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Selective difficulties with spoken nouns and written verbs: A single case study

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Abstract

We describe an individual who exhibits greater difficulties in speaking nouns than verbs and greater difficulties in writing verbs than nouns across a range of both single word and sentence production tasks. This double dissociation of grammatical category by modality within a single individual represents an important challenge to the claim that all apparent category grammatical deficits can be reduced to the effects of the various semantic variables. The modality-specific nature of the findings clearly support the representation of grammatical category distinctions at post-semantic levels of representations and processing and they raise a number of questions regarding the specific instantiation of these distinctions within current theoretical frameworks of language production. © 2002 Elsevier Science Ltd. All rights reserved.

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There have been a number of reports of individuals with neurological damage who seem to have especial difficulties with words from certain grammatical categories but not others. These dissociations may involve nouns vs verbs (Bastiaanse & Jonkers, 1998; Baxter & Warrington, 1985; Bates, Chen, Tzeng, Li & Opie, 1991; Berndt, Haendiges Burton & Mitchum, 2001; Berndt, Haendiges, Mitchum & Sandson, 1997; Berndt, Mitchum, Haendiges & Sandson, 1997; Bird, Howard & Franklin, 2000; Breedin & Martin, 1996; Breedin, Saffran & Schwartz, 1998; Caramazza & Hillis, 1991; Damasio & Tranel, 1993; Daniele, Silveri, Giustolisi & Gainotti, 1993; De Renzi & di Pellegrino, 1995; Hillis & Caramazza, 1995; Marshall, Chiat, Robson & Pring, 1996a,b; Orpwood & Warrington, 1995; McCarthy & Warrington, 1985; Miceli, Silveri, Villa & Caramazza, 1984; Rapp & Caramazza, 1998; Robinson, Rossor & Cipolotti, 1999; Shapiro, Shelton & Caramazza, 2000; Silveri & Di Betta, 1997; Williams & Canter, 1987; Zingeser & Berndt, 1990), open

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class vs closed class items or function words vs nouns (Goodglass, 1993; Lhermitte & Derouesne, 1974; Lecours & Rouillon, 1976; Assal, Buttet & Jolivet, 1981; Bub & Kertesz, 1982; Coslett, Gonzalez-Rothi & Heilman, 1984; Patterson & Shewell, 1987; Rapp & Caramazza, 1997). These category-specific grammatical difficulties sometimes manifest themselves in both comprehension and production (McCarthy & Warrington, 1985; Miceli, Silveri, Nocentini & Caramazza, 1988; Daniele et al., 1993; Breedin & Martin, 1996; Tranel, 1991; Silveri & Di Betta, 1997), sometimes only in production (Zingeser & Berndt, 1988; Damasio & Tranel, 1993; Miozzo et al., 1994; Silveri & Di Betta, 1997), and they are sometimes specific to a particular modality (written or spoken) of input or output (Baxter & Warrington, 1985; Caramazza & Hillis, 1991; Lhermitte & Derouesne, 1974; Lecours & Rouillon, 1976; Assal et al., 1981; Bub & Kertesz, 1982; Coslett et al., 1984; Hillis & Caramazza, 1995; Patterson & Shewell, 1987; Rapp & Caramazza, 1997, 1998). Reports of category-specific grammatical deficits have prompted a number of questions, most of which fall under the following two general headings: (1) do any of the category-specific grammatical deficits actually result from selective damage to *grammatical* categories?, (2) what do such deficits reveal about the representation of grammatical category information during the course of language processing? We review these questions, focusing our discussion primarily on noun/verb dissociations.

1. Do category-specific grammatical deficits reflect grammatical distinctions?

The most straight-forward, albeit rather general, interpretation of category-specific grammatical category deficits is that they reflect the fact that the brain distinguishes between/among grammatical categories in such a way that neurological damage can selectively affect the neural substrate of individual grammatical categories. Despite its plausibility, this conclusion has faced a number of challenges.

The fact that dissociations have been reported that selectively affect either nouns or verbs makes it difficult to argue that one category is somehow inherently more difficult than the other. Having set aside this potential objection, the primary concern that has been raised is that deficits that appear to be specific to one grammatical category or another may instead reflect differences among the grammatical categories along correlated non-grammatical dimensions. For example, verbs are generally more abstract and less imageable than nouns. Thus it has been argued that what appear to be difficulties with verbs may simply be difficulties with abstract words (Bird et al., 2000). Another explanation based on correlated semantic attributes is that nouns and verbs differ in the extent to which their meanings consist of perceptual or functional information. Bird et al. (2000) point out that ‘in general, concrete nouns have more perceptual features, and verbs (as well as abstract nouns) more functional’ (p. 248) and also that the difference in ‘the semantic representations of nouns and verbs might be similar to the difference suggested between animate and inanimate objects: the former (in both cases) depends more on sensory than functional information’ (p. 253). On this basis, Bird et al. specifically propose that apparent noun deficits should co-occur with difficulties with animate (living) vs inanimate (non-living) items and that apparent verb deficits should co-occur with difficulties with abstract vs concrete words (Moss, Tyler, Durrant-Peatfield & Bunn, 1998). We will refer to this as the ‘semantic/conceptual hypothesis’.

It is certainly possible, in fact likely, that some of the cases of noun/verb dissociation reflect semantic/conceptual deficits rather than grammatical ones (see Bird et al. (2000) for a review and Shapiro and Caramazza (2001) for a critical commentary). What is at issue, however, is whether or not there are any cases for which the semantic/conceptual hypothesis is unlikely to be true. Recent evidence that discredits the role of imageability in explaining all grammatical class deficits is provided by Berndt et al. (2001). These researchers report that selective difficulties in producing verbs persist for some individuals even when imageability is matched for in target nouns and verbs in a sentence completion task. In addition they describe a patient with a marked deficit for low imageability words in reading and sentence completion that showed no discernible difficulty in producing verbs. Additionally, there are other findings that are problematic for the semantic/conceptual hypothesis, most important among them are the modality-specific, category-specific grammatical deficits, which we discuss in detail below.

There are a number of reasons why it is important to determine whether true grammatical category deficits occur. One is that understanding the true nature of an individual's language difficulties may be necessary for designing and implementing effective remediation procedures. Another, and the one that we will be specifically concerned with here, is that, if some of these deficits can indeed be clearly identified as revealing grammatical distinctions, then these patterns may be used as a tool for investigating basic theoretical issues regarding the structure and functioning of the language processing system.

2. What do such deficits reveal about the representation and processing of grammatical category information?

To clarify a misconception that sometimes arises in discussing modality and grammatical category specific deficits, it is worth noting that what is most interesting about these deficits is not that they would constitute important evidence of the 'reality' of grammatical categories. Not that such deficits would not, of course, contribute to that conclusion, however, there is already more than ample linguistic evidence that the human mind/brain distinguishes nouns from verbs, nouns from function words, etc. It is difficult to find a linguist who believes that it is not necessary to posit that the brain represents the grammatical category of words. This is because it is not obvious how to formulate a language system that, while lacking such categories, can explain our ability to distinguish between grammatical and ungrammatical sentences and our ability to comprehend and generate novel sentences and words. In other words, it is necessary to assume grammatical class distinctions in order to give a coherent account of our syntactic and morphological knowledge and abilities.

Instead, category-specific grammatical deficits (should they prove to be truly grammatical) are potentially important because they may contribute to answering a wide range of more specific questions concerning grammatical representation and processing, such as: What is the relationship between grammatical category information and lexical form information? Does the language processing system distinguish between homonyms (words with the same sound and spelling) that differ in grammatical category

(RING—noun/RING—verb)? At what point/points in the course of language processing are grammatical distinctions maintained? and so forth.

In sum, if it can be established that the deficit/s in a particular case do indeed reflect a grammatical distinction, then empirical work may be carried out that makes use of such deficits in examining basic theoretical questions. In this paper we will be specifically concerned with the last of the questions listed above: At what point/points in the course of language processing are grammatical distinctions represented?

3. Modality-specific, category-specific grammatical deficits

As we indicated above, patterns of performance suggesting modality-specific, category-specific grammatical deficits—deficits restricted to one grammatical category (nouns or verbs or function words) in one modality (spoken or written)—are especially important both in responding to the challenges posed by the semantic/conceptual hypothesis, as well as in providing insights into the organization of the language system. Specifically, these deficits (we will refer to them as M&GCSDs—Modality and Grammatical Category Specific Deficits) suggest that grammatical categories may be represented at the level of phonological and orthographic lexical form. We first briefly review the small set of reported cases and then discuss their implications.

3.1. *Relevant cases*

Caramazza and Hillis (1991) were the first to describe dissociations in lexical production specific both to one grammatical category and to one modality of output. They described two individuals who showed complementary deficits in verb production following left-hemisphere damage. HW correctly produced 56% of object names, but only 22% of action names in spoken naming tasks, although she was able to access both action and object names in writing virtually without error. SJD exhibited the same pattern in contrasting modalities: she was only 70% correct with written action names while she was not impaired in naming actions orally (97% correct) or in producing nouns in either modality (99% correct in spoken and written production). Additionally, Rapp and Caramazza (1998) reported the case of PW who exhibited the same pattern as SJD of selective difficulties with written verbs.

There have also been a small number of reports of *double* dissociations of grammatical category by modality within a single individual. A few such cases have been reported for the function word/noun contrast. These individuals demonstrated relatively good function word and poor noun production in speaking, while, at the same time, exhibiting in writing the contrasting pattern of relatively intact noun production and severe difficulties with function words (Assal et al., 1981; Bub & Kertesz, 1982; Coslett et al., 1984; Lecours and Rouillon, 1976; Lhermitte & Derouesne, 1974; Patterson & Shewell, 1987; Rapp & Caramazza, 1997). Specifically with regard to nouns and verbs, however, there has only been the case of EBA described by Hillis and Caramazza (1995b). Unlike the noun/function word cases where complementary patterns occurred across written and spoken production modalities, EBA's complementary noun/verb deficits affected spoken production and written comprehension. As a consequence of two strokes, EBA had profound

impairments in spoken naming and reading. In spoken production EBA was more impaired in producing nouns (12%) than verbs (72%), a pattern also apparent in naming noun/verb homonyms. However, in contrast to her relatively good spoken production of verbs, in written comprehension EBA was able to match written verbs to pictures only 43% of the time, as opposed to 98% correct matching performance for nouns. She showed a similar pattern in visual lexical decision with 92% accuracy with nouns and chance performance (58%) with verbs.

3.2. *Implications for the semantic/conceptual hypothesis*

These performance patterns would seem to create severe difficulties for the semantic/conceptual hypothesis according to the following logic. Given the assumption that a common semantic system underlies both written and spoken production and comprehension, it is hard to see how the grammatical class deficits that are restricted to one modality can be the result of a strictly semantic deficit. If, in the cases of HW, SJD, and PW verbs are more difficult solely because abstract words are more affected by the neurological insult than concrete words, then this should have manifested itself in both written and spoken production (and comprehension). Similarly, if in EBA's case nouns were more difficult to say than verbs because of semantic level difficulties affecting the representation of sensory features, then the same pattern should have been apparent in her ability to comprehend written nouns, and yet it was not. These patterns of performance, therefore, constitute powerful evidence against the semantic/conceptual hypothesis and in favor of a grammatical category account.

4. **Remaining concerns and the case at hand**

The only objection that we can imagine raising against the M&GCSDs is that perhaps there is a mild semantic/conceptual deficit (to either abstract words or perceptually-laden animate concepts) that is apparent only in the context of a mild modality-specific phonological or orthographic deficit. The hypothesis would seem rather untenable because the semantic deficit would need to be sufficiently mild that it is not manifested in the other modality, and the production deficit also would need to be sufficiently mild that it is not manifested with items of the relatively preserved grammatical category. Thus, the fact that SJD was 97–99% accurate with spoken nouns and verbs and with written nouns but only 70% accurate with written verbs would seem difficult to reconcile with such a hypothesis.

Nonetheless, the double dissociation of modality by grammatical category within a *single* individual would clearly not be subject to this objection and, for this reason, such a pattern would represent the most compelling example of M&GCSDs. In this paper we describe the case of an individual, KSR, who suffered neurological damage that resulted in a double dissociation of grammatical category (noun and verb) by modality (spoken and written) in language production. Specifically, we will document that KSR exhibited greater difficulties in producing nouns than verbs in spoken production and the complementary pattern of greater difficulties with verbs than nouns in written production in a number of tasks. We will argue that on the basis of this pattern, as well as other

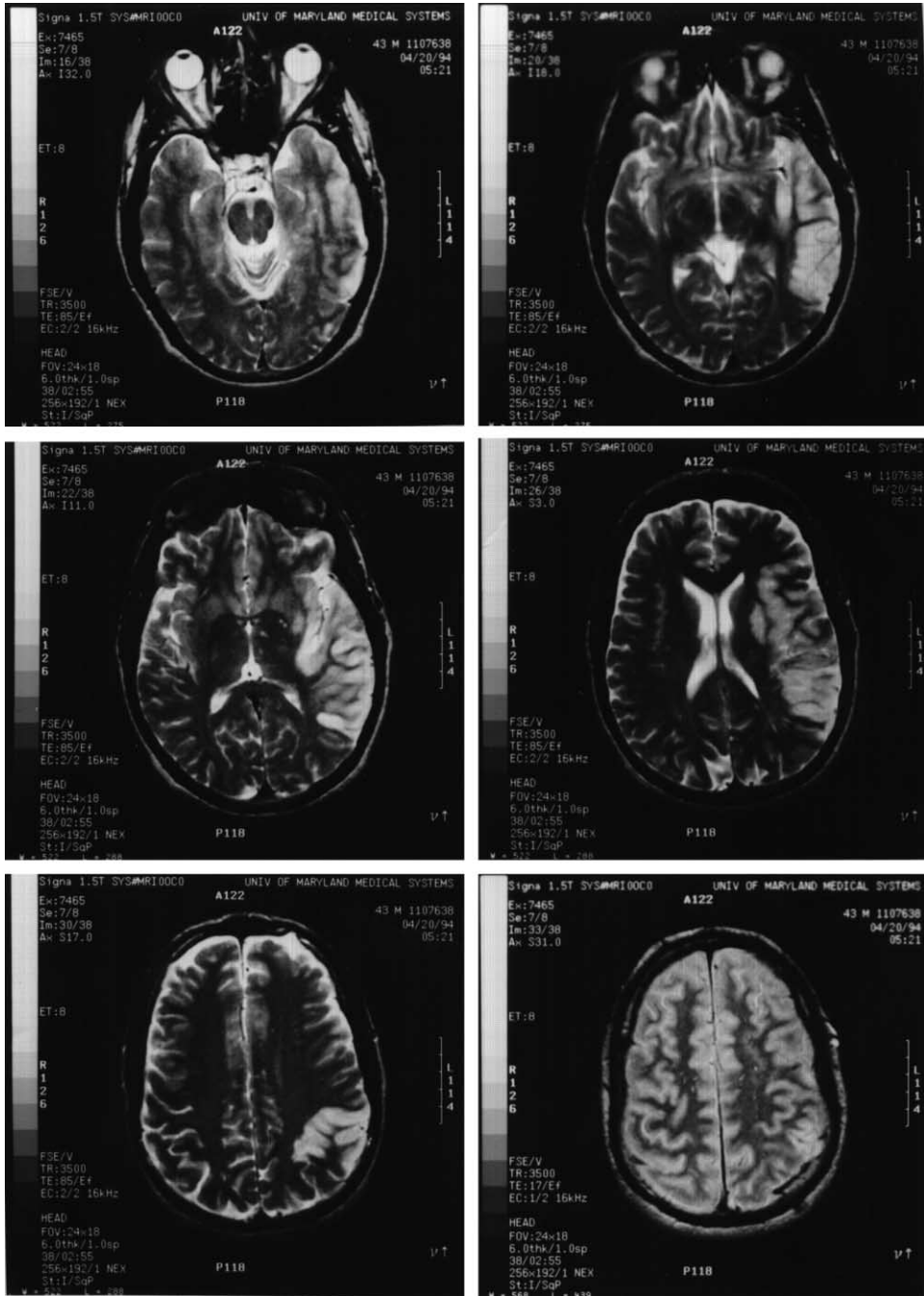


Fig. 1. MRI scans for KSR; April 1994.

independent evidence, KSR's production difficulties can be understood as arising from difficulties in retrieving and maintaining stable representations of word forms—noun forms in spoken production and verb forms in written production.

5. Case history

KSR was a right-handed man who suffered an embolic stroke at the age of 43 (April 1994). At the time of the CVA, KSR was studying for a post-graduate university degree in petroleum engineering while working in airline customer service. He reported a history of childhood stuttering with only a mild manifestation in adulthood prior to the stroke. MRI scanning reveals a large infarct affecting the entire area of the middle cerebral artery distribution, including: the left caudate, Broca's area, Wernicke's area, as well as the supramarginal gyrus. KSR had intact visual fields and no signs of visual/spatial neglect (Fig. 1). KSR exhibited difficulties in both language comprehension and production, in both spoken and written modalities. The investigation we report on here took place between May 1994 and April 1995, with the bulk of testing taking place in the 6-month period between May 1994 and November 1994 (see also Whalen, McCloskey Lindemann and Bouton (2001) for a report on KSR's number processing abilities).

6. Overview of spoken and written language comprehension and production

Testing 1 month after the stroke (May 1994) revealed considerably greater difficulty with spoken versus written comprehension of single words. In a synonym-matching task KSR was 91% correct with visual target presentation, while with auditory presentation he was only 71% correct.

Performance on the Wepman Auditory Discrimination Test (administered in July 1994) was 90%, indicating only a very mild impairment in auditory discrimination. Furthermore, KSR's auditory comprehension of single words improved considerably over the following 6 months, bringing it up to a level roughly comparable to his written comprehension. Six months after the stroke (October 1994) he scored 93% correct on an auditory word/picture verification task where he heard a word and was shown a picture and had to decide whether word and picture matched. His errors consisted of seven failures to recognize correct matches and 12 failures to detect mismatches. Of the latter, nine involved accepting semantic associates of the target (e.g. 'airplane'/helicopter, 'door'/window). Normal control subjects score between 95 and 100% on that task. KSR's written comprehension skills, evaluated at that same time (November 1994) with a visual lexical decision task yielded 88% accuracy (99% correct in detecting words and 72% correct with non-words).

KSR's spontaneous speech was fluent, marked by a considerable number of neologisms. Throughout the course of our investigation KSR's written production was consistently superior to his spoken production (except for the category of verbs), nonetheless spoken production abilities improved somewhat within the first 6 months of the investigation. This improvement in spoken production as well as the types of errors he produced are well exemplified by KSR's oral reading performance on the same list of words (the

Table 1

Comparison of percent correct in different production tasks with the same list ($n = 139$). Other errors include form related word and non-word responses as well as occasional unrelated word responses (administered September–October, 1994)

	Spoken pix naming %	Oral reading %	Repetition %	Written pix naming %	Writing to dictation %
Correct	21	37	50	81	69
Semantic errors	6	0	1	3	7
Other errors	73	63	49	16	24

abstractness/concreteness list of the JHU Dyslexia Battery) administered on two occasions 6 months apart¹. Accuracy on this list 1 month after the CVA was 0%. Errors consisted largely of non-word responses²: 50% neologisms (e.g. SYSTEM → /t r ʌ n ə/); 33% similar non-word errors (e.g. DEGREE → /g r i g ə). There were eight word responses: two unrelated word errors (WINDOW' → 'read'), two phonologically similar word errors, two semantic errors and one circumlocution. Testing on this same list 6 months later yielded 26% accuracy, and although KSR continued to produce neologisms (23% of his errors), this was no longer his predominant response type and his increased rate of similar non-word errors (58% of errors) indicates that responses were generally closer to the target. At that time he also produced five word responses (one morphological error and four unrelated word errors) as well as one phonologically plausible response.

Given that the focus of this investigation primarily concerns KSR's written and spoken naming difficulties, we now turn to data relevant to the localization of the naming deficits within the cognitive architecture that supports written and spoken production.

7. Localization of the production deficits

Apart from the striking pattern of modality-specific grammatical category impairments that will be documented in Section 10, there are a number of other findings that provide independent evidence of: (a) post-semantic, lexical deficits as well as (b) post-lexical deficits in both spoken and written modalities. The evidence indicates that these deficits affect KSR's ability to retrieve and/or maintain stable representations of phonological and orthographic word forms.

7.1. Post-semantic, lexical deficit loci

KSR's performance on the same list of 139 concrete nouns across a number of production tasks (Table 1) reveals two patterns that are informative with regard to the localization of his production difficulties: (1) superior written (81% correct) vs spoken naming (21%)

¹ Improvement was noted in naming and spontaneous speech as well, although it is not as easy to document as the same tasks were not administered at the two time points.

² We define neologisms as responses that share one or few phonemes with the target, regardless of position. Phonologically similar responses share two or more phonemes with the target, regardless of position.

Table 2

Percent correct by length and frequency in written picture naming ($n = 132$) (high frequency >20 and <100 ; low frequency <20 according to Carroll et al., 1971) (administered September, 1994)

Length	Low frequency %	High frequency %	Totals: %
3–4	90	95	98
5	77	90	84
6	53	100	77
7 +	47	60	47
Totals	67	86	

($X^2 = 99.8$, $p < 0.0001$) and (2) superior oral reading (37%) and repetition (50%) vs spoken picture naming (21%) ($X^2 = 8.4$, $p < 0.004$; $X^2 = 24.0$, $p < 0.0001$).

If the difficulties in spoken and written naming were largely the result of damage to an amodal, central level of representation/processing (such as the semantic system), then written and spoken production should have been impaired to a similar extent. Thus, the pattern of superior written vs spoken production in the context of relatively good written naming points to an important post-semantic component to the spoken production difficulties. Further support for significant post-semantic loci of impairment in both modalities is the fact that few semantic errors are produced in either modality. This may not be surprising in the spoken modality as performance was so poor that an additional and severe peripheral deficit may have rendered semantic errors unrecognizable; however, low semantic error rates in the relatively intact written modality clearly support an important role for post-semantic deficits in both modalities. On their own, these findings do not entirely rule out the possibility of additional, lesser deficits at the level of the semantic system. We take this up in a later section where we carry out a more detailed examination of semantic effects such as concreteness/abstractness and animate/inanimate.

The second point is that superior performance in oral reading and repetition vs naming indicates a specifically *lexical* contribution to the spoken naming impairment. This follows from the following logic. Reading and repetition (in particular) can be carried out non-lexically, while picture naming requires lexical processing. All three tasks, however, make use of common *post-lexical* processes (Goldrick, Rapp & Smolensky, 1999). If that

Table 3

Percent correct by length and frequency from multiple spoken picture naming lists. ($n = 141$) (high frequency >20 and <100 ; low frequency <20 according to Carroll et al., 1971) (administered July–August, 1994)

Length:	Low frequency %	High frequency %	Totals: %
2–3	8	14	11
4	17	5	11
5	4	20	12
6 +	0	0	0
Totals:	7	10	

is the case, then damage to a lexical process should result in particular difficulties in picture naming vs reading and repetition while damage to post-lexical processes should affect all three tasks comparably. On that basis, KSR's performance pattern suggests some lexical locus of impairment. Since a semantic locus has largely been ruled out, this points to impairment to a mechanism/process such as the phonological output lexicon.

It is worth noting that the superior oral reading and repetition also attest to the (at least) partial integrity of the non-lexical processes of grapheme–phoneme conversion and acoustics–phonology conversion that bypass the lexical system and may be used in oral reading and repetition respectively. At least partial integrity of grapheme–phoneme conversion processes is also indicated by KSR's superior performance in non-word (34%) vs word (17%) reading in the Part-of-Speech List of the JHU Dyslexia Battery.

Other evidence consistent with the hypothesis of lexical deficits in both modalities comes from the significant lexical frequency effects observed in a number of tasks. In written production, a large accuracy difference between high (86%) and low frequency words (67%) is reported in Table 2. With regard to spoken production, although Table 3 indicates only a very small frequency effect, significant frequency effects were observed in KSR's oral reading of words from the JHU Dyslexia Battery where high frequency words were read with 29% accuracy and low frequency words with 12% accuracy ($X^2 = 5.9$, $p < 0.02$).

In sum, a number of findings clearly indicate that significant post-semantic, lexical deficits contribute to KSR's written and spoken naming difficulties.

7.2. *Post-lexical deficit loci*

An additional post-lexical deficit in written production is supported by the clear effects of length in written picture naming (Table 2). This length effect, as well as the types of errors produced, specifically point to a deficit at the level of the graphemic buffer (Caramazza, Miceli, Villa & Romani, 1987). Overall accuracy on this task was 73% correct and the vast majority of errors involved letter substitutions, deletions, insertions and transpositions (e.g. octopus → OCOTUS; walrus → WARLLUS; elbow → ELBOW); with the only other errors being five possible semantic errors (e.g. stove → 'oven'; boots → 'shoes')³.

In contrast to the length effects in written production, neither the results in Table 3 nor the results in oral reading from the length list of JHU Dyslexia Battery reveal effects of length in spoken production. This may be because there is no damage to a length-sensitive mechanism such as the phonological buffer or because spoken production is sufficiently close to floor (with accuracy across a number of tasks ranging from 8 to 26%) that length effects are masked. Nonetheless, the fact that a task such as repetition which does not require lexical processing is considerably impaired (50% correct, see Table 1), is at least consistent with there being post-lexical damage within the spoken production system. This is particularly true given that KSR's extremely mild auditory discrimination

³ These errors might simply reflect the assignment of a name different from that intended by the test, rather than any confusion or 'misnaming'; it's difficult to be certain as to how to correctly classify such responses.

Table 4

Percent correct in written picture naming on animate and inanimate categories of the JHU Semantic Battery. All categories are matched for mean letter length and syllable length. Categories marked with * are matched for frequency (range 21–26); categories marked with + are also matched for frequency (range 56–68) (administered September, 1994)

Animate	%	Inanimate	%
Vegetables*	50	Clothing*	64
Birds*	70		
Fruits*	70		
Water animals*	58		
Body parts +	60	Transportation +	75
Other foods +	81	Household items +	68
Animals +	90		

difficulties (reported above) make it unlikely that the repetition difficulties were caused by a phonological input deficit.

8. Semantic variables: The living/non-living and abstract/concrete contrasts

The modality-specific nature of KSR's grammatical category deficits point clearly to a post-semantic locus for these effects. Nonetheless, given the various arguments that grammatical category effects may be reducible to either effects of the semantic contrast living/non-living (difficulties with nouns) or abstractness (difficulties with verbs), it is worth establishing whether or not these semantic variables have any effect on KSR's language comprehension and production performance.

8.1. Abstractness/concreteness

As indicated briefly above, in May 1994 KSR was administered a synonym matching task consisting of 46 abstract and 46 concrete targets, matched for length and frequency. For this task, he either heard or saw a target word (e.g. ADDITION) and then had to choose which of two written words more closely matched the meaning of the target word (CALCULATE/CHALLENGE). With visual target presentation, KSR scored 91% correct overall, with 100% accuracy on concrete items and 83% on abstract ones. With auditory presentation, he was only 71% correct overall, with 76% accuracy on concrete items and 65% on abstract ones. The difference in performance with abstract and concrete items was significant for visual presentation ($X^2 = 6.7$, $p < 0.01$) but not for auditory ($X^2 = 0.84$, $p > 0.35$).

In addition, as indicated above, the abstractness/concreteness list of the JHU Dyslexia Battery was administered twice: in May and November 1994. On the first administration KSR was 0% correct. Six months later, KSR was 26% correct and exhibited a statistically non-significant effect of abstractness: 38% correct with concrete words and 14% correct with abstract words ($X^2 = 2.0$, $p > 0.15$).

In sum, KSR's performance with abstract and concrete nouns was evaluated on four

occasions in comprehension and oral reading. Except for the time when he scored at floor in oral reading, he consistently performed better with concrete vs abstract words, although on only one of these tests was the effect statistically significant.

8.2. *The living/non-living contrast*

In some of the tasks described above, KSR carried out picture naming in both written and spoken modalities with both living and non-living items. However, his low overall accuracy in the spoken modality renders this task of little use in discerning differences between the living and non-living categories. In contrast, his superior written naming performance allows for a more careful examination of semantic category effects. Given the assumption that a shared semantic system underlies both written and spoken production, this allows for an entirely suitable evaluation of possible effects of semantic categories.

Table 4 reports KSR's written picture naming performance on the semantic categories represented in the JHU Semantic Battery. The results reveal no effects of the living/non-living contrast for sets of living and non-living items matched for frequency and length (in letters and syllables). Thus performance on the non-living category of clothing (64%) was no different than the average performance on frequency-matched items from the living categories of vegetables, birds, fruits and water animals (62%). Additionally, average performance on the non-living categories of transportation and household items (72%) was no different from average performance on the frequency-matched sets of body parts, foods, and animals (77%). If we remove the categories of foods and body parts from this comparison (because they have been shown to dissociate from the category of animals; see, e.g. Caramazza & Shelton, 1998), we still find that the accuracies of the frequency matched categories of animals (90%) vs transportation + household items (71%) are not different from one another ($X^2 = 1.6, p > 0.2$) (in fact, the results actually numerically favor living over non-living).

9. Summary of preliminary findings

With respect to written naming, the evidence clearly points to both lexical and post-lexical deficits, the latter possibly affecting the graphemic buffer. With respect to spoken naming, we can conclude that KSR suffers from a post-semantic, lexical deficit and it is unclear whether he suffers from additional post-lexical deficits. With regard to semantic processing, it is important to note the low rate of semantic errors across all tasks—these errors make up only 0–7% of his responses. In addition, no effects of the living/non-living contrast were observed in written picture naming. KSR does show an effect of abstractness/concreteness in his oral reading and comprehension. The implications of these various findings for an interpretation of modality-specific, grammatical category effects will be taken up in the General Discussion after these effects have been documented.

10. Experimental investigation of grammatical category effects

Based on informal observations of apparent difficulties in producing nouns in the

spoken modality and verbs in the written modality, we carried out a number of tasks to more carefully examine these effects.

10.1. Task 1: Fluency

In multiple testing sessions spanning the period of June–October 1994, KSR was asked to name as many items as he could in 1 min from various categories of nouns and verbs. The same categories were evaluated in spoken and written modalities. ‘Nouns’ included the following categories: body parts, transportation, furniture, beverages, clothing, vegetables, occupations, foods, tools, weapons, meats. ‘Verbs’ included: actions, things a nurse does, things a secretary does.

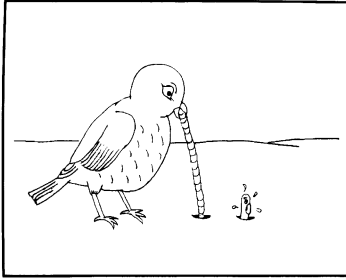
Although the task is far from ideal in that there is very little control over intended targets, the resulting pattern is quite clear: in the written modality, on average fewer verbs (2.7) were named than nouns (5.5); in the spoken modality, fewer nouns (3.1) were named than verbs (6.0). Furthermore, it is also the case that on average fewer nouns (3.1) were named in speaking than in writing (5.5) and that fewer verbs were named in writing (2.7) than in speaking (6.0) ($X^2 = 8.4, p < 0.005$). For example, for the category of ‘things that a secretary does’, in the spoken modality KSR produced seven responses, five of which were correct—‘writing, tells things, drinking, putting things away, sitting there’ (his errors included one non-word and a repetition of ‘writing’). In writing, however, he was only able to produce two correct responses: WRITE and TALK; erroneous responses in writing included objects that a secretary might handle: COFFEE, PAPERS, COMPAS. Although one might be concerned that the greater speed of spoken vs written output might make it easier to produce a greater number of responses in speech, we see the contrasting fluency pattern for nouns. For example, for the category of furniture KSR produced 12 spoken responses, none of which was correct (they were either other words—‘chin’, ‘dog’, ‘rats’ or non-words) while in writing he produced eight responses all of which were correct: CHAIR, TABLE, DESK, LAMP, VASE, PICTURE, SOFA, BENCH.

This pattern of results, therefore, suggests a differential availability of word forms in different grammatical categories that differs according to modality of output.

10.2. Task 2: Nouns and verbs in sentence generation

Across ten testing sessions in the period May–October 1994, KSR was shown 98 line drawings of an individual or individuals carrying out fairly simple actions that can be easily described with a single declarative sentence (e.g. a man is closing a window, a girl is riding a bicycle, a boy is catching a baseball). For each drawing he was asked to provide a single sentence description. The entire set of pictures was administered both for written and spoken production.

We scored the main verbs and all nouns of each sentence that KSR produced against what we took to be KSR’s intended sentence. For example, in response to a picture of a man turning off a lamp, KSR wrote: THE MAN CLOSES THE LAMP. The intended target sentence was assumed to be: THE MAN TURNS/SHUTS OFF THE LAMP. He was given credit for two correct nouns and one error on the verb. The verb error was classified as an incorrect verb. Another example is a drawing of a woman holding/looking at a dress. KSR said ‘The man is looking at the /b r e I s/’. The target sentence was assumed to be ‘The



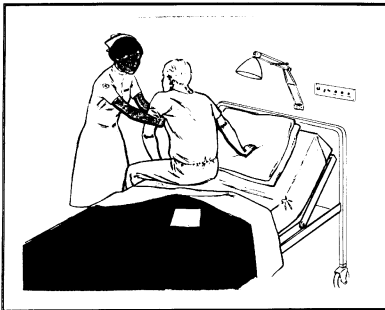
“The /p r ɛ d/ is eating a man.”

The bird is eating the worm.



“The greens are naked.”

The trees are naked.



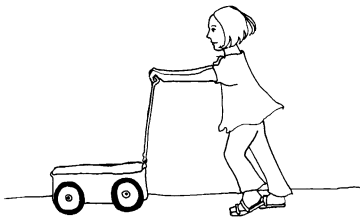
“The nurse is helping the man.”

The nurse is helping the man.



“The man turned his light out”

The man ch/closed th/ the lamp.



“The girl is holding the /b aɪ g/.”

The girl is ach/actions a/ a wagon.



“The teacher is holding the /tʃ æ k/.”

The teacher is hitting / /chalk.

Fig. 2. Examples of stimuli and KSR’s spoken and written responses from Task 2: Nouns and Verbs in Sentence Generation.

Table 5

KSR's accuracy in producing nouns and verbs in a picture description task (administered May–October, 1994)

	Spoken noun %	Spoken verb %	Written noun %	Written verb %
Correct	71	89	93	55
<i>Errors</i>				
Other words	10	6	1	14
Incorrect	(5)	(4)	–	(10)
Semantic	(5)	(2)	(1%)	(4%)
Non-word error	17	2	3	4
Omission	1	–	1	7
Morphological	1	2	2	11
Incorrect word + morph	–	–	–	7%

woman is looking at the dress'. This was scored as one correct verb and two incorrect nouns; 'woman' → 'man' was classified as a semantic error; 'dress' → /b r eI s/as an incorrect word error. Fig. 2 presents some examples of stimuli with KSR's corresponding written and spoken responses.

If the intended target sentence could not be established with considerable certainty, the item was eliminated from further analyses in both modalities (e.g. in response to a picture of a boy catching a baseball, KSR wrote THE BOY IS GLOVE; it was uncertain if the target sentence was THE BOY IS WEARING A GLOVE; THE BOY CAUGHT THE BALL WITH THE GLOVE; etc.). Of the 98 items in the test, nine were excluded for this reason. This left a total of 152 spoken and 150 written noun targets; and 97 spoken and 96 written verb targets. Errors were categorized as: incorrect words, semantic errors, non-words, omissions, morphological errors, mixed incorrect word + morphological errors. The results are reported in Table 5.

Within modality analyses reveal that spoken nouns were named significantly less accurately (71%) than spoken verbs (89%) ($X^2 = 9.7$, $p < 0.002$) and that written verbs were named significantly less accurately (55%) than written nouns (93%) ($X^2 = 48.2$, $p < 0.0001$). Furthermore, across modalities nouns were produced more poorly in spoken vs written naming ($X^2 = 24.0$, $p < 0.0001$) and verbs were produced more poorly in written vs spoken naming ($X^2 = 25.2$, $p < 0.0001$).

With regard to error types, the most common errors in spoken naming were non-words (18%). Some of these consisted of responses that were similar to the intended targets (e.g. 'coffee' → /k æ f/; 'puddle' → /p ʊ d l/; 'plate' → /p l eI s/) while others were distant (e.g. 'legs' → /b æ g z/; 'wagon' → /b aI g/). The second most likely error type consisted of other word errors (10%): either incorrect words (5%) (e.g. cookies → 'pigs'; food → 'pans'; bed → 'beard') or semantically related words (5%) (man → 'woman'; bear → 'dogs').

In writing, the most common error type were other word errors (14%), either incorrect words (10%) (e.g. help → HAPPEN; hold → HIT; spill → SLIP; ride → EAT) or semantic errors (4%) (e.g. seeing → LOOKING). Morphological errors were the second most prominent error type. However, some of these errors might be better understood as an omission of an auxiliary. For example, THE BABY SEEING THE BUTTERFLY was

Table 6

KSR's accuracy in producing spoken and written nouns and verbs in a single-word, picture naming task (administered May, 1994)

	Spoken noun %	Spoken verb %	Written noun %	Written verb %
Correct	8	37	70	23
<i>Errors</i>				
Other words	37	37	7	54
incorrect	(27)	(30)	(3)	(7)
semantic	(10)	(7)	(3)	(47)
Non-word error	55	27	23	23

classified as a morphological error with the intended verb being SEES but, alternatively IS SEEING might have been intended. In either case there is a problem with the verb. Other errors categorized as morphological involved clear morphological errors on the verb itself (e.g. is eating → IS EATS; had slipped → HAD SLIP; are eating → EAT ARE). Morphological errors form an important category of KSR's errors for written verbs. However, not only is there some ambiguity in their scoring but it is also possible that these errors might be ascribed to a separate failure from that of difficulty with the verb root itself. That is, it could be that morphological processes are disrupted *as a consequence of* difficulties encountered in retrieving the base forms of verbs. Given this, It is important to emphasize that (as can be seen in Table 5) the pattern of modality-specific grammatical category effects is highly robust even if we ignore all morphological errors. That is, the same pattern of performance across grammatical categories and modalities is maintained even if we discount morphological errors (i.e. consider them to be correct responses).

10.3. Task 3: Single word picture naming

Although the sentence generation task reveals the same modality-specific, grammatical category effects observed in the simple and relatively unconstrained fluency task, it suffers from the fact that target nouns and verbs are not matched for length or frequency. This concern can be addressed by considering KSR's performance on a picture naming task developed by Zingeser and Berndt (1988). The list consists of a set of 30 line drawings of verbs and two 30-item sets of nouns; one of the noun lists is matched to the frequency of the base forms of the verbs, the other with their cumulative frequencies; all lists are matched for length in letters and phonemes. KSR was administered the lists for both spoken and written naming in May 1994.

Accuracy on the two noun lists did not differ significantly from one another in either modality and, therefore, we combine the data from the two lists for further analysis. The results are reported in Table 6 and reveal the same modality-specific, grammatical category effects reported for the two previous experiments. Overall performance is far lower on this task than on the sentence generation task. This may be due to a variety of factors. First, the sentence generation task was actually administered after the picture naming task. Second, the sentence generation tasks allows for a wider latitude in word selection, providing a greater opportunity to choose higher frequency or otherwise easier/

more available words (e.g. using a verb such as ‘walk’ as opposed to ‘follow’ or ‘man’ as opposed to ‘clown’). Finally, it is possible that the syntactic frame plays some facilitatory role in word retrieval (Breen & Warrington, 1994; Berndt et al., 2001).

We find that within the spoken modality nouns are produced less accurately (8%) than verbs (37%) ($X^2 = 9.1, p < 0.003$) and that within the written modality verbs are produced less accurately (23%) than nouns (70%) ($X^2 = 15.7, p < 0.0001$). Within grammatical category, written nouns are produced more accurately (70%) than spoken nouns (8%) ($X^2 = 45.3, p < 0.0001$) and spoken verbs (37%) are produced more accurately than written verbs (23%), although this effect is not statistically reliable ($X^2 = 0.7, p > 0.4$).

There are several aspects of the errors produced in the spelling of verbs that are worth mentioning. We accepted as correct either the base form of the verb (write) or the present progressive). Morphological errors were not produced and the predominant error type was the ‘other word’ error. One interesting error type within the semantic error category consisted of errors that involved the application of verb morphology to a semantically related *noun* (e.g. reading → BOOKING; bleeding → BLOODING; hanging → PICTUREING; see also Berndt et al., 1997). This was observed four times in this task (and twice in the sentence generation task). In addition, there were a number of errors ($n = 6$) where a semantically related noun was produced for a verb (e.g. rob → CASH; beg → JOB; carry → HAND; add → ADDITION). Furthermore, many of the non-word errors that occurred in the verb spelling tasks appeared to be related nouns that were misspelled ($n = 4$) (e.g. rip → DRES (dress); dig → SHOVE (shovel); shoot → BULLENT (bullet). This was in contrast to the errors in noun spelling which consisted almost entirely of misspellings of the target word (fence → FENCs; witch → WICTh; camel → CARMEL). The prominent use of nouns in one form or another in response to drawings of actions suggests the preferential availability of nouns over verbs in the written modality.

Within the spoken modality, the predominant error type was (as in previous tasks) the non-word. If we exclude semantic errors and consider only non-word and unrelated word responses we find that regardless of grammatical category, approximately 50% of KSR’s errors share no phonology with the target. These responses are what are typically considered to be neologistic responses (e.g. ‘melt’ → /r eI/; ‘bake’ → /w α d I η/. The origins of such errors are still disputed (Buckingham & Kertesz, 1976; Butterworth, 1979); one interpretation is that they are generated in response to complete word retrieval failure, another interpretation is that they represent severe distortions produced by lexical and/or post-lexical failures.

KSR was also administered a noun/verb comprehension task using the items from the naming task as targets and distractors (20 nouns and 30 verbs). KSR was presented auditorily with a noun or verb target and shown two line drawings of items that were semantically related to the target and from the same grammatical category and was asked to choose the correct drawing (e.g. WRITING (target): ERASING/WRITING; BED (target): CRIB/BED). His performance with nouns and verbs was very similar: 95% correct with nouns and 90% correct with verbs (he confused sing/listen, globe/sun, stitch/rip, beg/rob). Thus his comprehension of these words did not reveal the grammatical category effects that were so salient in the production tasks (although this may be simply due to a ceiling effect).

Table 7

KSR's accuracy in producing spoken and written nouns and verbs in Tasks 2 and 3 when morphological errors and all responses that contain at least 50% of the target segments are considered to be correct responses

	Spoken noun %	Spoken verb %	Written noun %	Written verb %
Task 2	80	94	98	69
Task 3	17	47	93	33%

10.4. Task 4: Naming noun/verb homonyms

An additional concern that one might have with the pattern of modality-specific, grammatical category deficits reported here is that the noun and verb *forms* differ in ways that somehow make noun forms more difficult for spoken production and verb forms more difficult for written production. Although it is not at all obvious what such differences might be, one (albeit somewhat indirect) way of addressing this concern would be to try to identify those errors that are most likely to be lexical, eliminating those errors with possible post-lexical origins. To do so we rescored KSR's responses for Tasks 2 and 3, considering as incorrect only those responses that were either semantic errors or differed from the target in at least 50% of the target segments. Thus both morphological errors and 'close' non-word and word responses were considered to be 'correct'. This is one way of attempting to identify those errors that were most likely to have been generated by a failure of the lexical process⁴.

The results of this reanalysis are reported in Table 7. Although accuracy levels are higher overall, the results reveal the very same patterns that were reported in Tables 5 and 6. Furthermore, statistical testing also reveals the same significance results as were reported above. The fact that the M&GSDs are preserved despite a very conservative standard for accepting a response as an error, supports the notion that neither the morphological errors nor the phonologically/orthographically close errors are 'carrying' the M&GSD effects.

A more direct way of addressing the concern that noun and verb forms in the previous tasks differ in some way that make nouns more difficult for spoken production and verbs more difficult for written is to examine KSR's spoken and written production of noun/verb homonyms: words with identical spellings and pronunciations that exist as nouns and verbs (e.g. rock: the mineral vs the motion; fence: the structure vs sword fighting).

A set of ten homonyms was selected and line drawings depicting the objects and actions were developed (items were: fish, rock, fence, bowl, park, fly, plant, slide, brush, snap). KSR was administered the set of ten noun/verb pairs for spoken and written naming and the task was administered such that modality and grammatical category were counter-balanced across four testing sessions (July–August 1994). For each item KSR was presented with the line drawing and a sentence that contained the target word. Sentences

⁴ Note that this reasoning assumes that close phonological errors are unlikely to have arisen from a failure of the lexical process. This assumption is not especially warranted, but it certainly represents a very conservative way of scoring the data.

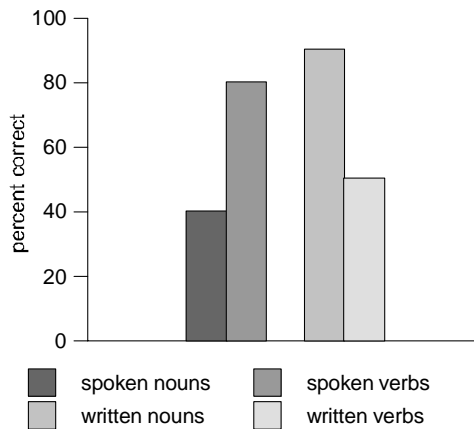


Fig. 3. KSR's accuracy in spoken and written naming of noun and verb homonyms.

were 'carrier sentences' designed simply to make clear the grammatical category of the target. Verbs were presented in the carrier sentence fragment: *I want to... (fish)*; nouns were presented in the sentence fragment: *Give me the... (fish)*. For spoken naming KSR was asked to look at the picture and read the sentence silently, producing orally only the underlined word. For written naming he was asked to look at the picture and to listen to the sentence presented to him orally and to write down the final word (that always corresponded to the noun or verb drawing/target).

The results (Fig. 3) reveal that written verbs were produced less accurately (50%) than written nouns (90%) and spoken nouns were produced less accurately (40%) than spoken verbs (80%). Within grammatical category, written nouns were superior (90%) to spoken nouns (40%) and spoken verbs (80%) were superior to written verbs (50%). Errors in written verb naming were two semantically related nouns, one unrelated word and two non-words; errors in spoken noun naming were: four unrelated words and two non-words.

Although the results follow the same pattern as in previous tasks, due to the small number of items none of the contrasts reach statistical significance at a p value of less than 0.05. Despite this limitation, the results go some distance in addressing the concern that form-specific differences in grammatical categories might account for the effects observed in the other tasks.

11. General discussion

KSR exhibits greater difficulties in speaking nouns vs verbs and greater difficulties in writing verbs vs nouns across a range of both single word and sentence production tasks. We have shown that this pattern of difficulties cannot be reduced to semantic, morphological or post-lexical deficits and, therefore, we can assume the pattern arises primarily from post-semantic, lexical loci of impairment within the two modalities.

This double dissociation within a single individual represents an important challenge to

the semantic/conceptual hypothesis of Bird et al. (2000) that attributes all apparent category specific, grammatical deficits to the semantic variables of imageability and animacy that may covary with verb/noun status. While it is certainly likely, as we indicated earlier, that some reported grammatical category dissociations may be reducible to these semantic level effects, there are some cases which cannot be (Berndt et al., 2001) and KSR clearly figures prominently amongst them.

If, as Bird et al. (2000) have argued, information regarding perceptual attributes plays a greater role in defining nouns (especially animate nouns) than verbs, we should expect damage affecting the representation of perceptual attributes to have, at least, two consequences: greater difficulties with items from animate categories and greater difficulties with nouns vs verbs. KSR, however, shows a clear dissociation with regard to these two predictions. Although he demonstrated striking difficulties in speaking nouns, he showed absolutely no sign of specific difficulties with animate words⁵. This fact, in combination with his relatively good performance in writing nouns, would seem to render a post-semantic characterization of KSR's difficulties with spoken nouns unassailable.

Bird et al. (2000) have also suggested that apparently selective difficulties with verbs arise from deficits affecting low imageability words. They specifically suggest that low imageability (abstract words and verbs) have relatively sparse semantic representations and that widespread semantic damage further reduces the number of semantic features supporting abstract words, making the activation of their forms more difficult. According to these assumptions (see Berndt et al. for counter-arguments) this form of damage should lead to difficulties in naming both abstract words and verbs. KSR does indeed exhibit greater difficulty with abstract words as compared to concrete words in oral reading and visual and auditory comprehension. However, this deficit alone would predict comparable levels of difficulties with verbs in both spoken and written production. This was not the case—not only was verb production superior to noun production in the spoken modality, but KSR's spoken verb production was superior to his *written* verb production on all tasks. Thus, the evidence indicates that even if there were some contribution of abstractness/imageability to KSR's naming performance, it cannot account for his selective difficulties with verbs in the written modality. Again, the conclusion that the difficulties with written verbs arise from a post-semantic locus of impairment seems inescapable. This conclusion is also consistent with other findings we reported earlier indicating that KSR experienced difficulties in retrieving and maintaining stable lexical form representations in both written and spoken modalities.

We can now turn to the question of more specifically localizing the deficits within post-semantic processing. One possibility to be considered, although it has not been specifically raised, is the fact that nouns and verbs (and open and closed class words) differ along various phonological dimensions. For example, in English, nouns and verbs differ in average length, vowel quality and (for bisyllabic words) stress patterns (Kelly, 1992). This raises the possibility that the noun/verb differences that have been observed might be better attributed to difficulties with particular phonological attributes, rather than a specific grammatical category per se—the 'phonological hypothesis'. This hypothesis runs into at

⁵ Effects of living/nonliving were tested using the JHU Semantic Battery which was sensitive enough to reveal significant differences between these two categories in the individuals reported in Hillis and Caramazza (1991).

least two important difficulties. First, the phonological differences along the dimension of vowel quality and stress do not translate into differences for orthographic forms. Furthermore, although nouns and verbs may, on average differ in length, this variable was controlled in at least some of the tasks we have used. The second, and most important reason, is that KSR (as did PW, HW, SJD, and EBA) exhibited M&GCSDs even with verb/noun homonyms that are identical with respect to their phonological and orthographic characteristics. These results would seem to be incompatible with the phonological hypothesis.

The rejection of the conceptual-semantic and phonological hypotheses provides support for the alternative notion that the dissociations observed in KSR's case do indeed represent grammatical category distinctions that are present at some stage/s of post semantic representation and processing. We are now in a position to consider how these findings serve to enrich current theories of word production.

12. Implications for the representation/processing of grammatical category information

While it is widely assumed that grammatical category is represented for use by abstract, amodal syntactic and morpho-syntactic processes, it has been far from clear whether such distinctions are present at the level at which modality-specific lexical forms are represented and processed. It is useful to consider the M&GCSDs within the context of competing theories of lexical representation/processing in word production: the Independent Network theory (IN) of Caramazza and Miozzo (1997) and the lemma-based theories of Levelt, Roelofs and Meyer (1999). These theories are similar in that they both assume that amodal syntactic information (such as grammatical category) is represented independently of both semantic and word form information (phonological and orthographic lexemes). They differ primarily with respect to whether or not (a) there exist amodal word nodes (referred to as lemmas) that activate syntactic category information and (b) whether lemmas (and/or syntactic information) obligatorily mediate between a word's semantic representation and its phonological and orthographic lexical forms.

How would the M&GCSDs be accounted for within such theories? In other words, if these deficits can be shown to represent grammatical distinctions, what contributions do they make to our understanding of spoken and written word production? Given current data, the M&GCSDs do not clearly discriminate between the two classes of accounts but can be understood under either account with certain modifications. Under the IN account, given that the locus of impairment is post-semantic and that access to modality-specific lexical forms does not require prior access to syntactically specified, amodal lexical node, the deficits must lie within the modality-specific lexicons or in access to them from semantics. Within the account of Levelt et al. (1999), the deficits must not only be post-semantic but also post-lemma. This is because damage at the lemma level should manifest itself in both modalities.

Given these considerations, the data can be accounted under either framework by incorporating the notion that the modality-specific lexicons are organized according to

grammatical category in such a way that one category might be more affected by brain damage than another one (Fig. 4a,b). Specifically, KSR's pattern can be understood as arising from selective damage to the verb regions of the orthographic output lexicon and to the noun regions of the phonological output lexicon.

Note, however, that such a proposal requires considerable changes to the theory of lexical access proposed by Levelt et al. (1999). First, it would require abandoning the assumption that modality-specific lexical representations (lexemes) are not distinguished grammatically. Second, it would require abandoning the assumption that homophonic word sets are each represented by a single lexeme node; that is, the assumption that, for example, the words *watch-noun* and *watch-verb* share a common lexeme, /w a tʃ/. An implication of this assumption is that verb/noun homonyms such as *watch*, *hammer*, *talk*, and so on have only one lexeme representation and therefore could not be represented separately as noun and verb forms.

Another account of the data can also be developed under the Levelt et al. (1999) theory. This alternative assumes that the deficits arise from selective damage to pathways between grammatically segregated amodal lemmas and the modality-specific lexemes (Fig. 4b). M&GCSDs could be accounted for in this way because, in this framework, processing obligatorily proceeds from the syntactically specified lemmas to modality-specific lexemes. However, this solution would create problems for a central assumption of the theory—namely, the assumption that input and output processes engage the same set of lexeme and lemma representations. The problem arises because if we assume damage to category-specific, modality-specific links between lemmas and lexemes that are used both in comprehension and production, then it is not obvious how to account for the performance of patients who show selective difficulties in one grammatical class in one modality (spoken/written) that are restricted to only output or input (Hillis & Caramazza, 1995b).

We have seen that KSR's pattern of relatively spared and impaired performance can be understood under either framework, given some modifications to incorporate post-semantic grammatical category distinctions. In addition, the Levelt et al. (1999) theory would require some additional modifications to incorporate the difficulties that the data create for their assumptions regarding the representation of homophones and the relationship between comprehension and production processes.

In addition to evaluating the implications of the patterns of accuracy across categories and modalities, it may also be useful to consider whether the specific types of errors produced by KSR (and other individuals exhibiting M&GCSDs) can also be accounted for under these theoretical frameworks.

In this regard, it is worth noting that Caramazza (2000) has argued that the production of semantic errors in only one modality (Basso, Taborelli & Vignolo, 1978; Caramazza & Hillis, 1990; Hillis & Caramazza, 1995; Nickels, 1992) is problematic for the Levelt et al. (1999) account. The problems this deficit pattern raises are not due to 'architectural' aspects of the Levelt et al. (1999) account, but rather to the assumptions that the theory makes regarding activation flow and stages of processing. Levelt et al. (1999) posit that the activation of a word *form* occurs exclusively for the word that has been selected at the lemma level; that is, they assume discrete and serial activation (for a further discussion and critique see Rapp & Goldrick, 2000). Thus, if the picture stimulus ⟨tiger⟩ is presented, multiple lemmas may become active, including ⟨tiger⟩, ⟨lion⟩, ⟨zebra⟩. However, at some

point in time the most active lemma will be selected for phonological encoding, and all other lemmas will be deactivated (a process referred to as lemma selection). Only the selected lemma passes on activation to the form levels. On this account, it is difficult to explain how a word could be correctly produced in the written modality but produced as a semantic error in the spoken modality. That is, if accurate written production is an indicator of intact processing through the stage of lemma selection, then there is no mechanism by which the form of a word that is semantically related to the target would be active in the phonological output lexicon subsequent to correct lemma selection. To accommodate this performance pattern it would be necessary to allow for the phonological encoding of multiple lemmas, through a mechanism such as cascading activation. With cascading activation, instead of allowing only for the activation of the word form corresponding to the selected lemma, activation could be allowed to ‘cascade’ from the semantic to the form level throughout the encoding process. In that way the phonological and orthographic forms of semantically related words would be somewhat active and available for production, regardless of the decision made at the point of lemma selection itself.

Under the IN account, the pattern of modality-specific semantic errors can be readily understood because semantic information *directly* activates word forms to an extent that is roughly proportional to their semantic relationship with the target (Caramazza & Hillis, 1990). Thus, the semantic representation of ⟨tiger⟩ will activate semantically related word forms in both the orthographic and phonological output lexicons. If the orthographic lexicon is intact, the target word TIGER will be the most active lexical node and will be selected, but if the phonological lexicon is damaged, the most active form will be produced; this may be a semantic neighbor such as ‘lion’. This would yield the pattern of intact performance in one modality but semantic errors in the other.

With regard to KSR’s errors specifically, there are two aspects of his errors that present something of a challenge to the Levelt et al. (1999) account, although neither has been investigated in detail. First, along the lines just described above is the observation that semantic errors are often produced in writing verbs while their forms are correctly produced in spoken production (Table 7). Second, and of particular interest, are the errors involving a noun with a verb inflection produced in response to a verb stimulus (reading → BOOKING (produced twice); bleeding → BLOODING; hanging → PICTUREING; sharpening → ROTARING). These errors are a challenge for the Levelt et al. (1999) account because they suggest ‘independent’ selection of form and grammatical category information. In the Levelt et al. (1999) framework, the selection of stem and affix forms is driven exclusively by the selected lemma, which specifies both the word and the grammatical category to be phonologically or orthographically encoded. Under this account, if the noun lemma for BOOK was erroneously selected in response to the picture of READING, one would not expect verb morphology to be applied to the stem, since BOOK has been specified as a noun at the lemma level. Under the IN account these errors can be understood if we assume that a lexeme such as BOOK, that is semantically related to the target (READING), was highly active and selected, but that the syntactic network received sufficiently strong activation of the verb node from the semantic system that morphological processes specific to verb inflection were launched, yielding BOOK + ING.

In summary, the patterns of deficits and errors exhibited by KSR serve to begin to expand our understanding of the representation of grammatical category in post-semantic representation/processing. Although the data do not clearly adjudicate between these theories, they do present a considerable challenge to various assumptions of the Levelt et al. (1999) framework.

13. Nouns and verbs or objects and actions?

There are two remaining forms of the semantic/conceptual hypothesis that should be discussed (Rapp & Caramazza, 1998). The first, a somewhat uninteresting alternative, suggests that grammatical category distinctions are actually represented along with semantic information at the *semantic level*. Given such a scenario, M&GCSDs arise, within an IN-like architecture, from damage to category-specific, modality-specific links between the semantic system and the form lexicons. Note that, in contrast to the Bird et al. hypothesis, under this account the deficits reflect true grammatical distinctions, they simply arise from a post-semantic locus. This is a rather unpromising hypothesis for several reasons. First, because it places syntax either entirely, or redundantly, at the semantic level, something which is contradicted by a number of findings, including reports that word meaning and syntax can dissociate (Badecker, Miozzo & Zanuttini, 1995; Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997, 1998; Vigliocco, Antonini & Garrett, 1997; Vigliocco, Vinson, Martin & Garrett, 1999). Second, it is difficult to imagine how such a hypothesis could be distinguished from the IN account depicted in Fig. 4a which places the grammatical distinction within the form lexicons themselves.

A somewhat more interesting alternative to the Bird et al. (2000) proposal, is one that posits that apparent grammatical category deficits arise because the defining features of many nouns and verbs correspond to perceptual features and motor actions, respectively. Under this hypothesis we must assume that these information types are stored in segregated brain areas— anterior motor-related areas for actions, and posterior visual areas for nouns (Pulvermuller, Mohr & Schleicher, 1999; Gainotti, Silveri, Daniele & Giustolisi, 1995a,b; Martin, Haxby, Lalonde, Wiggs & Ungerleider, 1995). If we further assume that these areas communicate with the form lexicons via different pathways, then apparent M&GCSDs may merely result from selective damage to these action/perceptual feature pathways rather than reflecting grammatical distinctions (Fig. 5). This is similar to the Bird et al. hypothesis in that the grammatical category distinctions are illusory, however it differs from it primarily in the way it accounts for the apparent verb effects. Rather than attributing verb effects to their abstractness, it implicates the role of action information in the definition of many verbs. By doing so it makes it more plausible to posit segregated pathways for these different feature sets (in contrast to the sparseness feature that Bird et al. (2000) suggest characterizes abstractness). In sum, this hypothesis would account for noun/verb differences in terms of the semantic differences between perceptual objects and actions.

There are two important problems with the object/action hypothesis as an account of all category-specific grammatical deficits. First, it would seem to be contradicted by the various individuals who exhibit grammatical category effects even with abstract and

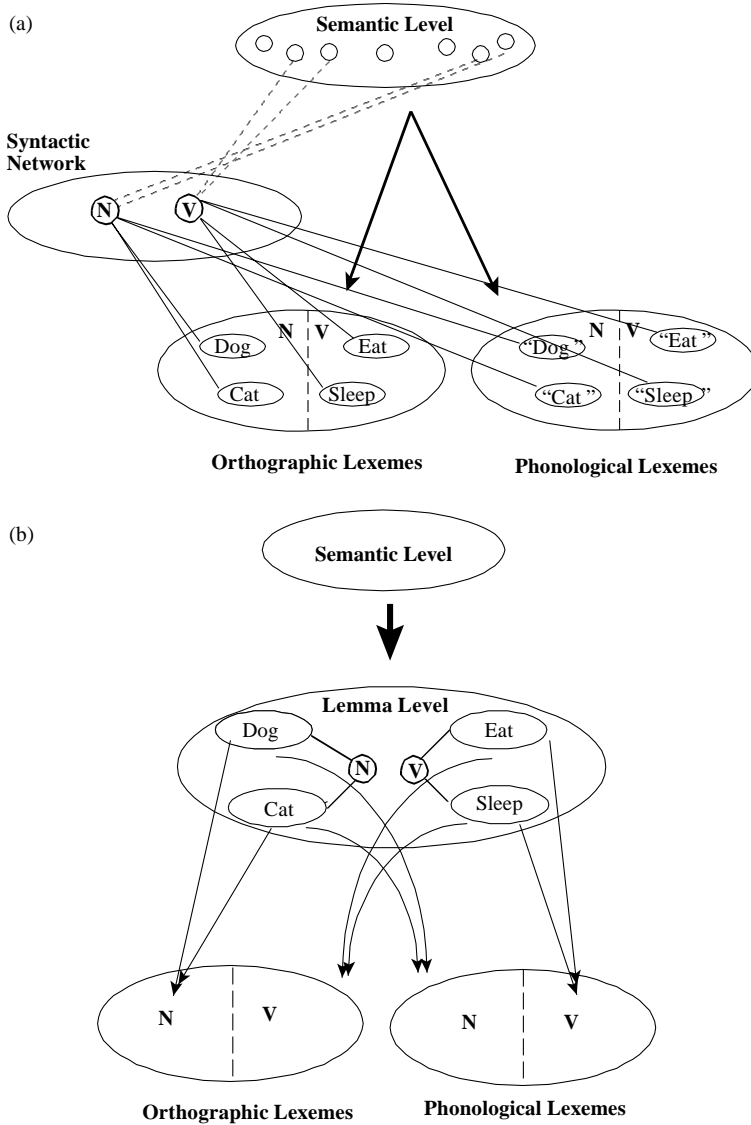


Fig. 4. (a) Schematic representation of the Independent Network theory of Caramazza (1977) with modifications to account for Modality and Grammatical Category Specific Deficits (M&GCSDs), (b) Schematic representation of the Levelt et al. (1999) theory of spoken word production with modifications to account for M&GCSDs).

stative verbs that do not involve motor actions and are certainly far less ‘motoric’ than other more concrete verbs. For example, Berndt et al. (2001) describe one individual (RE) who exhibited difficulties with verbs *only* when they were abstract (e.g. consider, appear, reveal, guess) and lacked the action content of more concrete verbs (e.g. speak, write, lift,

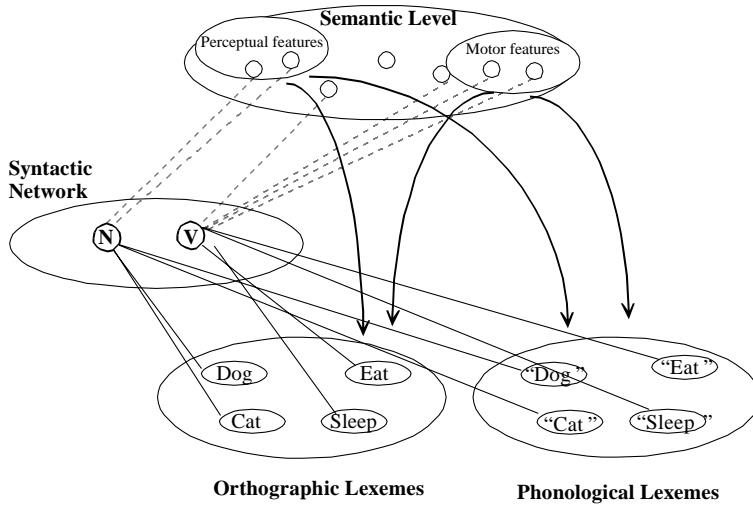


Fig. 5. Schematic depiction of an architecture that would allow for the interpretation of modality specific grammatical dissociations as modality-specific dissociations between words referring to objects and actions.

shoot). These researchers also describe two other individuals who exhibited superior performance with nouns vs verbs regardless of the abstractness of the nouns or the verbs. For example, RE exhibited better performance with nouns vs verbs whether the nouns were concrete and ‘perceptually laden’ (e.g. fence, cat, palm, hive) or abstract and ‘non-perceptual’ (occasion, context, belief, motive, substance). These results indicate that performance is not driven by the degree to which nouns or verbs are object or action-like but rather by their grammatical category. A second argument against the object/action hypothesis is provided by the case of JR (Shapiro et al., 2000) where the category-specific differences are specifically attributed to disruption to noun-based morphological knowledge (see Tsapkini, Jarema & Kehayia, 2001 for a related case showing selective difficulty in processing verbal morphology). JR exhibited difficulties in inflecting nouns but not verbs, despite the fact that identical phonological forms were used (e.g. he was asked to inflect a guide/to guide into either the plural and third person singular). Furthermore, these selective morphological difficulties could not easily be attributed to primary difficulties in retrieving the stored forms of noun stems since the difficulties were also observed in a task that required JR to inflect non-words (a wug/to wug). Given that it is not at all obvious how such selective morphological difficulties could be attributed to an object/action distinction, these findings seem quite clearly to be linked to the grammatical properties of the stimuli⁶.

Finally, a third argument against reduction of the noun/verb distinction into an object/action contrast is provided by a case showing disproportionate difficulty in writing verbs in sentence production tasks. Berndt and Haendiges (2000) report a patient, JH, who

⁶ The object/action hypothesis cannot explain M&GCSDs under the Levelt et al. (1999) framework as the object/action distinction would occur at a pre-lemma level.

performed roughly equally poorly in speaking and writing verbs in simple picture naming tasks. However, in written and spoken sentence production tasks, JH performed far worse with verbs in the writing than in the speaking task. In a detailed investigation of this pattern of performance, Berndt and Haendiges (2000) showed that JH's difficulty in writing verbs involved, among other things, the failure to correctly use the verbal morphology he used normally in speaking sentences. These findings suggest that JH's difficulty specifically concerns a grammatical and not a semantic property of verbs.

14. Conclusions

We have documented a case involving a double dissociation of grammatical category by modality. This pattern constitutes one of the strongest arguments to date against those proposals that assume that all category-specific grammatical deficits may be reduced to semantic level effects. In addition, this case serves to illustrate the importance of using a wide range of tasks in both spoken and written modalities in order to more precisely localize apparent category-specific grammatical deficits. The findings clearly support the representation of grammatical category distinctions at post-semantic levels of representation and processing and they raise a number of questions regarding the specific instantiation of these distinctions within current theoretical frameworks.

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