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Journal of Neurolinguistics 16 (2003) 85–111

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Journal of  
NEUROLINGUISTICS

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# Looming a loom: evidence for independent access to grammatical and phonological properties in verb retrieval

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## Abstract

In principle, a specific deficit in processing verbs relative to nouns might arise as a result of damage to any of several mechanisms involved in speech planning and lexical production. Here we describe a fluent aphasic patient HG who is much worse at retrieving verbs relative to nouns in picture naming and sentence generation, but who retains the ability to produce verbal morphology and even to generate novel verbs productively from nominal roots when she is unable to retrieve appropriate action words (e.g. ‘looming’ for *weaving*). Moreover, the results of single word and sentence comprehension tasks suggest that her ability to access lexical forms of verbs is sensitive to their thematic properties. When contrasted with patients who have specific deficits in processing morphosyntactic properties of verbs [J. Neurolinguist. 15 (2002) 265], HG’s pattern of performance can be seen as evidence that grammatical properties are functionally distinct from other aspects of lexical representation. We discuss the implications of this dissociation, and of HG’s performance specifically, in light of various models of lexical access.

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*Keywords:* Verb retrieval deficits; Speech planning; Lexical production

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## 1. Introduction: verb deficits in aphasia

Verb retrieval deficits in aphasic patients have long been associated with damage to general mechanisms of syntactic processing. Early reports described verb production impairments in patients with Broca’s aphasia (Fillenbaum, Jones, & Wepman, 1961; Myerson & Goodglass, 1972) or ‘dynamic’ aphasia, involving lesions anterior to Broca’s area (Luria, 1962; Luria & Tsvetkova, 1967). A systematic investigation by Miceli,

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Silveri, Villa, and Caramazza (1984) showed that patients with agrammatic sentence production tend to have difficulty producing verbs relative to nouns matched in length and frequency, while other studies have linked poor sentence production to impairments in verb comprehension (McCarthy & Warrington, 1985; Wayland, Berndt, & Sandson, 1996). Because verbs play a central role in the formulation of sentences, with distinct argument structures that assign the retrieved lexical items to appropriate slots in the syntactic frame (Bock, 1987; Garrett, 1988), some have speculated that the verb retrieval deficit observed in agrammatism may be causally related to poor sentence production and comprehension abilities (Saffran, 1982; Saffran, Schwartz, & Marin, 1980).

The link between verb processing and sentence processing has not proved ironclad, however. A number of studies have described patients with selective deficits in verb production whose speech is fluent but paraphasic (Caramazza & Hillis, 1991; Kremin & Basso, 1993) or characteristic of so-called Wernicke's aphasia (Berndt, Mitchum, Haendiges, & Sandson, 1997c; Kohn, Lorch, & Pearson, 1989; Williams & Canter, 1987). Nor is it the case that problems with sentence processing necessarily result in verb deficits: Berndt, Haendiges, and Wozniak (1997b) reported a patient SK who demonstrated problems producing and comprehending the kinds of semantically reversible sentences that are typically difficult for agrammatics with impaired verb retrieval, but who produced verbs much more readily than nouns in picture naming. For some aphasic patients, to be sure, problems with verbs may derive from or contribute to a more general syntactic impairment, but this pattern is clearly not universal.

What factors underlie selective verb deficits in patients who are otherwise fluent and show no substantial difficulty in sentence comprehension? One possibility is that such deficits arise because verbs are somehow more 'difficult' or complex than nouns, perhaps because they are on average acquired later or because they are generally more polysemous (Gentner, 1981). This kind of general explanation is on the face of it inadequate to account for patients who perform better with verbs than with nouns (Berndt et al., 1997a,c; Shapiro, Shelton, & Caramazza, 2000; Zingeser & Berndt, 1988, 1990), unless the notion of 'difficulty' is elaborated in some specific and empirically tractable dimension.

Along these lines, Bird, Howard, and Franklin (2000) have argued that verbs are, on average, less imageable than nouns, meaning—according to Bird and colleagues—that verbs have fewer semantic features and are thus more susceptible to impairment as a result of diffuse brain damage. In other words, the more impoverished a word's semantic representation is to begin with, the greater the likelihood that damage to some of its semantic features will impair the retrieval of its phonological form. Breedin, Saffran, and Schwartz (1998) advanced a similar proposal to account for the observation that some patients with verb deficits are better at retrieving verbs that are 'heavier' (e.g. *hurry* vs. *go*) and more specific in meaning (e.g. *wipe* vs. *clean*). Presumably the greater distinctiveness of these words is reflected in richer or more complex semantic representations, which may make them easier to retrieve in the context of brain damage. If, as Bird and colleagues maintain, this 'distinctiveness' rubric (operationalized as imageability) can distinguish not only different types of verbs but also, on a gross scale, nouns from verbs, it may be that verb deficits are relatively trivial side-effects of general damage to the semantic system.

This is an intriguing possibility, but an unlikely one in light of findings that noun/verb differences may persist in tasks in which imageability is controlled across categories, and

that patients who have difficulty producing low-imageability words do not necessarily have more trouble producing verbs than nouns (Berndt, Haendiges, Burton, & Mitchum, 2002). In other words, it cannot be the case that all verb retrieval deficits are attributable to the hypothesized ‘lightness’ of verbs, relative to nouns, in terms of semantic features. Indeed it is not clear that this hypothesis is well-founded: even assuming a notion of semantic features like that advanced by Katz and Fodor (1963), what does it mean to say that verbs have fewer semantic features than nouns? As we noted above, some researchers hold that representations of verbs have *more* semantic content on average than representations of nouns, and verbs unquestionably specify more complex thematic relations between people, objects, and abstractions (Gentner, 1981). It may be that prototypical verbs have fewer sensory or perceptual features than do prototypical nouns, but this does not mean that they are semantically impoverished.

Marshall, Chiat, Robson, and Pring (1996a) and Marshall, Pring, Chiat, and Robson (1996b) have advanced a semantic account of verb retrieval deficits that is sensitive to the qualitative differences in meaning between nouns and verbs. Their patient RG showed an overall advantage for producing verbs over nouns; interestingly, however, he seemed to be better at producing and comprehending nouns whose meanings were less concrete (Marshall et al. 1996b), while among verbs he was better with those whose meanings depended on thematic rather than sensory or perceptual information (Marshall et al., 1996a). Marshall and colleagues proposed that in RG’s case, perceptual semantic information was damaged, but thematic or relational information was intact, leading to an observed deficit in retrieving and comprehending nouns relative to verbs. By extension, they predicted that damage to thematic information would lead to an impairment in verb retrieval.

There is much reason to believe that this type of explanation may be valid for many cases of putative verb deficits; certainly there is evidence to suggest that accessing the relational properties of verbs poses a difficulty for some patients. Caramazza and Miceli (1991) described a patient with a mild verb deficit in naming who showed markedly impaired access to information about thematic structure<sup>1</sup> in the context of sentences, both in production and in comprehension tasks. Other studies have demonstrated that argument complexity is an important predictor of performance in some agrammatic patients (Kim & Thompson, 2000; Thompson, Lange, Schneider, & Shapiro, 1997), even when grammatical class and imageability are accounted for (Collina, Marangolo, & Tabossi, 2001). It has consistently been found that transitive verbs, which have two arguments (e.g. *to destroy*), are more difficult to produce and to comprehend than intransitives, which have only one argument (e.g. *to sleep*). Likewise, nouns that take arguments, like *destruction*, are more difficult to produce than nonargumental nouns (e.g. *medal*).

<sup>1</sup> In this paper we will use the terms ‘thematic structure’ and ‘argument structure’ more or less interchangeably, though there is a subtle difference between the two. In a sentence like *John fed the croutons to the platypus*, the argument structure can be represented as  $x(y,z)$ , where  $x$  is the external argument (subject) of *fed*, namely, the noun phrase (NP) *John*, and  $y$  and  $z$  are its internal arguments, the direct object NP *the croutons* and the indirect object prepositional phrase (PP) *to the platypus*, respectively. Each argument is also assigned a thematic (theta) role with a quasi-semantic interpretation: *John* is assigned the role of agent; *the croutons* is the theme; and *the platypus* receives a benefactive role. Many researchers (Pinker, 1989) have argued for lexical redundancy rules that link thematic roles to argument structure and other syntactic information.

At the same time, the ‘thematic’ hypothesis-like other semantic hypotheses-is clearly limited in its capacity to account for all cases of verb-specific deficits. Neither verbs’ relative paucity of perceptual semantic features nor their thematic structures can plausibly be invoked to explain why some patients can access either the spoken or written forms of verbs, but not both (Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Rapp & Caramazza, 1998, 2002). The fact that patients with such modality-specific deficits can nevertheless produce verbs without difficulty in the unimpaired modality strongly implies that semantic knowledge in these patients is intact. Rather, in these cases it is likely that modality-specific representations of verbs are inaccessible, either because the representations are themselves damaged or because they have been disconnected functionally from the semantic system (Rapp & Caramazza, 1997).

Both of these possibilities carry important implications with respect to the functional organization of lexical knowledge. To assume that the phonological or orthographic representations of verbs can be damaged selectively is to posit that nouns and verbs, at the level of lexical form, occupy anatomically distinct regions of the brain—not an implausible notion, but one for which there is no independent argument. At any rate, neuroimaging studies have so far failed to reveal clear spatial differences in activation during either noun and verb generation tasks (Buckner, Koutstaal, Schacter, & Rosen, 2000; Warburton et al., 1996) or lexical decision tasks (Fujimaki et al., 1999; Perani et al., 1999; see Tyler, Russell, Fadili, & Moss, 2001 also for a concise review of this literature).

Alternatively, in order for a semantic disconnection to give rise to a modality- and category-specific deficit, the semantic system must be organized functionally and anatomically in a way that distinguishes between nouns and verbs (otherwise, it is not clear what connections would have to be impaired). It may be that the thematic-perceptual distinction exploited by Marshall et al. (1996a,b) underlies this organization. More straightforwardly, we might assume that the crucial semantic distinction is that between the categories of actions and concrete objects (Damasio & Tranel, 1993; Gainotti, Silveri, Daniele, & Giustolisi, 1995; McCarthy & Warrington, 1985; Pulvermueller, 1999).

Still a third possibility is that both the semantic system and the representations of phonological and orthographic word forms are intact, along with all the connections between them; the damaged connections may be those between modality-specific lexical representations and specifically syntactic information about the category of verbs. For this to be true, syntactic information would have to have its own autonomous locus of representation. There is, indeed, some evidence that this type of grammatical knowledge can be damaged specifically: JR, a patient described by Shapiro et al. (2000), seems to have problems with morphosyntactic operations involving nouns, while another patient SK, described by Tsapkini, Jarema, and Kehayia (2002), has analogous problems with verbal inflection. The performance of at least one patient, SJD (Badecker & Caramazza, 1991; Caramazza & Hillis, 1991), can be interpreted as reflecting a disconnection between grammatical knowledge about verbs, on the one hand, and the orthographic lexicon on the other. SJD displayed both a general impairment in reading and writing verbs and a more specific impairment in reading regularly inflected verb forms, though her oral naming and comprehension of verbs was unimpaired.

Very likely it is the case that for some patients, like JR, SK, and perhaps SJD, word retrieval difficulties are traceable to problems in accessing grammatical information about

one grammatical category. This leaves open the possibility, however, that for other patients, knowledge of grammatical class is spared. Indeed, given the many kinds of damage that could potentially result in a deficit in retrieving nouns or verbs, we should expect that some patients with grammatical category-specific deficits are in fact well able to access and use syntactic information—for example, morphological inflections—relating to the impaired category.

Here we describe a patient HG who is impaired at retrieving verbs from the lexicon in spoken picture naming tasks, though her ability to process verbs as grammatical objects in tasks that require morphological manipulation is apparently preserved by comparison. Moreover, HG spontaneously and productively generates novel verbs using object names as stems (e.g. *looming*), even as she is unable to produce more typical verbs with ostensibly the same meanings (*weaving*). This pattern of performance demonstrates that morphosyntactic knowledge about verbs as a category may be relatively spared while access to stored verb word forms is compromised. Results from comprehension tasks suggest that HG's ability to use verbs in various contexts may be sensitive to semantic variables, but no single semantic dimension such as concreteness or imageability is sufficient to explain her pattern of performance.

## 2. Case history

HG is a 79-year-old right-handed woman with a BA in education and an MA in psychology. Before leaving work to raise her children, HG held jobs as a prison psychometrician and later as an elementary school teacher. Her premorbid medical history is notable for hypertension and adjustment disorder.

In February 1999, HG suffered a CVA involving branches of the left middle cerebral artery. Radiological reports indicated that initial CT imaging showed areas of mild hypodensity in the left basal ganglia and left frontal temporal lobes; follow up scans indicated internal evolution of the left frontal infarct and also revealed a small right sided lacunar infarct in the basal ganglia. This damage resulted in persistent right hemiparesis and a severe speech impairment diagnosed as global aphasia.

At the time of testing (December 1999–April 2000) HG felt uncomfortable speaking spontaneously and had marked word finding difficulties along with mild dysarthria. HG's description of the Cookie Theft Picture from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) illustrates her articulatory difficulties and frequent use of stock expressions (e.g. "I don't like this one"):

The picture is [pause] I'll have a guess but [pause] I don't like this one or this one [pause] a painting about nice, uh, puddle, and it's leaking out and the basin and the other one is [β ø], taking the [τΣΥκϭ] and I am falling off the stool. Okay.

In various screening tasks HG seemed to display greater difficulty with actions than with objects. For example, in picture naming she correctly identified 8/10 objects and only 5/10 actions. In auditory word-to-picture matching HG responded correctly for 10/10 objects but only 7/10 actions, though she performed flawlessly in an similar task with

Table 1

HG’s proportion of correct responses in three confrontational naming tasks with pictures of actions (verbs) and objects (nouns). Z&B indicates the task described by Zingeser and Berndt (1990); CN denotes a similar task with 49 action and object pictures matched for visual complexity and frequency and familiarity of the target words

	Z&B 1		Z&B 2		CN	
Verbs	7/30	0.23	8/30	0.27	12/49	0.24
Nouns	44/60	0.67	45/60	0.67	35/49	0.71

visually presented words. She also made no errors on auditory (10/10) or visual (10/10) lexical decision tasks. HG correctly read 7/8 verbs, 8/8 nouns, 3/4 function words and 18/20 nonwords, as well as 44/50 10-word sentences.

In order to elicit more connected speech samples, HG was asked to provide one-sentence descriptions of pictures from a familiar children’s book (Rey & Rey, 1994), with the accompanying text covered. A number of her utterances demonstrated omission of the main verb (“he is [holding] the rabbits”), though function word production seemed to be preserved (“Curious George is in [receiving] a letter from the postman”). HG’s apparent difficulties in retrieving verbs often resulted in circumlocutions, some of which were pragmatically appropriate (“here it is asleep in bed”), while others were not (“George is the basis of [is running after] this ball”).

### 3. Single word naming

A series of confrontational picture naming tasks was used to establish that HG had difficulty retrieving verbs relative to nouns.

HG was twice given the picture-naming test developed by Zingeser and Berndt (1990) (henceforth Z&B) to probe for grammatical category-specific deficits. The Z&B task 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, HG was shown a drawing and was asked to name the action or object depicted in it. HG also completed a second test modeled on Z&B, with 49 action and object pictures matched for visual complexity and for frequency and familiarity of target responses. Since HG’s performance was consistent across the three tasks (see Table 1), the analysis that follows will treat them together except when otherwise noted.

In scoring HG’s responses, substitutions of semantically related words for the target word were counted as semantic errors, and incomplete sentence frames or definitions were classified as circumlocutions. Phonological errors included only responses that differed in any one phoneme from their targets. Responses that differed more radically in phonology from target words were classified as neologisms (*spilling*: [κHoYIN]); when these occurred in the context of circumlocutions, the error was scored as mixed neologistic.

HG showed a highly significant advantage for naming nouns (123/169, 73%) compared to verbs (26/109, 24%;  $Z = 7.99, p < 0.001$ ). Interestingly, across both administrations of

Z&B she was slightly better at naming nouns matched to the base frequency of the verbs (39/60) than nouns matched to the verbs' cumulative frequency ( $Z = 2.29$ ,  $p < 0.05$ ), though in a regression model the target frequency was not a strong predictor of naming performance among either nouns ( $t(167) = -0.49$ , ns.) or verbs ( $t(107) = 0.37$ , ns.; Kucera & Francis, 1982). The same was true of imageability in a model with this variable and concreteness (nouns:  $t(107) = -1.30$ , ns.; verbs:  $t(29) = 1.13$ , ns.), although concreteness turned out to be a good predictor of naming for nouns ( $t(107) = 3.63$ ,  $p < 0.001$ ), but not for verbs ( $t(29) = -0.26$ , ns.; Paivio, Yuille, & Madigan, 1968; Togliola & Battig, 1978).

A large majority of HG's errors with nouns were semantic errors (27/46, 59%), like *globe*: 'atlas' and *crib*: 'baby nursery'. For several items she provided nontarget responses that were nevertheless judged appropriate, such as 'fedora' for *hat* and 'mallard' for *duck*.<sup>2</sup> HG produced relatively few phonological errors with nouns (6/46, 13%), failed to respond twice and made a few attempts at circumlocution (6/46, 13%), sometimes with humorous results (*ghost*: "I do that again, I say 'boo' but I don't like it"). The remaining errors with nouns (5/46, 11%) were mixed phonological and semantic errors, such as [βεΙλβακσ] for *mailbox* and [πφσκ◆□βΕ◆ιζ] for *strawberry*.

By contrast, HG made very few recognizable semantic errors for verbs (4/83, 4%; *shaving*: 'culling his whiskers'; *sledding*: 'sailboarding'). Most of her errors with this class of words consisted of circumlocutions (55/83, 66%; *teach*: 'this one is talking about this one to the boy and girl'; *eat*: 'the boy sits at a table with a spoon and its mouth becomes that one, sandwich'), some of which incorporated neologisms (7/83, 8%; *listen*: 'I like this one because it [φυτσ] the sound'). Occasionally in the context of circumlocutions HG used nouns zero-related to or derived from an appropriate target verb (*decorating/icing*: 'it's a cake with icing on it, the icer is doing it'). These instances were classified separately as 'nominalizations', and accounted for 6/83 (7%) errors. In other cases she produced nouns that were semantically but not morphologically related to the target verbs (such as 'nun' for *praying*, 'jackknife' for *diving*, and 'a garden of shrubs' for *watering*), and which were sometimes quite abstract (*saluting*: 'pledge of allegiance of a girl'; *bleeding*: 'it's cut, his finger... infection'). HG also produced a number of phrases with abstract nouns unrelated to the target (*typing*: 'discussion, you like that one and I like it too'; *waving*: 'doing that one, remembrance'; *melting*: 'he is paying attention to loftier spaces').

In addition, HG produced seven clear phonological errors (8%; *digging*: [ζIγIN]) and one apparent neologism that was not generated as part of a circumlocution (*following*: [ωο/ωIN]). In two instances she did not respond at all.

Clearly HG has much more trouble producing verbs than nouns in confrontational picture naming. She also produces different kinds of errors with nouns and verbs, although this may be attributable in part to the likelihood that semantic relationships among verbs

<sup>2</sup> It is perhaps notable that many of HG's responses appear to be of lower frequency than the target responses, sometimes strikingly so ('autogiro' for *helicopter*). A similar 'inverse frequency effect' was described by Marshall, Pring, Chiat, and Robson (2001) for patient JP, who systematically produced error words that were low in frequency and who named low frequency words better than high frequency words. However, in the present case there were not enough such errors across naming tasks to permit a meaningful analysis, and as we mentioned above there was no indication that HG was better at naming low frequency words than high frequency words (or vice versa).

are less clear-cut than among nouns (Levin, 1993). We next investigated whether HG's difficulties with verbs in single word naming extend to connected speech, that is, to phrase and sentence production.

## 4. Phrase formulation

### 4.1. Procedure

HG was given a structured phrase formulation task in which she was asked to form sentences using target words that were provided in spoken form by the experimenter (Berndt et al., 1997c). The target words include 12 unambiguous verbs and 24 unambiguous nouns,<sup>3</sup> 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.

We determined that HG had used a word correctly as a noun when it appeared as the subject of a verb or copular phrase (*door*: 'the door is fine') or as the object of a verb phrase (*basket*: 'I made a basket'; *swan*: 'the swan gave me trouble'), even when these phrases were illogical or unpragmatic (*salad*: 'a salad is making that'). Likewise, HG was given credit for having produced a verb when it occurred in the context of a recognizable verb phrase (*give*: 'give me a dollar', *plant*: 'I plant a garden'). Indeterminate and erroneous responses included ill-formed phrases (*hat*: 'go and hat, uh, put on') and idioms or other expressions where the grammatical class of the target was not obvious (*carry*: 'cash and carry is the P-R-O-J-E-C-T'; *day*: 'day after day when it comes light, isn't it frightening').

### 4.2. Results

According to these criteria, HG used unambiguous verbs correctly as verbs in 7/12 instances (58%), but used unambiguous nouns correctly in 19/24 instances (79%), a difference consistent with her relative impairment in verb production ( $Z = 1.32$ ,  $p < 0.05$ ). In one case she used an unambiguous verb apparently as a noun (*sew*: 'I like my picture and the sewing'). However, HG showed a marked preference for using ambiguous stimuli as verbs (13/18, 72%) compared to nouns (4/18, 22%); even with ambiguous stimuli that occur more frequently as nouns were used predominantly as verbs (5/6; *fan*: 'fan yourself with a tutu').

The latter finding is puzzling on the assumption that HG's difficulties with verbs should extend to sentence generation. On the one hand, it suggests that HG's difficulties in producing verbs do not reflect a conspicuous impairment in processing verbs syntactically,

<sup>3</sup> Some of these 'unambiguous' words may in fact have low-frequency homophones of another grammatical class (e.g. *to leaf through a magazine*). This possibility is difficult to avoid when constructing a task in English, in which grammatical class has no overt morphological reflex and the class of a word can often be changed productively. For the purposes of this task, the disparity in frequency between an 'unambiguous' noun or verb and its homophone (if one exists) is assuredly very large.

and can be ameliorated to some extent when she is provided with an explicit phonological target. Yet it is unclear why HG should *prefer* to use ambiguous target words as verbs in light of the observation that she is more successful at producing grammatical sentences with unambiguous nouns than unambiguous verbs.

It could be that providing a verb target spares HG the effort of generating a different verb around which to structure a sentence; thus, if she can use the word *plant* as a verb in the sentence ‘I plant a garden’, she need not come up with another verb appropriate for the noun *plant* (e.g. *to water, to prune, to admire*). But this explanation is not entirely adequate, as it still does not account for HG’s relative difficulty with unambiguous verbs.

Suppose, however, that to produce ambiguous words as verbs in a well-formed phrase, HG need not access verbs from the lexicon at all. Rather, it could be that in some cases HG retrieved the *noun* forms of ambiguous words, and employed a strategy of zero-deriving verbs online from noun roots.<sup>4</sup> It is well known that patients with verb-specific deficits sometimes (erroneously) produce novel zero-derived verbs. For example, a patient reported by McCarthy and Warrington (1985), ROX, sometimes used nouns as verbs with the progressive *-ing* suffix when he was unable to retrieve a target verb form (e.g. *climbing*: ‘the child was laddering’). HG makes similar errors occasionally in picture naming: for instance, in response to a picture with the target *sneezing*, HG said ‘achooing that one’. In principle, HG may be doing the same thing with unambiguous nouns, perhaps facilitated in these cases by the semantic and phonological relationship between the noun and its verb homophone.

To investigate the plausibility of this hypothesis, and to test whether HG is able to generate novel verbs online from noun roots, we devised a task that was designed specifically to induce verbalizations of the sort described by McCarthy and Warrington (1985), Rapp and Caramazza (2001), and others. We called this the ‘action/instrument naming task’.

## 5. Action/instrument naming task

### 5.1. Procedure

The stimulus set consisted of 10 line drawings depicting a man or woman performing some action (e.g. *sewing*) with an appropriate instrument (e.g. *needle*). The instruments in the drawings were colored red and indicated by red arrows. Each picture also included a distractor item that was matched for frequency and semantically related to the target object (e.g. *thread*). This foil was colored blue and was not indicated by an arrow. Additionally, five ‘practice’ items were prepared in which the action and instrument names were homonyms (e.g. *brushing/brush/mirror*); these were intended to bias the subject to use instrument names as verbs. Action and instrument names in both the practice and experimental sets were always monomorphemic and were matched to each other as closely as possible for frequency.

<sup>4</sup> By *zero-derivation* we refer to the derivation of a verb from a noun root without an overt change in the root’s morphology—for example, *to chair, to fax, to cable*.

Table 2

Analysis of HG's performance on the action/instrument naming task. *I then A*: instrument naming question; *A then I*: action naming question was asked first.  $N = 25$  for nouns and verbs in both question order conditions. For each grammatical class, the number of correct initial responses is listed, followed by the total number of correct responses (including self-corrections of errors) in parentheses. Error types are listed along with the number of initial errors of each type

	Question order		Error examples
	I then A	A then I	
Nouns	19 (22)	22 (23)	
Semantic foil	1	2	<i>bell</i> : 'a rope'
Perseveration	2	0	<i>bell</i> : 'a broom'
Other	3	1	<i>bell</i> : 'a clapper'
Verbs	6 (11)	3 (3)	
No response	1	3	
Semantic	3	2	<i>sewing</i> : 'he was darning'
Light verb	6	5	<i>weaving</i> : 'making a loom'
Nominalization	0	4	<i>ringing</i> : 'bell-ringer'
Verbalization	9	8	<i>sewing</i> : 'he needles'

The task was administered a total of six times (twice using only 5/10 items) in separate sessions. As each drawing was presented, the subject was asked to answer two questions: 'What is this person doing?' and 'What is this person using?' The order of the questions alternated between presentations, such that each question was asked first twice for each item. Questions were repeated when necessary, and the subject was prompted again when her response did not contain a one-word element that could plausibly be related to the target. For instance, when her initial response to the action-naming question took the form 'he is using X', she was asked, 'What is it called when people use X?' All responses were tape-recorded.

## 5.2. Results

Practice items (in which the noun and verb were homonyms) were not counted in the analysis. Errors were scored on the basis of HG's initial responses only, though Table 2 also indicates the number of items for which HG eventually gave a correct response (whether self-corrected or prompted). As is evident, HG displayed a large advantage for producing nouns, both when the instrument name was elicited prior to the action name ( $Z = 3.68$ ,  $p = 0.0001$ ) and when the action name was elicited first ( $Z = 5.37$ ,  $p < 0.001$ ).

Most of HG's errors with instrument items involved substitution of another concrete noun, usually either the name of the semantic foil (*brush*: 'mirror') or of an item presented earlier (*rake*: 'a [ $\pi$ H $\blacklozenge$ v $\mu$ ] (broom)'), though sometimes of an object not in the picture set (*needle*: 'sewing machine, scissors'). In one case she seemed to substitute an abstract noun for the pictured target (*ladder*: 'idea'). HG self-corrected more than half these errors (5/9), so that she eventually produced appropriate names for 46/50 noun targets.

By contrast, HG was able to produce only 9/50 verb targets (five of which were later corrected). Only 5/41 of HG's initial errors in action naming consisted of semantically related verbs (*sewing*: 'darning'). A large group of errors involved light verb constructions (*climbing*: 'using the ladder'), not all of them grammatically appropriate (*weaving*: 'making a loom'; *chopping*: 'doing an axe'). In a few cases, HG produced nouns related to the pictured action—either agentives (*ringing*: 'bell-ringer', *digging*: 'spader') or simply the names of the instruments (*watering*: 'hose').

A plurality of errors in action naming, however, were verbalizations of the sort that the task was designed to elicit (*sweeping*: 'brooming'; *climbing*: 'laddering'). These constituted 44% of HG's initial errors (18/41). Counting all responses, including attempted self-corrections, HG produced 27 verbalizations in which she used the target noun as a verb with either the progressive *-ing* or the third person singular *-s* inflection (in the latter case, the verb was preceded by a pronoun).<sup>5</sup>

HG's ability to produce novel verbs like 'brooming' and 'laddering' demonstrate clearly that she retains access to information about the syntactic and morphological properties of the category of verbs; otherwise, such 'errors' would be impossible. This implies that she should also perform quite well on tasks in which she is asked directly to manipulate the morphology of target verbs, for instance by alternating between third person singular and plural forms, or between past and present tense. In fact, we found that HG has no trouble performing such manipulations, even with pseudo-words presented as verbs.

## 6. Regular and irregular verbs

### 6.1. Procedure

To gauge HG's ability to generate inflected forms of regular and irregular verbs we used a task designed to elicit verbs in either the past or future tense. (The 'future' tense form elicited here is unmarked, since the modal auxiliary *will* was supplied by the experimenter.) Stimuli for the task consisted of 71 regular verbs (which take *-ed /d/* as a marker of the past tense) matched for frequency to 108 verbs of various irregular patterns, as classified by Pinker and Prince (1988). The subject was asked to complete sentence frames like the ones given below:

"Yesterday I walked; today I will..." (*walk*)

"Today I will come; yesterday I..." (*came*)

Altogether, there were 358 such sentence frames; the order of presentation was determined randomly. The subject was allowed to stop at any time, and completed the task in several blocks over the course of two sessions.

<sup>5</sup> It is true that many, if not all, of HG's supposed 'verbalizations' correspond to verbs, zero-derived from nouns, that have at one time or another been current in English. For example, the second edition of the Oxford English Dictionary lists *to loom* and *to needle* as verbs meaning 'weave' and 'sew', respectively, both attested in the 1880s. Needless to say, such forms are infrequent, and even if HG was familiar with this rare usage, it is certainly noteworthy that she employed it more readily than she retrieved more familiar verbs with the same or similar meanings (e.g. *weaving*, *sewing*).

## 6.2. Results

In general, HG's level of performance was quite high, reaching 87% (187/216) correct for irregular verbs and 95% (135/142) for regular verbs. The difference between regular and irregular verbs was significant ( $Z = 2.39$ ,  $p < 0.01$ ); among irregulars, HG was especially impaired with verbs in the 'miscellaneous' category (23/30 correct;  $Z = 1.79$ ,  $p < 0.05$ ), which comprises words that do not belong to any of the major irregular patterns, including defective paradigms (*go–went*) and unpredictable alternants (e.g. *see–saw*, *stand–stood*). HG made equally as many errors with past-tense forms as with unmarked forms (Fig. 1).

A plurality of HG's errors (12/35, 34%) involved substitution of a phonologically similar word for the target form (*tear*: 'take'). HG also produced several participial forms in place of irregular past tense forms (6/35, 17%; *forgot*: 'forgotten'; *sleep*: 'sleeping'). There were only two regularizations in the error corpus (6%, *clung*: 'clinged'; *pled*: 'pleaded'). Other errors were scored as 'failed' if HG reproduced the stimulus word without changing its tense (6/35, 17%; *swung*: 'swing too'), 'lexical–semantic' if she substituted a semantically related word for the target (3/35, 8%; *returned*: 'went'), 'complex' if the response seemed to exemplify more than one error type (4/35, 11%; *buy*: 'boxing'), or 'no response' (4/35, 11%).

What is especially noteworthy about this task for our purposes is that HG did not exhibit much difficulty in regular inflection, which we would expect if she were impaired at manipulating syntactic information about verbs. Her modest difficulties with irregular verbs may point to an impairment at retrieving idiosyncratic lexical forms—an interpretation that would not be inconsistent with her observed problems in action naming. It is interesting in this light that HG had the most trouble with precisely those verbs that do not belong to large similarity groups, and are hence more likely to be memorized as lexical units. At the same time, even with irregulars HG was able to respond accurately almost 90% of the time, which is no doubt impressive given her age and the tediousness of the task.<sup>6</sup>

Although these results seem to provide strong evidence that HG's deficit is not syntactic in nature, it is conceivable that the verb morphology task just described is insufficiently sensitive to detect subtle problems in morphosyntactic processing. For instance, perhaps HG's performance was boosted by her familiarity with the words she was required to manipulate. It is possible that HG would be even better (i.e. virtually perfect) at producing regularly inflected forms of nouns equivalent in frequency and familiarity to the verbs used in the task. In order to control for any possible effect of familiarity or grammatical class, we tested HG with the pseudo-word morphology task developed by Shapiro et al. (2000).

<sup>6</sup> A potentially interesting aspect of HG's performance on this task is that she made very few regularization errors with irregular verbs (perhaps only one, if we count *pleaded* as an acceptable alternative to *pled*). This may suggest that, even if HG is slightly impaired at retrieving irregular past forms in response to their unmarked forms, and vice versa, she nevertheless retains the knowledge that a given verb is irregular.

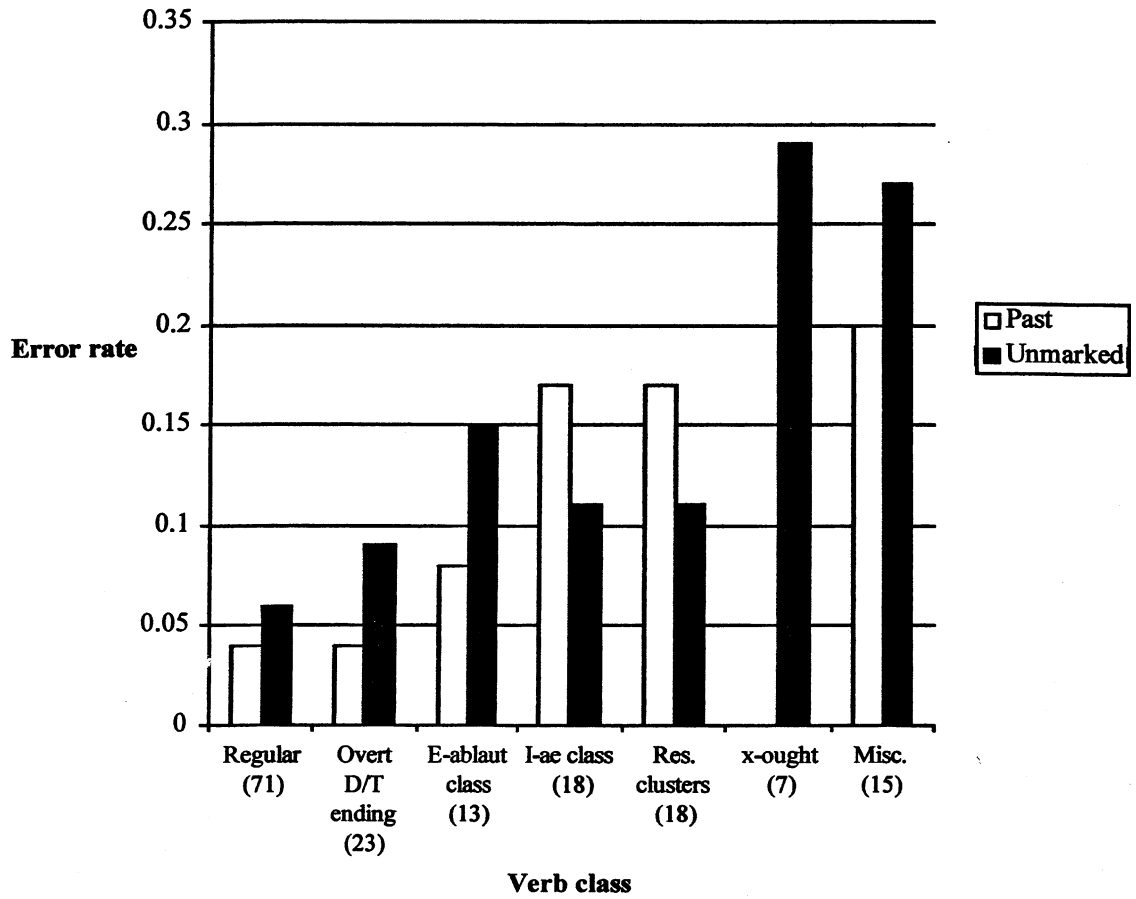


Fig. 1. Distribution of HG's errors in morphological processing of regular and irregular verbs. Verb classes according to Pinker and Prince (1988). Numbers in parentheses indicate the number of token of each class; HG was asked to produce each token in the past-tense and unmarked (future) form, given the other form as a stimulus.

Table 3

HG's correct performance on the pseudo-word morphology task, collapsed across all administrations

Noun		
Add -s	44/48	0.92
Remove -s	47/48	0.98
<i>p</i> -value	0.08	
Verb		
Add -s	45/48	0.94
Remove -s	45/48	0.94
<i>p</i> -value		0.50

### 6.3. Procedure

The task was based on two lists of stimuli, each with 24 phonotactically licit one-syllable nonwords (e.g. *wug*, *fleeve*, *narf*). 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 person *narfs*; these people...” (*narf*)
- “These people *snetch*; this person...” (*snetches*)

Lists of ‘pseudo-noun’ and ‘pseudo-verb’ 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. HG was asked to repeat each stimulus after the first matrix clause in the prompt.

### 6.4. Results

It is evident from the data in [Table 3](#) that HG had few problems with the pseudo-word morphology task, correctly producing 90/96 verbs (94%) and 91/96 nouns (95%). HG's errors usually reflected a failure to change the morphology of the stimulus word, and rarely an inability to produce a response at all. The mean phonetic similarity of HG's responses to the stimulus items was 0.91 for nouns ( $s = 0.15$ ) and 0.88 for verbs ( $s = 0.20$ ), scored according to the procedure described by [Shapiro et al. \(2000\)](#). This difference, though small, is marginally insignificant for matched pseudo-word noun-verb pairs ( $t(95) = 1.53$ ,  $p = 0.06$  paired one-tailed), suggesting that HG might be slightly more impaired at creating phonological representations for verbs compared to nouns in working memory. The implications of such a dissociation, if it exists, are not obvious, but the finding is at

least compatible with the relatively high proportion of phonologically related word substitutions observed in the verb morphology task.

HG did not show a difference between nouns and verbs in either condition of the task. Likewise, there was no difference between the add *-s* and remove *-s* conditions for either nouns or verbs. In light of these observations, along with the results of the action/instrument naming task, it seems reasonable to conclude that HG's ability to engage morphological and syntactic operations involving verbs is relatively preserved, despite her profound difficulties in retrieving the names of pictured actions.

## 7. Interim discussion

Although we can say with reasonable certainty what *cannot* be the source of HG's difficulty with verbs (namely, difficulty with verbal morphology), distinguishing her from other verb impaired patients like SK (Tsapkini et al., 2002), we are at this point still unable to say much about what factors do influence HG's ability to access verbs. Though concreteness and imageability were not found to predict HG's picture naming performance, it is true that in this task concreteness and imageability values were constrained by the obvious necessity that all target items be pictureable. (At the same time, there was sufficient variability in these values to reveal a significant effect of concreteness on noun naming.) We therefore administered several tests of single word and sentence comprehension to test whether semantic variables might affect HG's access to nouns and verbs.

## 8. Single word comprehension

### 8.1. Procedure

We used the synonymy triplets tasks from Breedin, Saffran, and Coslett (1994) to investigate aspects of HG's comprehension of nouns and verbs of different types. In this task, the patient was presented with a set of three words, all of the same category, in written form while they were simultaneously read aloud. She 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. nonrelational verbs ( $n = 27$  each).

### 8.2. Results

A trend toward greater difficulty with verbs in the noun-verb triplets task was not significant (nouns: 13/16; verbs: 11/16;  $Z = 0.82$ , ns.), and there was also no observable difference between comprehension of abstract (21/26) and concrete nouns (20/26;  $Z = 0.34$ , ns.). However, a striking pattern emerged when HG was required to discriminate among verb triplets of various types: she did much worse with relational triplets, where the

relevant distinction was based on argument structure (e.g. *to eject*–*to exit*–*to expel*), than with triplets where the distinction relied either on manner (e.g. *to mutter*–*to whimper*–*to mumble*) or on some nonrelational semantic opposition (e.g. *to open*–*to close*–*to shut*). Indeed, HG's performance with relational triplets (9/27) was identical to chance. By contrast, she seemed almost unimpaired with nonrelational triplets relative to the other two types (24/27 vs. 17/27 manner,  $Z = 2.23$ ,  $p < 0.02$ , vs. 9/27 relational,  $Z = 4.19$ ,  $p < 0.001$ ).

It is intriguing that HG seems to have trouble recognizing differences specifically among verbs in the relational set. Note that in these triplets, the 'core' semantics of each of the verbs are essentially the same; for example, all three verbs in the triplet *to die*–*to kill*–*to murder* involve the death of some living entity. However, the verbs differ in their argument structure (*kill* and *murder* imply external agents, while *die* does not; one cannot say \**Harold died the dog*) and in the thematic roles they assign to the noun phrase that refers to whomever or whatever is dying (*kill* and *murder* assign the role of patient to this argument, while *die* assigns it the role of experiencer). It would seem, then, that HG has difficulty comprehending verbs' thematic/argument structures, though she is much better at picking out differences in meaning between verbs with essentially the same argument structure (e.g. *to live*–*to die*–*to expire*).

One possibility is that HG, like many other patients with verb deficits (cf. Caramazza & Miceli, 1991), is impaired in her ability to access verbs' thematic structures. If this were the case, we might expect that HG should also have difficulty mapping theta-roles onto the arguments of verbs in the context of sentences, resulting in an inability to distinguish, for example, the agent (subject) and patient (object) of a two-predicate verb.

## 9. Sentence comprehension

### 9.1. Procedure

To assess HG's ability to assign thematic roles in comprehension, we used an English version of an Italian sentence-to-picture matching task in the Batteria per l'analisi dei deficit afasici (Miceli, Laudanna, & Burani, 1991), similar to the task described by Caramazza and Miceli (1991).

The task consisted of a set of 60 stimulus sentences constructed with two-predicate verbs. Each stimulus was paired with two line drawings, the first of which portrayed the action described in the stimulus sentence. The second drawing corresponded to one of the three types of foil sentences: a role reversal foil in which the thematic roles were reversed; a morphological foil in which the number of either the agent or the patient differed from that used in the stimulus; and a lexical foil in which either one of the nouns or the verb was semantically related to the stimulus sentence. Thus the sentence *The cat scares the rabbit* might occur with any of the following foils:

Role reversal: *The rabbit scares the cat*

Morphological: *The cats scare the rabbit/The cat scares the rabbits*

Lexical: *The cat scares the dog/The dog scares the rabbit/The cat attacks the rabbit*

Stimulus sentences were read aloud and the subject was asked to point to the picture that most closely matched each sentence. If necessary, the stimuli were repeated up to three times.

## 9.2. Results

As expected, HG was significantly worse in the reversal foil condition than in either other condition (13/20 vs. 18/20 lexical,  $Z = 1.89$ ,  $p < 0.05$ , vs. 19/20 morphological,  $Z = 2.37$ ,  $p < 0.01$ ), performing essentially at chance ( $Z = 0.96$ , ns.). No difference was observed between active and passive reversible sentences (5/10 active vs. 8/10 passive,  $Z = 1.41$ , ns.), though this may have been due in part to the small number of sentences in each group. If the active-passive difference were real in this case, it might indicate that HG is able to use additional morphological elements associated with passive sentences—notably the preposition *by*—to deduce thematic role assignments she could not retrieve from the verb.

HG's performance on the synonymy triplets and sentence comprehension tasks suggest that she has most difficulty in comprehension when she is required to make distinctions that hinge upon the way verbs assign grammatical arguments.

## 10. General discussion

HG presents with a complex pattern of impairment across various tasks, showing a consistent advantage for nouns over verbs in spoken production but no clear effect of grammatical class or concreteness in comprehension.

At least one crucial generalization can be extracted from this picture. Though HG appears to have difficulty accessing specific verb forms, her knowledge about morphosyntactic processes associated with verbs is broadly intact. Thus, in confrontation naming of action pictures she often produces neologisms with apparently well-formed verbal inflections (e.g. 'I like this one because it [ $\varphi\nu\tau$ ]s the sound', 'my mother is [ $\kappa\text{HoY}$ ]ing also because of that one'), and shows no difficulty in inflecting pseudowords as verbs in the third person (or, for that matter, as plural nouns). Moreover, HG can be induced to apply verb morphology productively to noun stems (e.g. 'this is a broom and he is brooming').

Interestingly, in manipulating the tense of auditorily presented verbs, HG shows a slight advantage for regular over irregular inflection. The sparing of regular inflection corroborates the notion that HG retains knowledge of verb-specific morphological operations. On the other hand, the relative disadvantage for irregular forms, which cannot be retrieved simply by applying a morphological rule, points to a deficit in retrieving word forms from the lexicon (Ullman et al., 1997).

The apparent preservation of grammatical knowledge in the face of a deficit in verb retrieval is interesting for a number of reasons. To begin with, it provides further evidence that patients with verb-specific deficits do not necessarily have concurrent deficits in

sentence production<sup>7</sup> or in the production of grammatical morphemes. In other words, there is no causal connection between verb deficits and agrammatic or nonfluent speech (Berndt et al., 1997b). This in turn casts doubt on the hypothesis that verb deficits and function word deficits are jointly traceable to problems in processing low-imageability words (Bird, Franklin, & Howard, 2002).

More notably, HG (and other patients like her) provide an important contrast to cases in which grammatical category-specific deficits co-occur with an impairment in using words of the damaged category in their syntactic and morphosyntactic context. JR, whom we mentioned earlier, showed a robust category-specific deficit for nouns that manifested itself clearly in morphological production tasks: he was worse at producing the plural forms of nouns and pseudo-nouns than the phonologically identical third person singular forms of verbs and pseudo-verbs (Shapiro et al., 2000). Unlike HG, however, JR used ambiguous words preferentially in contexts appropriate to the unimpaired grammatical category (i.e. as verbs).

Though JR's deficit is limited to nouns, Tsapkini et al. (2002) have described a Greek-speaking patient SK with a morphological deficit that is apparently restricted to the category of verbs. When SK was asked to produce verbs in the past perfective form, he was unable to respond correctly 72% of the time. By contrast, he made only 9% of errors in producing the plural forms of neuter nouns, though the two manipulations being compared (forming plural neuter nouns and past perfective verbs) are ostensibly equivalent in morphophonological complexity. Sentence to picture matching tasks indicated that SK had little difficulty comprehending past perfective verbs (or plural nouns), and his repetition and reading were largely intact. Tsapkini and colleagues conclude based on these data that grammatical class is an 'organizing principle' of the lexicon.

Especially in accounting for the very different kinds of verb deficits displayed by HG and SK, it seems reasonable to posit that morphosyntactic information about verbs (and presumably about nouns also; cf. Shapiro et al., 2000) constitutes a functionally autonomous component of the lexicon that can be spared or impaired independently of semantic or form-related information. In many ways such a conclusion is similar to earlier claims about cases of isolation of the language area (Whitaker, 1976), progressive dementia (Irigaray, 1973; Schwartz, Marin, & Saffran, 1979) and so-called transcortical sensory aphasia (Berndt, Basili, & Caramazza, 1987), which were said to demonstrate the independence of semantic and grammatical processing components within the language system. Such patients present with intact sentence generation, and may correct morphological errors on repetition even when comprehension is impaired—just as HG is able to perform well on morphological processing tasks involving repetition, regardless of grammatical or semantic category.<sup>8</sup>

<sup>7</sup> It is true that many of HG's utterances, taken at face value, do not constitute what we would regard as normal, grammatical sentences. However, the apparent ill-formedness of these utterances in many cases may result from word-finding difficulties (and subsequent failed attempts at repair), and not syntactic difficulties per se. This does not seem unlikely given that HG produces many other utterances that *are* well-formed and syntactically quite complex (if sometimes semantically or pragmatically bizarre).

<sup>8</sup> We are indebted to John Marshall for pointing out this connection.

Though our position is at odds with the idea that grammatical class-specific deficits can only arise as epiphenomena of more general semantic deficits (Bird et al., 2000, Bird, Howard, & Franklin, 2001), it is in line with several influential models of word production, all of which include some component devoted to the representation of class-specific grammatical and morphosyntactic information (Caramazza, 1997; Dell, 1986; Garrett, 1980, 1988; Levelt, Roelofs, & Meyer, 1999). We will devote the rest of the discussion to examining the ways in which the data we have discussed here relates to these models, and how it may help us decide whether any one model (or certain features of one model) can account more readily than others for the full range of normal and aphasic speech.

## 11. Grammatical class in lexical access

The question central to this endeavor is, how is grammatical class represented in relation to other kinds of lexical information, and how is it retrieved in the course of lexical access? According to what is perhaps the most widely accepted view, information about grammatical class becomes available at a level of representation in-between the semantic/conceptual level at which meaning is represented and the ‘lexeme’ level that contains the phonological and orthographic forms of words. This intermediate level, sometimes called the ‘lemma’ level (Levelt et al., 1999), is assumed to be amodal and to serve as a pointer to a word’s associated syntactic properties (e.g. grammatical class, gender, classifier, auxiliary). Because lemmas are thought to link the semantic and formal aspects of a word’s representation, Caramazza (1997) has dubbed this the ‘syntactic mediation’ (S.M.) hypothesis. As an alternative, Caramazza proposed the ‘independent networks’ (I.N.) hypothesis, which dispenses with the lemma level and postulates that grammatical information is accessible directly at the level of modality-specific lexical representations.

The I.N. model is motivated in large part by the kinds of modality-specific grammatical class deficits we described earlier in the Introduction. Such deficits are difficult to interpret if we assume both that an amodal lexical node is interpolated between representations of form and meaning and that grammatical class can be accessed *only* through this amodal lemma (but see Miozzo & Caramazza, 1998; Roelofs, Levelt, & Meyer, 1998). Nevertheless, S.M. models can be modified in ways that allow them to account for modality-specific deficits (though these modifications may come at the cost of some of the core assumptions of the S.M. framework: see Caramazza, 1997; Rapp & Caramazza, 2002).

Can the data reported here help to adjudicate between the S.M. and I.N. models of lexical access? Rapp and Caramazza (2002) have pointed out that the productive zero-derivation of verbs by aphasic patients poses a problem for the S.M. hypothesis because it suggests that the selection of a word form does not depend on the prior selection of its grammatical properties.

One could argue that in an S.M. framework, zero-derivation of verbs is accomplished by a sort of ‘multiple selection’ of lemmas. That is, the lemma for *sweep* may be selected normally, but if its phonological form is inaccessible, the speech production system may be forced to retreat and select another lemma corresponding to a different but semantically

related concept, say, *broom*. (We are deliberately vague here with respect to the dynamic implementation of this process.) Hence at the lemma level, both *sweep* and *broom* will have been retrieved, but only the phonology of ⟨broom⟩ is selected—and then somehow appended to, or combined with, the lemma for *sweep*, in order to be produced as a verb. This last ‘somehow’ poses a crucial problem for S.M. models, however. How does one combine the lemma of one word with the form of another? What becomes of the other lemma that has been selected but whose grammatical properties must be suppressed? Alternatively, if grammatical properties can be accessed and selected contrary to a word’s lemma representation (supposing that only *broom* is selected, and then produced as a verb), what is the function of the lemma?

An I.N. model can accommodate zero-derivation more or less straightforwardly by assuming that the phonological representation ⟨broom⟩ is selected because it is the most highly activated accessible lexical node, while input from the syntactic (and perhaps the semantic) system boosts the activation of the grammatical representation Verb enough to override the selection of the Noun representation normally associated with ⟨broom⟩. Yet this account too is lacking in some respects. The question here is not one of suppressing grammatical information that has already been retrieved, but of supplying information that is seemingly unspecified: for example, what determines the meaning and argument structure of ⟨broom⟩<sub>V</sub>? Is *brooming* something one does to the floor (like *sweeping*), with a broom (like *using*), or something one simply does (like *doing*)?

The answer to this question under an S.M. model is readily predictable: *brooming* should have the same referent and argument structure as *sweeping*, if *brooming* is really the product of the lemma *sweep* and the phonological representation ⟨broom⟩. (As we have indicated, however, it is not at all obvious how an S.M. system would arrive at such a product.) Under an I.N. model, we would be forced to assume that some ‘default’ set of properties is invoked—that is, that the category Verb is associated with certain generic argument structures, referential mappings, and so forth, which are deployed automatically when this information is not otherwise specified in a word’s representation.

What kind of data might help us to discern where the argument structure and other properties of zero-derived verbs come from? Some clues may be provided by the light verb phrases produced by HG in conjunction with novel, zero-derived verbs. Recall that HG, when asked to name the actions portrayed in the action/instrument naming task, sometimes responded by saying that the person was ‘using’, ‘doing’, or ‘making’ something. Occasionally these phrases were followed by spontaneous verbalizations: for instance, ‘making a loom, looming’; ‘doing an axe, axing it’. Perhaps the thematic information associated with zero-derived verbs is co-opted from these light verbs, which themselves may correspond to the most generic bundles of grammatical and relational properties in the language. If this is so, it would tend to weigh in favor of the I.N. over the S.M. hypothesis.

## 12. A note on distributed morphology

Let us suppose that if aphasic patients like HG can indeed zero-derive novel, meaningful verbs productively by retrieving phonological forms associated with certain semantic features and then applying to them generic argument structures and referential

mappings. Building on this assumption, we might go further still and ask whether unimpaired speakers do the same thing—not only in producing novel forms, but in the normal course of speech. This is essentially the position represented by Distributed Morphology (D.M.; Halle & Marantz, 1993; Marantz, 1997) which posits that the lexicon does not contain information about grammatical class. Rather, D.M. holds that grammatical class is a function of the computational system of language (i.e. the syntax), and is assigned to individual words only in local syntactic contexts.

Though D.M. has been elaborated thus far only as a formal model and not as an architecture for representation and processing, its basic stipulations allow us to make certain interesting predictions about the ways in which the lexical system might be susceptible to damage. To begin with, D.M. would rule out the possibility mentioned in the Introduction that some modality-specific grammatical class deficits arise as a result of a disconnection between form-related and grammatical information; under this hypothesis, those connections simply do not exist. Except possibly for the case of SJD (Badecker & Caramazza, 1991), there is little evidence as yet to suggest that this might be empirically problematic.

The idea that word-form representations of nouns and verbs are segregated anatomically would also seem to be incompatible with D.M., for obvious reasons: if word forms are not associated with intrinsic grammatical class information, it is hard to see how they could be organized on this basis. Indeed, D.M. allows only for the semantic disconnection account of modality-specific grammatical class deficits. This in turn implies that the semantic system must be organized in a way that roughly segregates nouns and verbs, or at any rate prototypical members of the two categories.

As we have already noted, there are at least two potential modes of organization that may yield such a distinction. The first is categorical: actions and objects may be represented in different parts of the brain, rendering the two categories differentially susceptible to traumatic brain damage (McCarthy & Warrington, 1985). This view has been advocated by a number of investigators who have studied the anatomical correlates of word naming through lesion studies and neuroimaging (Damasio & Tranel, 1993; Gainotti et al., 1995; Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995; Pulvermueller, 1999; Pulvermueller, Mohr, & Schleicher, 1999). Taking both this hypothesis and D.M. to be true, we would expect to find that certain patients with verb deficits (and especially modality-specific verb deficits) should be impaired at producing both the verbal and nominal derivatives of action-related roots: i.e. not only *to destroy* but also *destructive*, *the destruction* and *the destroyer*.

The second possibility is that the relevant distinction is not between actions and objects per se, but between words that take arguments and those that do not (Collina et al., 2001; Marshall et al., 1996a,b). To put this in a slightly different way, it may be that the thematic features and perceptual features of words are represented separately, and that damage to either of these feature stores (or to the pathways for accessing them) leads to observed deficits in producing nouns or verbs. If this were true, certain aphasic patients might be sensitive both to the kinds of thematic features associated with a root and the contexts in which they must be accessed. When producing a verb, access to some thematic structure is obligatory; arguments and thematic roles must be assigned in order to generate well-formed sentences. On the other hand, some nonverbal derivatives of action words do not

necessarily enjoin arguments. For example, *the singer* has the same thematic properties in many contexts as *the doctor* or *the fool* (though in other contexts it may take an internal argument, as in *the singer of ballads*). Thus some patients may be able to produce ‘relational’ roots in nonrelational contexts.

Though the data on this point are sparse, certain arguments seem to favor the ‘thematic hypothesis’ over the ‘action hypothesis’. To begin with, there is the observation that certain patients with modality-specific verb deficits can produce noun homophones of verbs that they cannot produce—for examples, *the change* but not *to change* (Caramazza & Hillis, 1991). Yet in many of these instances, the nouns and verbs in question may be derived from different roots (the meaning of *the fly* is not obviously predictable from *to fly*). More informative is the observation that HG seems to be able to produce agentive nouns in place of verbs she cannot produce. In response to a picture with the target *rowing* (*sculling*), for example, she said ‘it’s a sculler’<sup>9</sup>; likewise, she produced the forms ‘ringer’, ‘singer’, ‘skier’, in place of *ringing*, etc., and ‘fishing pole’ instead of *fishing*. It is not clear how this would be possible if the action-related semantic features of these words, as opposed to their thematic features, were inaccessible.

There is independent reason to postulate that HG has difficulty retrieving stored thematic features of words. Based on the triplets task, we know that she has particularly marked problems discriminating among words based on their argument structures. This problem seems to carry over to sentence to picture matching, where she is unable to reliably select the correct picture over a reverse-role foil. These patterns, as well as HG’s more general deficit in producing verbs, can be explained if we posit a loss of access to the thematic features associated with word forms. Note that HG cannot have lost the ability to assign thematic roles at all, or she would not be able to produce sentences or to use novel verbs grammatically; rather, her deficit must specifically implicate the retrieval of *stored* thematic structures.<sup>10</sup>

Loss of access to thematic features can in principle explain verb deficits in HG and similar patients whether word forms are category neutral, as in D.M., or category-specific, as in I.N. models of lexical access. The evidence necessary to distinguish between these two assumptions is, unfortunately, lacking. More fundamentally, it is not clear how a D.M.-inspired production architecture could handle some of the challenges inherent to a root-based lexicon—notably the problem of semantic opacity, which refers to the fact that presumably derived forms sometimes have unpredictable and idiosyncratic meanings (consider *a casualty*, *to table*; cf. McQueen & Cutler, 1998). Nevertheless, the D.M. model raises interesting possibilities for the organization of the lexicon and would seem to provide an elegant accounting for a range of phenomena, including the kinds of errors produced by patients like HG.

<sup>9</sup> Indeed, when pressed to say what the ‘sculler’ was doing, HG responded: ‘sculling the waves out there’. Though *to scull* is a perfectly licit (albeit infrequent) English verb, its typical thematic structure is that of *to row* (cf. \**rowing the waves*) and not, e.g. *to ply*, as HG apparently used it.

<sup>10</sup> To explain HG’s problems in single word production, we would have to assume additionally that the lexical production system must always have access to thematic information when a verb is produced, even when the task at hand does not call for the production of a full sentence.

### 13. Conclusions

We have shown that a fluent aphasic patient HG is generally well able to access and productively utilize grammatical and morphological operations associated with verbs despite severe difficulties retrieving action words relative to object words in picture naming and sentence formulation. This appears to be consistent with reports of some other patients with similar patterns of production in one or more modalities of output (Berndt et al., 1997a,c; McCarthy & Warrington, 1985; Rapp & Caramazza, 2002), but importantly contrasts with reports of patients who have trouble processing verbs as morphosyntactic units (Tsapkini et al., 2002), as well as verb-impaired patients with more general syntactic difficulties (Miceli et al., 1984, etc.).

Though semantic variables such as concreteness evidently influence HG's ability to access lexical representations, our (admittedly limited) investigation failed to reveal any pattern consistent across nouns and verbs or across comprehension and production tasks. However, there is some evidence to suggest that HG's comprehension of verbs is constrained by difficulties in accessing their thematic properties. This in turn may play some role in her verb retrieval difficulties, depending on the assumptions we make about the organization of thematic properties relative to other kinds of semantic features in the brain. Another patient EB, described by Caramazza and Miceli (1991), seems to have presented with a similar deficit: he was impaired at naming actions (though to a milder degree than HG) and at comprehending reversible sentences. In addition, EB was impaired at assigning thematic roles in sentence production, though his morphological and syntactic abilities were well preserved.

Such cases suggest that the morphosyntactic and thematic properties of verbs are represented separately in the brain, and are differentially susceptible to impairment in the wake of traumatic brain damage. If this is true, we would expect that some patients with verb-specific morphosyntactic deficits should be unimpaired in processing verbs' thematic features—a prediction that remains to be borne out by careful investigation.

### Acknowledgments

The research reported here was supported in part by NIH grants NS22201 and DC 045422. We gratefully acknowledge Julia Finch, who administered the screening tasks described under 'Case History'. We also thank HG for her participation and for her extraordinary good humor.

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