmental content of a word does not depend on prior access of a word's syntactic features.

To account for these converging data, Caramazza (1997) proposed a model of lexical access (the “independent networks” or IN model) featuring an independent syntactic system receiving input from both phonological and orthographic lexemes. This model dispenses with the lemma as a strictly syntactic mediator between conceptual and modality-specific lexical representations and assumes that lexical knowledge is organized in sets of independent networks (semantic, syntactic, and form structure) connected by a modality-specific lexeme. Word meanings are represented in the lexical-semantic properties as distributed sets of semantic properties, features, and predicates, while the syntactic network contains an inventory of grammatical features.

Practically speaking, the IN and SM models are indistinguishable on the basis of the cases we have discussed thus far with respect to grammatical class and semantic effects². It is important, however, to have some theoretical architecture in mind when

²Though Breedin et al. (1998) interpret the “complexity effect” as reflecting faulty access to lemmas from verb conceptual representations, the results they discuss do not really speak to the question of whether syntactic and semantic features of words are accessible only via abstract lemma representations. Even if grammatical class effects did arise at the semantic level (or at its interface with another tier of representation), it would make no difference under this account whether the semantic system has access directly to the lexeme or whether lexeme selection is mediated by lemmas.

evaluating claims about lexical representation and “skills” ostensibly involved in lexical access. We will therefore choose the IN model as a framework for further discussion on the basis of its applicability to other types of neuropsychological data, though it should be kept in mind that the distinction is not meaningful in this context. What is of interest is not whether grammatical features are accessed at the level of the lemma or the lexeme, but rather whether grammatical features pertaining to form class are functionally dissociable from semantic features of actions and objects.

Here we report on an anomic patient, JR, who is clearly better at naming verbs than nouns. If this putative grammatical class effect were secondary to a semantically based deficit (i.e., the associated skills hypothesis) we would expect JR to perform better with abstract than concrete words. It may also be that semantic variables have no effect on JR's ability to retrieve words; in this case the associated skills hypothesis would have nothing to say. What we should *not* find, following the reasoning of Marshall and colleagues (1996b), is a *positive* effect of concreteness in retrieval of either nouns or verbs. Assuming that a single semantic system serves both input and output for spoken language, we would also expect that any deficit originating at the semantic level should manifest itself in comprehension as well as production, barring task-specific ceiling or floor effects.

If, however, JR's deficit is specific to syntactic properties of nouns, we might anticipate a very different pattern of results. Although we would not expect to find any relationship between grammatical class and semantic dimensions like concreteness, a syntactic impairment could affect processes in production that interact with syntax—for example, inflectional morphology. Along these lines, Badecker and Caramazza (1991) reported a patient, SJD, who read nouns better than verbs and produced a large number of morphological errors in reading regularly inflected verbs. Probing JR's morphological abilities in a systematic fashion may allow us to elucidate not only the nature of his particular deficit, but also the relationship between morphological production and grammatical class.

METHODS AND RESULTS

Case report

JR is a 55-year-old right-handed man who holds a PhD in philosophy and was formerly a professor of mathematics and philosophy. He suffered a left CVA involving the middle cerebral artery on July 11, 1995. Magnetic resonance imaging revealed damage to the left frontal temporal and bilateral parietal regions. Various screening batteries administered approximately one year after JR's stroke suggested a clinical classification of anomic aphasia. JR's difficulty in retrieving nouns is illustrated by his description of the Cookie Theft Picture from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983):

The boy is trying to get a cookie. Uh, cookie, um. This is high. The danger is that the person is in danger of falling. And, women is trying to cook. Um, with a plate and a couple of these. This is running and the lady is getting wet. What she needs to do is turn off that.

Tests for the present study were conducted between October 1997 and October 1998, around 2–3 years after the insult.

Background: Repetition and auditory comprehension

In preliminary screening tasks completed by January 1997, JR showed excellent immediate repetition for both nouns (114/120) and verbs (111/120), but much poorer delayed repetition for nouns (78/120) than verbs (103/120; $Z = 3.75$, $p < .0001$). (“Delayed repetition” indicates that JR was asked to count backwards from 5 to 1 before producing a response.) No significant effect of frequency was found in either immediate (high-frequency [HF]: 171/180; low-frequency [LF]: 164/180) or delayed repetition (HF: 145/180; LF: 132/180), though in both conditions there was a trend toward greater difficulty with low-frequency words. JR did produce high-frequency words (17/24, 71%) better than mid-frequency (19/32, 59%) or low-frequency words (22/44, 45%) on the Philadelphia Naming Test, but frequency is correlated with length in this

test and therefore any frequency effect cannot be interpreted with confidence.

JR's auditory comprehension skills were on the whole remarkably intact: He performed in the 99th percentile on the Peabody Picture Vocabulary Test and responded correctly to 149/150 items in a single word-picture matching task. JR was also able to discriminate between words and nonwords in a lexical decision task with high accuracy (38/40).

Single word elicitation: Noun/verb naming

Procedure

To assess JR's relative ability to name words of the grammatical classes noun and verb, we administered the picture-naming test developed by Zingeser and Berndt (1990). The test includes one list of 30 verbs and two lists of 30 nouns. Items in the first noun list are matched for frequency to the surface forms of the verbs, while those in the second are matched to the cumulative frequency of all forms of the verbs. For each word in the task there is a corresponding black-and-white line drawing. During the testing session, the subject is shown a drawing and is asked to name the action or object depicted in it.

Results

JR was able to name correctly 25/30 verbs and 30/60 nouns, establishing a statistically highly significant advantage for verb naming ($Z = 3.06$, $p < .001$). Two semantic substitutions for cumulative-frequency matched noun items were accepted: *fawn* for *deer* and *range* for *oven*. A breakdown of errors by type is shown in Table 1. Substitutions of semantically related words for the target word were

counted as semantic errors; phonological errors were neologisms that shared at least the initial phoneme with their targets, and incomplete sentence frames or definitions were classified as circumlocutions.

There was no difference between JR's facility at naming nouns matched to the base and cumulative frequencies of verbs in the task ($Z = 0.26$, n.s.), and no difference in the mean frequencies of the words JR successfully named and those he failed to name ($t(56) = 0.22$, n.s.). Of the nouns used in the task, 55/60 had ratings for both concreteness and imageability (Paivio et al., 1968; Toggia & Battig, 1978). Interestingly, when JR's responses to these noun stimuli were examined post hoc, an effect of concreteness was found: The nouns JR correctly named had a higher mean concreteness ($\langle c \rangle_{cor/N} = 606$, $s = 49$) than the nouns he was unable to name ($\langle c \rangle_{inc/N} = 584$, $s = 27$; $t(38) = -2.06$, $p < .05$, two-tailed). There was also evidence for a marginal effect of imageability in the same direction ($\langle i \rangle_{cor/N} = 602$, $s = 27$; $\langle i \rangle_{inc/N} = 590$, $s = 34$; $p = .079$, $t(48) = -1.42$, one-tailed). Only 17/30 verbs were rated for concreteness; JR correctly named 15 of these ($\langle c \rangle_{cor/V} = 469$, $s = 73$; $\langle i \rangle_{cor/V} = 446$, $s = 28$).

These results suggest that there is an effect of concreteness on JR's lexical production, but in a direction opposite to that predicted by the associated skills hypothesis: JR is better, not worse, at producing nouns of greater concreteness. This is significant in that it poses a problem, prima facie, for the claim that relative skills with verbs should always be associated with abstract word skills (Marshall et al., 1996b). So far, however, the data permit conclusions only about JR's production of nouns, and leave open the possibility that JR may have

Table 1. Analysis of JR's responses in a noun-verb picture-naming task with 3 sets of 30 stimuli (after Zingeser & Berndt, 1990)

	Verb	Cum. Noun	Base Noun	Example
Correct	25 (0.83)	16 (0.53)	14 (0.47)	
Errors				
Semantic	1 (0.03)	5 (0.17)	5 (0.17)	sharpen → "shave"; sun → "rain"; bee → "spider"
Phonological	1 (0.03)	1 (0.03)	1 (0.03)	melt → [mɛlɪŋ]; leaf → [liŋk]
Circumlocution	3 (0.10)	0	0	decorate → "put on special things"
No response	0	8 (0.27)	11 (0.36)	

Cum. Noun refers to nouns matched to the cumulative frequencies of verbs used in the task; Base Nouns were matched to the base frequencies of the same verbs.

difficulties of other sorts in comprehension, or with verbs. To examine this possibility, we next tested JR's comprehension of nouns and verbs relative to each other and along several semantic dimensions.

Synonymy triplets

Procedure

The synonymy triplets tasks from Breedin et al. (1994) were used to test aspects of JR's comprehension of nouns and verbs of different types. In this set of tasks, the patient was presented with a set of three words, all of the same category, in written form while they were simultaneously read aloud. He was then instructed to indicate which of the three words was least similar in meaning to the other two. For example, in the noun triplet *lake-brook-stream*, *lake* is less related to *brook* or *stream* than the latter two words are to each other. Seven sets of triplets were used to test three oppositions: nouns vs. verbs ($N = 16$ for each, 32 in total), abstract vs. concrete nouns ($N = 26$ each) and manner vs. relational vs. non-relational verbs ($N = 27$ each).

Results

The results of this task are presented in Table 2. Overall, JR was significantly better at comprehending nouns than verbs—precisely the opposite of his production deficit—though he showed no significant differences between different types of nouns or verbs. If anything, JR was best at comprehending concrete nouns and verbs specific for manner, consistent with the concreteness effect observed in noun production but again contrary to what we might anticipate based on the associated skills hypothesis. Thus, JR presents with a dissociation between comprehension and production with respect to grammatical class, but not with respect to perceptual-semantic variables.

If we accept these results as evidence that JR's representation of and access to semantic knowledge about nouns is intact, we can narrow our search for the locus of his production deficit—though not by much. At the coarsest level of analysis, at least two possibilities remain. JR may have trouble accessing the lexeme representations (phonological forms) of nouns, or he may be impaired at retrieving nouns' syntactic features.

We attempted to tease apart these possibilities by testing JR's production of noun and verb homonyms (e.g., *to watch* vs. *a watch*) with and without sentence frame cues. Previous studies have shown that the retrieval of nouns by some anomic patients can be significantly potentiated when the patients are asked to complete sentences with the same target nouns (Zingeser & Berndt, 1988), even when the sentence frame cues contain no relevant semantic information (Breen & Warrington, 1994). This probably occurs because sentence frames place syntactic constraints on the type of word required for their completion, and so enhance production by specifying features like grammatical class beforehand. If JR retains access to syntactic features of nouns, we might expect his performance at noun naming to improve when he is asked to complete sentence frames.

Single word elicitation: Homonym picture naming

Procedure

In this task 20 words of ambiguous grammatical form class were chosen and divided into 4 blocks (2 noun blocks and 2 verb blocks) of 10 words each. It would have been impossible, or nearly so, to find homonym pairs with nouns and verbs of equivalent frequency; instead, noun blocks and their corresponding verb blocks were matched for mean

Table 2. JR's performance on synonymy tasks from Breedin et al. (1994)

Nouns	13/16 (0.80)		Abstract	12/26 (0.46)	
Verbs	8/16 (0.50)	$Z = 1.86, p < .04$	Concrete	16/26 (0.62)	$Z = 1.11, n.s.$
Manner	12/27 (0.44)				
Nonrelational	7/27 (0.26)				
Relational	10/27 (0.27)	$Z = 1.42, n.s. (manner vs. nonrelational)$			

frequency and imageability. Each word was paired with a pictorial stimulus, consisting of a black-and-white line drawing that clearly depicted either an action or an object.

The stimuli were presented under two different experimental paradigms at an interval of 1 week. In the *confrontational* paradigm the subject was instructed to name either an object ("Tell me the name of the thing in the picture") or an action ("Tell me what is happening in the picture"). In the *sentence-frame completion* paradigm the subject was instructed to supply a word to complete correctly a given sentence frame that bore no semantic information to facilitate the retrieval of specific nouns or verbs. For nouns the cues were "This is a..."; for verbs, "Every day, this person does the same thing. Every day, this person...". For nouns and verbs under each paradigm, two sample items were presented to establish that the subject understood instructions. Nouns and verbs were presented in staggered blocks of 10 stimuli.

Results

Responses to stimuli in single word elicitation tasks were scored as correct if JR produced the target word, except when it was clear that the response differed from the target in grammatical class (*fight*, N → "they're fighting"). Semantically related errors (*plant* → "flower"), neologisms (*swing*, V → [ɪəʊwz]), circumlocutions and incomplete sentence frames were all scored as errors. For two relatively infrequent items, *canoe* and *barbecue*, JR never produced the target response. In these cases *canoe* → "boat" was accepted as a semantically appropriate nontarget nominal response, *canoe* → "row/rowing" and *barbecue* → "cooks/cooking" as appropriate verbal responses. That the targets were never in fact retrieved, however, renders these items problematic.

The results showed that JR was significantly better at verb production than noun production under the sentence-frame completion paradigm ($Z = 2.19, p < .02$), but did not perform at significantly different levels under the confrontational naming paradigm ($Z = 1.27, n.s.$). Moreover, JR's production of nouns was not significantly different under the two paradigms ($Z = 0.95, n.s.$), although the difference in verb performance was significant ($Z = 1.89, p < .05$). An analysis of JR's errors is shown in Table 4.

It is notable that in 19/20 verbal responses under the sentence-frame completion paradigm the correct morphological form (present tense third person singular or plural) was produced. Even the neologism [ɪəʊwz] appeared to be inflected, in contrast to what was presumably the same neologism ([ɪəʊw]) in response to verbs under confrontational naming. This observation underscores the general pattern of spared verb production in the face of impaired noun production.

Indeed, even when sentence frames were provided, only verb retrieval, and not noun retrieval, was improved. Why? It could be that the sparse sentence frames employed in this task ("this is a...") did not provide contextual support as rich as those used by others who found an effect on noun production. Zingeser and Berndt (1988) used frames that included full verbs, which may have facilitated noun retrieval by assignment of roles within a thematic grid, for example. Alternately, perhaps JR was so severely impaired at retrieving specifically syntactic information about nouns that even sentence frames could not facilitate a response.

Up to this point we have only looked at JR's production of single words, though in some cases syntactic cues were provided. We have yet to examine his ability to generate words within their syntactic context, i.e., in novel sentences. To this end, JR was given a sentence formulation task (Berndt et al.,

Table 3. JR's performance on homonym naming tasks

	Sentence-Frame Completion		Confrontational Picture-Naming		
Nouns	12/20 (0.60)		9/20 (0.45)		$Z = 0.95$
Verbs	18/20 (0.90)	$Z = 2.19^{**}$	13/20 (0.65)	$Z = 1.27$	$Z = 1.89^*$

* $p < .05$; ** $p < .02$.

Table 4. Analysis of errors produced by JR in response to single word elicitation tasks

	Sentence-Frame	Picture-Naming	Example
<i>Nouns</i>			
Semantic	0	3 (0.27)	plant → "flower," skate → "ice"
Categorical	0	3 (0.27)	swing → "she's rowing"
Neologism	0	1 (0.09)	sled → [bɪs]
Sentence frame	2 (0.25)	1 (0.09)	barbecue → "a thing that you bake on and cook hot dogs on is called..."
No response	6 (0.75)	3 (0.27)	
Total	8	11	
<i>Verbs</i>			
Neologism	2 (1.00)	3 (0.43)	swing → [bɪs], skate → [ɔʊwz]
No response	0	4 (0.57)	
Total	2	7	

1997b) designed to elicit samples of connected speech utilising selected target words.

Sentence formulation

Procedure

The sentence formulation task described by Berndt et al. (1997b), with some modifications, was used to provide an idea of how well JR is able to produce nouns and verbs in the appropriate syntactic context. The target words consist of 12 unambiguous verbs and 24 unambiguous nouns, matched pairwise to the cumulative and base frequencies of the verbs, as well as 18 words of ambiguous grammatical class. Among the ambiguous targets, six were "completely ambiguous," six had more frequent verb usage, and six had more frequent noun usage.

The full set of 54 stimuli was presented in random order. Along with each target word, JR was read either the name "John" (and shown a line drawing of a man) or the name "Mary" (and shown a line drawing of a woman). He was then asked to produce a sentence using both the target word and the name that had been presented. Responses were taperecorded.

Results

In scoring this task, no judgement was made as to whether JR's utterances were semantically informative or syntactically well-formed sentences. Any

utterance with apparent phrasal structure was counted eligible for analysis, including sentences where JR used subjects different from the target subjects "John" or "Mary." If JR did not repeat the target word at all, his response was scored as "failed." Failed responses ranged from attempts at circumlocution (*cannon* → "fire, the person used the, relies on the word I just said") to jargon (*swan* → "swing and died into the water") and aborted utterances. Scoring criteria for sentences that did contain the target word were relatively conservative. When the target was preceded by a determiner, it was scored as a noun; when it was overtly inflected for person or tense, it was scored as a verb. JR never produced target nouns in plural form. Nor did he produce any sentence with a plural (nontarget) subject.

"Indeterminate" cases were those in which JR began a sentence by repeating the uninflected target (*eat* → "eat too much," *ketchup* → "ketchup down the dress," *leaf* → "leaf is a salad also"). It should be noted that all three of the verb targets whose uses were scored as indeterminate could be considered subjectless but otherwise well-formed verb phrases. This also seemed to be true of one ambiguous target (*brush* → "brush the hair") and one noun target (*crutch* → "crutch the bad leg"). In one case an unambiguous target noun was used as a verb in a syntactically well-formed but meaningless sentence (*word* → "Mary words a plant"). The verb stimulus *pour* was not counted in the analysis because JR was

Table 5. JR's performance in a sentence formulation task (Berndt et al., 1997)

	V	N	AMB	AMB(V)	AMB(N)	Total AMB
Failed	0	11 (0.46)	0	0	2 (0.33)	2 (0.11)
Verb	8 (0.73)	1 (0.04)	5 (0.83)	6 (1.00)	3 (0.50)	14 (0.78)
Noun	0	6 (0.25)	0	0	1 (0.17)	1 (0.06)
Indeterminate	3 (0.27)	5 (0.21)	1 (0.17)	0	0	1 (0.06)
Total	11	24	6	6	6	18

The top row indicates the category of the stimulus to be used in formulating a sentence (V: verb; N: noun; AMB: ambiguous; AMB(V): ambiguous, verb-dominant; AMB(N): ambiguous, noun-dominant). The leftmost column lists the categories into which JR's responses were classified, according to the manner in which the stimulus word was incorporated into a spoken sentence or phrase.

unable to discriminate auditorily between *pour* [pou.ɹ] and *poor* [pu.ɹ].

Overall, the proportion of unambiguous target words incorporated into sentences in a clearly class-appropriate manner differed significantly between nouns and verbs ($Z = 2.68$, $p < .005$). JR also displayed a distinct bias for producing ambiguous targets as verbs (14/18) rather than as nouns (1/18; $Z = 4.39$, $p < 10^{-5}$). Together these results suggest that JR preferentially used target words as verbs because he was unable to process lexical representations as nouns. In other words, it seems likely that JR's difficulties are connected in some way to nouns' syntactic properties, which govern the use of nouns in phrases and sentences.

Morphological production

Goodglass and colleagues (cf. Goodglass, Gleason, Bernholtz, & Hyde, 1972) first proposed examining the availability of grammatical inflections, like the final *-s*, as a means of probing syntax in English-speaking agrammatic patients. A similar approach, contrasting noun and verb inflections, may allow us to determine more precisely which aspects of JR's noun production, if any, remain intact. Here we can capitalise on the fact that the nominal plural inflection *-s* and the third person singular verbal inflection *-s* have phonologically identical properties: Both are realised as a nonsyllabic allomorph [z] (or [s]) after most final segments and as [əz] after final sibilants ([s], [z], [ʃ], [ʒ]). Because we suspect that JR's deficit lies in

the domain of nominal syntax, and not of phonology (or morphology per se), we might anticipate a pattern of morphological production in which verbs in *-s* are processed correctly whereas nouns in *-s* are not.

Procedure

Two tasks were used to assess JR's ability to apply rules of morphological inflection (specifically, the addition and removal of the suffix *-s*, associated with number) to nouns and verbs. In order to isolate the effect of semantics, separate tasks were devised using real homonyms (e.g., *a guide/to guide*) and invented monosyllables (*a wug/to wug*). For the *homonym morphology task*, lists consisting of words that can be used as either regular nouns or regular verbs in English (e.g., *guide, sail*) were used. List 1 consisted of 55 words ending in sibilants (e.g., *judge*), and list 2 consisted of 56 words ending in other phonemes (e.g., *guide*). Words on the lists varied in length (from one to three syllables) and in syllable structure. In each list the average frequencies of plural and singular nouns and verbs were matched as closely as possible. List 1 was administered twice and list 2 three times over a period of several months.

At each administration of the task, one list was presented four times in four separate conditions, with the order of the list randomised in each condition. The conditions required the subject to add *-s* to the root form of a noun (i.e., form the plural); remove *-s* from an inflected noun; add *-s* to the root form of a verb; or remove *-s* from the inflected form

of a verb, by completing sentence frames like the ones given below:

- "This is a *guide*; these are ____" (*guides*)
 "These are *sails*; this is a ____" (*sail*)
 "This person *guides*; these people ____" (*guide*)
 "These people *sail*; this person ____" (*sails*)

The *pseudoword* version of the task was based on two lists of stimuli, each with 24 one-syllable ([C]CVC[C]) nonword strings conforming to the phonotactic rules of English—for example, *wug* [wʌg] (CVC), *fleeve* [fliv] (CCVC), *narf* [nɑf] (CVCC) and *snetch* [snɛtʃ] (CCVCC). To accompany these lists, two sets of four pictures were prepared as visual aids. Each picture had two panels: in the upper panel there was a line drawing either of a single made-up object or of an animal engaging in some unusual action (such as a pig chewing wheat), while in the bottom panel there were two objects or animals identical to that depicted in the upper panel. The drawings were matched approximately for complexity across the two sets.

At each testing session, one of the lists was used with the object pictures and the other with the action pictures. Presented with the appropriate pictures, the subject was asked to complete sentences like the following:

- "This is a *fleeve*; these are ____" (*fleeves*)
 "These are *wugs*; this is a ____" (*wug*)
 "This pig *narfs*; these pigs ____" (*narf*)
 "These pigs *snetch*; this pig ____" (*snetches*)

Lists of "pseudonoun" and "pseudoverb" stimuli were presented separately. Half of the stimuli in each list required plural target forms, the other half singular forms; the initial sequence of these targets was determined by random assignment.

The task was administered a total of four times at four separate sessions. At each administration either the putative grammatical category (noun or verb) or the sequence of target forms (plural or singular) was reversed for each list of words, so by the end of the sessions each stimulus had been presented once as a singular noun, a plural noun, a singular verb, and a plural verb. The subject was asked to repeat each stimulus after the first matrix clause in the prompt.

Results

Responses in both conditions of the morphology task were scored based on the target morphological form (presence or absence of final *-s*) irrespective of the phonological accuracy of the stem, except in cases where it could not be determined whether the target morpheme was present (e.g., *bice* → [baɪz]); these were scored as incorrect.

All of JR's errors with real words, as well as most of his errors with pseudowords, were direct repetitions of the stimulus. (For a few pseudowords JR produced no response.) To determine whether JR showed differences in repeating pseudonouns and pseudoverbs, a simple phonological rating scale was devised. Each phoneme in JR's response was given a score of 0, 0.5, or 1.0 based on its similarity to the stimulus phoneme in the same intrasyllabic position. Phonemes that differed in only one articulatory feature from the corresponding stimulus phoneme (e.g., [b] for [p]) were scored 0.5; missing phonemes and phonemes differing in two or more features received a score of 0, while added phonemes resulted in a deduction of 0.5 points from the composite score of the response. Each composite score was then divided by the total number of phonemes in the response utterance to yield a score between 0 and 1.0. On this scale the mean phonetic similarity of JR's responses to the stimulus words was 0.79 for both nouns ($s = 0.18$) and verbs ($s = 0.21$).

A breakdown of the results from all 12 task conditions is shown in Tables 6 and 7. Among real words, only one condition was significantly different from any of the others; this was when JR was given a noun with a sibilant ending and was asked to produce its plural form. This differed strongly from the add *-s* condition for nouns with nonsibilant endings ($Z = 3.77$, $p < 10^{-4}$) and from the remove *-s* condition for nouns with sibilant endings ($Z = 4.62$, $p < 10^{-6}$).

Each condition of the task using pseudowords was significantly different from the corresponding condition using real words, collapsed across both lists (see Table 7). Again, however, the only condition that differed from others among the group of pseudowords was the one in which JR was asked to produce the plural forms of nouns; here the propor-

Table 6. JR's performance on real-word morphology tasks, change versus no change collapsed across all administrations

	Syllabic Change		No Syllabic Change		
Noun					
Add -s	107/165 (0.65)		94/110 (0.86)		Z = 3.77†
Remove -s	143/165 (0.86)	Z = 4.62‡	101/110 (0.92)	Z = 1.49	Z = 1.32
Verb					
Add -s	154/165 (0.93)		105/110 (0.96)		Z = 0.74
Remove -s	149/165 (0.90)	Z = 1.00	104/110 (0.93)	Z = 0.31	Z = 1.27

Syllabic Change refers to nouns and verbs ending in sibilants and requiring the syllabic inflection [əz]; No Syllabic Change refers to nouns and verbs taking the inflection [əz].

† $p < 10^{-4}$; ‡ $p < 10^{-5}$.

tion of correct responses was significantly lower than when JR was asked to add -s to pseudoverbs ($Z = 4.82, p < 10^{-6}$) and when he was asked to remove -s from pseudonouns ($Z = 3.28, p < .01$).

Summarising briefly, JR is impaired at producing nouns in picture naming, sentence completion, and sentence formulation tasks, though he seems to be better with nouns than verbs in comprehension tasks. When asked to generate different inflectional forms of nonsense words supplied as stimuli, JR performed significantly better with pseudoverbs than with pseudonouns; most of this discrepancy arose from a specific failure to produce target plural forms when the stimulus forms were singular. A similar pattern obtained when the task involved real words rather than pseudowords, but here the difference was plainly significant only for nouns with plural forms ending in [əz]. This phenomenon cannot reflect a simple phonological deficit or a general syllabic addition effect, as the same phonological information is included in contrasting verb conditions. Moreover, JR was on the whole unimpaired at repeating both real word and nonword stimuli, precluding an input or repetition deficit.

DISCUSSION

A verdict on the "associated skills hypothesis"

We should begin by noting that JR's deficit in noun production does not appear to reflect any general semantic effect, such as an inability to retrieve concrete words. Whereas it is true that the verbs used to assess JR's relative access to words of different grammatical classes were rated lower for concreteness than the nouns, it is also important to keep in mind that the nouns JR named correctly were slightly but significantly *more* concrete than those he failed to name. Moreover, in the synonymy triplets task there was no difference in JR's comprehension of abstract and concrete nouns, suggesting that at least for JR the discrepancy between noun and verb retrieval cannot be attributed to a generalised loss of knowledge of the "perceptual features" of things. In fact, JR was *better* at comprehending nouns than verbs, even though he showed a consistent disadvantage for noun production. There was no significant difference in JR's comprehension of different types of verbs; he was essentially at chance

Table 7. JR's performance on morphology tasks, pseudowords versus real words collapsed across all administrations

	Pseudowords		Real Words (Homonyms)		
Noun					
Add -s	18/48 (0.38)		201/275 (0.73)		Z = 4.83†
Remove -s	34/48 (0.71)	Z = 3.28**	244/275 (0.89)	Z = 4.67**	Z = 3.30**
Verb					
Add -s	41/48 (0.87)		259/275 (0.94)		Z = 2.18*
Remove -s	37/48 (0.79)	Z = 1.00	253/275 (0.92)	Z = 1.01	Z = 3.15**

* $p < .05$; ** $p < .01$; † $p < 10^{-4}$; ‡ $p < 10^{-5}$.

with all verbs regardless of their thematic or perceptual properties.

These results offer little support for the notion that grammatical class dissociations in aphasia arise from a deficit at the semantic level (Breedin et al., 1998; Marshall et al., 1996a, b), what we have called the associated skills hypothesis. We have observed that JR displays a dissociation, rather than the expected association, between verb production and abstract noun production. From this we may conclude, if nothing else, that grammatical categories of words are not confined to a perceptual hierarchy, in which nouns occupy a higher place than verbs. We also found that the effect of grammatical class reverses its direction in comprehension, whereas the effect of concreteness either disappears or remains constant. Short of positing separate semantic systems for lexical input and output, this result can only be interpreted to mean that the syntactic and semantic features of words are represented separately.

Firmer evidence against a generalised semantic interpretation of JR's deficit can be found in an analysis of JR's performance on the morphological production task. Here, his deficit was restricted not only to nouns, but to nouns of a particular phonological type under only one morphological condition. What is remarkable about these results, however, is that JR displayed exactly the same pattern of impairment with pseudowords as with real words. Unless one takes a rather diffuse view of semantics, it cannot be said that pseudowords have any conceptual representation. By contrast, the morphology task essentially required JR to retrieve knowledge about grammatical class even when he was dealing with pseudowords. JR's deficit in noun production must therefore derive primarily from a difficulty in accessing or manipulating information about nouns without respect to their meaning.

This is not to say that there was no effect of semantics on JR's production. Indeed, the data support an interpretation that takes account of lexical and conceptual factors like concreteness. A great deal of evidence suggests that in some patients, like the case of semantic dementia described by Breedin et al. (1994), conceptual factors may play a much larger role; in these cases, the inference that under-

lying semantic difficulties give rise to observed deficits in either noun or verb production, as predicted by the associated skills hypothesis, may be entirely warranted. At the same time, these patients are perhaps more profitably described as having specific difficulties with concrete or abstract words than with nouns or verbs. We would not expect such patients to show impairments restricted to one or the other grammatical class on the pseudoword task used with JR, for example.

It is clear from JR's pattern of production that the associated skills hypothesis is not adequate to account for grammatical class deficits as such. This conclusion is supported by reports of other patients who failed to display associated semantic deficits in the context of clear grammatical class impairments (e.g., Caramazza & Hillis, 1991). In JR's case, whatever the effect of semantics may be, it seems to be functionally distinct from the effect of grammatical class.

JR's deficit: The problem at hand

What, then, is the nature of JR's impairment with respect to grammatical categories of words? In discussing the results of various experiments designed to assess JR's ability to access nouns and verbs in production, we presented an argument to the effect that he was unable to retrieve and/or manipulate specifically syntactic information about nouns. By contrast, JR apparently faces few if any hindrances in manipulating information about verbs. In sentence-frame completion, he sometimes even seemed to add verbal inflections to neologisms (*swing*, V → [ɔʊwz] vs. *vacuum*, N → [ɔʊw]). Of course, inflecting neologisms is not in itself uncommon for aphasic patients (e.g., Caplan, Kellar, & Locke, 1972), and as we have seen, JR was easily able to produce inflected forms of pseudoverbs like *snetch* in the phrase *this pig snetches*.

On the other hand, we know that JR's morphological production is not perfectly preserved: He has difficulties producing the plural forms of pseudonouns, and of real nouns with sibilant endings. Earlier we argued that this deficit must be

independent of semantics. It also cannot be the result of an isolated phonological impairment—for example, in the addition of [z] (to pseudowords) or [əz]—since JR has no trouble at all producing exactly the same phonetic strings when the context identifies them as third person singular forms of verbs. The upshot of all this is that there exists some dimension of lexical representation encoding grammatical class which is both susceptible to selective damage and important for morphological processing.

One possibility is that noun lexemes have a different physical organisation in the brain than verb lexemes, and are as a consequence specifically vulnerable to a focal lesion. Some neuropsychological and neuroanatomical investigations, including PET studies and evaluation of brain-damaged patients, have suggested that noun naming depends on areas in the left anterior and middle temporal lobe, whereas verb naming is dependent on the left prefrontal and premotor region (Damasio & Tranel, 1993; Daniele, Giustolisi, Silveri, Colosimo, & Gainotti, 1994; Miceli, Silveri, Villa, & Caramazza, 1984; Tranel, Damasio, & Damasio, 1998). Although in these studies the grammatical classes noun and verb are conflated with the semantic categories of concrete objects and actions, respectively, it is worth noting that JR's lesion and deficit are consistent with the earlier-mentioned anatomical model: He has damage to left frontotemporal regions and shows a selective impairment for nouns. We might imagine, then, that there exist regionalised neural systems (whether identical to, overlapping, or distinct from those mentioned earlier) that subservise the representation of grammatically segregated noun and verb lexica—though we are not aware of any evidence that would specifically support an argument to this effect.

In JR's case, lexemes representing nouns may be damaged in such a way that their phonological and grammatical features will not be activated reliably. Under this interpretation, JR is unable to process nouns for morphology because, for example, their phonological features are too degraded (or degrade too rapidly) to allow for selection of the appropriate allomorph ([z] or [əz]). In most cases, [z] will sim-

ply be selected as a “default” allomorph: correct for the majority of words, but impossible to process in cases where concatenation of [z] would result in a violation of phonotactic constraints (e.g., after a sibilant ending). More generally, damage to lexemes will impede noun generation even when no inflection is required.

Though perhaps attractive, this account raises several nettlesome questions. First of all, it is not clear how JR should be able to produce the correct phonetic forms of nouns at all if their phonological representations are so prone to degradation. In fact, when naming real words JR makes almost no phonological errors at all, let alone at the ends of words. To reconcile this with the phonological degradation account we would have to suppose that articulatory processing of the word stem begins before the specification of bound morphemes. On the face of it this presents difficulties: How, then, are inflections properly syllabified? And how does the production system deal with bound morphemes that are not suffixes? What is more, the data show that JR's overall pattern of morphological impairment is the same for pseudowords, regardless of phonology, as for real words with sibilant endings. Since none of the pseudowords used in the task were represented as lexemes prior to testing, it would be somewhat odd if they fell prey to lesion-induced lexeme degradation.

Alternatively, JR may have a deficit in retrieving or manipulating specifically syntactic features of nouns, an argument to which we have already alluded. It is important to stress at this juncture that a term like “noun feature,” used in an expository manner, should not be taken to indicate a physical node or a unitary representation, but rather a package of closely associated computational processes that apply exclusively to a certain syntactic category of speech elements—to wit, nouns. In naming tasks, which require little morphological or syntactic manipulation of the target word, these processes will be engaged minimally, though not necessarily undetectably. On the other hand, “propositional” tasks like sentence formulation and inflection will place greater demands on the mechanisms in question. In general, utilising a word in its syntactic context enjoins access to “class features” or

grammatical properties specified in its lexical representation.

Approaches to inflection and allomorphy

The next question that arises then, is, how do we accommodate processes for inflectional morphology in a lexical access model?

Levelt et al. (1999) treat morphemes as modality-specific quasi-lexical entities selected by a “form” switch emanating from the lemma, analogous to the way in which lexemes are selected. Likewise, until now we have treated phonological morphemes (in their various allomorphic incarnations) as units of selection, implying that they exist as preformed elements that need only to be concatenated to lexemes retrieved in citation form from the mental dictionary. This view is somewhat naïve from the point of view of many formal theories of grammar, in which inflectional morphology is generated by rather abstract word formation rules. For example, the rule for English plural formation in the terms of lexical phonology (Kiparsky, 1982) might be written as: “Insert an epenthetic vowel before /z/ after a sibilant; otherwise, devoice /z/ to /s/ after a voiceless consonant” (after Spencer, 1991). Expressing the process of inflection and allomorphy in such a way captures the distinction between a most general or “default” case (add /z/ or /s/) and a least general, “exceptional” case (add /əz/).

For our purposes, it is unimportant whether allomorphs are generated by rule-like processes (affixation and epenthesis) or whether they are selected as prepackaged elements akin to lexical nodes. What is crucial is that the production system at some point faces a choice between adding /z/ and adding /əz/, whatever the status of these elements. However, just as certain empirical considerations led us earlier to adopt an IN framework over an SM framework for lexical selection, there are reasons to favour the generative account of inflection over a more discretised approach.

Perhaps the most significant of these reasons is the theoretical utility of distinguishing between the interactions of morphology with syntax on the one hand, and with phonology on the other. The dis-

crete view of allomorphy commits us to assuming that the phonological and grammatical features of morphemes are selected all at once, but this may not always be practical; Rather, the speech production system may in some cases require that morphophonological processes take place relatively long after the grammatical properties of a morpheme have been selected. For instance, Fromkin (1971) noted that the phonetic form of a morpheme involved in or proximal to an exchange error (e.g., *bloody students* /s/ → “bloodent stewdies” /z/; *a current argument* → “an arrent curgment”) will accommodate to the error-induced phonetic environment, implying that the processes involved in generating these errors precede the stage at which phonology is specified. More recently, Miozzo and Caramazza (1999) have argued that the phonological form of an Italian determiner is specified at a late stage in the production of noun phrases, even though selection of the determiner’s grammatical features occurs much earlier. “Late selection” of phonological features is necessary because the form of a determiner in Italian often depends on its immediate phonological context (e.g., *lo scoiattolo* “the squirrel” vs. *il grande scoiattolo* “the big squirrel”), a situation similar in some respects to that of the English *-s* inflection.

We will assume, therefore, that morphemes are represented as phonologically generative elements distinct from unitary lexemes, and that each morpheme is specified by a set of grammatical features in the syntactic network—including both intrinsic features, which relate to the classes of words to which the morpheme binds (e.g., grammatical class, gender, etc.), and extrinsic features, like number and case, which are dependent on context. Such an organisation echoes the distinction made by Garrett (1980) between open and closed class vocabularies, where the latter includes bound and free syntactic morphemes. In Garrett’s analysis, such closed class elements belong properly to a “planning frame” into which open class items (“content” words) are eventually inserted; similarly, we will argue that grammatical morphemes are selected by a mechanism functionally distinct from that responsible for retrieving lexical items like nouns and verbs.

A model for morphology

During the speech process, the production system must somehow select both a lexeme and, in many cases, also an appropriate morpheme, which must then be bound to the lexeme in order to generate a target word form. This undertaking is far from trivial, and so far there has been no convincing psycholinguistic account of how it might be accomplished (see Stemberger, 1998, for review).

Let us assume that when the speech system is required to produce an inflected form, at least the extrinsic grammatical properties of an inflectional morpheme (often common to a set of allomorphs) are selected by some externally derived information relating to sentence structure or semantic content. As soon as a lexeme is selected, it becomes necessary for the production system to discriminate between the various allomorphs specified by this information and choose the one form that is appropriate for inflection of the lexeme. We suggest that this discrimination process is the role of a morphological subsystem that is triggered by the selection of grammatical class information, which may be said to control or “coordinate” inflection. The term *coordination*, as used here, expresses the intuitive notion that a word’s inflectional features pertain specifically to its grammatical class, irrespective of form. Since these features are in a sense subordinate to grammatical class, it seems reasonable to postulate that class information mediates between lexical and inflectional representations.

Once the subsystem is online, it ought potentially to be able to accomplish three tasks: first, it must match the intrinsic grammatical features of the lexeme that has been selected to those of a contextually activated syntactic morpheme; second, it must arbitrate among the morpheme’s allomorphs on the basis of phonology; and third, it must allow for the concatenation of the proper allomorph with the lexeme. These tasks need not all be functionally separate; nor do they all require new theoretical machinery. For instance, grammatical discrimination among allomorphs may follow directly from the selection of the syntactic features of a lexeme, and binding may be specified by some function or operator internal to the morpheme representation.

Our main concern here, however, is not to address such important details so much as to suggest a framework in which they may be resolved. Crucially, the mechanism for morphological inflection must have some way of “reading” the grammatical and phonological features of the activated lexeme (or of its terminal segment). One potential solution is that grammatical class information gates access to syntactically restricted phonological buffers in which phrase-level constituents are assembled, somewhat like Garrett’s (1980) “planning frames.” By this account, a selected phonological noun lexeme might feed segmental information into such a buffer, where stored phonemes can be read and manipulated by noun-related morphological processes (Figure 1).

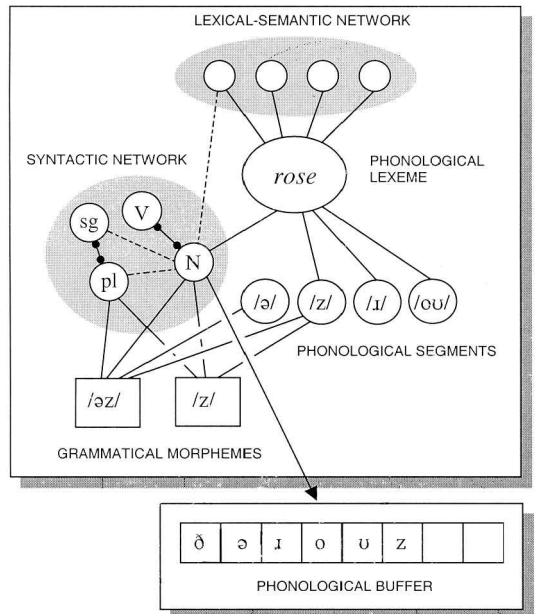


Figure 1. Schematic illustrating the coordinated selection of a lexeme and its morphological inflection. In this example the grammatical class node Noun (N) is activated by the lexeme (rose) and gates access to both a phonological buffer for noun phrase assembly and to grammatical processes pertinent to noun production, including morphology. Grammatical morphemes also receive activation from extrinsic syntactic features (such as singular or plural number) that are specified independently by the sentence context. Once a lexeme and its inflection have been selected, the phonological segments appropriate to each are loaded into the assembly buffer.

The morphological subsystem in this model, then, is an “interactive” mechanism that selects from among a set of (potential) allomorphs the one whose phonological and grammatical properties agree with those of the selected lexeme. We will assume that, in normal production, the morphological system is activated automatically whenever grammatical class is specified. When there is coordinated activation between the lexeme and morpheme layers, the system should select the appropriate allomorph, concatenate it to the already selected lexeme, make any necessary phonological alterations, and feed the new string into the queue for syllabification and other downstream processes leading to articulation. If it happens that there are no activated morphemes (as must often be the case in, for example, English, unless an abundance of null morphemes are postulated), the system should simply “approve” the selected lexeme for phonetic processing.

Suppose that there is damage to the syntactic network, and specifically to the portion of that network containing grammatical class information about nouns. If this class information cannot be accessed at all, then our model predicts a failure to initiate morphological processing and, consequently, an inability to produce spoken nouns. If its selection is erratic or unpredictable, morphology will be activated and some nouns will ultimately be produced; there is no guarantee, however, that other processes dependent on grammatical class will proceed normally. Specifically, class information may lose its function of coordinating lexemes phonetically and syntactically with the allomorph(s) determined by contextual cues.

In JR’s case, we assume that the relevant task facing the production system is to choose which of at least two nominal plural allomorphs, /əz/ or /z/, applies to a selected lexeme on the basis of phonological constraints. Syntactic processes relating to nouns may have been activated, perhaps with the aid of syntactic information provided in the cue (cf. Breen & Warrington, 1994; Zingeser & Berndt, 1988), but they are so damaged that they are of no use in coordinating activation between lexemic and morphemic representations. Perhaps, then, the production system simply throws up its figurative

hands, ignores the activated allomorphs, and does the best it can safely do, which is to produce the uninflected lexeme. This is unlikely, however; we know that JR does fairly well when he is asked to generate regular plural forms in /z/. The key here may be that /z/ is the most frequent and hence the “default” nominal plural for English words, and is selected “automatically” when no informed choice can be made. (Alternately, following Kiparsky, 1982, the system may automatically bypass the insertion of an epenthetic vowel and resort to the elsewhere condition in all cases.) For most real words, this works well, though phonotactic constraints intervene in a subset of cases to block impermissible resultant strings like *[dʒz].

Obviously, a great deal more experimental work, both with patients and with normal subjects, will be necessary to support and flesh out this model. The central feature of the “coordinated” or “interactive” approach, however, is a critical role for information about grammatical class in morphological production. In this respect it fits well with existing theories of lexical production, including both the IN and SM models, that view grammatical class information as an integral part of the representation of lexemes, necessary at some level for morphological and syntactic processing (Caramazza, 1997; Garrett, 1992; Lapointe & Dell, 1989; Levelt et al., 1999). For the most part these models have not been specified in sufficient detail to make predictions about specific morphological deficits like the one reported here; coordination can be seen as a blueprint for extending their explanatory capacity into the domain of inflectional morphology. Our approach is more difficult to reconcile with accounts of the lexicon that do not hold grammatical class to be a property of stored lexical representations, and instead posit that such information is assigned to words exclusively by generative syntactic processes (e.g., Halle & Marantz, 1993; Marantz, 1994). Such theories, however, cannot readily explain why a patient like JR should have problems producing nouns even in delayed repetition or picture-naming tasks, which would not seem to rely heavily on the syntactic system.

JR is not the first patient to present with both a selective grammatical class deficit and a restricted

morphological deficit; we have already mentioned SJD (Badecker & Caramazza, 1991), who displayed both a general impairment in reading verbs and a more specific deficit in reading regularly inflected verb forms. If the coordinated morphology model is correct, we should expect a number of other patients to show similar patterns of production.

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