BRAIN AND LANGUAGE 32, 278–305 (1987)

The Analysis of Morphological Errors in a Case of Acquired Dyslexia

WILLIAM BADECKER AND ALFONSO CARAMAZZA

The Johns Hopkins University

An issue that is persistently raised in studies of subjects who produce morphological errors in reading and other tasks is whether these errors are the consequence of a morphological processing deficit, or whether they in any way reflect morphological principles of organization in the lexicon. We discuss the performance of one such subject on a number of tasks and evaluate standard arguments for attributing aspects of his performance to a morphological processing deficit. Although there are several features of his performance that are suggestive in this regard; we argue that, when these issues are addressed in the context of a sufficiently elaborated theory of lexical processing, a morphological processing deficit cannot be demonstrated. We also survey a number of recent reports that purport to provide evidence for a morphological processing deficit and argue that, in most cases, they fail to support such claims for similar reasons. An important moral to be drawn from a critique of these studies is that in order to make valid inferences concerning the role of morphology in organizing the lexicon, we must consider these errors in the context of theories of the lexicon that take seriously the effects of converging lexical factors in processing.

INTRODUCTION

The linguistic analysis of words provides a rich array of formal and functional characteristics that would appear to be at least potentially

The research reported here was funded by NIH Grant NS23836 to The Johns Hopkins University. We thank Roberta Goodman and Barry Gordon for allowing us access to their data and research reports, and to Gabriele Miceli, Kathy Straub, and an anonymous reviewer for helpful comments on an earlier draft of this paper. Address correspondence and reprint requests to William Badecker or Alfonso Caramazza, Department of Psychology, The Johns Hopkins University, Baltimore, MD 21218.

0093-934X/87 $3.00

relevant to an understanding of language processing.[1] However, while the description and explanation of numerous phenomena from the domain of grammatical competence rely importantly on these concepts, there has been little progress in demonstrating their relevance to the explanation of linguistic performance. The crux of the problem is that, if we wish to construct a psychologically valid model of lexical processing, theoretically minimal, linguistic solutions cannot be given precedence over the actual mechanisms that subjects employ. The question of whether a morphologically complex word will be generated by a rule-like mechanism or will simply be listed in the lexicon, for example, must be given the same answer by the linguist and the psychologist at some level of description.[2] In this paper we will consider some of the issues that are special to the study of processing mechanisms, and we will examine how they bear on demonstrations of the effects of word structure on lexical processing. In particular, we will focus on the analysis of lexical mechanisms as revealed by neurolinguistic data.

Studies of lexical processing by subjects with selective language deficits have tended to deal primarily with the processing of visually presented stimuli. With regard to the effect of lexical structure on lexical processing, the question that has received the most attention is whether morphologically complex words are decomposed and, if so, whether decomposition occurs prior to or after lexical access. Many researchers have argued from the occurrence of dyslexic errors such as reading *initiate* as *initiative,* or *slavery* as *slaving* that complex words are indeed decomposed by one means or another (see, for example, Patterson, 1980, 1982; and Job & Sartori, 1984); and have referred to such paralexias as derivational errors. In order to avoid confusion with linguistic terminology regarding the types of affixation (inflectional vs. derivational), we will adopt the more apt term "morphological error" when referring to paralexias of this kind. Commonly, morphological errors are distinguished in neurolinguistic reports

[1] For example, lexical items may be unanalyzable units of meaning (i.e., monomorphemic), or they may be composed of two or more meaningful parts (morphemes). Formally, we may distinguish between stem and affixal morphemes, between prefixes, infixes, and suffixes, and between affixation and compounding to name just a few of the defining contrasts in the typology of word formation. The contrasts between inflectional and derivational morphological processes, and between regular and suppletive inflective straddle the formal/functional opposition; and there are other concepts of lexical typology which lie more squarely in the camp of functional properties of word formation—grammatical function and productivity being the two most obvious of these. For detailed discussions of these formal and functional aspects of morphology, the reader should consult Matthews (1984), Aronoff (1976), Anderson (1985a,1985b), and Bybee (1985).

[2] Note that this requirement would not rule out a (motivated) psychological analysis that posited both decomposed and nondecomposed representations for (certain) morphologically complex words when linguistic criteria by themselves require morphological decomposition alone. Whereas this sort of disparity can be tolerated, though, contradictory analyses cannot.

from visual errors (e.g., reading *threat* as *thread)* and semantic errors (e.g., reading *spout* as *nozzle,* or *contents* as *index).* Ideally, though, the classification of errors should reflect the nature of the functional impairment that results in their production: visual errors following from deficits in the (visual) input processing stages of reading, semantic errors resulting from some less peripheral impairment in the lexical system (e.g., a lexical-semantic system), and morphological errors engendered by damage to some morphological processing component. Nevertheless, the fact that subjects who produce morphological reading errors in many cases also produce one or both of these other error types makes it quite difficult to establish that the functional locus of the effect leading to the morphological errors is indeed a processing component that is organized according to the morphemic structure of words. A visual error often cannot be construed as being semantically related to the target (as with *threat* and *thread),* just as many semantic errors are visually dissimilar from the stimulus (e.g., when *harder* was read as *strong,* or *common* as *freight).* When the same subject reads a word like *disconnect* as *connection,* though, we have an error response that is both visually and semantically related to the stimulus.[3] How can we establish (one way or the other) whether these so-called morphological errors are actually visual, semantic or (true) morphological errors? (That is, errors resulting from damage to visual and/or semantic and/or morphological processing mechanisms?) More generally, do these errors in any way reflect morphological principles of organization in the lexicon?

In order to answer these questions in a particular case, one must begin by selecting some sort of theoretical framework within which these errors could be explained. The model of lexical processing that appears most tenable to us is one which distinguishes mechanisms according to level (positing distinct lexical input and output mechanisms in addition to central, semantic processing mechanisms) as well as discriminating input- and output-component modalities. That is, the model posits separate lexical input mechanisms for visual and for auditory stimuli (and similarly for lexical output mechanisms). Figure 1 indicates the relational characteristics of such a model.

One consequence of this functional architecture is that it should be possible for the components of this system to be selectively compromised by brain damage, and this selective disruption should be reflected in the patterns of performance on various tasks. For example, a deficit in the Orthographic Input System should not affect a subject's performance on repetition tasks, although it would be expected to impair performance on reading and auditory/visual stimulus matching tasks. In particular,

[3] These errors were, in fact, produced by the same subject (FM), whose lexical processing we describe in greater detail below.

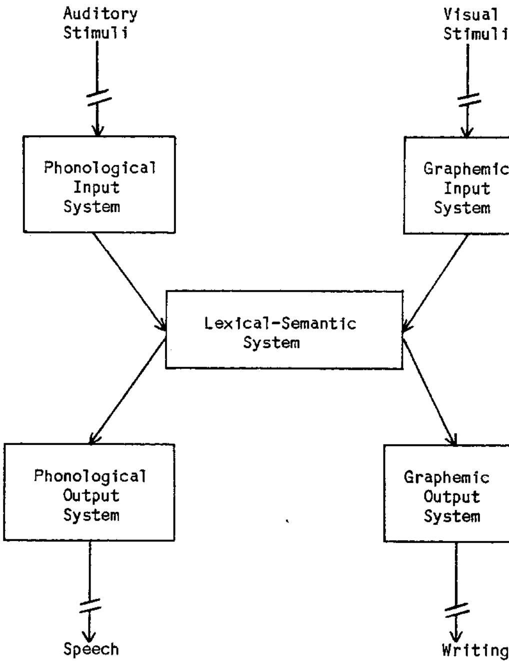

FIGURE 1

damage to a visual processing component of this input system may be expected to result in the production of visual error responses, since this component is, by hypothesis, organized along dimensions corresponding to the visual properties of words. Similarly, errors resulting from a disruption in the lexical semantic system (which should be evident in performance on tasks involving either input modality) should reflect those lexical properties according to which that system is organized (e.g., semantic associations). If a morphological processing mechanism has been disrupted, then it is also reasonable to expect that, for example, reading errors resulting from this disruption will reflect the lexical characteristics which organize the impaired component (including the morphological properties of words).

In addition to the lexical properties that we have identified in terms of this broadly specified architecture of lexical mechanisms, there are certain other factors which are known to affect lexical processing, among which are included letter length, concreteness (e.g., Kroll & Merves, 1986), frequency (e.g., Gordon, 1983), and grammatical category (e.g., Miceli, Silveri, Villa, & Caramazza, 1984). However, an appeal to these or other lexical factors to account for a subject's performance on lexical tasks can only make sense in the context of a tenable theory of how and when these lexical characteristics induce their effects under various conditions of dysfunction. For example, in the models of lexical processing we accept, it is not the characteristics of an item in isolation, but only the characteristics of an item in the context of the set of items related along particular dimensions that may affect reading performance. Furthermore, there are instances where a deficit in one lexical component can induce a pattern of performance that reflects the organizing principles of another, intact mechanism which interacts with the disrupted processing component—a point which we will elaborate on below. We would contend that a major flaw in most studies of patients whose lexical paraphasias include morphological errors is that they have not formulated their analysis in the context of any theory of when such performance patterns can occur. In this paper we will present some hypotheses concerning the influence of these factors in cases of lexical processing deficits, presenting our suggestions primarily in a discussion of our own attempts to analyze the reading performance of one subject, FM, whose errors include those of the type operationally defined as morphological. After presenting this subject, we will return to a discussion of the standard arguments concerning the interpretation of morphological reading errors of brain-damaged subjects. We will argue that most of these attempts to establish the existence of a morphological deficit have been unsuccessful, largely because they have failed to pursue their analyses in the context of a sufficiently explicit model of lexical processing.

CASE HISTORY

FM is a 43-year-old, right-handed, male high school graduate who suffered a large left middle cerebral artery infarct in 1981, which left him with moderate right hemiparesis and with language impairments. A CT scan done 2 years after his CVA showed a large area of lucency on the left involving the posterior inferior frontal lobe, the inferior parietal lobe, the anterior temporal lobe, and the underlying white matter and lateral basal ganglia, together with some atrophy of the cortex of the remainder of the left frontal convexity.

At the time of this study (4 years postonset), FM's speech is considered nonfluent with reduced phrase length, and his performance on sentence processing tasks such as sentence-picture matching reveals "asyntactic" comprehension (i.e., he was significantly worse on matching thematically "reversible" sentences like *the boy kissed the girl* than on "nonreversible" sentences like *the boy threw the rock).* His speech is labored, and he produces literal paraphasias and some morphological errors. FM's reading performance includes errors of visual, semantic, inflectional (*sew* → *sewing; decayed* → *decays;* or *walks* → *walk),* derivational (*achieve* → *achievement; disconnect* → *connection* or *worker* → *work),* and other (unclassified) types, as well as correct responses. Morphological errors (especially affix

TABLE 1
SUMMARY OF READING RESPONSES AND BREAKDOWN OF NUMBER AND OVERALL PERCENTAGE OF ERROR TYPES (REPORTED IN CARAMAZZA, 1985)

Analyzable responses	Number	Percent
Correct	1778	43
Incorrect	2393	57
Derivational errors	202	5
Inflectional errors	478	12
Visual errors	556	13
Semantic errors	461	11
Other classifiable errors	709	17

deletions and substitutions) were the most common error type for morphologically complex stimuli, although FM's reading errors also include a substantial number of affix insertions for monomorphemic stimuli.

Summary of Reading Performance

FM's reading was evaluated extensively (Gordon, Goodman, & Caramazza, 1987; Caramazza, 1985), with emphasis on analysis of his visual and semantic errors. The resulting corpus of reading responses serves here as the basis for a preliminary description of his performance. The pattern of his analyzable responses is indicated in Table 1. As Gordon et al. (1987) report, words that were read incorrectly were consistently longer (by letter length) and less concrete than those that were read correctly, although the overall frequency comparison between stimuli and responses was equivocal. However, for both the visual and semantic errors, FM's responses tended to be more frequent than the stimuli (as determined from the Kucera & Francis, 1967, norms), in addition to being shorter and less abstract.

In reading and lexical comprehension tasks, visual and semantic errors were shown to be distinguishable in terms of the lexical processing stage that is compromised. For example, because he tended on retesting to produce visual errors on words that he had **previously** responded to with a visual error (and because he was similarly consistant for items which induced semantic errors), it was possible to determine whether these stimuli were understood correctly. FM showed "good" comprehension of words which he had consistently read correctly and for which he had produced semantic errors (86 and 80% correct, respectively), while he demonstrated correct comprehension of words which had induced visual errors on previous presentations substantially less often (36% correct response rate). Similarly, preliminary results from a single-subject lexical decision experiment with FM indicate that there is semantic priming when the prime is a word that had been read correctly or had induced a semantic error, but not when the priming stimulus is a word which he had produced a visual error for on earlier occasions (Raymer & Caramazza, in preparation). These results provide strong evidence concerning where the lexical processing system breaks down for particular words. A word that is read correctly activates an entry in both the graphemic input lexicon and the phonological output lexicon, while a word which induces a semantic error activates the proper entry in the graphemic input lexicon, but not the correct entry in the phonological output lexicon. This could be because the lexical-semantic system has been compromised, or because of damage to the phonemic output lexicon. Finally, a word which induces a visual error fails to activate the correct entry in the orthographic input lexicon.[4] These aspects of FM's reading performance provide an important starting point for an interpretation of the morphological errors he produces.

An analysis of the inflectional and derivational errors referred to in Table 1 revealed two interesting contrasts: FM performed better on words with the agentive *-er* suffix than with the comparative *-er* suffix (54% vs. 2% correct responses), and was more likely to mistakenly insert or substitute the agentive suffix (21 insertions, 5 substitutions) than the comparative suffix (zero insertions and substitutions).[5] Similarly, the plural morpheme *-s* was read correctly more often than the third person singular suffix *-s* (75/240 correct vs. 2/28 correct), and the plural morpheme was also inserted more often than the verbal inflection (103 vs. 2 insertions).[6] While it was entirely possible that some of these contrasts merely reflect a disparity in the number of nouns, verbs, and adjectives that occurred in the corpus[7] (especially in the case of morphological insertion and substitution errors), this could not be the entire story (as, for example, with the correct responses and deletions). Furthermore, there were some interesting contrasts with the visual and semantic errors that FM produced. Recall, for example, that when he produced a visual or semantic error, the response was consistently more frequent than the stimulus. This was also the case when FM produced a morphological deletion error on the agentive and comparative stimuli (e.g., *dancer* → *dance* and *smaller* →

[4] Another sort of evidence that visual and semantic errors arise from different functional loci is the fact that FM produces visual-to-semantic errors like *minstrel* → (minister) → *gospel* and *trifles* → (rifle) → *hunter*, where hypothesized intermediate representations appear in parentheses.

[5] These figures are of course based on the assumption that when the *-er* suffix is added to a verb, it is the agentive ending and not the comparative (which only attaches to adjectives). Since there are very few (three) instances in which FM produced a morphologically illegal nonword response, in comparison to the hundreds of morphologically legal complex words he has produced as a morpheme insertion or substitution error, this would appear to be a rather safe assumption.

[6] Another suffix, *-y*, was also mistakenly inserted often in comparison with the other affixes in the corpus: 13 insertions, 18 deletions, and 10 correct responses.

[7] There were 2987 nouns, 936 verbs, and 783 adjectives in the corpus.

small). However, when the agentive *-er* was either inserted or substituted for another suffix, the response was less frequent than the stimulus in 21 of the 26 cases. Given that the comparative *-er* was never inserted or substituted for another suffix, we have a strong candidate for a dissociation defined along a morphological dimension. For these reasons, it might appear that some of the errors FM produced were the result of a deficit to a morphological processing component. To test this hypothesis, FM was given a series of reading tests with new controlled lists.

Controlled Morphological Processing Tasks

The first reading tasks to be described here were administered to determine whether the factor most affecting the likelihood of FM producing a morphological error is the visual similarity between the stimulus and morphologically related response. Three separate lists of test items were composed, each matching items that contain pseudostems (like *earn* in *earnest)* with affixed and unaffixed controls. If morphological errors result from a visual processing deficit simply because the stem of an affixed stimulus competes with the whole stimulus item for activation, then lexical items with embedded words (the pseudostems) should induce analogous, pseudomorphological errors (i.e., where the pseudostem is preserved in the response, but the "affix" has either been deleted or replaced with an actual prefix or suffix).

(1) Pseudosuffix list. There were 43 monomorphemic, pseudosuffixed words (e.g., *wicked, corner,* etc.) matched in surface frequency[8] and letter length with 43 regularly suffixed and 43 unaffixed controls. Frequencies ranged from 200.4 to 0.1 on the Carroll, Davies, and Richman (1971) U distribution (mean frequencies for the three sublists were 44.8, 31.2, and 43.6 for pseudosuffixed, suffixed, and unaffixed words, respectively); and letter length ranged from 5 to 9 (with mean length of 5.9, 6.5, and 6.1 for the pseudosuffixed, suffixed, and unaffixed lists).

(2) Embedded words list 1 ("suffixed"). There were 85 monomorphemic words[9] containing initial letter sequences which are also words (e.g., *yearn, dogma, pierce,* etc.) matched in surface frequency and letter length with 85 regularly suffixed and 85 unaffixed controls. The "suffixes" attached to the embedded words in the test items (*-n*, *-ma*, and *-ce* in the examples) ranged from one to two letters in length. Frequency values

[8] By "surface frequency" we mean the frequency measure of a particular word (e.g., *untying),* as opposed to the combined frequency of inflected variants (which would include *untie, untied,* etc.) or the cumulative frequency of the root (*tie*). Except where otherwise noted, surface frequency matching and frequency comparisons for this and the other controlled lists discussed here were based on the U distribution of frequency norms from Carroll, Davies, and Richman (1971).

[9] One item, *fatal,* was miscategorized as monomorphemic, and was discarded in the analysis of FM's performance.

TABLE 2
NUMBERS (AND PROPORTIONS) OF READING RESPONSE TYPES FOR THE PSEUDOAFFIXED WORD LIST

	Pseudoaffixed words	Affixed controls	Unaffixed controls
Correct	23 (.53)	14 (.33)	29 (.67)
Errors			
Morphological	7 (.16)	19 (.44)	2 (.05)
Deletions	4[a]	16	—
Substitutions	2[a]	3	—
Insertions	1	—	2
Semantic	4 (.09)	2 (.05)	4 (.09)
Visual	5 (.12)	3 (.07)	5 (.12)
Other	4 (.09)	5 (.12)	3 (.07)
Total	43	43	43

[a] These numbers represent pseudomorphological errors like *earnest* → *earning*.

ranged from 173.6 to 0.1 on the Carroll et al. U distribution, with means of 17.4, 17.4, and 17.3 for the embedded words, affixed controls, and unaffixed controls, respectively. Letter length ranged from 5 to 7, with a mean value of 5.5 on each list.

(3) Embedded words list 2 ("prefixed"). There were 52 monomorphemic words containing final letter sequences which are also words (e.g., *bland, borough, frock,* etc.) matched in letter length and surface frequency with 52 prefixed and 52 unaffixed controls. The "prefixes" attached to the embedded words in the test list ranged in length from one to three letters. Frequency values ranged from 179.7 to 0.1 on the U distribution (with means of 14.3, 13.9, and 13.1 on the embedded, prefixed, and unaffixed lists, respectively); and letter length ranged from 4 to 9 (with means of 5.5, 6.4, and 5.9 on embedded words, prefixed controls, and unaffixed controls, respectively).

Stimuli from these three sets of items were typed on 3×5 unlined index cards and were presented in pseudorandom, unblocked order. Responses were transcribed at the time of testing, and were recorded on a cassette tape recorder for comparison when needed. Errors were scored as morphological, visual, semantic, or other; and morphological errors were further categorized as deletions, substitutions, or insertions. The results for the three tasks are presented in Tables 2–4.

At first blush, the results for these lists appear to support the hypothesis that visual similarity between stimuli and responses cannot account for FM's morphological errors: while differences between correct and incorrect reading of the test words and unaffixed controls were not significant in any of the three tasks, this was not true for comparisons between test words and suffixed controls (χ^2 = 41.27, $p < .001$, two-tailed) from the

TABLE 3
NUMBER (AND PROPORTION) OF READING RESPONSE TYPES FOR THE EMBEDDED WORDS LIST 1 ("SUFFIXES")

	Embedded words	Suffixed controls	Unaffixed controls
Correct	52 (.62)	11 (.13)	55 (.65)
Errors			
Morphological	15 (.18)	57 (.67)	3 (.04)
Deletions	10[a]	49	—
Substitutions	1[a]	8	—
Insertions	3	—	3
Semantic	5 (.06)	7 (.08)	4 (.05)
Visual	10 (.12)	4 (.05)	14 (.16)
Other	2 (.02)	6 (.07)	9 (.11)
Total	84	85	85

[a] These numbers represent pseudomorphological errors: e.g., *castle* → *cast*.

first embedded words list, nor between test words and prefixed controls (χ^2 = 13.05, $p < .001$, two-tailed) from the second embedded words list. (The comparison between pseudosuffixed words like *corner* and suffixed words, however, failed to reach significance: χ^2 = 3.46, $p < .10$, two-tailed.) Pseudomorphological errors like *fleece* → *fled* or *device* → *vice* occurred much less often than morphological errors like *bowled* → *bowling* or *deport* → *import, outport.* If FM's "true" morphological errors (in the operational sense) arise because of the visual similarity between a stimulus and his morphologically related response, one would not expect to find differences between the test items from the embedded words lists

TABLE 4
NUMBER (AND PROPORTION) OF READING RESPONSE TYPES FOR EMBEDDED WORDS LIST 2 ("PREFIXES")

	Embedded words	Prefixed controls	Unaffixed controls
Correct	25 (.48)	7 (.13)	27 (.52)
Errors			
Morphological	10 (.19)	25 (.48)	5 (.10)
Deletions	8[a]	20	—
Substitutions	—	1	—
Insertions	2	4	5
Semantic	2 (.04)	8 (.15)	1 (.02)
Visual	15 (.29)	7 (.13)	15 (.29)
Other	—	5 (.10)	4 (.08)
Total	52	52	52

[a] This number represents pseudomorphological errors like *crevice* → *vice*.

and their affixed controls. The fact that FM produces more pseudomorphological errors (e.g., deletions like *corner* → *corn,* and substitutions like *earnest* → *earning)* on the pseudosuffix list might, in fact, serve as evidence for an input deficit affecting whole word recognition, but not morphological parsing, as in the model of lexical processing proposed by Caramazza, Miceli, Silveri, and Laudanna (1985).

However, a rival account of FM's performance on these tasks attributes the differences between the error patterns on the embedded words lists and the affixed controls to differences in surface frequency and stem frequency[10] patterns. Given that it is generally true that the stem of an arbitrary affixed word is more frequent than its surface form, apparent morphological deletion errors might arise from a visual processing deficit that favors the access of the more frequent form. So, on this account, if the (pseudosuffixed) stimulus *wicked* activates both *wick* and *wicked* in the orthographic input system, one factor that can reasonably be expected to affect the outcome of the competition between the two items is their frequency relative to one another. Thus, one might predict that, given the frequency sensitivity evidenced in the pattern of visual error responses in FM's corpus of errors, FM would be more likely to produce a morphological deletion or substitution error if the stem or pseudostem of an item is more frequent than the stimulus. On this account we need only posit a visual processing deficit to explain the pattern of responses indicated in Tables 2–4. An analysis of FM's errors on the pseudosuffix words list and the embedded words list 1 (suffixed), broken down according to the relative frequency of the surface form and pseudostem, was carried out to determine the proportion of errors that were scored as pseudomorphological in the different frequency categories. FM's errors were more likely to be pseudomorphological errors on forms whose pseudostem frequency exceeded their surface frequency than on forms whose surface frequency was greater than their pseudostem frequency of FM's errors, 46% (17/37) were scored as pseudomorphological for items whose pseudostems were more frequent than their surface form, while only 17% (2/15) of the errors on items whose surface form was more frequent than the corresponding pseudostem were pseudomorphological errors. (Chi-square comparisons fall just shy of significant levels: $\chi^2 = 3.59$, $df = 1$, $p < .10$, two-tailed.) Since stem frequency is known to have an effect on the access of morphologically complex words (Taft, 1979; Bradley, 1980; Burani, Salmaso & Caramazza, 1984), and since most of FM's morphological and pseudomorphological errors are deletion errors, one must entertain the possibility that the better performance on the pseu-

[10] By stem frequency we refer to the surface frequency of the morphological stem or pseudostem of the stimulus: *happy* in the case of *happier,* and *earn* in the case of (the morphologically unrelated) *earnest*. Clearly, this frequency rating will underestimate the cumulative frequency of stems.

dosuffix and embedded words lists is the product of a number of converging factors (including visual similarity and lexical frequency) that simply favored the production of more "functionally" visual errors on the morphologically complex control items. That is, the fact that FM read the stimulus *center* correctly, but read *faster* as *fast*, may simply be due to the fact that *center* is more frequent than its pseudostem *cent*, while *faster* is much less frequent than its stem *fast*, and the lexical representation corresponding to the more frequent item—whether it be the actual stimulus or its (pseudo-) stem—is significantly easier to access. As we already mentioned, this proposal is especially relevant given that the visual errors in the reading corpus were generally more frequent than their correspsonding stimuli.

One way to circumvent the frequency-effect counterargument is to look at cases where the morphemes involved are known not to be governed by the relative frequency of the stem morpheme. Recall that in the corpus of errors, the agentive suffix *-er* was not only preserved more often than the comparative *-er* suffix, but it was also produced more often in morpheme insertion errors. Since the form produced in the case of insertion errors was virtually always (21/26 instances) less frequent than the stimulus item, stem frequency would not appear to be the controlling factor in the production of the agentive ending. Furthermore, the fact that the distribution of the two *-er* morphemes differed in the corpus is also important, as it appears to provide a good candidate for a pattern of reading performance that is definable in morphological terms. In order to test whether this contrast would stand up under controlled conditions another reading task was administered comparing the two types of *-er* words. While we could not expect to induce specific morpheme insertion errors on the controlled tasks, we can expect to see if a similar pattern of correct responses vs. morphological deletions and substitutions will obtain.

(4) Agentive vs. comparative -er list. There were 34 deverbal nouns formed with the agentive *-er* suffix matched in surface frequency and letter length to 34 comparative adjectives formed with the regular *-er* suffix. Frequency values range from 183.0 to 3.7; with mean frequency of 38.6 (SD = 43.9) and letter length of 6.2 for the comparative adjectives, and frequency and letter length of 19.5 (SD = 26.6) and 6.3, respectively for the agentive nominals.[11]

Of course, one stimulus feature that could not be controlled for in this comparison is the grammatical category of the stimulus item. This is particularly relevant because of a grammatical category asymmetry found in FM's reading corpus: he read nouns correctly more often than adjectives

[11] These lists could not be controlled for abstractness and concreteness. See our comments below concerning the problems this raises.

and verbs (63, 42, and 30% correct, respectively). Thus, even if FM does perform better on the agentive forms in list (4), this might only be because these words are deverbal nouns. If the verbs that constitute the stems of these words are more difficult to access than the agentive nominal they are embedded in, then superior performance on these words could result even if the underlying deficit were a visual (i.e., orthographic) processing impairment. So, in order to test the effects of grammatical category on FM's reading performance, two additional sets of stimuli were presented: list (5) was presented to test the effect of surface grammatical category on FM's performance; and list (6), the effect of stem category.

(5) Part of speech list. High frequency, monomorphemic nouns, verbs, and adjectives (7 monosyllabic, 7 bisyllabic each) were matched in letter and syllable length with low frequency, monomorphemic nouns, verbs, and adjectives (7 monosyllabic, 7 bisyllabic each). The mean frequency for nouns, verbs, and adjectives in the high frequency lists was 142, 141, and 139, respectively, and 7, 6, and 7, respectively, for the low frequency lists.

(6) Derived noun and verb list. There were 50 morphologically derived verbs (25 denominal verbs like *scandalize* and *hospitalize,* and 25 deadjectival verbs like *intensify* and *equalize)* matched in letter length and surface frequency with 50 morphologically derived nouns (25 deverbal nouns like *betrayal* and *spillage,* 25 deadjectival nouns like *intensity* and *blindness).* Frequency norms for this list are derived from Francis and Kucera (1982): mean frequency for deverbal and deadjectival nouns was 8.7 and 9.0, respectively; and for denominal and deadjectival verbs, 8.7 and 8.4, respectively.

The materials for the three lists were prepared in typed form on 3×5 unlined index cards and were presented pseudorandomly in unblocked order along with a large set of monomorphemic fillers of varying frequency and letter length. Results for the agentive vs. comparative *-er* list and the derived noun vs. derived verb lists are presented in Tables 5 and 6.

As expected from the data from the corpus we discussed earlier, FM's reading performance showed an effect for surface grammatical category on the part of speech list (correct vs. incorrect: $\chi^2 = 8.99$, $df = 1$, $p < .02$, two-tailed) and on the derived noun vs. derived verb list (correct vs. morphological error vs. other error type X verbs vs. nouns: $\chi^2 = 11.00$, $df = 2$, $p < .01$, two-tailed). Nouns were read reliably more often than adjectives, which were read correctly more often than verbs. However, when comparisons were made within derivational types (deverbal nouns vs. deadjectival nouns vs. denominal verbs vs. deadjectival verbs), the results were not significant ($\chi^2 = 10.93$, $df = 6$, $p > .05$, two-tailed). We should note, though, that this may be a floor effect: FM's overall performance level was quite low for this task (perhaps due to the relatively

TABLE 5

NUMBERS (AND PROPORTIONS) OF READING RESPONSE TYPES FOR AGENTIVE AND COMPARATIVE -ER FORMS

	Agentive nominals	Comparative adjectives
Correct	23 (.68)	—
Errors		
Morphological	9 (.26)	29 (.85)
Deletions	7	28
Substitutions	2	1
Semantic	—	3 (.09)
Visual	1 (.03)	1 (.03)
Other	1 (.03)	1 (.03)
Total	34	34

low frequency of the items), so it should not be taken as showing that stem category has no effect.

Results for the agentive vs. comparative *-er* list replicated the pattern found in the corpus: scores for agentive and comparative *-er* forms differed significantly on correct vs. morphological errors vs. other errors: $\chi^2 = 34.86$, $df = 2$, $p < .001$, two-tailed). Furthermore, when we compare the surface-to-stem frequency ratios for the agentive words read correctly and those which induced morphological deletions or substitutions, there is no reliable difference ($t = 1.15$, $df = 29$, $p > .05$, two-tailed). Thus, the convergence of frequency and visual similarity effects cannot be used to argue from these data that FM's morphological errors are functionally

TABLE 6

NUMBERS (AND PROPORTIONS) OF READING RESPONSE TYPES FOR MORPHOLOGICALLY DERIVED NOUNS AND VERBS

	Derived nouns		Derived verbs	
	Deverbal	Deadjectival	Denominal	Deadjectival
Correct	7 (.28)	2 (.08)	—	1 (.04)
Errors				
Morphological	7 (.28)	14 (.56)	18 (.72)	17 (.68)
Deletions	4	11	14	14
Substitutions	3	3	4	1
Insertions	—	—	—	2
Semantic	1 (.04)	5 (.20)	2 (.08)	4 (.16)
Visual	5 (.20)	4 (.16)	4 (.16)	—
Other	5 (.20)	—	1 (.04)	3 (.12)
Total	25	25	25	25

TABLE 7

NUMBERS (AND PROPORTIONS) OF RESPONSE TYPES FOR AGENTIVE AND COMPARATIVE -ER FORMS AND EMBEDDED WORDS WITH PSEUDOSTEMS THAT ARE MORE CONCRETE AND MORE FREQUENT THAN THE COMPLETE WORD

	Agentive -er	Comparative -er	Embedded words
Correct	23 (.70)	—	9 (.43)
Errors[a]			
Morphological	9 (.27)	29 (.89)	6[b] (.29)
Semantic	—	3 (.09)	3 (.14)
Visual	1 (.03)	1 (.03)	3 (.14)
Total	33	33	21

[a] There were two "other" errors, one each in the two *-er* categories.
[b] There were five pseudomorphological errors (e.g., *pierce* → *pier*) and one morphological error (*carve* → *carves*) in this category.

attributable to a "visual" input processing impairment in entirety. Nevertheless, there are additional factors which could in fact contribute to the production of visual errors in the case of the comparative adjectives: grammatical category and concreteness. Given that FM's visual errors analyzed in the corpus of responses showed effects for both of these factors, it might be objected that the difference in FM's performance arises in this case as in others because of the convergence of these four factors: visual similarity of stimulus to response, the grammatical category of the stimulus items, and the asymmetries of frequency and concreteness between stimuli and responses.

Unfortunately, there does not appear to be any way to construct a list of morphologically complex stimuli that controls for all of these factors. One way around this problem, though, is to try a bootstrap approach to the comparisons we need in order to rule out an input processing explanation of FM's morphological errors. We extracted a sublist from the embedded words (suffix) list and the pseudosuffix list of test items by taking all stimuli which met the following criteria: (i) the item's surface frequency is lower than that of the corresponding pseudostem; (ii) the embedded word is a noun, and the surface form is either a verb or an adjective; (iii) the pseudostem is more concrete than the item it is embedded in. (Of course, all of these words would meet the requirement of having a pseudostem that is visually similar to the entire test item.) Of the 21 items obtained in this manner, 10 were from the pseudosuffix list and 11 from the embedded words list 1 ("suffixed"). FM's reading performance on these and the agentive and comparative words is summarized in Table 7.

Chi-square comparisons between the embedded words (e.g., *rustle)* and the comparative *-er* items (e.g., *taller)* were significant both when correct responses, morphological errors, and other errors are analyzed separately (χ^2 = 22.4, df = 2, $p < .001$, two-tailed), and when error types were collapsed (χ^2 = 14.03, df = 1, $p < .001$, two-tailed). The comparison of the agentive *-er* list (containing items like *reader)* with the embedded words also revealed a statistically reliable difference when morphological errors and other errors are separated (χ^2 = 8.02, df = 2, $p < .02$, two-tailed), but not when the error types are collapsed (χ^2 = 2.79, df = 1, $p > .05$, two-tailed).[12] It would appear, then, that the differences between the agentive and comparative *-er* lists cannot be attributed to the effect of these various factors at the input (visual) level of lexical processing. This, of course, does not mean that none of the morphological errors that FM produces are actually visual in nature, but it does entail that *some* of these errors are not visual errors.

An additional bit of evidence to this effect derives from FM's performance on delayed repetition tasks. The reader will recall that in the model of lexical processing we proposed in the introduction to this paper we posited two modality specific lexical input systems: an orthographic input system and a phonological input system. The predictions made by this division are clear. If FM's morphological reading errors were actually all visual input errors, then he should not produce any such errors in a lexical processing task that does not involve the orthographic processing components of the input system. If, on the other hand, these errors are (at times) the product of a lexical semantic and/or morphological output deficit, then any task which involves these components (such as repetition) should also induce error responses comparable to the morphological errors found in FM's reading. So, in order to compare his performance in reading and repetition, FM was asked to read items which contrasted regularly and irregularly inflected words with uninflected controls.

(7) Inflectional regularity list. There were 50 irregularly inflected words (e.g., *fought, broke, swam,* etc.) matched in letter length and surface frequency with 50 regularly inflected words (e.g., *waited, standing,* etc.) and 50 uninflected words. Frequencies ranged from 390.8 to 17.8 from the Carroll et al. U distribution: mean frequency was 102.4 for the irregularly inflected words, 101.0 for the regularly inflected words, and 102.5 for the uninflected controls. Mean word length in letters was 4.6, 5.3, and 5.1 for irregularly inflected, regularly inflected, and uninflected words, respectively.

The materials were presented typed on 3 × 5 unlined index cards in unblocked, pseudorandom order, with monomorphemic fillers of varying

[12] If the morphological errors (operationally defined) are actually visual, then it is the latter comparison, with error types collapsed, that is most relevant to the discussion: i.e., if morphological errors are in fact visual errors, then they should be grouped as such in the comparisons.

TABLE 8
NUMBERS (AND PROPORTIONS) OF READING RESPONSE TYPES FOR REGULARLY INFLECTED, IRREGULARLY INFLECTED, AND UNINFLECTED CONTROLS

	Irregularly inflected	Regularly inflected	Uninflected controls
Correct	17 (.34)	5 (.10)	26 (.52)
Errors			
Morphological	19 (.38)	35 (.70)	7 (.14)
Deletions	14	28	—
Substitutions	5	7	—
Insertions	—	—	7
Semantic	2 (.04)	2 (.04)	6 (.12)
Visual	7 (.14)	5 (.10)	7 (.14)
Other	5 (.10)	3 (.06)	4 (.08)
Total	50	50	50

letter length and frequency. FM's reading performance is indicated in Table 8.

Comparisons of scores for the three test conditions (with morphological errors analyzed separately from other error types) were significant ($\chi^2 = 35.03$, $df = 4$, $p < .001$, two-tailed), and pairwise comparisons between regularly and irregularly inflected words, and between irregularly inflected and uninflected words were also significant (respectively, $\chi^2 = 11.95$, $df = 2$, $p < .01$, two-tailed; and $\chi^2 = 7.71$, $df = 2$, $p < .02$, two-tailed). FM performed best on the uninflected items, and better on the irregular words than the regular ones.

This same list of items was employed as stimuli for the following repetition task: FM was read items one word per trial and was asked to repeat the word after he had counted to five.[13] FM's repetition performance is indicated in Table 9.

While FM produced fewer errors in the repetition task (and χ^2 comparisons were not significant), we cannot compare these aspects of performance on the different tasks directly. For example, the fact that FM's performance was better on the repetition task may be due to the availability of a phonological record of the stimulus that is not present in the case of reading tasks. Nevertheless, the remarkable thing about his responses on these two tasks is that he produces the same types of errors (with

[13] The delay component of the task was introduced to bring FM's performance down from ceiling levels. Ideally, the stimuli in the repetition task should have been controlled for syllable length and stress pattern, but this is not possible when comparing regular and irregular verbs without introducing other confounds such as consonant cluster complexity. However, these problems do not affect our argument since it does not rely on quantitative differences in repetition performance on the sublists, but rather on qualitative similarities in performance on the reading and repetition tasks.

TABLE 9
NUMBERS (AND PROPORTIONS) OF REPETITION RESPONSE TYPES FOR MATCHED IRREGULARLY INFLECTED, REGULARLY INFLECTED, AND UNINFLECTED WORDS

	Irregularly inflected	Regularly inflected	Uninflected controls
Correct	37 (.74)	28 (.56)	31 (.62)
Errors			
Morphological	10 (.20)	13 (.26)	8 (.16)
Deletions	4	12	—
Substitutions	6	1	1
Insertions	—	—	7
Semantic	—	1 (.02)	3 (.06)
Phonological	2 (.04)	2 (.04)	3 (.06)
Other	1 (.02)	6[a] (.12)	5[a] (.10)
Total	50	50	50

[a] Includes two perseverative responses.

the obvious exception of the occurrence of visual errors in the reading task and phonological errors on the repetition task). The memory task does introduce an additional source of potential impairment (memory), but there is no motivated reason for suggesting that the morphological errors produced in the two tasks are caused by different sorts of impairment. Since we have been operating under the assumption that there are separate input systems for visual and auditory lexical processing, we conclude parsimoniously that the morphological errors that FM produces in these and other reading tasks are not all visual input processing errors. That is, some of these morphological errors are the result of a lexical semantic and/or morphological output deficit. Otherwise one would have to hypothesize two independent input deficits (orthographic and phonological) that have exactly the same consequences for production.

The question remains, however, as to whether we can unambiguously determine if, in addition to the deficit which induces FM's semantic errors, FM has an impairment to an output processing component that is organized along morphological lines. That is, can we establish whether or not the morphological errors he produces are actually semantic errors (in the functional sense)? One possibility for doing so would be to establish an intact morphological ability in another output modality (writing), which would thereby rule out a lexical-semantic deficit as an account of these errors. Unfortunately, FM's writing performance is impaired to the point that we could not attempt to establish a reliable dissociation of this sort (between speech and writing).[14] In fact, since it is plausible that the

[14] FM produces some semantic errors in writing words (e.g., *cattle* → *cow*), and cannot write nonwords. However, so many of his responses to words are either entirely unrelated

phonological and orthographic output systems might share a common morphological processing component, indeed it may not be possible to find a morphologically specified dissociation as defined by output modality even in a true instance of a postsemantic, output morphological deficit. If the orthographic and phonological output systems share such a morphological processing component, an impairment in this component should have the effect of inducing morphological errors in both output modalities. Furthermore, it is an obvious consequence of the phenomena that we are concerned with here that the items that tend to induce morphological errors (i.e., morphologically complex words) will tend to be linked semantically to all of their morphologically related cohorts. Given the fact that FM produces both semantic and morphological errors on reading and repetition tasks, then, it is unlikely that one could design a task that could unambiguously tease these two types of errors apart in this case.

GENERAL DISCUSSION

It has not been the goal of the preceding discussion to place into doubt the role of morphological decomposition in normal language processing. Evidence that the surface forms of words are parsed into morphological components during lexical access, and that morphologically complex words are generated from more basic stems and inflections during production has been derived from psycholinguistic experimentation with normal subjects (e.g., Taft, 1979, 1981, 1984; Stanners, Neiser, Hernon, & Hall, 1979; Burani et al., 1984), from research with brain-damaged subjects (e.g., Caramazza, Miceli, Silveri, & Laudanna, 1985), and from studies of normal speech errors (e.g., Garrett, 1980a, 1980b, 1982; MacKay, 1979). What has been at issue, beyond the characterization of a particular instance of reading impairment, is whether the type of error operationally defined as morphological in acquired dyslexia can be attributed to impairments to these hypothesized morphological processing components. FM, whose pattern of reading responses is commonly associated with such a deficit (e.g., Morton & Patterson, 1980; Coltheart, 1980), provides an excellent opportunity for exploring just what is involved in making such an assessment. However, before we summarize our characterization of FM's lexical processing abilities, especially with regard to the processing of morphologically complex words, it would be useful to consider in more detail the architecture of the normal lexical processing system that we have been assuming.

The psychological lexicon is not, in the models that we consider tenable, a unitary functional structure. What corresponds to a single "lexical

to the target (e.g., *cheer* → tully) or only partially related to the target (e.g., *trout* → *tucat*) that it is not possible to assert one way or the other whether FM's writing responses include morphological errors.

entry'' in linguistic grammars is considered here to be a distributed representation relating parts of several input, output, and central processors that comprise a modular lexical system. Furthermore, it is hypothesized that at least some of the processing components of the psychological lexicon are modality specific. On the basis of studies such as those mentioned above, we have also assumed, for example, that the graphemic input system can be further analyzed into a set of morphological parsing and whole-word address procedures, and an orthographic input lexicon (see Caramazza et al., 1985, for details). With these uncontroversial assumptions, though, we must still confront the issue of what constraints they impose on the interpretation of impaired lexical processing. When FM's lexical processing is examined closely, a number of additional properties of the lexical system emerge for consideration in this regard.

Besides the errors that are operationally defined as morphological, FM's reading responses include those which can be clearly attributed to separate visual and noninput lexical processing deficits. In the former case, the stimulus activates visually similar items in the input processing components, but due to an impairment at this processing stage, a cohort of the stimulus representation in the input system erroneously succeeds in activating its own corresponding representation in the semantic system. For our concerns, the characteristic of FM's visual errors that is important to bear in mind is that, in addition to being more frequent than the stimulus, visual error responses tended to be more concrete than the stimulus word as well. Despite the fact that a concreteness effect has been found for errors that we suggest originate in a visual processing component, we do not mean to imply that this "semantic" parameter functions to organize the visual input lexicon (the hypothesized locus of impairment). Instead, we consider this feature of FM's visual errors to constitute a convincing demonstration of how errors induced by impairment to one component can reflect organizing characteristics of another, interfacing component. For example, suppose, as in this case, that there is a disruption in the graphemic input system which impedes the mechanisms of these components in terms of their ability to access representations in the lexical-semantic system. If concrete words are more easily activated in the semantic system than abstract words, then the composition of the set of visually related response candidates may indeed be influenced by this asymmetry. (For expository purposes, we will refer to this phenomenon as interface influence.) It is because of this very phenomenon that it has proved difficult to unambiguously account for FM's morphological errors in terms of the functional impairments which give rise to them. In a controlled study of his performance on morphologically complex words, we have demonstrated that at least some of these errors are not visual errors reflecting interface influences (or other, nonmorphological properties which organize the input mechanisms themselves); yet we have not been able to demonstrate that these remaining cases do not follow from the independently motivated processing deficit that induces semantic errors (i.e., a deficit for which evidence is available that is independent of the occurrence of morphological errors).

It is important to keep in mind at this point that a deficit in a semantic processing or representational system is not the only type of impairment that could be expected to induce "semantic" errors. Reading *priest* for *pastor,* for example, could also plausibly result from a disruption in the phonological output lexicon. That is, if an entry in the lexical semantic system cannot activate a representation in an impaired phonological output lexicon, it may still be possible for spreading activation in the semantic system to result in the activation of a corresponding entry in the output lexicon—the net effect of which is a semantic error.[15] (There are, in fact, reasons why this account of FM's semantic errors is preferable to positing a semantic deficit (see Gordon et al., 1987). However, even if we want to maintain that the phonological output lexicon is organized along morphological dimensions, one need not appeal to that apsect of the output lexicon in order to account for the production of morphological errors. As long as the deficit in question results in the production of semantic errors, and given the semantic relatedness of morphologically related words, only those features of the system that allow for the production of the semantic errors need be invoked. Thus, regardless of the origin of FM's semantic errors, we cannot demonstrate that the source of these errors differs from that of FM's morphological errors.

Nor has it been ruled out, however, that these errors are indeed induced by an impairment directly affecting the functioning of one or more morphological processing components. If one examines FM's scores on the various reading lists, for example, a strikingly suggestive feature of his performance can be seen: the proportion of responses corresponding to correct plus morphological errors combined is approximately equal across conditions for each list! The problem is that this could be because FM's morphological errors are the product of a separate morphological processing deficit; or because these errors reflect the effects of deficits which otherwise result in visual and semantic errors, when various lexical and nonlexical factors converge in a particular category of stimuli (i.e., morphologically complex words).

While these findings may remain incorrigible with respect to the goal of formulating a concise account of the functional nature of FM's lexical impairment, they have at least succeeded in making one thing apparent: the standards that should be demanded of evidence for a morphological

[15] Similarly, it could be that activation of a semantic representation normally results in the activation of a whole cohort of (semantically related) items in the phonological output lexicon, and it is this one-to-many nature of the mapping that enables a deficit in the phonological output lexicon to result in the production of a semantic error.

impairment are underrepresented in studies of subjects whose dyslexic errors include deletions, substitutions, and/or insertions of affixes. In what follows we provide a brief survey of such studies and the arguments raised for interpreting these errors as reflecting the operation of morphological processing mechanisms. Included are reports of subjects whose overall pattern of reading responses is very similar to FM's (i.e., including visual, semantic, and morphological errors when operational standards are applied), as well as subjects who produce only a subset of these error types.

In his discussion of the multiple-lexicon account of the clinical category of deep dyslexia, Coltheart (1980) cites the following explanation (provided by Patterson, 1978) for why affix errors should not be considered as special cases of visual or semantic errors:

> Patterson (1978) has argued that derivational errors cannot be semantic errors because they differ with respect to the confidence ratings assigned to them by patients, and also because the two types of errors yielded different results in her forced-choice task. She has also argued that derivational errors are not visual errors either, since the two error types also yield somewhat different patterns of results. (p. 371)

However, since subjects' confidence ratings for their reading responses may be affected by how "close" the stimulus and response are semantically, as well as how visually similar they are, the fact that these different ratings were obtained for different operational error types cannot be construed as evidence for different loci of associated deficit. Similarly, interface influences could be responsible for "the somewhat different patterns of results" for visual and "derivational" errors. Patterson (1980) concedes nearly as much in her discussion of these results:

> Though suffix deletions and substitutions in reading seem compatible with the notion of morphological decomposition, these phenomena cannot be localized to a prelexical stage of word recognition, or even to word recognition (as opposed to production) at all. (p. 290)

The results of Patterson's (1980) lexical decision studies of these subjects, while potentially capable of identifying the presence of a lexical input deficit, were not designed to distinguish morphological from other (i.e., more purely visual) input impairments.

Job and Sartori (1984) argue, in their discussion of the reading performance of patient Leonardo, that the morphological errors he produces are the result of an impairment to a morphological decomposition mechanism (i.e., that the errors are functionally morphological). Leonardo's overall pattern of reading performance is as follows: he produces affix errors (with the same stem), stem errors (with the same affixes), and visual errors for words, and his nonword reading was poor (with mostly visually similar word and nonword responses). Job and Sartori also report that in the early stages of his dyslexia, Leonardo's errors included gross semantic paraphasias. This last observation is worth mentioning simply because one could argue from it that Leonardo's improved performance was not devoid of semantic paraphasias, but only now they involve less dramatic shifts in meaning—i.e., they are limited to morphologically related cohorts. Even if we disregard this possibility, though, the explicit arguments that are advanced in support of a morphological deficit can be seen as inadequate.

Job and Sartori (1984) present two main arguments for their analysis. First, they argue that, if there were an impairment affecting a morphological parsing component, then only regularly inflected words should be affected, since (they hypothesize) only regular words are subject to morphological parsing. In fact, Leonardo did perform better on irregular than regular inflected forms (15/33 vs. 6/33 correct, respectively). Second, he produced only one pseudomorphological error on pseudoprefixed words (substituting a stem for the stimulus's pseudostem (*ricordo* → *ritardo),* though he performed much worse on words with true prefixes. This too, they argue, is to be expected if a morphological parsing device has been compromised by brain damage, since only words that are composed of actual stems and prefixes should be affected by such an impairment. As we argued from similar patterns in FM's performance, however, this is not the only reasonable account of these results. For example, we have suggested, in our discussion of interface influences, that the likelihood of producing a visual error that can be operationally defined as morphological can depend on some factors which organize the lexical-semantic system. (Concreteness vs. abstractness is one such factor.) Whether or not the activation of visually similar words at the visual stage of processing results in the activation of a set of words that are related in the lexical-semantic system could also affect the probability of whether a visual deficit will result in a morphological error. To use an English example, we are suggesting that, while a pseudoprefixed stimulus like *religion* may have a potential cohort of visually related items (such as *legion, lion,* etc.), these representations will not be related in the lexical-semantic system. An affixed word like *repayment,* on the other hand, will have a cohort of visually related words that are also semantically related (*payment, repay, pay, repaying, paying,* etc.); and this may contribute to the probability of producing a morphologically related form even if the deficit which induces such errors is visual in nature. Thus, in the case of the pseudoprefixed words, one could expect fewer visual errors than for true prefixed forms because there are fewer (or no) lexical representations that are visually confused with the pseudostem in the input system (and that will converge on the same stem in the lexical-semantic system).[16] Similarly, since regularly inflected words will, almost by definition, be more visually similar to inflectional paradigm cohorts than irregular forms will be, the fact that Leonardo makes fewer reading errors on irregular verbs fails to differentiate the visual and morphological deficit hypotheses. In fact, if only regular words are parsed by the morphological processing mechanisms, then by the very logic of Job and Sartori's (1984) argument, there should not have been instances of reading errors involving substitutions of regular forms for irregular forms, contrary to what they report.[17]

Patterson (1982) describes a dyslexic subject, AM, who presents with the following pattern of reading performance: he (i) has difficulty in assembling phonology from print (i.e., reading nonwords); (ii) makes errors reading function words (mostly function word substitutions); (iii) produces morphological paralexias (i.e., deletes, inserts, and substitutes affixes as in *initiate → initiative);* and (iv) "makes some visual errors". The argument she presents for treating AM's morphological errors as functionally morphological is constructed out of observations about the different error types and her explanation of the clustering of AM's performance characteristics:

> (1) so few of his errors are visual but clearly not derivational; (2) on a **purely** visual basis, *initiate* for example is probably more similar to *imitate* than to *initiative;* (3) AM's reading performance constitutes a more coherent and more theoretically interesting pattern if we can conclude that only one type of paralexic error, derivational, occurred often enough to require an account. (p. 87)

The lynch pin of her argument is her explanation of co-occurring impairments, so we will address this part of her argument first.

[16] In order for pseudoprefixed words to be comparable to affixed words in this regard, we have assumed that, minimally, they must have lexical pseudostems. On this point, see Caramazza et al., 1985.

[17] We would also contend that their argument from inflectional regularity for a morphological deficit underrepresents the complexity of the situation. There are two sorts of inflectional irregularity in Italian (although from Job and Sartori's discussion, they appear to have been conflated in their experiments): suppletive forms (e.g., *and-are* "to go" has the suppletive forms *vado* "I go" and *va* "he goes") and irregular verbs with small inflectional subparadigms (e.g., *fing-ere* "to pretend" has irregular stems in participial and indicative past tense forms: *fint-o, fint-a, fint-i, fint-e* are the third person m.sg, f. sg., m. pl., and f. pl. past participle forms, respectively; and *fins-i, fins-e, fins-ero* are the 1st sg., 3rd sg., and 3rd pl. forms of the irregular root used in the past tense). While Job and Sartori's claim that irregular verbs are not morphologically parsed is reasonable for the suppletive forms, this is not clearly so for the irregular verbs with irregular subparadigms. It is reasonable to suppose that, pressed on this point, Job and Sartori would make differing predictions regarding Leonardo's performance on these two kinds of verbs, although no such judgments appear in their paper (nor is Leonardo's performance described in terms of this difference). In any event, our arguments concerning the visual similarity between regular and irregular forms of verbs hold for both varieties of irregular verb.

Patterson (1982) attempts to account for the co-occurrence of (i)–(iii) with the following dual-route model of normal lexical processing. The lexical route is best suited to stem processing, while affix and function-word processing relies heavily on sound-based (i.e., grapheme-to-phoneme mapping) mechanisms. An impairment to the latter mechanisms can thus account for the first three aspects of AM's performance. The embarrassment for Patterson's explanation is that there have been reported instances of subjects who exhibit a pervasive nonword reading deficit (and who produce affix errors), but whose performance shows no grammatical category effects (e.g., Funnell's, 1983, subject WB), as well as instances of nonword reading deficits without morphological impairment (Caramazza et al.'s, 1985, subject AG). Yet Patterson's theory would suggest that the function-word and "morphological" deficits should not be dissociable from the impairment affecting nonwords. Thus, even if AM's "morphological paraphasias" and nonword processing deficits are functionally linked in AM's case, it would appear that hypothesizing an independent impairment affecting function-word reading would be required. Since the theories of lexical processing such as the one Patterson invokes are not sufficiently explicit to differentiate the deficits of AM, WB, and AG, the explanatory force of the account is much diminished.

The removal of this theoretical support for treating AM's "morphological paralexias" as functionally morphological topples the remaining legs of Patterson's argument much as one would expect. In order to reason to her conclusion from the facts that fewer "pure" visual errors than "affix errors" are produced, and that (by some unspecified criteria) there may be less visual similarity between the stimulus and a morphologically related response than between the stimulus and some other visually related word, one must assume that only purely visual properties of a stimulus word will have any bearing on the composition of the set of response candidates for visual errors. As we argued in our discussion of interface influences, this assumption is unlikely to be true.

The foregoing discussion may well have created the impression that, with the complexity of the language processing models that we consider plausible, it might not ever be possible to identify true instances of morphological processing deficits. This is not a conclusion that should be drawn, however; and so we describe a recent case study of an Italian-speaking subject, FS (Miceli & Caramazza, in press), in order to make this clear.

In addition to producing function-word errors, FS makes morphological errors in spontaneous speech, as well as in reading and repetition tasks. Notably, nearly all of the morphological errors he produces are inflectional substitutions. Given the constancy of this feature across the different tasks, a parsimonious approach to this pattern of performance requires a common account. That is, while it is logically possible, we would argue that it is highly unlikely that FS has two or more distinct deficits that result independently in the same restricted type of morphological errors in reading, repetition, and spontaneous speech. Miceli and Caramazza (in press) reason from his spontaneous speech and repetition performance that the deficit is in fact a morphological output processing impairment, as opposed to a lexical-semantic or phonological output impairment. For example, in controlled repetition tasks involving inflected adjectives, FS's responses showed a strong tendency to favor the masculine singular form, regardless of whether this form of the item took the *-o* or *-e* suffix, or whether masculine singular was the most frequent inflected form for the stem. Thus, lexical frequency cannot explain this pattern of errors: FS's errors tend to be the "basic" form of the inflectional paradigm (see Bybee, 1985). Similarly, one feature of FS's linguistic output which argues against a lexical-semantic deficit account is the performance asymmetry between inflectional and derivational morphology. Furthermore, his performance on auditory/visual stimulus-matching tasks is quite good, in contrast to performance on the production tasks—a fact that would be left largely unexplained if the morphological errors FS produces were not attributed to an output processing deficit. In the absence of phonological or form-class effects, and given the fact that FS does not produce any semantic errors (either in reading or repetition tasks), we must appeal to those factors, specified by our theory of lexical processing, which are known to affect FS's performance on production tasks. Since the primary determinant of the probability of producing a particular inflected adjectival form, for example, appears to be a morphological principle; the evidence for a true morphological processing impairment is quite compelling.

In summary, we have argued that despite the possibility that many instances of reported reading errors which involve affix deletions, substitutions, and insertions are indeed the product of deficits to morphological processing mechanisms, there have been few convincing arguments to this effect. Most putative examples of morphological deficit can be subsumed under the consequences of independently motivated visual and/or semantic processing deficits. What sets the convincing example that we have discussed apart from the rest is that the examples of true morphological error have had to satisfy both linguistic and psychological criteria for their classification as such. The linguistic criteria, dissociation along a purely morphological dimension, is significant; but our discussion of FM's peformance on agentive vs. comparative *-er* words demonstrated the importance of processing considerations as well. The difference, in the case of FS, is that the effect corresponding to the linguistic contrast cannot be derived from independent linguistic or psychological properties of the processing mechanisms or representations (e.g., frequency, phonological complexity, concreteness, etc.).

In the case we have reported here, though, we have not been quite as successful in demonstrating a morphological deficit. We cannot exclude the possibility that a significant proportion of FM's morphological errors are induced by such a deficit, nor can we exclude the possiblity that these errors result from the influence of converging factors governing the effects of independently motivated processing impairments that induce visual and semantic errors. The linguistic contrasts which emerged in various reading tasks could not, on their own, suffice to settle this issue. Nevertheless, FM's pattern of performance is instructive because it reveals the complexity of the process whereby one may reason validly from observable patterns of performance to the nature of the impairments responsible for them.

REFERENCES

Anderson, S. 1985a. Typological distinctions in word formation. In T. Shopin (Ed.), *Language typology and syntactic description, vol III: Grammatical categories and the lexicon.* London/New York: Cambridge Univ. Press.

Anderson, S. 1985b. Inflectional morphology. In T. Shopin (Ed.), *Language typology and syntactic description, vol III: Grammatical categories and the lexicon.* London/New York: Cambridge Univ. Press.

Aronoff, M. 1976. *Word formation in generative grammer.* Cambridge, MA: MIT Press.

Bradley, D. 1980. Lexical representation of derivational relation. In M. Aronoff & M.-L. Kean (Eds.), *Juncture.* Saratoga, CA: Anma Libri.

Burani, C., Salmaso, D., & Caramazza, A. 1984. Morphological structure and lexical access. *Visible Language,* **18,** 342–352.

Bybee, J. 1985. *Morphology: A study of the relation between meaning and form.* Amsterdam: John Benjamins.

Caramazza, A. 1985. Reading and lexical processing mechanisms. *Reports of the Cognitive Neuropsychology Laboratory,* No. 12, The Johns Hopkins University.

Caramazza, A., Miceli, G., Silveri, M., & Laudanna, A. 1985. Reading mechanisms and the organization of the lexicon: Evidence from acquired dyslexia. *Cognitive Neuropsychology,* **2,** 81–114.

Carroll, J., Davies, P., & Richman, B. 1971. *Word frequency book.* New York: American Heritage.

Coltheart, M. 1980. Deep dyslexia: A right hemisphere hypothesis. In M. Coltheart, K. Patterson, & J. Marshall (Eds.), *Deep dyslexia.* London: Routledge & Kegan Paul.

Francis, W., & Kucera, H. 1982. *Frequency analysis of English usage.* Boston: Houghton Mifflin.

Funnell, E. 1983. Phonological processes in reading: New evidence for acquired dyslexia. *British Journal of Psychology,* **74,** 159–180.

Garrett, M. 1980a. Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production.* New York: Academic Press. Vol 1.

Garrett, M. 1980b. The limits of accomodation. In V. Fromkin (Ed.), *Errors in linguistic performance.* New York: Academic Press.

Garrett, M. 1982. Production of speech: Observations from normal and pathological language use. In A. Ellis (Ed.), *Normality and pathology in cognitive functions.* New York: Academic Press.

Gordon, B. 1983. Lexical access and lexical decision: Mechanisms of frequency sensitivity. *Journal of Verbal Learning and Verbal Behavior,* **22,** 24–44.

Gordon, B., Goodman, R., & Caramazza, A. 1986. *Separating the stages of reading errors.* (Reports of the Cognitive Neuropsychology Laboratory, No. 28). The Johns Hopkins University.

Job, R., & Sartori, G. 1984. Morphological decomposition: Evidence from crossed phonological dyslexia. *The Quarterly Journal of Experimental Psychology,* **36A,** 435–458.

Kroll, J., & Merves, J.1986. Lexical access for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory and Cognition,* **12,** 92–107.

Kucera, H., & Francis, W. 1967. *Computational Analysis of present-day American English.* Providence, RI: Brown Univ. Press.

MacKay, D. 1979. Lexical insertion, inflection, and derivation. *Journal of Psycholinguistic Research,* **8,** 477–498.

Matthews, P. 1984. *Morphology: An introduction to the theory of word-structure.* London/New York: Cambridge Univ. Press.

Miceli, G. & Caramazza, A. Dissociation of inflectional and derivational morphology. *Brain and Language,* in press.

Miceli, G., Silveri, M., Villa, G., & Caramazza, A. 1984. On the basis for the agrammatic's difficulty in producing main verbs. *Cortex,* **20,** 207–220.

Morton, J., & Patterson, K. 1980. A new attempt at an interpretation, or, an attempt at a new interpretation. In M. Coltheart, K. Patterson, & J. Marshall (Eds.), *Deep dyslexia.* London: Routledge & Kegan Paul.

Patterson, K. 1978. Phonemic dyslexia: Errors of meaning and the meaning of errors. *Quarterly Journal of Experimental Psychology,* **30,** 587–601.

Patterson, K. 1980. Derivational errors. In M. Coltheart, K. Patterson, & J. Marshall (Eds.), *Deep dyslexia.* London: Routledge & Kegan Paul.

Patterson, K. 1982. The relation between reading and phonological coding: Further neuropsychological observations. In A. Ellis (Ed.), *Normality and pathology in cognitive functions.* New York: Academic Press.

Raymer, S., & Caramazza, A. In preparation. *Semantic priming in a patient with acquired dyslexia.* The Johns Hopkins University.

Stanners, R., Neiser, J., Hernon, W., & Hall, R. 1979. Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior,* **18,** 399–412.

Taft, M. 1979. Recognition of affixed words and the word frequency effect. *Memory and Cognition,* **7** 263–272.

Taft, M. 1981. Prefix stripping revisited. *Journal of Verbal Learning and Verbal Behavior,* **20,** 638–647.

Taft, M. 1984. Evidence for an abstract representation of word structure. *Memory and Cognition,* **12,** 264–269.