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# Morpheme Units in Speech Production: Evidence from Laboratory-induced Verbal Slips

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The present experiment sought evidence of the involvement of derivational word morphology in speech production processes. A version of the word order competition technique (Baars & Motley, 1976) was used to induce a special kind of verbal slip, namely stranding exchange errors. In these errors, word fragments belonging to two words exchange by stranding their remaining fragments. The linguistic material was selected so that it could be determined whether morphemic stranding exchanges had a higher probability of occurring than non-morphemic ones under conditions in which various phonological and structural properties of the target words were controlled. The distribution of slips obtained clearly points to the implication of word derivational morphology in speech production processes.

## INTRODUCTION

Is the morpheme only a theoretical linguistic concept or is it also a psychologically relevant unit? There is now sufficient empirical evidence for considering the morpheme a relevant unit for the human language processing system as far as written word recognition processes are concerned (see for example, among recent works: Colé, Beauvillain, & Segui, 1989; Holmes & O'Regan, 1992; Laudanna, Badecker, & Caramazza,

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1992; Pillon, 1993, 1998; but see Seidenberg & McClelland, 1989 for a challenging view). The evidence is, however, much less clear as regards the involvement of word morphology in oral speech production processes, especially *derivational* morphology, on which this article will focus.

In this modality, the main source of evidence comes from the analysis of naturally occurring speech errors. Since the stimulating work of Fromkin (1971), it has been well-established that all kinds of linguistic units are likely to be involved in speech errors: Phonetic feature, phoneme, syllable, word, and semantic feature, and also morpheme. However, attempts to interpret the occurrence of *apparent* morphemic errors comes up against a particular difficulty: What appears to be a speech error involving a morphemic unit might, in fact, be a special instance of a word-substitution error, or just an error affecting a multiphoneme- or syllable-sized unit that is only accidentally coextensive with a morpheme unit. In other words, the underlying processing mechanism(s) and unit(s) that have given rise to an apparent morpheme error may have nothing at all to do with morphologically based mechanisms and units. Because of this ambiguity, one can ascribe morphemic errors to morphologically based mechanisms only if it can be shown that they display a different pattern than other word or phonemic speech errors, that is, that they display properties that are only explainable by appealing to morphological principles.[1]

This kind of argument was used by Garrett (1980, 1982) (and also, by Dell, 1986 and Stemberger, 1985) to argue that the selection of the stem portion of lexical items was separate from the selection of *inflectional* morphemes in the course of sentence construction processes: Inflectional suffixes were found not to behave like any other end portion of words in naturally occurring speech errors.[2] However, there is little, if any, evidence for asymmetry in the pattern of sound errors depending on whether they involve derivational affixes or non-morphemic end portions of word.

Cutler (1980a, 1980b) reported a kind of noncontextual speech error involving derivational suffixes that appears, at first sight, to require a morphological account. These are stress misplacement errors occurring in derived words, like [1], and inappropriate affix selection [2] or application [3] errors. In these cases, the erroneous form is very often produced with the stress pattern that is appropriate for the base word or for a morphologically

[1]Another source of evidence comes from case reports of aphasic patients producing morphemically analysable "neologisms" in spontaneous speech and/or naming tasks (Lecours, 1982; Lecours & Rouillon, 1976; Pillon, de Partz, Raison, & Seron, 1991; Semenza, Butterworth, Panzeri, & Ferreri, 1990).

[2]See Butterworth (1979, 1983), Bybee and Slobin (1982), and Garrett (1980, 1982) for naturally occurring speech error data regarding the involvement of inflectional morphology in speech production processes. For experimental data, see Bybee and Slobin (1982), MacKay (1976), and Stemberger and MacWhinney (1986).

related word. Such “over-regularisations” of derivational patterns have also been observed in an experiment in which subjects were asked to produce the derived nominal form of a verb on the presentation of the base form (MacKay, 1978). A plausible account for these errors is that derivational rules were incorrectly or incompletely applied to a base form during lexical retrieval. Such errors, therefore, point to a lexical retrieval process that handles both morpheme units and word-formation rules. However, as Butterworth (1983) has suggested, word-formation rules might be used as fall-back procedures when, temporarily, the requisite form is not available and so has to be constructed.

| | *Intended* | *Error*[3] |
|---|---|---|
| [1] | admínistrative | administrátive |
| [2] | derivátion | derívál |
| [3] | expectátion | expéction |

Over-regularisation errors observed in an experimental setting (MacKay, 1978) could be explained along the same lines, except that it would be assumed that not only the unavailability of the target word but also specific task demands might trigger word-formation rules. The task of producing a derived noun when presented with a base form might, indeed, induce the derived word to be retrieved via the base form, while normal retrieval usually goes straight to a stored derived form. In any case, one cannot reject an alternative interpretation for these errors, which would not need any appeal to word-formation rules. Instead, apparent over-regularisation errors might result from the blending of two simultaneously activated forms that are morphologically and semantically related.

Other noncontextual errors, like derivational suffix substitution [4] (Fromkin, 1971) or prefix substitution [5] and omission [6] (Stemberger, 1985) have been taken as *prima facie* evidence that derived words are mentally “stored as combinations of separate formatives, i.e. stems and affixes” (Fromkin, 1971, p. 45). The size of the unit involved in such errors renders it unlikely that they are mere consequences of phoneme substitution or deletion errors: Non-contextual phoneme substitutions and deletions rarely involve syllable-sized units or pluriphoneme-sized units other than consonant clusters (cf. Fromkin, 1971; Shattuck-Hufnagel, 1983; Stemberger, 1985).[4] However, as for apparent over-regularisation errors, it

[3]The segments involved in the errors are underlined.

[4]Prefix addition errors (marked → remarked) have also been reported (Stemberger, 1985), but Stemberger (1985) observed that they always produced a real word. Thus, they are interpretable as whole-word substitution errors.

is difficult to rule out an interpretation of affix substitution errors in terms of blending. According to Stemberger (1985, p. 152), blends themselves argue for an internal structure in prefixed words because, when two prefixed words are blended together, transition from one word to the other occurs far more often than would be expected by chance at the point where the prefixes end and the stems take over (MacKay, 1972; Stemberger, 1985). There is still the problem that the analyst, faced with such non-contextual errors, has to speculate about what could have been the two interacting words in the speaker's mind that have blended. There is no way to be sure that it was indeed two prefixed words, and not, say, a truly prefixed word with a pseudoprefixed one (that is, a word beginning with a prefix-like string that is not a real prefix in that word).

| | | |
|---|---|---|
| [4] | grouping | groupment |
| [5] | inquisitive | she's so exquisitive |
| [6] | conjealing | they weren't _jeal |

On the other hand, *contextual* errors involving derivational morphemes are less ambiguous in this respect, since the interacting units that resulted in an error can be directly observed. One kind of misordering error involving derivational morphemes consists of stem (or root) exchange errors, also called "stranding errors", where the stem portion of two adjacent words exchange and leave their affixes behind, as in [7]–[8] (from Garrett, 1975).

| | | |
|---|---|---|
| [7] | all the starters scored in double figures | all scorers started |
| [8] | Fancy getting your nose remodelled | your model renosed |
| [9] | my shoulders are frozen | my frozers are shoulden |

Unfortunately, in English speech error studies, such errors have as yet not been specifically dealt with. Hence, no clear data are available that would indicate whether derivational affixes have a higher probability of being stranded than non-affix end fragments and/or whether derivational affix strandings obey a given morphological principle. One reason for this is probably the rarity of the phenomenon in error collections. Stemberger's (1985) corpus contains only 3 instances of derivational affix stranding but 120 instances of inflectional affix stranding. Likewise, in the MIT corpus, the elements stranded in stem exchanges are most often inflectional. Garrett (1980, p. 198) noted that 64% of the stranding errors involve only inflectional morphemes, while 23% involve an inflectional morpheme and a derivational morpheme like [7] or a non-morpheme like [9]. He did not report the distribution of the remaining 15% stranding errors, among which one might reasonably expect to find, in various proportions, stranding errors involving only derivational morphemes, strandings of a derivational morpheme in conjunction with a non-morpheme fragment, and strandings of two non-morpheme word portions. He merely noted that, in the MIT corpus, non-morpheme portions "do not exchange stranding fragments, or only rarely". This observation has been challenged by Butterworth (1983, pp. 267–268), who pointed out that "there are plenty of examples" in Fromkin's (1973) published corpus of speech errors where initial non-morphemic word portions exchange leaving behind final non-morphemic word portions, as in [10]–[11]. Both observations, Garrett's and Butterworth's, lack precision, and neither of them reports the critical data about frequency of derivational morpheme vs. non-morpheme stranding errors. Finally, the question of whether the morphemic status of the misordered elements is actually relevant in accounting for derivational morpheme strandings in English remains unanswered.

| | | |
|---|---|---|
| [10] | <u>th</u>ird of <u>Dec</u>ember | /dijsərd/ of /θɛmbər/ |
| [11] | <u>Cam</u>bridge <u>Fen</u>way | <u>Fen</u>widge <u>Cam</u>way |

More precise data are available in German on the pattern of stem exchanges in derived words. MacKay (1979) analysed the 220 stem exchanges in the corpus of Meringer (1906) and Meringer and Mayer (1895).[5] Contrary to what is observed in the MIT corpus, where morpheme units are sometimes stranded in conjunction with non-morpheme units, MacKay noted that there was no error involving an exchange of a stem and a non-stem—hence, no error where an affix is stranded together with a non-affix. More importantly, misplaced stems almost always exchanged with stems of the same syntactic class: Noun stems were exchanged with noun stems, verb stems with verb stems, and adjective stems with other adjective stems—a property that seems indeed to require an analysis in terms of the morphological structure of the misordered elements.

MacKay analysed another kind of misordering error involving derivational morphemes, namely, derivational suffix exchanges like [12]. He noted that the 32 suffix exchanges of the Meringer's corpus display a suffix class effect. Suffixes were always exchanged with suffixes of the same general type, that is, derivational suffixes were always exchanged with other derivational suffixes and never with inflectional suffixes. Moreover, derivational suffixes for forming nouns were always exchanged with other nominalisation suffixes. The existence of such a suffix class effect constitutes

[5]While the author does not explicitly state the distribution of the different kinds of affix stranded, the properties of stem exchanges are reported under the heading "derivational phenomena", rather than "inflectional phenomena". Thus, I presume that only derivational affix strandings are involved here.

a strong case for viewing suffix exchanges as true morpheme exchanges rather than as mere sound exchanges. MacKay added that a similar phenomenon is almost certain to hold for speakers of English. He noted that Fromkin's (1973) corpus contains several examples in which suffixes from the same class are exchanged but no unambiguous exchanges of suffixes from different classes. Nevertheless, in the MIT corpus, affixal elements were almost absent in word-final exchanges; when sound segments occupying word-final position exchange, non-morphemic elements were predominantly involved, as in [13]: Of the 41 cases of word-final exchanges, only 4 were possibly exchanges of bound morphemes, e.g. [14] (Garrett, 1980).

| | | |
|---|---|---|
| [12] | his dependence on the government | his dependment[6] |
| [13] | structure and function | strunction and fucture |
| [14] | passive usage | passage usive |

In sum, speech errors apparently involving derivational morphemes turn out to be ambiguous in various respects. Non-contextual errors are open to accounts that take morphological rules to be handled by speech production processes only in particular instances, or even to interpretations that do not appeal at all to morphological principles. As for contextual errors, critical pieces of data, such as the probability that a derivational affix as opposed to a non-morpheme ending will be stranded or exchanged, are either missing or inconsistent. Although some discrepancies in the results might be due to language differences, this cannot be the whole story. For example, while suffix exchanges are virtually absent in the MIT corpus, suffix exchanges are found in Fromkin's, where they appear to display the same suffix class effect as found in the German exchange errors (MacKay, 1979). Likewise, nonstem exchanges were rare in the MIT collection but apparently not in Fromkin's (cf. Butterworth, 1983). It might be that these intra-language—but perhaps also cross-language—inconsistencies are due to the critical error types not being frequent enough in a speech error corpus to yield reliable results.

In fact, the collection procedure might not be an appropriate way to address the issue. To add further to the difficulties arising from the rarity of the phenomenon, there are sampling biases in speech error collections, which are particularly problematic when critical evidence rests on the relative frequency of various types of word-portion errors. As Cutler (1982, p. 7) stressed, every collection of speech errors confounds the occurrence of particular types of error with detectability (see also Ferber, 1991).

[6]In the MacKay (1979) paper, the principles underlying the German errors are illustrated by means of English examples, either observed by the author or hypothetical; the English example cited here is hypothetical.

Arguments such as “errors involving word portions like *x* are more frequent/rare than errors involving word portions like *y*”, therefore, are particularly susceptible to the detectability problem. Indeed, the frequency of occurrence of a particular type of error in the collection might be determined by the differing psychological salience of the word portions examined. For example, errors involving meaningless word portions may be less easily perceived and/or recalled than errors involving morphemic, i.e. meaningful, word portions.[7] There is also the problem of detectability from the speaker’s point of view. The probability that an error will not be edited out prior to output, is influenced by several factors, such as the semantic, syntactic, or lexical properties of the erroneous utterances (Motley, Baars, & Camden, 1983). Thus, particular error types might appear more often because they are less prone to semantic, syntactic, or lexical editing. Finally, speech error samples might be biased by the combinatorial and distributional properties, both in language and speech, of the various units examined. For example, since morpheme exchange errors are mainly within-phrase errors (Garrett, 1980, 1982), they are most likely to occur in a speech context that includes two polymorphemic words within a single phrase. It might well be, however, that such a configuration is not as likely to be produced as a configuration containing two morphologically simple forms.

The hearer’s detectability problem could be overcome by systematic recording and transcribing of a large body of speech, but this method is difficult to apply. Stemberger (1985) reported that one can observe only 20–30 slips per hour. Only 191 slips were noted in the 170,000 words of the London–Lund corpus of tape recorded spontaneous conversations (Garnham, Shillcock, Brown, Mill, & Cutler, 1982), and, to my knowledge, no larger error collection has ever been constituted with this method. Another way to overcome the detectability problem of both the hearer and the speaker is by using laboratory techniques for the elicitation of errors. These techniques allow one to collect and transcribe errors under very reliable conditions and to control factors that influence editing mechanisms. In addition, they allow one to control the speech context in which the units under consideration appear and hence to obtain actual error probabilities as opposed to error frequencies.

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[7]If morphemic word-portion errors were indeed more easily perceived, that would not necessarily favour the hypothesis that morphemes are relevant units in speech *production*. There is in fact evidence that people are aware to a degree of the morphemic composition of words (cf. Smith & Sterling, 1982). However, such an awareness could be the consequence of some morphemic decomposition arising during speech *comprehension* processes, either as an automatic (Marslen-Wilson, Tyler, Waksler, & Older, 1994; Taft, 1988) or a “fall-back” (Butterworth, 1983) device; it could also be a manifestation of meta-lexical knowledge (Hudson, 1984; Spencer, 1988).

These were the reasons why I chose to use an experimental paradigm to collect critical data missing in the speech error literature related to derivational morphology—namely, data regarding the probability of a given word portion being misordered, depending on whether it is a morphemic unit or not. Since the question appears unlikely to be settled on the basis of analysis of naturally occurring speech errors, an experiment was designed as to elicit, under controlled conditions, word-fragment misordering errors in derived and control (nonderived) target words.

# METHOD

## Overview

Contextual verbal slips were induced by employing a version of the Word Order Competition (WOC) technique proposed by Baars and Motley (1976). In the WOC technique, sequencing errors of the word components are induced by presenting subjects with cues to say aloud word pairs in either the order presented or in reverse order, the order itself being unexpected for the subject.

In this experiment, the subjects were presented with noun–adjective word pairs that varied in their morphological properties. In the "suffixed" condition, the two words in a pair were suffixed words (e.g. troup**eau** traîn**ard**,[8] *flock straggler*;[9] pens**eur** haut**ain**, *thinker haughty*; croch**et** mur**al**, *hook wall*); in the control condition, the two words were monomorphemic words bearing a final phoneme string that was homophonic with a suffix (e.g. ~cad**eau** bât**ard**, *gift hybrid*; ~aut**eur** soud**ain**, *author unexpected*; ~chal**et** riv**al**, *chalet rival*), that is, pseudosuffixed words. Uncertainty about the order in which the two words of a given pair had to be said aloud was expected to give rise to stranding errors, that is, errors where portions of the two words exchange while stranding other portions. For example, by presenting subjects with a cue to say aloud the word pairs troup**eau** traîn**ard** or ~cad**eau** bât**ard** in reverse order, I attempted to induce the slips traîn**eau** *troup**ard** or ~bat**eau** *cad**ard**. In the first case, this is a slip caused by the roots being exchanged, while the suffixes are stranded. In the second case, the pseudoroots would be exchanged, leaving the pseudosuffixes stranded. Derived word pairs should give rise, more often than control ones, to such stranding errors, if lexical retrieval actually entails the selection of intermediate morpheme-level units between words and phonemes.

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[8] In order to help non-French speakers, I have adopted the following conventions, in these examples and throughout the article: (1) Suffixes and pseudosuffixes are bold-typed in the words; (2) Pseudosuffixed and suffixed word pairs are differentiated by marking pseudosuffixed pairs with "~"; (3) Nonsense strings are marked with "*".

[9] Word pairs are translated word-for-word to keep the French N–ADJ word order.

My use of the WOC technique should not, however, be taken as an endorsement of Baars and co-workers' assumption that competition between two speech plans is the proximal cause of virtually all speech errors, whether elicited or spontaneously produced (cf. Baars, 1992). The assumptions underlying the use of this methodology are somewhat different. First, I assumed that there is a single speech mechanism[10] by which misordering errors occur, whatever the speech production conditions. This mechanism may be described as follows: When two units are in contiguity (and hence must be activated almost at the same time), misordering would occur when the mistaken unit has a higher activation that the target unit (cf. Dell, 1986). Second, I assumed that, whatever the cause precipitating the operation of this mechanism may be—and competing plans might be one of the possible causes—the resulting erroneous form will be dependent only on the structure and units of the speech processing system. In other words, I assumed that it is the characteristics of the speech production system that ultimately determine the shape of the error, it is not the phenomenon that caused it to occur.[11]

I used the WOC procedure to induce higher activation of a non-target unit than the target one. The subjects do not know in advance which of the two target words will have to be uttered first. Accordingly, both words will have a high level of activation before the cue to reverse the word pair is presented. If there is insufficient increase of activation of the first word to be spoken, the incorrect activation of its lower-level units may result in an erroneous ordering of these lower level units. (I will return to this point in the General Discussion section.)

## Subjects

Sixty undergraduate students of the Université de Mons-Hainaut (Belgium) took part as volunteers in this experiment. They ranged from 18 to 25 years old and were all native French speakers.

## Material

Sixty-four experimental polysyllabic word pairs were formed to be presented with the WOC technique. These experimental target pairs were noun–adjective word pairs. Half of the pairs were formed with two suffixed words, and the other half with two pseudosuffixed words.

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[10]See Cutler (1982) for a discussion about the distinction that has to be drawn between the cause and the mechanism of errors.

[11]This assumption concurs with Cutler's (1982) suggestion that error mechanisms ought to be both speaker and language universal although the causes of errors might differ across languages, across individuals, and across occasions.

The 32 suffixed pairs were constructed from 32 suffixed nouns and 32 suffixed adjectives.[12] All these suffixed words were composed of a free root and a derivational suffix. (Fifteen different suffixes—eight composed of two phonemes and seven of one phoneme—were borne by these suffixed words; Appendix A). The great majority displayed a regular (albeit not necessarily productive) morphological pattern, that is, the derivation did not alter the base form, and the word meaning was predictable on the basis of its morphemic components. The majority (fifty-five) had two syllables, and nine had three syllables.

The 32 pseudosuffixed pairs (i.e. control pairs) were built from 32 pseudosuffixed nouns and 32 pseudosuffixed adjectives. These pseudosuffixed words had the same endings as the suffixed words selected for the suffixed word pairs, and the various pseudosuffixes were each repeated across the various pseudosuffixed words in approximately the same manner as the corresponding suffixes across the suffixed words (Appendix A). All the pseudosuffixed words conformed to the following criteria: (1) The word fragment remaining after the putative suffix is stripped off (the pseudoroot) could not be given a meaning related to the meaning of the word in which it appears; (2) this word fragment did not enter another French word that had a meaning related to the meaning of the word in which it appears; (3) likewise, the putative suffix did not contribute any meaning to the word, nor was it likely to be given the meaning of the corresponding suffix. Three pseudosuffixed words had three syllables; all the others had two syllables.

The 64 word pairs were made up so that they conform to the following constraints: (1) All the pairs were made up of a noun followed by an adjective; (2) the noun + adjective combination was semantically plausible; (3) in order to increase the rate of the particular errors I attempted to induce, i.e. root and pseudoroot exchanges, half of the 64 target pairs were built up in such a way that a root or pseudoroot exchange would lead to an utterance whose first word was a real French word, and furthermore, that this word was a noun. (Since nouns generally precede adjectives in nominal phrases in French, this error outcome would not violate phrasal rules.) These pairs will be called "biased pairs". Half of these were suffixed pairs, and half were pseudosuffixed pairs. In sum, among the 64 experimental pairs, there were 16 biased suffixed pairs, 16 non-biased suffixed pairs, 16 biased pseudosuffixed pairs, and 16 non-biased pseudosuffixed pairs. The biased pairs were like the stimulus pair [15] for the suffixed pairs, and like [16] for the pseudosuffixed pairs: The expected root and pseudoroot exchange

[12] I had to use three suffixed words twice: two nouns and one adjective appear in two different pairs, because of a lack of material. I also had to use ten pseudosuffixed words twice: six nouns and four adjectives appear in two different pairs.

leads to the production first of a French noun (mur**et**; riv**et**); the same mechanism leads to the production of two nonsense strings in the case of the non-biased pairs, suffixed like [17] or pseudosuffixed like [18].

| | *Stimulus pair* | *Expected error* |
|---|---|---|
| [15] | croch**et** mur**al** | mur**et** *croch**al** |
| | *hook wall* | *low wall* *… |
| [16] | ~chal**et** riv**al** | ~riv**et** *chal**al** |
| | *chalet rival* | *rivet* *… |
| [17] | chat**on** frouss**ard** | *frouss**on** *chat**ard** |
| | *kitten cowardly* | |
| [18] | ~flac**on** stand**ard** | ~*stand**on** *flac**ard** |
| | *bottle standard* | |

In addition, the syllabic ending pattern was matched across the four sets of experimental word pairs. In each of these sets, there were four word pairs presenting each of the four following ending patterns: "-CV -CV", "-CVC -CVC", -CV -CVC", and "-CVC -CV" (according to the CV pattern of the first and the second word of the pair). These ending patterns were always related to the morphological or pseudomorphological structure in the same manner: The onset of the last syllable always corresponded to the final consonant of the root or pseudoroot; the following V or VC phonemes (the last syllable's rhyme) always corresponded to suffixes or pseudosuffixes. To permit unambiguous analysis of the word portions likely to be misordered, the roots or pseudoroots of the two words in a given suffixed or pseudosuffixed pair never bore the same end consonant, and the suffixes or pseudosuffixes of the two words never bore the same initial vowel. This control also kept the results from being biased by a repeated-phoneme effect.[13] The experimental word pairs, with their phonetic transcriptions, are given in Appendix B.

The overall phonological similarity between the two words appearing in a given pair was checked. I examined the features by which each phoneme appearing in a given syllabic position in the two words differed[14] and then determined the mean number of features differing between the words of a given pair. This procedure is illustrated here for the word pair buv**eur** bon**asse** (*drinker meek*):

[13]Repeated sounds tend to induce the misordering of the sounds around them (Dell, 1984; Nooteboom, 1969).

[14]Between-word sound errors suggest that segments generally interact with segments in a parallel part of the syllable, i.e. syllable onsets with syllable onsets, syllable nuclei with syllable nuclei, and syllable codas with syllable codas (Nooteboom, 1969).

| | Syllable 1 | | | Syllable 2 | | |
|---|---|---|---|---|---|---|
| | *Onset* | *Nucleus* | *Coda* | *Onset* | *Nucleus* | *Coda* |
| Word 1 | b | y | – | v | œ | R |
| Word 2 | b | ɔ | – | n | a | s |
| Number of differing features | 0 | 2 | – | 3 | 2 | 4 |
| Mean number of features by which the two words differ: 11/5 = 2.2 | | | | | | |

When the two words in a given pair did not display a parallel syllabic structure, two indexes were computed: For $index_1$, the maximum number of differing features (that is, five) was counted for syllabic positions that were filled only in one word; for $index_2$, I did not take such unfilled positions in consideration. An example is provided here for the word pair <u>croch**et** mur**al**</u> (*hook wall*):

| | Syllable 1 | | | Syllable 2 | | |
|---|---|---|---|---|---|---|
| | *Onset* | *Nucleus* | *Coda* | *Onset* | *Nucleus* | *Coda* |
| Word 1 | k R | ɔ | – | ʃ | ɛ | – |
| Word 2 | – m | y | – | R | a | 1 |
| Number of differing features | (5) 4 | 2 | – | 5 | 1 | (5) |
| Mean number of features by which the two words differ: | | | | | | |
| $index_1$: 22/6 = 3.66 | | | | | | |
| $index_2$: 12/4 = 3 | | | | | | |

The mean $index_1$ of between-word phonological similarity for biased suffixed and pseudosuffixed pairs is, respectively, 2.95 ($SD = 0.73$) and 2.70 ($SD = 0.65$), a difference that is not significant ($t = 1.03$, $df = 30$, $P > 0.1$). The mean $index_2$ for these two types of pair is, respectively, 2.48 ($SD = 0.60$) and 2.14 ($SD = 0.61$), also not a significant difference ($t = 1.62$, $df = 30$, $P > 0.1$). Likewise, unbiased suffixed and pseudosuffixed word pairs do not differ as to $index_1$ (2.84, $SD = 0.77$ and 2.98, $SD = 2.98$; $t = -0.56$, $df = 30$, $P > 0.1$) or to $index_2$ (2.36, $SD = 0.66$ and 2.42, $SD = 2.42$; $t = -0.27$, $df = 30$, $P > 0.1$).

Since the occurrence of an expected word error might be favoured if it has a higher frequency of use than the target word, I also checked the frequency of the first target word and the expected word-error across suffixed and pseudosuffixed biased pairs. Subjective frequencies were first considered because the words selected for the experiment were not listed in the only frequency table available for French spoken words (Gougenheim, 1958), which only reports values for the 3000 most frequent words.[15] The results reveal no significant asymmetries between suffixed and pseudosuffixed pairs: (1) The mean subjective frequency was 3.12 ($SD = 1.1$) for the first suffixed target word, and 3.16 ($SD = 0.80$) for the first pseudosuffixed target word ($t = -0.10$, $df = 30$, $P > 0.1$); (2) There was no significant difference in mean frequency of the expected word error: 3.61 ($SD = 0.98$) for suffixed pairs and 3.21 ($SD = 0.98$) for pseudosuffixed pairs ($t = 1.17$, $df = 30$, $P > 0.1$); (3) The distribution of the differences between the frequency of each target word and the frequency of its corresponding expected error did not significantly differ for suffixed and pseudosuffixed words ($t = -1.08$, $df = 30$, $P > 0.1$). Second, as subjective frequencies might be biased by the morphological composition of the stimuli, objective frequencies were also checked on the basis of the Baudot's (1992) written words count, with exactly the same set of outcomes for the three comparisons.

I added 108 noun-adjective filler pairs to the 64 experimental pairs. To construct these filler pairs, 216 words were selected of which 72 were monomorphemic words, 72 were suffixed words, and 72 were pseudosuffixed words. These three categories of words were used to construct heterogeneous word pairs, where the two words were not from the same morphological category. For presentation, the 172 word pairs (64 experimental and 108 filler pairs) were divided into two blocks, with an equal number of each kind of word pair being randomly interspersed within each block.

## Procedure and Apparatus

All the word pairs were presented in lower-case letters on a B&W video display unit controlled by an IBM PC. The subjects' responses were tape recorded on a UHER tape equipped with a lavalier microphone. The sequence of events for each word pair was as follows: (1) Warning tone lasting 100ms; (2) exposure of a word pair for 1300ms; (3) a 100ms blank

[15]To collect subjective frequencies for the target words and the corresponding expected word errors, I orally and individually presented 20 subjects (matched in age and instructional level to the subjects in the experiment) with a 64-word list. This list consisted of the 16 suffixed and 16 pseudosuffixed words for which a morpheme/pseudomorpheme exchange leads to a lexical response and the 32 corresponding expected word errors. The order of presentation was random and different for each subject. These subjects were asked to estimate the frequency of each word on a five-point scale ("very frequent" to "very rare"). The responses were then attributed a numerical value (from 1 to 5 for "very rare" to "very frequent"), and a mean subjective frequency was computed for each of the 64 words.

interval; (4) presentation of a horizontal arrow, pointing either right or left, for 400ms; (5) a 200ms blank interval preceding the next trial.[16]

The subjects were told that the experiment was intended to study word reading. They were given the following written instructions (translated here) on the video screen: "You are going to see various word pairs. Read each pair silently. It will then disappear, and be replaced by an arrow, pointing either right or left. If it points right, say aloud the word pair exactly as it appeared on the screen. But if it points left, say the two words in the reverse order in which they appeared on the screen. For example, . . . [an example for each case was displayed on the screen]. It is important to repeat aloud the words as quickly as possible when the arrow appears. A beeper will inform you when the following pair will appear on the screen." The subjects were then given five practice pairs before the experimental trials.

The experimental target pairs were all followed by a leftward arrow. Thus, in these cases, subjects were required to retain each pair momentarily and, after the pair had been exposed, to reorder the members of the pair from right to left. Only 16 filler pairs were followed by a leftward arrow, the 92 others being followed by a rightward arrow. Therefore, subjects had to say aloud 92 word pairs in the same order they were displayed and 80 word pairs in reverse order.

The subjects were run individually. A short rest period was allowed between the two blocks, each of which took approximately 15 minutes.

## RESULTS AND DISCUSSION

### Error Categorisation

All the verbal slips produced for the experimental target pairs were written down phonetically by two transcribers. If one of them was uncertain or in the event of disagreement, the tape was replayed until certainty and/or agreement was reached. All the slips were then classified as follows:

#### *Contextual Vs. Non-contextual Errors*

Contextual errors result from the misordering of one or more of the segments of the target string; in non-contextual errors, segments were omitted or segments that were not part of the target string were added or substituted.

[16]The exposure and blank delays were set after running several trials with seven subjects who did not participate in the experiment. The delays were progressively adjusted so as to introduce sufficient time pressure for errors to be uttered but still to allow the subjects to give a complete response. Thus, I did not use Baars and Motley's (1976) conditions, which were used with different material (monosyllabic words and non-words).

### *Within-word Vs. Between-word Errors*

Among the contextual errors, within-word errors are those resulting from misordering of one or more segments within one of the two target words (thus interacting elements belong to the same word); between-word errors occur when one or more of the segments belonging to a target word appear within the other target word (here, the interacting elements belong to two different words).

As the experiment was designed to induce contextual between-word errors, only these errors were analysed further as a function of the word portion and the error mechanism involved:

### *Critical Vs. Non-critical Word-portion Errors*

Critical word-portion errors involve an *entire* morpheme unit (root or suffix) of a suffixed word [19a, 19b], or an *entire* pseudomorpheme unit (pseudoroot or pseudosuffix) of a pseudosuffixed word [20]–[21]; non-critical word-portion errors involve a word part or parts that are not coextensive with a morpheme [22]–[24] or pseudomorpheme portion [23]–[25] of the target word.

### *Error Mechanism*

To describe the error mechanism that led to an erroneous response, a decision had to be made about what to count as the target utterance. Unlike Baars and Motley (1976), who took the stimulus pair as the target, I adopted the convention of describing errors by considering that the target utterance was the stimulus pair in reversed order. The main reason for this decision was that, in almost all the trials, the subjects followed the instruction to reverse the word pair displayed on the screen. Out of all experimental-pair trials (n = 3840), there were only 7 instances where subjects failed to reorder the two words or the major part of the words, and in 4 of these 7 instances, the subject corrected him/herself. This indicates that, from the subject's point of view, it was indeed the stimulus pair in reversed order that constituted the target. Moreover, when sublexical contextual errors arose, they most often occurred as the result of a sublexical unit that moved within an utterance where the major part of the two words in the stimulus pair was reversed.[17] Therefore, the most natural way to analyse these sublexical errors was to describe them according to the reversed stimulus pair.

[17]There were only three between-word contextual errors where the major part of the two words of the stimulus pair were not reversed. For example, given the stimulus pair <u>tir**et** fin**al**</u>, the response was <u>*tir**al**, tir**et** fin**al**</u>.

*Substitution Errors.* This category includes complete and partial exchanges and other substitution (i.e. anticipation/perseveration) errors. In complete exchange errors [19a], two word portions, each belonging to a different word, exchange (i.e. substitute for each other), stranding the remaining word portions. In partial exchanges [19b], the first half of an exchange occurred but was then interrupted and corrected by the speaker before the second half could occur. In other substitution errors, a portion of a given word was mislocated and substituted for a word portion in the other target word, but not the reverse; accordingly, only one word is mispronounced [20]–[21]–[22]–[23].

| | *Stimulus pair* | *Target pair* | *Error* |
|---|---|---|---|
| [19a] | pens**eur** haut**ain** | haut**ain** pens**eur** | haut**eur** *pens**ain** |
| | *thinker haughty* | *haughty thinker* | *height *…* |
| [19b] | pens**eur** haut**ain** | haut**ain** pens**eur** | haut**eur**, haut**ain** pens**eur** |
| | *thinker haughty* | *haughty thinker* | *height, haughty thinker* |
| [20] | ~aut**eur** rur**al** | rur**al** aut**eur** | *rur**eur** aut**eur** |
| | *author country* | *country author* | *… *author* |
| [21] | ~vis**on** coqu**et** | coqu**et** vis**on** | coqu**et** *vis**et** |
| | *mink charming* | *charming mink* | *charming *…* |
| [22] | hérit**age** personn**el** | personn**el** hérit**age** | *personnal hérit**age** |
| | *inheritance personal* | *personal inheritance* | *… *inheritance* |
| [23] | ~tunn**el** soud**ain** | soud**ain** tunn**el** | *sud**ain** tunn**el** |
| | *tunnel sudden* | *sudden tunnel* | *… *tunnel* |

*Addition Errors (perseveration/anticipation).* In these errors, a word portion was produced twice in the sequence, once in the right place, then in a wrong place, being then added to a target word [24]–[25].

| | *Stimulus pair* | *Target pair* | *Error* |
|---|---|---|---|
| [24] | terr**eau** coût**eux** | coût**eux** terr**eau** | *crout**eux** terr**eau** |
| | *compost expensive* | *expensive compost* | *… *compost* |
| [25] | ~ham**eau** rad**in** | rad**in** ham**eau** | rad**in** *harm**eau** |
| | *hamlet stingy* | *stingy hamlet* | *stingy *…* |

Only one slip was counted when the two words of a given pair were mispronounced as a result of a single error mechanism (that is, in word-portion exchanges). Two slips were counted, however, when the two erroneous words of a given pair were each the product of a distinct error mechanism (when, for example, a word in a given pair was affected by an addition error, while the other word was affected by a non-contextual error). Thus, for each word pair, the number of slips could be 0, 1, or 2.

## Error Distribution

Overall, the 64 experimental word pairs gave rise to 146 slips. On average, each pair elicited 2.3 slips, and each subject produced on average 2.4 slips. Over all trials (n = 3840), there was a 3.8% error rate. The number of slips produced for each word pair is given in Appendix B. Table 1 shows the distribution of slips across the error types and according to the morphological structure of word pairs. When all kinds of error are considered, the error rate for suffixed word pairs is higher than for pseudosuffixed word pairs. This difference is reliable across subjects (Wilcoxon-T: $z = -4.62$, 2-tailed $P < 0.001$) and word pairs (Mann-Whitney-U: $z = -3.37$, 2-tailed $P < 0.001$). The distribution of errors across contextual, non-contextual, and miscellaneous categories does not differ, however, for the suffixed and pseudosuffixed pairs ($\chi^2 = 0.32$, $df = 2$, $P > 0.1$). As expected, biased pairs gave rise to more slips than non-biased pairs, a difference that proved to be reliable across subjects (Wilcoxon-T: $z = -2.96$, 2-tailed $P < 0.01$) and word pairs (Mann-Whitney-U: $z = -2.12$, 2-tailed $P < 0.05$). This difference is primarily due to the excess of contextual errors for biased pairs (Table 1), and indicates that the lexical bias in the construction of the stimuli had the planned effect.

The critical comparison concerns the number of between-word contextual errors that involve critical (i.e. morpheme or pseudopmorpheme) vs. non-critical word portions in suffixed and pseudosuffixed pairs (Table 2). The results indicate that the number of errors involving non-critical word portions is similar for suffixed and pseudosuffixed pairs. However, while suffixed pairs gave rise to four times as many errors involving a morpheme portion on its own than errors involving a non-morpheme portion, pseudosuffixed pairs did not yield pseudomorpheme-portion errors more often than did other word-portion errors ($\chi^2 = 10.94$, $df = 1$; $P < 0.01$). Morphemic parts of words have a much higher probability of being mislocated in verbal slips than do non-morphemic word parts.

TABLE 1
Error Distribution According to Condition

| | *Suffixed Word Pairs* | | | *Pseudosuffixed Word Pairs* | | |
|---|---|---|---|---|---|---|
| *Error Type* | *Biased* | *Non-biased* | *Total* | *Biased* | *Non-biased* | *Total* |
| Contextual between-word error | | | | | | |
| Critical word portion | 45 | 12 | 57 | 6 | 4 | 10 |
| Non-critical word portion | 6 | 7 | 13 | 9 | 3 | 12 |
| Contextual within-word error | – | 1 | 1 | 3 | – | 3 |
| Non-contextual error | 11 | 18 | 29 | 7 | 3 | 10 |
| Miscellaneous | 4 | 5 | 9 | 2 | – | 2 |
| Total | 66 | 43 | 109 | 27 | 10 | 37 |

TABLE 2
Error Mechanisms in Contextual Between-word Errors According to the Condition and the Word Portion Involved

| *Error Mechanism* | *Suffixed Word Pairs* | *Pseudosuffixed Word Pairs* |
|---|---|---|
| Critical word-portion errors: | | |
| Complete exchange | 26 | 4 |
| Partial exchange | 7 | 4 |
| Other substitution (anticipation/perseveration) | 24 | 2 |
| Total | 57 | 10 |
| Non-critical word-portion errors: | | |
| Complete exchange | 1 | – |
| Partial exchange | 2 | 1 |
| Other substitution (anticipation/perseveration) | 8 | 5 |
| Addition (anticipation/perseveration) | 1 | 5 |
| Miscellaneous | 1 | 1 |
| Total | 13 | 12 |
| Total | 70 | 22 |

All morpheme misordering errors were substitution errors. When one considers the morpheme category (suffix or root) that was substituted in these errors, a striking asymmetry appears (Table 3). Whenever morphemes were substituted, that is, exchanged, anticipated, or perseverated, it was almost always a derivational suffix that was involved, as in [26]–[27]–[28]. The root morpheme was exchanged in only two instances (one complete and one partial exchange), as in [29], and was never anticipated or perseverated.

| | *Stimulus pair* | *Target pair* | *Error* |
|---|---|---|---|
| [26] | cuiss**ard** chauff**ant** | chauff**ant** cuiss**ard** | chauff**ard** *cuiss**ant** |
| | *short heating* | *heating short* | *roadhog *…* |
| [27] | cuiss**ard** chauff**ant** | chauff**ant** cuiss**ard** | chauff**ard** cuiss**ard** |
| | *short heating* | *heating short* | *roadhog short* |
| [28] | cuiss**ard** chauff**ant** | chauff**ant** cuiss**ard** | chauff**ant** *cuiss**ant** |
| | *short heating* | *heating short* | *heating *…* |
| [29] | cuiss**ard** chauff**ant** | chauff**ant** cuiss**ard** | *cuiss**ant** chauff**ard** |
| | *short heating* | *heating short* | **… roadhog* |

Other possible kinds of misordering errors, which would appear as the result of a root anticipation/perseveration error together with a suffix exchange or a root exchange together with an affix anticipation/perseveration error were also not observed. In the context of the task instructions of the present experiment, this means that when morpheme errors occur, they most

TABLE 3
Units Involved in Contextual Between-word Errors According to the Condition

| *Error Mechanism/Units* | *Suffixed Word Pairs* | *Pseudosuffixed Word Pairs* |
|---|---|---|
| Substitution errors: | | |
| Complete exchange | | |
| Root/pseudoroot | 1 | – |
| Suffix/pseudosuffix | 25 | 4 |
| Single phoneme | 1 | – |
| Partial exchange | | |
| Root/pseudoroot | 1 | – |
| Suffix/pseudosuffix | 6 | 4 |
| Single phoneme | 1 | 1 |
| Single syllable | 1 | – |
| Anticipation/perseveration | | |
| Root/pseudoroot | – | – |
| Suffix/pseudosuffix | 24 | 2 |
| Single phoneme | 8 | 5 |
| Miscellaneous (multiple one-phoneme substitutions) | 1 | 1 |
| Addition errors: | | |
| Single-phoneme anticipation | 1 | – |
| Single-phoneme perseveration | – | 5 |
| Total | 70 | 22 |

generally resulted from the subject correctly reordering the root part of the stimulus words by leaving one or both suffixes in their original position in the stimulus pair. In other words, given the cue to reorder the words in the stimulus pair, the subjects very rarely failed to reorder the root morphemes, but did fail, far more often, to reorder the suffixes.

## Post-hoc Analyses

The main finding of this study is that morphemic parts of words have a much higher probability of being mislocated in verbal slips than do non-morphemic word parts. Could some uncontrolled factor have produced this result? In fact, two extraneous variables might have influenced the probability of making morpheme vs. pseudomorpheme substitution errors. First, a morpheme substitution might be more probable than a pseudomorpheme substitution because the former leads necessarily to the production of a string constituted by a real root and a real suffix, and such a combination might have a higher probability of being a word than the combination of a pseudoroot with a pseudosuffix. Note, however, that the probability for a substitution error to result in a real word was balanced between suffixed and pseudosuffixed word pairs. None the less, this might not have been a sufficient control: Morpheme substitution in suffixed word pairs might result in root/suffix combinations that constitute possible, grammatically correct, French words. This could increase the likelihood of a substitution error in suffixed words compared with pseudosuffixed words. However, this does not seem to have been the case. Examination of the 36 nonsense responses resulting from a morpheme substitution in suffixed word pairs (Table 4) reveals that very few of them (n = 4) might be viewed as acceptable French words: Most of these nonsense strings were formed either with an ungrammatical morphological structure (the syntactic category of the base word did not allow it to combine with the suffix) or with a non-productive pattern. Moreover, the two word-pair categories gave rise to a similar proportion of morphemic/pseudomorphemic substitutions resulting in nonsense responses: 36/82 (44%) nonsense responses for suffixed word pairs, and 6/14 (43%) for pseudosuffixed pairs.[18] This makes it unlikely that the higher rate of morpheme-substitution errors for suffixed word pairs was due to the differential likelihood of producing different types of nonsense error.

Another factor that was not controlled across the two categories of word pairs is the semantic relationship between the first target word and the expected word error in the biased pairs. The target and the error outcome were not found to have a semantic relationship in contextual errors observed in natural settings (Dell, 1986; Garrett, 1980, 1982; MacKay, 1980; Shattuck-Hufnagel & Klatt, 1979). It is important, however, to show that the morphological effect observed in the present experiment could not be reduced to a conjunction of syntactic, semantic, and phonological effects. The subjects were asked to produce an adjective (the target) in the first position of a nominal phrase, though it would be more acceptable in French to produce a noun in this position. If there is a noun stored in the subject's lexicon that is similar both in meaning and form to the target adjective, this noun might be likely to be retrieved and substituted for the target. Such a word-substitution error would be less probable with the pseudosuffixed pairs since, in these cases, the competing noun would be related only in form, not in meaning. Therefore, the higher rate of "morpheme substitutions" observed for the suffixed biased pairs, could be explained without appealing to morphemically based retrieval mechanisms.

For the biased pseudosuffixed stimuli, no target–error pair was semantically related. Inspection of the target–error pairs for the biased suffixed stimuli revealed, however, that only a minority of them had a clear

[18]The total number of responses considered here (that is, 82 and 14 for suffixed and pseudosuffixed pairs, respectively) differs from the total number of morpheme/pseudomorpheme exchanges mentioned previously (Table 2). This is because here I have to consider the total number of erroneous words resulting from slips not the total number of slips (as previously). In the cases of complete morpheme exchanges, a single slip yields two erroneous words.

TABLE 4
Morphological Properties of "Root + Suffix" Combinations in Morpheme Substitutions Resulting in Nonsense Responses

| *Nonsense Error* | *Morphological Structure* | *Grammaticality* | *Productivity* | N |
|---|---|---|---|---|
| *cuissant | Noun + -ant | – | – | 7 |
| *chatant | Noun + -ant | – | – | 1 |
| *oursaud | Noun + -aud | – | – | 3 |
| *cubeur | Noun + -eur | – | – | 1 |
| *pensain | Verb + -ain/-in | – | – | 6 |
| *héritel | Verb + -el | – | – | 1 |
| *tiral | Verb + -al | – | – | 2 |
| *garçonin | Noun + -in | + | – | 5 |
| *vestot | Noun + -ot | + | – | 3 |
| *charmeau | Verb + -eau | + | – | 1 |
| *noiron | Adjective + -on | + | – | 2 |
| *finet | Adjective + -et | + | + | 4 |
| Total | | | | 36 |

semantic relationship. Indeed, there were three kinds of relationship between the target adjective and the erroneous noun across the 16 biased suffixed stimuli:

1. There were four instances in which both the target adjective and the erroneous noun were suffixed words composed with the same root; the target and the error were in these cases clearly morphologically and semantically related: chlor**ure** piqu**ant**/piq**ûre** (*chloride stinging/sting*), vieill**ard** soûl**aud**/soûl**ard** (*old man drunken/drunkard*), croch**et** mur**al**/mur**et** (*hook wall/low wall*) and troup**eau** nas**ard**/nas**eau** (*flock whiny/nostril*). Only one of these word pairs (vieill**ard** soûl**aud**) resulted in morpheme-substitution errors (four morpheme substitutions).

2. There were five instances in which the target adjective was a suffixed word, but the erroneous noun was not: garçonn**et** cheval**in**/chevalet (*small boy horsy/easel*), chat**on** sav**ant**/savon (*kitten performing/soap*), terr**eau** coût**eux**/couteau (*compost expensive/knife*), cuiss**ard** chauff**ant**/chauffard (*short heating/roadhog*), and barr**age** sauv**eur**/sauvage (*barrage saviour/savage*). For example, while in the stimulus pair garçonn**et** cheval**in**, the expected erroneous noun, chevalet (*easel*), is the result of the combination of the root composing the suffixed target adjective (cheval-) and the suffix of the target noun (-et), neither of these two components have a morphemic status in the error (chevalet), and chevalet is not a suffixed word. In the five such instances, the target and error are not only morphologically but also semantically unrelated. Yet each of them gave rise to morpheme-

substitution errors, and were responsible overall for 26 out of the 45 (58%) morpheme-substitution errors elicited in the experiment. It appears that what are called "morpheme-substitution errors" in these cases did, indeed, result from the reversal of the root and the stranding of the suffix of the suffixed target words and not from mere word substitution between two semantic relatives.

3. The situation of the seven remaining suffixed stimuli was intermediate: While both the target and error were suffixed words, they had at best only a loose semantic and morphological relationship. This is mainly because, in either the target adjective (pens**eur** haut**ain**/haut**eur**, *thinker pretentious/height*) or the erroneous nouns (buv**eur** bon**asse**/bon**heur**, *drinker meek/happiness*; hérit**age** personn**el**/personn**age**, *inheritance personal/character*; troup**eau** traîn**ard**/traîn**eau**, *flock straggler/sleigh*; guid**on** front**al**/front**on**, *handlebars frontal/pediment*; mont**age** cub**ique**/cub**age**, *assembly cubic/volume*), or both (vest**on** manch**ot**/manch**on**, *jacket one-armed/muff*), the root and suffix combination is not semantically transparent (that is, the meaning of the words is not fully derivable from the meaning of their morpheme components). Only three of these seven stimulus pairs were involved in morpheme substitution errors, for a total of fifteen morpheme substitutions (33% of the total).

To what extent the semantic relationship between the target and the error is likely to have favoured—or prevented—morpheme-substitutions errors is a question that cannot be given a clear answer from these observations. But it must be stressed that the 5 suffixed pairs for which the target and the error were semantically unrelated gave rise to 26 morpheme substitutions (58% of all substitutions), while the 16 pseudosuffixed pairs gave rise to only 6 pseudomorpheme substitutions. It is thus unlikely that the higher rate of morpheme substitutions than of pseudomorpheme substitutions can simply be reduced to a semantic effect. One can also add that there were three times as many morpheme-substitution errors for unbiased suffixed pairs than pseudomorpheme-substitution errors for unbiased pseudosuffixed pairs. An explanation for this asymmetry in terms of semantic similarity between target and error is implausible, since the error outcomes here were non-lexical.

## GENERAL DISCUSSION

The main finding of this study is that, in laboratory-induced verbal slips, the morphemic components of derived words have a much higher probability of being involved in sequencing errors than otherwise similar non-morpheme word components. In the context of the particular task the subjects were assigned—that is, to reorder the two suffixed or pseudosuffixed words of a noun–adjective sequence—it was found that subjects stranded far more often the derivational suffixes of suffixed words than phonologically similar word-ending fragments of pseudosuffixed words. The laboratory setting allowed the control of many of the properties that are liable to influence the verbal slip rate (i.e. phonological structure of the two interacting words, syntactic structure within which they appear, lexical outcome of the expected slips, etc.). This finding therefore suggests that morpheme units like roots and derivational suffixes are handled at some stage of the real-time speech production process.

Within the most popular model of sentence production, Garrett's (1980, 1982) model, there is no specified processing level at which derivational morpheme errors could theoretically arise. This model describes the sentence construction processes as including the successive construction of a "functional" and a "positional" sentence representation level. The functional level determines the phrasal membership and the grammatical functions of lexical items, which are retrieved from the lexicon on the basis of their meaning and syntactic specifications; the positional level is responsible for the serial ordering of segmentally interpreted elements in the surface string. Mapping from the functional to the positional level includes the retrieval of lexical forms (i.e. their segmental interpretation) and their assignment to serially ordered slots. Such an assignment is guided by a "phrasal planning frame" that bears inflectional and free grammatical morphemes. Within this model, errors whereby stems are exchanged by stranding their inflectional suffixes can be ascribed to the stage of positional level construction: This kind of stranding exchange occurs because stems are assigned to the wrong sites in a phrasal frame that already bears inflectional morphemes. However, the present finding that derivational suffixes may be stranded in speech errors cannot be given the same explanation, because selecting one derivational variant or another often has meaning implications that cannot be handled by strictly syntactic processes, but also because derivational word formation processes, unlike inflectional processes, often affect the grammatical category of the base word. Since the grammatical category is assumed to be determined at the functional level, derivation cannot be assigned to the mechanisms that construct positional representations from functional ones. Involvement of the word derivational structure in speech production processes, therefore, has to be located at a point later than meaning/syntactic lexical retrieval and prior to form-based lexical selection.

The spreading-activation theory for sentence production developed by Dell (1986) assumes such an intermediate processing level—a morphological level—between the syntactic (which is, by and large, Garrett's functional level) and the phonological (Garrett's positional level) ones. The processes by which the morphological level is assumed to be constructed are likely to yield an appropriate framework for the explanation of derivational morpheme misordering errors.

In Dell's theory, the lexicon is represented as a network containing conceptual, word, morpheme and phoneme nodes. The conceptual nodes are connected to the word nodes and the word nodes to the morpheme nodes, which then connect to the phoneme nodes. Each lexical node is marked with category information. This marking is referred to as "insertion rules": Words are marked by their syntactic class (noun, verb, etc.), morphological units by their morphological class (stem, suffix, prefix), and phonological units by their phonological class (initial vowel, consonant, etc.). Each level is associated with a set of rules that generates a frame with categorised slots that are filled by insertion rules through decisions based on the activation levels of the nodes representing candidate items. Thus, at each level, lexical selection and insertion processes occur, words being selected and inserted at the syntactic level, morphemes at the morphological level, and phonemes at the phonological level. The syntactic, morphological, and phonological sentence representations that are constructed in this way are conceived as ordered sets of tagged word, morpheme, and phoneme nodes. The construction of each representation level is guided by the representation above it, the tagged nodes constituting a higher representation activating nodes that may be used for the immediately lower representation, which is constructed as the generative rules associated with that level build a frame and the categorised slots are filled by insertion rules.

As regards the way polymorphemic words are represented in the model, it is assumed that derived but not inflected forms exist as word nodes in the lexical network. Thus, for example, there is a word node for swimmer, labelled as a noun, but no single node for swimmers. Inflectional suffixes like -s are associated with their own node at the syntactic level, but not derivational affixes. However, the derived forms break down into their morphemes at the morphological level: Although swimmer is a single word node at the syntactic level, it connects to swim- and derivational suffix -er nodes at the morphological level. A derived word is assumed to retrieve and order each of its morphemic constituents by linking them to slots in a morphological frame. It is precisely the need to link each morphemic constituent to a slot in a frame that creates, within this model, the opportunity for a morpheme misordering error: A morphemic slip occurs when the wrong constituent is more activated than the correct one, being then selected and inserted within a slot of the categorically specified morphological frame. Thus, for this wrong constituent to be selected, it must be member of the same morphological category as the correct item.[19]

Let us consider how, within such a model, a target phrase like un chauff**ant** cuiss**ard** is constructed and how it could be erroneously produced as un chauff**ard** *cuiss**ant**. At the syntactic level, the phrase representation consists of word nodes that are linked to slots in a syntactic frame (Determiner Adjective Noun). Let us suppose that the determiner (UN) and adjective slots (CHAUFFANT) have already been filled in and that the insertion rule for nouns is presently searching for the noun with the highest activation level for inclusion in the representation. Thus, CUISSARD would be one of the activated word nodes. At the same time, however, the previously selected adjective (CHAUFFANT) remains activated because it is the current node for the construction of the lower morphological representation: The morphological frame for CHAUFFANT has been constructed (Stem Suffix), the stem node (CHAUFF) has been inserted within its corresponding stem slot, and the insertion rule for suffixes is now seeking out a suffix with the highest activation level—it should select ANT. At this time, an affix anticipation may occur if an upcoming item of the same category as the correct item—another suffix, say ARD—possesses a higher activation level than the correct item. This may happen because the upcoming item ARD receives activation from the word node in the higher level representation: While the word CHAUFFANT is being encoded at the morphological level, the node for ARD happens to be activated because the syntactic representation is working on CUISSARD. From spreading activation from this word node, the node for ARD may be more activated than ANT and will replace ANT in the slot marked for suffix in the morphological frame. At this point, the current node of the syntactic representation should be changed to the next word node, that is, the noun node (CUISSART). Then, a morphological frame will be constructed (Stem Suffix), the stem with the highest activation level (CUISS) inserted within the

[19]The presently most prominent theory of speech production, the one developed by Pim Levelt and his coworkers (Levelt, 1989, 1992; Roelofs, 1992), also assumes a morphological processing level intervening once “lemmas” (that is, lexical items unspecified for phonological form) have been accessed and ordered in syntactic phrases by “grammatical encoding” processes. Thus, the first step in constructing the phonetic program for each lemma (“phonological encoding” processes) consists in retrieving the morphemes composing each lemma (its root and, if any, its derivational and inflectional affixes) and inserting them into a morphological frame. On this basis, speech segments and, then, syllables will be retrieved and linked to slots in word-form frames. In considering how, during phonological encoding processes, the stored forms are accessed and inserted into slots, and how errors may arise during these processes, Levelt (1989) chiefly relies on the Dell’s (1986) treatment of the issue. To my knowledge, this aspect of the model has not been given further or new development ever since, the more recent articles of the group focusing specially on lemma retrieval processes (Roelofs, 1992, 1993; Schriefers, 1993) or segment and syllable retrieval processes (Levelt & Wheeldon, 1994; Wheeldon & Levelt, 1995).

stem slot, and the most activated affix in the suffix category sought out to be inserted within the suffix slot of the morphological frame. However, when the incorrect item ARD has been selected, its activation level was set to zero, while the proper item ANT, having not been selected, remained activated. This mechanism causes an exchange to occur: Because ANT remains available for selection, it can be selected to fill in the next suffix slot of the morphological frame.

It has been mentioned that, within Dell's theory, a misordering error occurs when an upcoming unit has higher activation than the target unit, so it is selected before the target. The reason why the activation level of an upcoming unit is higher than the target mainly derives from the spreading of activation and the construction of multiple representation levels: When a word is being encoded at the morphological level, the syntactic representation level is working on an upcoming word, and that word node spreads its activation to its lower-level, morphological nodes. Thus, misordering errors are the natural consequences of the theory's assumptions. Further, it is assumed that some source of variability in the patterns of activation that result during production is provided by the background activation of the lexical network.

Within this framework, an explanation can be proposed about how the elicitation procedure used in the present study proved effective in inducing sublexical misordering errors. Stated in terms of the theory's assumptions, there are aspects of the experimental situation that could have occasionally caused an upcoming sublexical unit to have a higher activation level than the target one and then to replace it. The subjects had to retain momentarily the two words of the stimulus pair in memory before speaking them aloud, and they did not know in advance in which order they would have to speak them. This situation is likely to create a background activation of the lexical network that favours the misordering of sublexical units. Before the cue "reverse" is presented for the noun–adjective experimental pairs, each of the two words has a high activation level in the lexical network. On some occasions, the subject may expect to say the stimulus pair in the same order as presented. In such cases, the noun will have a higher activation level than the adjective. By spreading its activation to its sublexical components, the activation level of the noun sublexical nodes would be higher than the adjective sublexical nodes. After the cue "reverse" is presented, the increase of activation level for the adjective and, then, for its sublexical nodes, might not be sufficient (under time pressure) to prevent the selection of one of the previously highest activated nodes.

The main alternative explanation would be in terms of the Competing Plans Hypothesis (Baars, 1992; Baars & Motley, 1976) where, due to the uncertainty about the word order, two syntactic frames—one noun–adjective, the other adjective–noun—were constructed, both being filled with the corresponding words, which then blended later in the production processes (at the morphological or phonological level). This account seems inconsistent, however, with the observation that the subjects almost never made reversal errors (that is, produced noun–adjective strings) and that, when sublexical units were mislocated, the root portions of the words were ordered according to an adjective–noun string. If two syntactic frames were actually planned on some occasions, the rate of reversal errors and of errors where roots were not reordered should have been higher.

It is beyond the scope of this study to settle the issue of exactly what is going on in the WOC experimental procedure. The proposal that is made here only intends to make the point that, although the situation that caused the misordering to occur in the experimental situation has little chance of being found in a natural speech situation, the mechanism itself, by which the sublexical errors arose, may be accounted for by appealing to a more general error mechanism.

I should acknowledge, however, that the planning processes involved in the experimental situation might differ from those involved in a natural speech situation. The subjects, here, have to reorder explicitly the two words presented in an adjective–noun string, while ordering mechanisms are largely implicit in speech production. However, this problem probably holds only for word sequencing and not for the processes by which word components are ordered. Even if the subjects in this experiment used some special explicit device to reorder the words presented, it is very unlikely that they were aware of the process of ordering word parts like morphemes or phonemes—and it was word-part sequencing processes, not word-order processes, that were the focus in this study. I found that derivational affixes were stranded in the course of reordering the words, while phonologically similar material tended not to be. This suggests that speakers do represent the morphological structure of words during speech production.

The speech production model proposed by Dell (1986) allows a number of predictions to be made that were not tested in this study, but which would be worth testing with the same methodology. First, there is no feature in the model that would entail an asymmetry between the stem and the derivational affix in misordering errors: Both morpheme categories are liable to be mislocated in speech errors. MacKay (1979) reported both kinds of errors in his study of Meringer's German corpus. In the present study suffixes were stranded far more often than roots when words were reordered. However, such a result might be tied to the specific experimental conditions used, which made all kinds of potential errors not as likely to be produced. In the course of reordering the two suffixed words of a given pair, a suffix stranding error (cf. [26]) was more probable than a root stranding error (cf. [29]) because, in the context of the present manipulation, the former yielded a word and the latter a nonword to be spoken first.

Furthermore, the instruction to reverse the two words of the stimulus pair strongly induces a response whose onset corresponds to the onset of the second word; such a bias also made a suffix stranding error more probable than a root stranding error in the present study. To seek appropriate evidence for a morpheme category effect in morpheme misordering errors, other experimental manipulations should, therefore, be used with a similar methodology. The material could be constructed in such a way that the lexical bias would favour suffix stranding errors in one condition, and root stranding errors in another condition. In order to set apart the specific influence of the instruction to reverse, one could manipulate a further variable, namely, the affix position (prefix vs. suffix). If the instruction bias was the only determinant of the apparent morpheme category effect observed here, then one should observe that word endings are more often stranded than word beginnings, whatever their morpheme category, when subjects reorder the words of a stimulus pair: Roots should be stranded more often than prefixes when two prefixed words have to be reversed while suffixes should be stranded more often than roots in case of two suffixed words.

Another aspect of Dell's theory that deserves experimental testing concerns the influence of the stem and affix category on morpheme misordering errors. Within the theory, the only category constraint on morphemic errors is more a positional than a syntactic constraint: Morpheme nodes are labelled as stem, prefix, or suffix, so that stems can only move to stem positions, prefixes to prefix positions, and suffixes to suffix positions. There is no syntactic marking such as noun stem, verb prefix, or nominalising verb suffix. Though these variables were not directly investigated in the present study, it was found that suffixed nouns interact with suffixed adjectives in such a way that their derivational suffixes were substituted; in other words, nominalisation suffixes were found to interact and substitute for adjectivalisation suffixes. Moreover, many of the morpheme substitutions occurred between words whose stem were of different categories (for example, in <u>pens**eur** haut**ain**</u>, <u>pens-</u> is a verb stem and <u>haut-</u> is an adjective stem). It seems, therefore, that in the present study the syntactic category of morphemes did not constrain the morphemic errors. There is, however, an observation that contradicts this finding. MacKay (1979) reported that, in Meringer's corpus, suffixes were always substituted for suffixes of the same general type (e.g. nominalisation suffixes for other nominalisation suffixes) and that stems almost always exchanged for stems of the same syntactic class (e.g. noun stems were exchanged with noun stems). This contradiction might be related to a difference in productivity. The material selected in the present study contained suffixed nouns and suffixed adjectives that were formed, for the most part, on non-productive formation patterns, while the German lexicon might display a high rate of productive patterns. One can speculate that syntactic information is marked only for productive affixes, since it is really only needed when morphology is used productively (that is, when morphemes are combined together to build a new word). Obviously, more data are needed here. Further error-elicitation studies would allow one to test systematically for syntactic influences on morphemic errors and their interaction with productivity and possibly, the language studied.

Finally, experimental evidence is also required in relation to the role of semantic transparency in the representation of word derivational structure: Are all derived words analysed at the morphological level or only those that can be meaningfully related to their morphological components? The data reported here are silent about this issue, since the great majority of the suffixed words selected was semantically transparent. There is experimental evidence in spoken (Marslen-Wilson et al., 1994) and written (Sandra, 1990; Zwitserlood, 1994) word recognition suggesting that semantic transparency is a relevant feature in the representation of polymorphemic words. However, this factor appears to be involved at a *lexical* representation level (i.e. a modality-independent level of linguistic representations; see Marslen-Wilson et al., 1994) or a semantic level (Zwitserlood, 1994), not at a *word-form* or access (cf. Taft, 1994) representation level. Within Dell's theory of sentence production, there is, in principle, no reason for semantic factors to play a role at the processing/representation level that is assumed to be morphologically decomposed. First, because the morphological processing level is probably to be conceived of as a step or guide to phonological encoding processes, whose rules might depend on word internal structure, not on meaning. Second, because the morphemic components of a derived word are not directly retrieved from the concept nodes, but from its corresponding word nodes. However, one could suppose that whether or not the derivational structure of a given word is "discovered" during lexical acquisition and, then, represented at the morphological level, depends on various cues of parsability, among which semantic transparency might combine with phonological characteristics (see Schreuder & Baayen, 1995, for example, for a discussion on this topic, in relation to speech recognition).

In summary, there are important issues about the way the word derivational structure is captured in the speech production system that remain unresolved by this study, but it does make two contributions. First, this study provides the first data collected in controlled conditions that support the hypothesis that word *derivational* structure is, indeed, represented in the speech system. Second, it shows that the methodology employed is a potentially fruitful way to start studying systematically more specific issues about *how* derivational structure is represented and processed during speech production.

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# APPENDIX A

## Distribution of the Various Word Endings Across the Four Categories of Words Entering in the Experimental Pairs

| *Word Endings* | *Suffixed Words in Biased Pairs* | *Suffixed Words in Non-biased Pairs* | *Pseudosuffixed Words in Biased Pairs* | *Pseudosuffixed Words in Non-biased Pairs* |
|---|---|---|---|---|
| /aʒ/ <u>-age</u> | héritage | plumage | ménage | ménage |
| | barrage | lainage | visage | voyage |
| | montage | paysage | bagage | visage |
| /al/ <u>-al</u> | mural | final | cardinal | banal |
| | frontal | royal | rival | |
| /ã/ <u>-ant</u> | piquant | charmant | galant | pimpant |
| | chauffant | brillant | garant | enfant |
| | savant | | | |
| /aR/ <u>-ard</u> | traînard | campagnard | homard | hagard |
| | nasard | froussard | bâtard | standard |
| | vieillard | dossard | bâtard | standard |
| | cuissard | vieillard | picard | blafard |
| /as/ <u>-asse</u> | bonasse | molasse | cocasse | cocasse |

| | | | | |
|---|---|---|---|---|
| /o/ -eau -aud | terreau | berceau | hameau | cadeau |
| | troupeau | morceau | costaud | nigaud |
| | troupeau | noiraud | cadeau | bureau |
| | soûlaud | | | |
| /ɛl/ -el | personnel | mortel | pastel | tunnel |
| /ɛ/ -et | garçonnet | feuillet | coquet | chalet |
| | crochet | tiret | chalet | cadet |
| /œr/ -eur | penseur | éleveur | auteur | couleur |
| | buveur | trompeur | couleur | rumeur |
| | sauveur | danseur | honneur | |
| /ϕ/ -eux | coûteux | crasseux | généreux | onéreux |
| /ɛ̃/ -in, -ain | chevalin | féminin | radin | mesquin |
| | hautain | porcin | taquin | coquin |
| | | cubain | soudain | soudain |
| /ik/ -ique | cubique | typique | éthique | moustique |
| /õ/ -on | chaton | capuchon | baron | marron |
| | veston | ourson | vison | faucon |
| | guidon | cabanon | colon | melon |
| | | chaton | dragon | flacon |
| /ɔ/ -ot | manchot | vieillot | cabot | tricot |
| /yR/ -ure | chlorure | monture | nature | nature |

# APPENDIX B

## Number of Morpheme/pseudomorpheme Substitutions (Sb) and Total Number of Slips (Total) Obtained for Each of the Experimental Word Pairs

| Biased Pairs | | | | | |
|---|---|---|---|---|---|
| *Suffixed pairs:* | *Sb* | *Total* | *Pseudosuffixed pairs:* | *Sb* | *Total* |
| garçonnet chevalin | 6 | 6 | cardinal généreux | – | – |
| /gaRsɔnɛ ʃœvalɛ̃/ | | | /kaRdinal ʒeneRø/ | | |
| chaton savant | 2 | 3 | baron galant | 3 | 4 |
| /ʃatɔ̃ savɑ̃/ | | | /baRɔ̃ galɑ̃/ | | |
| veston manchot | 7 | 7 | cabot taquin | – | 3 |
| /vɛstɔ̃ mɑ̃ʃo/ | | | /kabo takɛ̃/ | | |
| terreau coûteux | 7 | 8 | hameau radin | 2 | 8 |
| /tɛRo kutø/ | | | /amo Radɛ̃/ | | |
| chlorure piquant | – | 2 | visage nature | – | – |
| /klɔRyR pikɑ̃/ | | | /vizaʒ natyR/ | | |
| cuissard chauffant | 9 | 10 | colon bâtard | 1 | 1 |
| /kwisaR ʃofɑ̃/ | | | /kɔlɔ̃ bataR/ | | |
| penseur hautain | 7 | 8 | auteur soudain | – | – |
| /pɑ̃sœR otɛ̃/ | | | /otœR sudɛ̃/ | | |
| vieillard soûlaud | 4 | 7 | homard costaud | – | 2 |
| /vjɛjaR sulo/ | | | /ɔmaR kɔsto/ | | |
| crochet mural | – | 1 | chalet rival | – | 2 |
| /kRɔʃɛ myRal/ | | | /ʃalɛ Rival/ | | |

| | | | | | |
|---|---|---|---|---|---|
| troupeau traînard<br>/tRupo tRɛnaR/ | – | 2 | cadeau bâtard<br>/kado bataR/ | – | – |
| guidon frontal<br>/gidɔ̃ fRɔ̃tal/ | – | 1 | vison coquet<br>/vizɔ̃ kɔkɛ/ | – | 6 |
| héritage personnel<br>/eRitaʒ pɛRsɔnɛl/ | 1 | 3 | couleur pastel<br>/kulœR pastɛl/ | – | – |
| barrage sauveur<br>/baRaʒ sovœR/ | 2 | 4 | ménage garant<br>/menaʒ gaRɑ̃/ | – | 1 |
| montage cubique<br>/mɔ̃taʒ kybik/ | – | 3 | bagage éthique<br>/bagaʒ etik/ | – | – |
| buveur bonasse<br>/byvœR bɔnas/ | – | – | dragon cocasse<br>/dRagɔ̃ kɔkas/ | – | – |
| troupeau nasard<br>/tRupo nazaR/ | – | 1 | honneur picard<br>/ɔnœR pikaR/ | – | – |
| | 45 | 66 | | 6 | 27 |

| | | Non-biased Pairs | | | |
|---|---|---|---|---|---|
| *Suffixed pairs:* | *Sb* | *Total* | *Pseudosuffixed pairs:* | *Sb* | *Total* |
| capuchon féminin<br>/kapyʃɔ̃ feminɛ̃/ | – | – | tunnel soudain<br>/tynɛl sudɛ̃/ | – | 3 |
| ourson noiraud<br>/uRsɔ̃ nwaRo/ | 4 | 10 | visage nigaud<br>/vizaʒ nigo/ | – | – |
| feuillet vieillot<br>/fœjɛ vjɛjo/ | – | 5 | tricot marron<br>/tRiko maRɔ̃/ | 3 | 4 |
| berceau charmant<br>/bɛRso ʃaRmɑ̃/ | 1 | 2 | couleur standard<br>/kulœR stɑ̃daR/ | – | – |
| éleveur porcin<br>/elvœR pɔRsɛ̃/ | – | – | ménage coquin<br>/menaʒ kɔkɛ̃/ | – | – |
| danseur cubain<br>/dɑ̃sœR kubɛ̃/ | 1 | 1 | cadeau mesquin<br>/kado mɛskɛ̃/ | – | – |
| plumage brillant<br>/plymaʒ bRijɑ̃/ | – | 3 | chalet pimpant<br>/ʃalɛ pɛ̃pɑ̃/ | – | 1 |
| lainage crasseux<br>/lɛnaʒ kRasø/ | 1 | 2 | voyage onéreux<br>/vwajaʒ ɔneRø/ | – | – |
| cabanon campagnard<br>/kabanɔ̃ kɑ̃paɲaR/ | – | 9 | flacon standard<br>/flakɔ̃ stɑ̃daR/ | – | – |
| chaton froussard<br>/ʃatɔ̃ fRusaR/ | – | 2 | faucon hagard<br>/fokɔ̃ agaR/ | – | – |
| tiret final<br>/tiRɛ final/ | 5 | 7 | enfant cadet<br>/ɑ̃fɑ̃ kadɛ/ | – | – |
| morceau royal<br>/mɔRso rwajal/ | – | – | bureau banal<br>/byRo banal/ | – | – |
| vieillard mortel<br>/vjɛjaR mɔRtɛl/ | – | – | melon nature<br>/mœlɔ̃ natyR/ | – | – |
| paysage trompeur<br>/pɛizaʒ tRɔ̃pœR/ | – | – | auteur rural<br>/otœR RyRal/ | 1 | 2 |
| dossard typique<br>/dɔsaR tipik/ | – | – | moustique blafard<br>/mustik blafaR/ | – | – |
| monture molasse<br>/mɔ̃tyR mɔlas/ | – | 2 | rumeur cocasse<br>/RymœR kɔkas/ | – | – |
| | 12 | 43 | | 4 | 10 |